FORTISBC ENERGY INC.

Application for a Certificate of Public Convenience and Necessity for the Lower Mainland Intermediate Pressure System Upgrade Projects

Appendices
Volumes 2 to 4

December 19, 2014

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Appendix A

COQUITLAM GATE AND FRASER GATE IP

Appendix A-1

DYNAMIC RISK
QUANTITATIVE RELIABILITY ASSESSMENT

FortisBC Pipeline
508mm Intermediate Pressure Pipeline

Quantitative Reliability Assessment

July 4, 2014

Prepared by:

Dynamic Risk

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Quantitative Reliability Assessment

Prepared for:

Fortis BC

16705 Fraser Hwy,

Surrey, BC,

V4N 0E8

Prepared by:

Samah Hasan, P.Eng.

Integrity Engineer, Engineering _____ July 4, 2014

Reviewed and Approved by:

Jim Mihell , P.Eng.

Vice President, Engineering _____ July 4, 2014

Dynamic Risk Assessment Systems Inc.
APEGGA Permit #P08193

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Executive Summary

Dynamic Risk was contracted to provide a quantitative reliability assessment of the 508 mm pipeline operating at 1207 kPa through Coquitlam and Burnaby into Vancouver.

Although no in-line inspection data were available to support the reliability analysis, there was a significant amount of excavation/assessment data related to external corrosion, and these data included documentation on wall loss measurements. These excavation/assessment data served as the basis of the reliability analysis. Because the excavation data were mostly obtained from locations where prior leaks had occurred, an attempt was made to remove those features that were believed to overly-bias the dataset. Four features, consisting of one through-wall defect, two near-through-wall defects, and one feature with a much higher burst pressure value causing a spike in the data set were reviewed to justify being removed, leaving 40 corrosion features from which depth and burst pressure distributions were derived. These data were obtained from excavations on 25 individual girth weld regions.

In order to further mitigate potential sampling bias, data collected from the leak sites were excluded for the purposes of estimating the corrosion feature incident rate.

In order to determine the consequences associated with an unintended release of gas from the pipeline, two potential modes of failure were considered – leak and rupture. A 'leak' is defined as a loss-of-containment arising from a through-wall penetration of a corrosion defect, with the extent of the penetration being confined to the area of through-wall corrosion, and with no extension of the opening through instability at the edges of the flaw. A rupture is defined as a loss-of-containment that results from instability of the wall loss area, leading to the formation of fracture faces and a full-bore opening.

The analysis showed that the probability of rupture was below the resolution of the reliability method (10^{-07}) for the twenty-year evaluation period 2013 – 2033. This is attributed to the low operating stress level of the pipeline, relative to the defect size distribution, which results in a lack of predicted structural instability through all possible combinations of defect geometry and growth period.

The probability of failure by leak increases by a factor of 3.7 through the period 2013 – 2033. The estimated failure frequencies for both leak and rupture as a function of time is summarized in Table 1 below.

Table 1
Leak and Rupture Frequencies Vs. Time

Year	Frequency of Rupture	Frequency of Leak
2013*	0	8.7
2018	0	12.8
2023	0	17.9
2028	0	23.8
2033	0	31.9

* 2013 results are provided only for purposes of a comparison against actual incident rates (note that seven leaks and zero ruptures occurred in 2013).

As can be seen from the above Table, based on the dataset used, the predicted number of leaks in the year 2013 is slightly higher, but very close to the value that was actually experienced. This helps confirm the predictive nature of the reliability method used.

For natural gas transmission pipelines, the consequences that are associated with ruptures are much more significant than the consequences associated with leaks. In that respect, because the analysis illustrates that ruptures are not likely to occur through the next 20 years of operation, risk is associated only with leak scenarios through that operating period. It should be borne in mind, however, that with respect to leaks, the potential for adverse consequences increases with leak magnitude. This is particularly true in urban environments, where leaks can potentially migrate into adjacent buildings via subterranean pathways. The release rate associated with a leak is proportional to both the area of the hole and operating pressure. For instance, the leak rate will double with a doubling of hole area; similarly, it will double with a doubling of operating pressure. Due to a lack of data, it was not possible to comment on the range of potential hole sizes or leak magnitudes, and so it is feasible that despite the negligible risk associated with ruptures, there may be a significant operating risk associated with leaks. This is particularly true for large hole sizes and higher operating pressures. For the particular pipeline that was the focus of this study, the operating risk associated with leaks is expected to increase by a factor of 3.7 over the period 2013 – 2033.

1. Introduction

The scope of work is to provide a quantitative reliability assessment of the 508 mm pipeline operating at 1207 kPa through Coquitlam and Burnaby into Vancouver. FortisBC has experienced leaks on this pipeline and visual examinations have confirmed disbonded coating and external corrosion at a number of girth welds.

While FortisBC has managed to respond to leaks on this pipeline without incurring significant consequences, it is apparent, based on discussions with FortisBC that consequences will have the potential to increase to significant levels as the leak magnitude increases. It is critical, therefore, for FortisBC to maximize its understanding of how the reliability of this pipeline might change in the near-to-intermediate-term future.

The proposed FortisBC pipeline was constructed in 1957 and commissioned in 1958. Some modifications to the pipeline were completed at the Stoney Creek crossing in 1995, at Gaglardi Way in 1965, at Clark in 1995, and at the new TransCanada Highway crossing in 1999.

The pipeline transports natural gas and is located primarily underneath roadways until the intersection of 2nd Avenue and Woodland Drive where it connects to the 762mm (NPS 30) 1,200 kPa pipeline from Fraser Gate; it then continues west as a 406mm (NPS 16) and 762mm (NPS 30) pipelines. The majority of the pipeline is buried up to 1.2m (4') deep but is significantly deeper at the TransCanada Highway crossing location. Pipeline block valves, illustrated in Figure 1, are installed along the route; these valves are pipeline emergency devices utilised for operation and maintenance purposes.

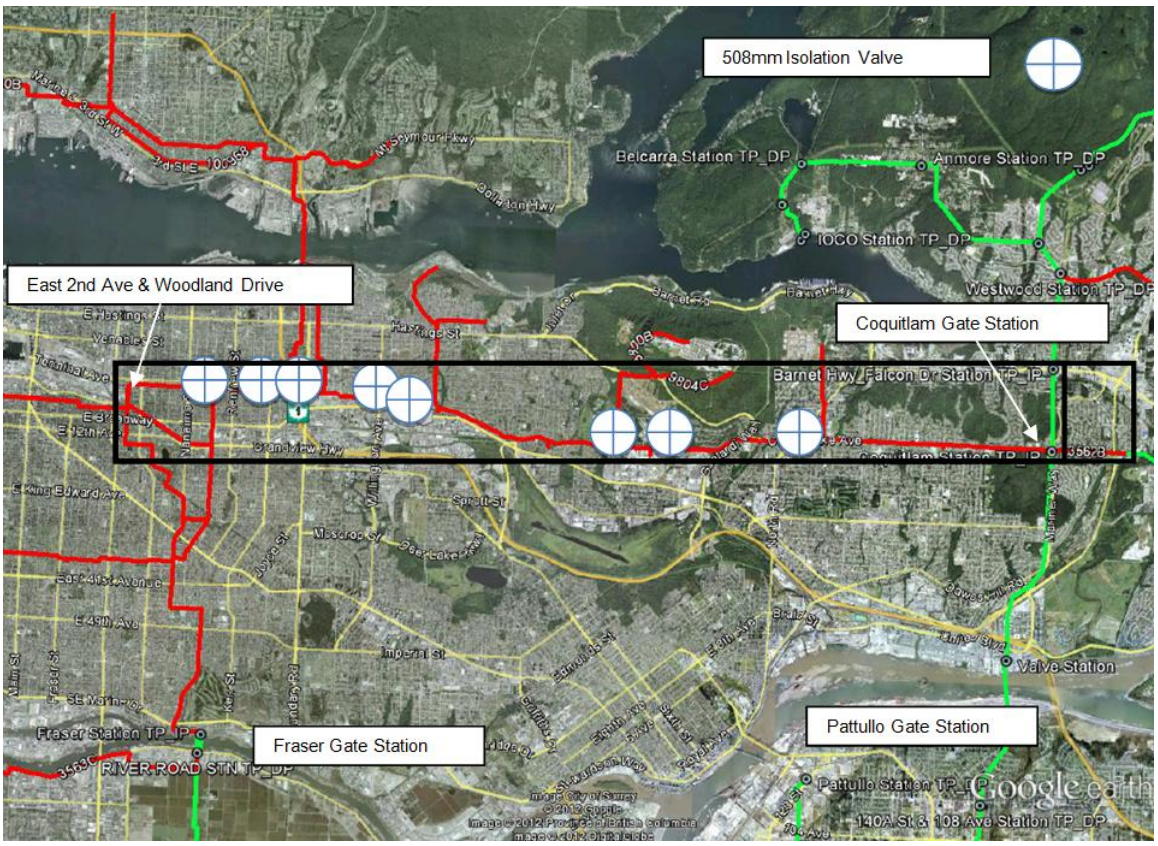


Figure 1 – Fortis BC Coquitlam - 2nd & Woodlands 508mm IP Pipeline Route

Based on the 2003 ECDA DATA ELEMENTS FORM for the 20" IP – Coquitlam Gate Station to 2nd & Boundary line, the pipeline has the following Specifications:

OD	= 508.0 mm
Wall Thickness	= 6.35 mm
Material Standard	= API 5LX-42
Grade	= 290 MPa
Certified O.P.	= 1207 KPa
Type of Joints	= Weld
Internal Coating	= no
Mainline External Coating	= Coal tar with outer wrap
Joint External Coating	= Field applied Coal Tar
1959 Hydrotest pressure	= 1827 KPa

2. Threats Considered

Based on interviews with FortisBC staff, it was determined that the leak history for this pipeline is dominated by external corrosion failures. Accordingly, the assessment work that has been performed to date consists primarily of excavation / assessments that were performed both in the vicinity of prior external corrosion leak sites and some randomly selected sites along the pipeline. The data derived from these excavation / assessments served as the basis of the reliability analysis, which focussed only on the threat of external corrosion.

The data acquired from the excavation / assessments are representative for the most part of regions in the vicinity of field girth welds, where the bulk of the coating failure had been observed. It should be noted however, that where over-the-ditch coating systems might be used, there is no reason to suspect that the girth weld area would be any more or less susceptible to coating failure than the rest of each joint of pipe. For the purposes of the reliability analysis, data from all excavations (with the exception of data from four features, which were considered to be statistical outliers) were used in developing the size distribution functions. For the development of corrosion feature incident rates, however, data from the leak site excavations were excluded so as to remove potential sampling bias.

2.1. Data Review

In addition to addressing the relevance and significance of the external corrosion threat on the Coquitlam - 2nd & Woodlands 508mm IP pipeline, a review was undertaken of the availability, quality, and completeness of the data attributes, with respect to the type and viability of reliability approach that might ultimately be employed to quantify the magnitude of the failure likelihood.

A summary of the data review and assessment for the external corrosion threat is provided in Table 2.

Table 2
External Corrosion Threat Data Review

Threat Attribute	Data Evaluation	Discussion
Coating Type	- Line pipe for the pipeline is coated with Coal tar with outer wrap. - Field Girth Welds are coated with field applied coal Tar	Based on communications with Fortis BC
Cathodic Protection	- Based on available data, cathodic protection was first applied in 1964 (7 years after construction) and has been monitored and maintained in accordance with the applicable pipeline operation Standards and Codes since that time. - Cold applied polymer backed tape is expected at most repair locations - Rectifier 3: Located at survey distance 8050m approximately 120m east of Underhill Avenue with 1 circuit connected to the IP pipeline. The groundbed is approximately 5m from the IP pipeline and is at vertical depth of cover of 30m. - In 2004, an ECDA survey was conducted by DNV. Approximately 61% of the Broadway and Underhill to 2nd and Woodland failed the -850mV criteria. - In 2004, a depolarization survey conducted at the test points only indicated that the 100mV shift criterion was satisfied for 95% of the inspected sections. - In 2012, a CIS survey analysis was conducted from Coquitlam gate Station to Boundary and Underhill (approximately 50% of the total pipeline length). The survey results indicate that cathodic protection potentials do not meet the -850mV criterion. - In 2013, a depolarization survey covering the entire pipeline length was completed. Preliminary results indicate that the 100mV polarization shift criterion was satisfied for 98% of the pipeline. Fortis BC has plans to mitigate areas of non-conforming CP potentials.	Based on the 2012 Coquitlam Vancouver IP CIS survey Report and communications with Fortis BC.
Above-ground pipe	- Average depth is 2.20m and adequate DOC is maintained over 100% of the length of the pipeline. - The shallowest DOC measurement was 0.75m on a 2-track (or trail).	Based on the 2012 Coquitlam Vancouver IP CIS survey Report

Based on a review of the above information, the pipeline is considered to have a significant susceptibility to failure resulting from external corrosion. This is attributed primarily to the following factors:

- History of pipeline failures attributed to external corrosion
- Sufficient amount of excavation / assessment data showing external wall loss
- Documented evidence of coating failure and/or disbondment at girth welds

3. Reliability Approach

Excavation / assessment data served as the basis of the reliability analysis, which focussed only on the threat of external corrosion.

The presence and severity of external corrosion depends on many factors including but not limited to the location of the pipeline (soil corrosiveness), the type and condition of external coating present, and the effectiveness of the cathodic protection system.

The reliability approach taken to assess the threat of external corrosion for an existing pipeline employs the use of available assessment data (in this case excavation data). A reliability analysis using excavation data essentially models how the pipeline materials and design responds to an anticipated degradation process and establishes how quickly the reliability degrades to a point where failure likelihood becomes significant. For this reason, it is important that the excavation data is representative of the degradation process of the entire line, including defect incidence rate, defect size distribution, and defect growth rate distribution.

3.1. Data

A total of 44 corrosion features, obtained from 25 girth weld regions were obtained. Three of the 44 features, including one feature that had penetrated through-wall, had maximum corrosion depths in excess of 70% of the wall thickness. These three features were deemed to be representative of a sampling bias, since the excavation data were obtained from regions where leaks had occurred previously. One feature was located on a section with heavier wall thickness (11.8mm) and caused a spike in the failure pressure data sampling. Therefore, in order to mitigate the potential for conservatism in the analysis, those four corrosion features were removed from the dataset, leaving 40 corrosion features. The excavations that were performed to collect these data focussed on 25 girth weld areas. Out of the 25 girth weld areas, 14 girth weld areas were associated with leak sites whereas the other 11 were randomly selected. Therefore, the 13 corrosion features within the randomly selected 11 excavation sites were used to calculate an average corrosion feature incidence rate of 1.18 corrosion features per girth weld region.

The pipeline is approximately 20 km long. Assuming a 12 m pipe length, there are approximately 1667 girth weld regions in the pipeline. The calculations of the estimated failure frequencies are outlined in Section 3.2 below.

3.2. Reliability Approach

The above section described the data that were used as the basis of the reliability analysis. As described in Section 3.1, data processing was undertaken to address potential sampling bias so that the data used in the analysis was as representative as possible of a random sample of wall loss features located in the girth weld area, where the bulk of wall loss has been reported.

The wall loss data were pooled, and for each wall loss data point, a failure pressure (valid for the year of consideration) was calculated in accordance with the modified ASME B31G equation:

$$P_f = \frac{2t\bar{\sigma}}{D}\left[\frac{1-0.85\frac{d}{t}}{1-0.85\frac{d}{t}\frac{1}{M}}\right]$$

Equation 1

Where,

P_f = Failure pressure (psig)

$\bar{\sigma}$ = SMYS+10 ksi,

M = $\sqrt{1+0.6275\left(\frac{l}{\sqrt{Dt}}\right)^2-0.003375\left(\frac{l}{\sqrt{Dt}}\right)^4}$ for $\left(\frac{l}{\sqrt{Dt}}\right)^2 \le 50.0$

M = $0.032\left(\frac{l}{\sqrt{Dt}}\right)^2+3.3$ for $\left(\frac{l}{\sqrt{Dt}}\right)^2 > 50.0$

d = corrosion feature depth (in)

l = corrosion feature longitudinal length (in)

t = pipe wall thickness (in)

D = pipe diameter (in)

In addition to the failure pressure value that was calculated for each wall loss feature, an apparent average corrosion growth rate was calculated for each feature, in accordance with the following relationship:

$$R = \frac{d}{y_i - (1957+5)}$$

Equation 2

Where,

R = Wall loss rate (in/yr)

d = corrosion feature depth (in)

y_i = Year of excavation / assessment associated with the corrosion feature

The significance of the quantity (1957+5) is that 1957 is the year of installation for the pipeline, and the value 5 is the amount of time (in years) that has been assumed for coating degradation and corrosion initiation to occur. Accounting for such an 'incubation period' for coating failure is a prudent protocol, since it allows for degradation mechanisms that have been observed in coal tar coating systems.

Using Equation 1 and Equation 2, failure pressure distributions and corrosion depth distributions were created for each of five-year intervals between the years 2013 and 2033. These distributions are summarized in the following Section.

3.2.1 Distributions

An analysis of the corrosion feature depth and burst pressure data was performed for each of the five year intervals, and in each case, a distribution that most closely fits the data was determined. A summary of these fitted distributions is provided in the following Tables.

Table 3
Corrosion Depth Distribution Parameters for Each Year of Analysis

Year of Analysis	Defect Depth, d (mm)		
	Distribution Parameter		
	Distribution	μ	σ
2013	Lognormal	0.028674	0.695265
2018	Lognormal	0.122200	0.695265
2023	Lognormal	0.207723	0.695265
2028	Lognormal	0.286503	0.695265
2033	Lognormal	0.359529	0.695265

Table 4
Corrosion Burst Pressure Distribution Parameters for Each Year of Analysis

Year of Analysis	Burst Pressure, P_f (MPa)		
	Distribution Parameter		
	Distribution	α	β
2013	Weibull	8.70406	18.7346
2018	Weibull	8.67177	16.3808
2023	Weibull	8.63763	14.3961
2028	Weibull	8.60134	12.6939
2033	Weibull	8.56252	11.2112

3.2.2 Monte Carlo Analysis

Using a Monte Carlo analysis, the failure frequency was determined for each of the years of evaluation, where failure was defined as occurring where either of the following limiting conditions have been exceeded:

1. $P_f \leq P_{op}$

Where P_{op} is 1207 kPa (175 psi)

2. $d \geq t$

The failure frequency calculated in this manner is representative of the year of operation, and is conditional, given the presence of a corrosion feature. This failure frequency was then multiplied by the average number of corrosion features discovered in the vicinity of a girth weld. This yielded a value that was representative of the conditional failure frequency, given the presence of a girth weld region for the operating year being considered. The overall failure frequency for both leaks and ruptures for the pipeline as a whole for that particular year of operation was then multiplied by the expected number of girth weld regions in the pipeline. The approach is summarized as follows:

$$FF_P = FF_F \times \rho_{f(w)} \times N_w$$

Equation 3

Where,

FF_P = Failure Frequency for the pipeline in a given year of consideration

FF_F = Conditional Failure Frequency, given the presence of a corrosion feature

$\rho_{f(w)}$ = Corrosion feature density (features / girth weld region)

N_w = Number of girth weld regions in the pipeline

.

4. Results

The predicted failure frequencies over the entire pipeline for both leaks and ruptures for each year of analysis are summarized below, along with fractional increases in leaks and ruptures over the year 2013.

Table 5
Pipeline-Wide Failure Frequency for Leaks and Ruptures Vs. Time

Year	Predicted Failure Frequency for Entire Pipeline		Fractional Increase in Failure Probability (Over the Year 2013)	
	Ruptures	Leaks	Ruptures	Leaks
*2013	0.0	8.7	-	-
2018	0.0	12.8	0	1.5
2023	0.0	17.9	0	2.1
2028	0.0	23.8	0	2.8
2033	0.0	31.9	0	3.7

* 2013 results are provided only for purposes of a comparison against actual incident rates (note that seven leaks and zero ruptures occurred in 2013).

As can be seen from the above Table, based on the dataset used, the predicted number of leaks in the year 2013 is slightly higher, but very close to the value that was actually experienced. This helps confirm the predictive nature of the reliability method used.

Therefore, the results in Table 5 above may be used to convey how failure likelihood will increase over time – expressed as a percent increase over the 2013 failure likelihood as a base.

As can be seen from the Table 5 above, the probability of rupture was below the resolution of the reliability method (10^{-07}) for the twenty-year evaluation period 2013 – 2033. This is attributed to the low operating stress level, relative to the defect size distribution, and results in a lack of predicted structural instability through all possible combinations of defect geometry and growth period. The probability of failure by leak increases by a factor of three (3.7) through the period 2013 – 2033.

Appendix A-2

OIL AND GAS COMMISSION GENERAL ORDER 2013-25

October 30, 2013 Enforcement File: 13-96

Fortis BC Energy Inc.
16705 Fraser Highway
Surrey, BC, V4N 0E8
Attention: Keith Recsky, Sr. Integrity Engineer

Re: General Order 2013-25

Dear Mr. Recsky

Please find attached a Commission order in regard to pipeline Project 1045 in the Burnaby area, and the recent leaks associated with it.

If you have any questions or concerns, please do not hesitate to contact Mr. Jason Wilson, Pipeline Engineer with the Commission at 250 980-6072.

Thanking you in advance.

Yours Truly,

Keith Rande
Manager Enforcement
Oil and Gas Commission

cc. Dean Zimmer, Director C&E, OGC
Jason Wilson, Pipeline Engineer, OGC

GENERAL ORDER 2013-25
Section 49 *Oil and Gas Activities Act*

Issued to:

Fortis BC Energy Inc.
16705 Fraser Highway
Surrey, BC, V4N 0E8

Attention: Keith Recsky

Order:

Pursuant to section 49(1)(b) of the *Oil and Gas Activities Act* (the Act), I, Dean Zimmer, order that Fortis BC Energy Inc. (Fortis BC) must:

1. On or before December 1, 2013 complete and submit to the Oil and Gas Commission (Commission):
    a. An engineering assessment of Pipeline Project 1045 (the subject pipeline) that includes but is not limited to:
        i. a timeline to repair, replace or discontinue the use of the subject pipeline;
        ii. interim measures to continue the safe operation of the subject pipeline and rationale for those measures;
        iii. a contingency plan in the event that the pipeline becomes inoperable prior to its repair or replacement;
        iv. the performance measures and defined acceptability criteria which would demonstrate fitness for service, as per CSA Z662-11, Clause 3.3;
        v. description of the leak detection program and its efficiency;
        vi. all information obtained from cut-outs of the subject pipeline performed within the last ten years that provides evidence of the subject pipeline condition;
        vii. the cause, size, and axial location of the through-wall failure, and the integrity of the surrounding material for each failure in 2013.

    b. An estimate of the volume of gas lost during the most recent leak;

    c. Records of the closed interval surveys of the cathodic protection system for the past five years, and;

    d. A map of the subject pipeline that shows all failure locations over the past five years.

2. Complete leak surveys on the subject pipeline at a minimum of once per week.

3. Submit the information required in Item 1 electronically to the Commission at C&E@bcogc.ca.

Conditions:

A. This order shall remain in effect until amended or terminated in whole or in part by the Commission.

Reasons:

I make this order for the following reasons:

i. Fortis BC is the operator responsible for the subject pipeline.

ii. The subject pipeline has experienced seven leaks to date in 2013, two leaks in 2012, and six leaks prior to that.

iii. Fortis BC has identified external corrosion as the cause.

iv. I am of the opinion that the subject pipeline may pose a risk to public safety and the environment.

Review and Appeal:

Fortis BC may request a review of this order under section 70 of the Act by submitting a request for review to: ogc.determinationreviews@bcogc.ca.

Fortis BC may appeal this order to the Oil and Gas Tribunals under section 72 of the Act. The process for appeals may be found at www.ogat.gov.bc.ca and a notice of appeal may be sent to the Oil and Gas Appeals Tribunal at:

Oil and Gas Appeals Tribunal
PO Box 4925 Stn Prov Govt
Victoria, BC, V8W 9V1

_____
Dean Zimmer
Director, Compliance and Enforcement
Oil and Gas Commission

DATED AT Fort St. John, in the Province of British Columbia, this 30th day of October, 2013.

Appendix A-3

FEI RESPONSE TO OIL AND GAS COMMISSION GENERAL ORDER 2013-25

VIA EMAIL to: C&E@bcogc.ca

Attn: Dean Zimmer
Director, Compliance and Enforcement
BC Oil and Gas Commission

Re: General Order 2013-25

FortisBC is submitting the attached documentation in response to Order 2013-25, pertaining to BC Oil and Gas Commission ("Commission") Pipeline Project 1045. FortisBC has assessed that the 508 mm pipeline installed in 1958 as Pipeline Project 1045 ("subject pipeline") is suitable for continued service, and is being operated in accordance with the requirements of CSA Z662-11.

Through implementation of an Integrity Management Program, FortisBC manages and/or mitigates hazards on our system that have the potential to result in failure with significant consequences. This has resulted in incremental mitigation activities, including increased leak survey frequency. In addition, FortisBC has outlined a replacement plan for the subject pipeline that is currently planned for submission to the BC Utilities Commission in 2014. This plan addresses FortisBC's requirement as a Permit Holder under Section 37 (1) (a) of the BC Oil and Gas Activities Act to "prevent spillage".

We would appreciate the opportunity to meet with representatives of the Commission to review and discuss the content of our submission. I can be reached at 604-592-7701 (office) or 604-908-3060 (cellular) to discuss a suitable time and location.

Sincerely,

Nov. 27, 2013

Bryan Balmer, P.Eng.
Manager, System Integrity Programs
FortisBC

FortisBC response to General Order 2013-25

1.

a. FortisBC's engineering assessment of Pipeline Project 1045

FortisBC has assessed that the 508 mm pipeline installed in 1958 as Pipeline Project 1045 ("subject pipeline") is suitable for continued service, and is being operated in accordance with the requirements of CSA Z662-11.

Through implementation of an Integrity Management Program, FortisBC manages and/or mitigates hazards on our system that have the potential to result in failure with significant consequences. This has resulted in incremental mitigation activities, including increased leak survey frequency. FortisBC's replacement plan for the subject pipeline, currently planned for submission to the BC Utilities Commission in 2014, appropriately addresses FortisBC's requirement as a Permit Holder under Section 37 (1) (a) of the BC Oil and Gas Activities Act to "prevent spillage".

Please see Appendix 1 for the assessment.

b. An estimate of the volume of gas lost during the most recent leak

The most recent leak on this pipeline was on October 9, 2013. FortisBC is currently in the process of preparing our submission of a Form D "Permit Holder Post Incident Report". The estimate of "Volume spilled/released" that will be reported in Part C of the form is 661 m^3.

c. Records of close interval surveys of the cathodic protection system for the past five years

This data is included within Appendix 2 – Cathodic Protection Evaluation.

Cathodic protection is a key activity within FortisBC's Integrity Management Program to mitigate the hazard of external corrosion, and as such we have included a CP Evaluation of the subject pipeline. However, the assessment contained in Appendix 1 demonstrates that corrosion observed on the subject pipeline has resulted from disbonded coating that is preventing cathodic protection current from reaching the pipe ("shielding"). The disbonded coating is a field-applied coal tar that was applied at girth welds during the original construction, and this failure mechanism at the girth welds is considered prevalent along the entire length of the pipeline. 77% of girth welds examined since

2010 have shown evidence of disbondment at the field-applied coating.

Due to the occurrence of cathodic protection shielding, CP data has limited relevance to the assessment – either from the perspective of potentially contributing to the occurrence of past failures, or from the perspective of preventing possible future failures.

d. A map of the subject pipeline that shows all failure locations over the past five years

Appendix 3 contains a map of all failure locations over the past five years, and other known corrosion-related failure locations.

2. Complete leak surveys on the subject pipeline at a minimum of once per week.

FortisBC has been conducting weekly leak surveys on the subject pipeline since August 22nd, 2013 and will continue to do so until such time as General Order 2013-25 is amended or terminated by the Commission and FortisBC believes that it is safe and prudent to do so.

3. Submit the information required in Item 1 electronically to the Commission at C&E@bcogc.ca

This documentation has been prepared for electronic submission to C&E@bcogc.ca.

Signed:

Nov. 27, 2013

Bryan Balmer, P.Eng.
Manager, System Integrity Programs
FortisBC

Digitally signed by Paul M. Chernikhowsky
Date: 2013.11.27 11:40:11 -08'00'

Paul Chernikhowsky, P.Eng.
Director, Engineering Services
FortisBC

Appendix 1 - FortisBC's engineering assessment of Pipeline Project 1045

This assessment pertains to a 508 mm pipeline owned and operated by FortisBC, running from Coquitlam Gate Station (near intersection of Como Lake Avenue and Mariner Way, Coquitlam, BC) to 2 Avenue and Woodland Drive District Station in Vancouver. The pipeline serves tens of thousands of customers in the Vancouver and surrounding area, with varying degrees of outage criticality throughout the year.

The pipeline, installed in 1958, is approximately 20 km in length. As the operating stress level is 17% SMYS, the pipeline is operated in accordance with CSA Z662 Clause 12 for gas distribution systems. Pipeline data is included as Table 1 at the end of this assessment (within Appendix 1).

Issue Assessment/Study

Beginning in 2011, a condition assessment was undertaken on the subject pipeline in response to previous corrosion leaks (1 leak in each of 1994, 1999, 2001, 2010, and 2011).

Excavations were conducted at 13 sites in 2011 and 2012 to understand the leak cause and to evaluate potential tools for preventing future leaks on the pipeline (i.e. above-ground cathodic protection and coating surveys for predicting corrosion susceptibility). The information obtained at these excavations, as well at past and recent leak sites, indicate corrosion under disbonded and shielding field-applied joint coatings. Data from leak sites is included as Table 2 at the end of this assessment. Data from excavations (including available data from "in-progress" 2013 excavations) is included as Table 3, also at the end of this assessment.

Due to the coating failure mechanism causing apparent shielding of the cathodic protection system, it has been deemed unlikely that cathodic protection will mitigate corrosion growth and prevent future leaks. Above-ground tools (CP and coating surveys) also support the conclusion of CP shielding, as they have been ineffective at identifying where disbonded field-applied joint coatings have been observed at excavations. The disbonded coating is a field-applied coal tar that was applied during original construction at girth welds.

As indicated through the map included as Appendix 3 in this submission, corrosion leaks have occurred at varied locations along the entire length of the subject pipeline (all at girth welds). Although it is recognized that some leaks have occurred in relatively close proximity, analysis of leak and excavation data has indicated the failure mechanism is prevalent at girth welds along the entire length of the pipeline. 77% of girth welds examined since 2010 have shown evidence of disbondment at the field-applied coating.

Pipeline Replacement

Options to address this systemic issue are limited. In-line inspection has not been deemed a viable option due to low operating pressures and the expected presence of inside diameter restrictions. With consideration to the cause of leaks, extent of leaks, expected increase in leak frequency, and lack of effective prevention methods, FortisBC has determined that pipe replacement is the most appropriate mitigation method.

Replacement meets the requirements of CSA Z662 Section 12.10.2.3 (d) which states "Where the condition of distribution or service lines, as indicated by leak records or visual observation, deteriorates to the point where they should not be retained in service, they shall be replaced, reconditioned, or abandoned". Replacement also meets the requirements of the BC Oil and Gas Activities Act Section 37 (3) which states "A person who is aware that spillage is occurring or likely to occur must make reasonable efforts to prevent or assist in containing or preventing the spillage".

FortisBC has a Mains and Services Renewal Program that identifies and funds condition-based replacements of our distribution piping system, operating at less than 30% SMYS. This Program addresses required asset replacements valued at less than $5 million. As a publically regulated utility, a different process has been mandated by our financial regulator, the BC Utilities Commission, for expenditures of $5 million or greater.

Section 45(1) of the Utilities Commission Act (UCA) requires that a person must not begin the construction or operation of a public utility plant or system, or an extension of either, without first obtaining from the Commission a CPCN (Certificate of Public Necessity and Convenience) approving the construction or operation. Section 46(1) of the UCA requires an application for a CPCN be filed with Commission. A copy of the UCA can be found at http://www.qp.gov.bc.ca/statreg/stat/U/96473_01.htm. The threshold of the CPCN requirement for FortisBC has been set at $5 million. Given the diameter, location, and required length of replacement, replacement of the subject pipeline will significantly exceed $5 million.

The required scope of CPCN Applications is contained in the 2010 Certificates of Public Convenience and Necessity Application Guidelines (http://www.bcuc.com/Documents/MiscDocs/2010/DOC_4238_G-50-10_2010-CPCN-Application-Guidelines.pdf). The requirements include various consultations (First Nations, public), as well as a cost estimate of a minimum Class 3 degree of accuracy as defined in AACE International Recommended Practice No. 10S-90, Cost Engineering Terminology (May 20, 2009).

Obtaining the required degree of accuracy of cost estimate requires preliminary Engineering to be completed, including route selection and pipe specifications. Route selection requires coordination and approvals from multiple municipalities. If the existing routing is selected, pipeline construction will have to be done in sections to ensure supply to existing customers is maintained.

The expected filing date of the CPCN application is currently Q3 2014. The expected filing date of the OCG application is Q2 2015. Once CPCN approval is obtained from the BC Utilities Commission, final engineering, material procurement, and construction can commence. A detailed construction schedule is not available at the current time.

Pipeline Operation

Through implementation of an Integrity Management Program (IMP), FortisBC manages and/or mitigates hazards on our system that have the potential to result in failure with significant consequences. FortisBC's IMP also comprises measures to mitigate potential consequences of failure in accordance with CSA Z662-11 Clause N.10.5.

Consequence reduction measures are relevant to the subject pipeline's operation, due to the assessed lack of effective methods to prevent future leaks. Due to the pipeline operating at low stress levels (17% SMYS) it is expected to fail by leak, not rupture. The corrosion failure mechanism will result in pinhole penetrations that would grow only if left unrepaired.

FortisBC's standard leak survey frequency for pipelines in Class 3 locations operating at pressures above 700 kPa is annual. To locate leaks at the pinhole stage, FortisBC has implemented increased leak survey frequency for the subject pipeline. A further degree of feature growth and/or of gas migration may be necessary prior to leaks becoming detectable by the public (through odorant present in the gas) versus targeted leak surveys.

Therefore, primarily in response to observed leak frequencies, FortisBC increased leak survey frequency of the subject pipeline to quarterly on March 4th, 2013. This frequency was further increased to weekly on August 22nd, 2013. To facilitate leak survey, vegetation control frequencies have also been increased over some segments. This enables ready access to the pipeline for surveys, and also to complete any subsequent repairs.

Leak data is included as Table 2, including the identification source (e.g. public or leak survey). Since the implementation of the weekly leak survey in August 2013, all leaks have been identified prior to public reports being received. FortisBC believes weekly leak survey is an effective means of early leak detection on the subject pipeline.

Leak management and response is another important element of FortisBC's operations. To support optimal leak response for the subject pipeline, FortisBC has implemented the following measures:

- Pretested pipe and stopple equipment have been acquired to facilitate leak repair during cold weather conditions if a bypass is needed to maintain service to customers.
- Bypass sizing requirements have been assessed to expedite repair planning.
- Repair sleeves have been manufactured and are being stored for use on the subject pipeline.

Leak response documentation specific to the subject pipeline is in development to facilitate decisions by "on-call managers" who may be responding to leaks identified during evenings, weekends, or holidays. The documentation contains information regarding isolation strategies, critical customers, blow down procedures, storage location of repair materials, and repair methods.

Suitability for Continued Operation

With the operating practices identified above, FortisBC does not anticipate the subject pipeline becoming inoperable. Safety risk is being managed through odorization, leak detection, and leak response.

Environmental impact is also being managed through early leak detection and response. In addition, FortisBC has analyzed gas volume estimates at past leaks and concluded that the incremental environmental risk due to leaks on the subject pipeline is not material. Leaks that have occurred in 2013 on the subject pipeline comprise less than 0.1% of the FortisBC Energy Inc. yearly GHG emissions.

FortisBC has recognized the potential for increasing resource pressures in our Operations group if the leak frequency increases significantly prior to replacement. Potential mitigation strategies to address this are under development.

FortisBC also recognizes the potential for public inconvenience due to excavations in roads if the leak frequency increases significantly or if mitigation strategies involve significant excavations in roads. To manage inconvenience and potential safety risk to the public regarding excavations, FortisBC implements site-appropriate traffic control and safety measures for our entire operations (i.e. these mitigating measures are not specific to the subject pipeline).

As part of FortisBC's Integrity Management Program, a Dashboard of various measures and indicators is updated and reviewed quarterly. The Dashboard contains over 100 measures related to development of plans to manage potential hazards to our system, completion of preventive and monitoring activities, as well as hazard event and incident occurrences.

Specific to the subject pipeline, we will continue to monitor the following measures within our Integrity Management Program Dashboard:

- completion of leak surveys in accordance with plan
- odorization management
    - sampling program completion
    - odor sample results within tolerances
    - odorizer adjustment and re-sampling completion, when required
    - odorizer level measure and fill completion
    - completion of injection odorizer maintenance

Conclusion

FortisBC has assessed that the subject pipeline is suitable for continued service, and is being operated in accordance with the requirements of CSA Z662-11. Through implementation of an Integrity Management Program, FortisBC manages and/or mitigates hazards on our system that have the potential to result in failure with significant consequences. This has resulted in incremental mitigation activities, including increased leak survey frequency.

FortisBC's replacement plan for the subject pipeline, currently planned for submission to the BC Utilities Commission in 2014, appropriately addresses FortisBC's requirement as a Permit Holder under Section 37 (1) (a) of the BC Oil and Gas Activities Act to "prevent spillage".

Tables

Table 1: Pipeline Data

Data Element	**Data Value**
Asset Name	508mm Coquitlam - Vancouver IP Pipeline
BC Oil and Gas Commission Pipeline Project Number	1045
FortisBC Pipeline FID	42057
Original Construction Year	1958
Pipeline Diameter	508 mm (NPS 20)
Pipeline Length	20 km
Pipeline Material Specification	API 5L
Pipeline Grade	290 MPa (X42)
Class Location	3
Pipeline Wall Thickness (mm)	6.34 mm
Test Pressure	1,827 kPag
Maximum Operating Pressure (MOP)	1,200 kPag
Pipeline Operating Stress (% SMYS)	17% SMYS
External Factory Coating	Coal Tar Enamel
External Field Coating	Coal Tar Enamel

Table 2: Leak Data (2010 to current)

Year	Date	Location	Cause of Leak	Identification Source	Axial Location (o'clock facing upstream)		Size of Through Wall Feature (measured from outer extents of the feature containing the throug wall pinhole)		Factory Coating Cutback (mm)	Field Applied Coating Extents Beyond Factory Cutback (mm)		Disbonded Factory Applied Coating Extents Beyond Field Applied coating (mm)		Codition of Surrounding Pipe Material Outside of feature extents	Repair Type	Comments	Estimated Volume of Gas Released (as Reported) cubic meters
					From	To	Length (mm)	Width (mm)		Upstream	Downstream	Upstream	Downstream				
2010	February 18, 2010	Como Lake Ave 64 m west of Mariner Way, Coquitlam	***external corrosion*** under field applied coating at girth weld	Not Available (N/A)	N/A	N/A	N/A	N/A	200	N/A	N/A	N/A	N/A	Sound Pipe	Weld Patch	-	N/A
2011	March 18, 2011	7584 Broadway, Burnaby	***external corrosion*** under field applied coating at girth weld	N/A	4:00	8:00	800	400	200	0	0	200	0	Sound Pipe	Cut Out	Removed all corrosion	N/A
2012	April 30, 2012	3422 E 2nd Ave, Vancouver	on the ***weld*** on a bolt on a Plidco repair sleeve from a previous leak	FortisBC (during Integrity Excavation)	Not Applicable	Not Applicable	Not Applicable	Not Applicable	Not Applicable	Not Applicable	Not Applicable	Not Applicable	Not Applicable	Sound Pipe (Leak on Plidco Sleeve)	Cut Out	Removed all corrosion	N/A
	May 24, 2012	2525 Como Lake Rd., Coquitlam	***external corrosion*** under field applied coating at girth weld	N/A	6:00	6:00	60	40	200	0	0	0	0	Sound Pipe	Split Sleeve	Repair sleeve encompassed all corrosion	1200
2013	May 6, 2013	7578 Broadway, Burnaby	***external corrosion*** under field applied coating at girth weld	Leak Survey	5:30	5:30	60	60	200	0	0	0	0	Sound Pipe	Split Sleeve	Repair sleeve encompassed all corrosion	1286
	June 27, 2013	Halifax & Springer St., Burnaby	***external corrosion*** under field applied coating at girth weld	Public (over odorization event)	4:00	8:00	813	457	200	0	38	370	38	Sound Pipe	24" Casing	Repair sleeve encompassed all corrosion	2148
	July 17, 2013	4100 Halifax St., Burnaby	***external corrosion*** under field applied coating at girth weld	Public	5:30	5:30	30	30	200	100	100	850	100	Isolated corrosion pits (max depth 50%) within small area of general corrosion (25% average depth)	Weld Patch	Repair patch encompassed all corrosion	2356
	August 8, 2013	4330 Blk Halifax St., Burnaby	***external corrosion*** under field applied coating at girth weld	Leak Survey	3:30	8:30	800	750	200	700	700	0	0	Sound pipe	24" Casing	Repair sleeve encompassed all corrosion	734
	August 20, 2013	4330 Halifax St., Burnaby	***external corrosion*** under field applied coating at girth weld	FortisBC (personnel on site for August 8th leak)	5:30	5:30	50	50	200	0	0	150	1000	Scattered isolated pitting within areas of general corosion(max pit depth 80%, general corrosion depth 40%)	24" Casing	Repair sleeve encompassed all corrosion	587
	August 23, 2013	Como Lake Rd & Baker St., Coqutilam	***external corrosion*** under field applied coating at girth weld	Leak Survey	6:30	6:30	30	30	200	0	0	0	0	Two additional corrosion pits located within an area of general corrosion extending between the 5:30 and 6:30 o'clock position (Max depth 50%)	Weld Patch	Repair patch encompassed all corrosion	293
	October 9, 2013	4100 Block Halifax St, Burnaby	***external corrosion*** under field applied coating at girth weld	Leak Survey	5	5	65	60	200	0	0	0	150	Four additional isolated corrosion pits (max depth 50%)	Split Sleeve	Repair sleeve encompassed all corrosion	661

N/A - Not Available

Table 3: Excavation Data (2011 to current)

Year	*Dig Location*	*Summary of Findings*	*Mitigation*	*Number of Girth Welds Exposed*	*Approximate Length of Pipe Exposed (m)*
2011	Lane behind Brentlawn west of Fairlawn	Corrosion under disbonded field applied coating at girth weld – 70% through Wall. Shop applied coating in excellent condition.	Weld Sleeve Installed and recoat	2	14
2011	Lane behind Brentlawn west of Fairlawn	Corrosion under disbonded field applied repair coating from 2001 Leak (Polymer Tape). Shop applied coating in excellent condition.	Recoat	1	4
2011	Lane behind Brentlawn west of Fairlawn	No corrosion found under field applied coating. Filed applied and shop applied coating in excellent condition.	Recoat	1	2.86
2011	West of 7584 Broadway Avenue	Corrosion under disbonded field applied coating at girth weld – 49% through Wall. Shop applied coating in excellent condition.	Recoat	1	3.9
2011	West of 7584 Broadway Avenue	No corrosion found under field applied coating. Filed applied and shop applied coating in excellent condition. Minor disbondment noted.	Recoat	1	3.66
2011	West of 7584 Broadway Avenue	No corrosion found under field applied coating. Filed applied and shop applied coating in excellent condition. Minor disbondment noted.	Recoat	1	3.61
2012	Como Lake Avenue west of Mariner	No corrosion found under field applied repair coating (Polymer Tape). Shop applied coating in excellent condition.	Recoat	1	4.8
2012	Como Lake Avenue west of Mariner	No corrosion found under field applied coating. Shop and field applied coating in excellent condition. 4 coating holidays found in shop applied coating which corresponded to 4 active corrosion features (max depth 46%)	Recoat	1	11.4
2012	Como Lake Avenue west of Mariner	Corrosion found under disbonded field applied coating. 7 Corrosion feature identified (max Depth 32%) Shop and field applied coating in good condition. 2 coating holidays found in shop applied coating which corresponded to 2 active corrosion features (max depth 34%)	Recoat	2	21.3
2012	2nd Ave. west of Skeena	No corrosion found under field applied coating. Shop and field applied coating in excellent condition. 2 coating holidays found in shop applied coating which corresponded to 2 inactive corrosion features (max depth 27%)	Recoat	1	5.02
2012	2nd Ave. west of Skeena	Corrosion under disbonded field applied repair coating from 1999 Leak (Polymer Tape). Shop applied coating in excellent condition. Three leaks on the PLIDCO Repair sleeve were found and repaired.	Cut Out	0	5.07
2012	2nd Ave. west of Skeena	Corrosion found under disbonded field applied coating. Shop and field applied coating in excellent condition. 1 coating holiday found in shop applied coating which corresponded to 1 active corrosion feature (max depth 24%)	Recoat	1	3.27
2012	2nd Ave. west of Skeena	No field coated girth weld exposed. 1 coating holiday found in shop applied coating which corresponded to 1 inactive corrosion feature (max depth 8%)	Recoat	0	4.6
2013	2nd Ave. west of Skeena	Two field coated girth welds exposed. No coating disbondment or corrosion found	Recoat	2	14
2013	2nd Ave. between Garden and Templeton	Three field coated welds exposed. Minor coating disbondment found on 1 of three welds. Two isolated corrosion features with max depth of 12%	Recoat	3	Not available
2013	Broadway East of Gaglardi	Two filed coated welds exposed. First weld cohesive coating disbondment (between layers) found, however base layer of coating bonded well to pipe. No corrosion found. 2nd weld disbonded filed coating found with corrosion underneath - three corrosion features found , max. 34% through wall.	Recoat	2	Not available

Appendix 2

FortisBC Response to General Order 2013-25

508mm Coquitlam to Vancouver IP Pipeline

Cathodic Protection Evaluation

Cathodic Protection Evaluation:

Prepared By: **Ian Thornton, AScT**
Integrity/Corrosion Analyst
NACE CP Specialist No. 7388

20”IP Coquitlam to Vancouver

This document is maintained as an ongoing assessment of the cathodic protection (CP) system applied to the 20” IP Coquitlam to Vancouver Pipeline. CP data is continuously being gathered and assessed at all integrity dig locations, leak sites, and test points. CP enhancements are implemented when deemed necessary, including rectifier adjustments, additional strategic test point locations (leak sites), interference assessments and mitigation.

SUMMARY

As cathodic protection data is simply a measurement in time, its evaluation and interpretation is subject to a high degree of uncertainty and assumptions. Seasonal changes in temperature, water table, and weather all play a significant role in the application of cathodic protection as well as its measurement. In addition, changes to CP system configuration over the operational life of a distribution pipeline network render historical assessment of annual CP data extremely difficult.

Cathodic protection has been applied, monitored and maintained to industry standards and has been proven to be effective on this pipeline where true coating holidays (steel exposed to soil) exist. This is evidenced by several direct pipeline examinations where coating holidays have been found and have little or no corrosion evident on the pipe, in conjunction with pipeline potentials exceeding criteria and corrosion product or calcareous deposits consistent with successful cathodic protection. Cathodic protection is ineffective where a coating or foreign object is shielding the CP currents path to the steel.

All of the pipeline leaks to date have been located at or near a girth weld beneath disbonded field applied coating or adjacent factory applied coating. In all cases the origin of the coating disbondment was at the field applied girth weld coating.

Based on available historical CP data, it is difficult to make a conclusion on the achieved level of cathodic protection on this pipeline over its life. However, based on direct examinations completed to date and details of the leaks that have occurred, it appears that the possible periodic deficiencies in CP, over the life of the pipeline, cannot be attributed to the leaks that have occurred nor their frequency. This is evident by the fact that leaks have occurred beneath disbonded coatings and not at true coating holidays where steel is exposed to soil. On the contrary, where actual coating holidays have been located and examined, the corrosion product is consistent with successful CP in that minimal or no corrosion and calcareous deposits are present.

FortisBC is confident that enhancements or application of additional cathodic protection current to the pipeline will not reduce the number or frequency of leaks occurring on this pipeline as all of the evidence gathered to date indicates the corrosion is occurring beneath disbonded coating, where CP is proven to be ineffective.

Assessment:

Factory Coating Type: Coal Tar Enamel with felt outer-wrap

Joint Coating type: Coal Tar Enamel without outerwrap

Repair Coatings: Cold applied Polymer Backed bitumen Tape

Cathodic protection:

1. Impressed current cathodic protection (CP) was first applied to the pipeline in 1964.
2. Records indicate system wide application of impressed current CP in 1964, including the original rectifier installed for the 508mm IP at 2nd Avenue and Skeena in Vancouver.
3. Historical records indicate the use of galvanic anode CP prior to 1964 however no records exist that indicate this to be the case for the 508mm IP pipeline.
4. A second ICCP rectifier located at Broadway & Underhill (CPM 110), in Burnaby, was installed in 1989 to enhance protection levels on the 508mm IP.
5. CPM 110 now provides CP for the eastern section of the 508mm IP only (from 2nd Ave. and Boundary to the Coquitlam Gate Station), since the installation of electrical isolation at 2nd Avenue & Boundary in 1999.
6. CPM 11 located at 2nd Ave and Skeena provides protection to the western section of the 508mm IP pipeline, from 2nd Ave and Boundary to 2nd Ave and Woodland.
7. Both anode beds are installed at a vertical depth of 30 meters.

Cathodic Protection Survey History (generally in reverse chronological order):

Source: FortisBC 508mm (NPS20) IP Pipeline Re-survey Following Implementation of Recommendations from 2012 report (EMAC Corrosion Inc.) November 2013

Survey Extents: Coquitlam Gate Station to Broadway and Underhill (8400m)

Results:

- 74% meets -850mV (CSE) Criteria
- 99% meets 100mV polarization criterion
- 1850m of ACVG Survey conducted over non paved surfaces
- 14 "Moderate" ACVG indications located

Interference effects from foreign rectifier confirmed to be negligible by synchronized interruption

Source: FortisBC 508mm (NPS20) IP Pipeline DOC/CIS Survey 2012 (EMAC Corrosion Inc.) January 2013

Survey Extents: Coquitlam Gate Station to Broadway and Shellmont(8400m)

Results Summary:

- 50% meets -850mV (CSE) Criteria
- 2 FortisBC DP rectifiers are interfering with CP potentials on the 508mm IP pipeline
- 1 foreign rectifier is interfering with CP potentials on the 508mm IP pipeline

Follow-up:

- Depolarization Survey Conducted in 2013.
- DP rectifier at Coquitlam Gate Station bonded to 508mm IP pipeline. Potentials improved at test points. Re-CIS with bond in place and Coquitlam Gate rectifier interrupting completed in 2013.
- DP rectifier at Broadway and Norquist found to have only a small localized influence on IP pipeline potentials. Direct bond between DP and IP needs to be further evaluated and facilities installed.
- Re-CIS of 508mm IP pipeline in the vicinity of the foreign ICCP rectifier to determine the magnitude of interference was conducted in 2013.

Source: 2004 ECDA Data (CC Technologies)

Survey Extents: Underhill to 2nd & Woodland (9950m)

Results:

- 61% meets -850mV (CSE) Criteria. (Based on analysis of graphical data)
- Based on Depolarization data gathered at test points only in 2004, Fortis BC concludes that 100% of this section of pipeline meets the 100mV polarization criterion.

Source: FortisBC Annual Test Point Data 1990-2013

Survey Extents: Entire Pipeline – Test Points Only

Results:

- Annual survey data since 1990 indicates that the previously adopted criteria for protection of -1.0V ON has been achieved and maintained at the majority of test points.
- Instant OFF data gathered in 2003, 2012 and 2013 indicated that the -850mV criteria was achieved at most test points.
- Where -850mV was not met, application of depolarization data gathered in either 2004 or 2012 indicates that the 100mV criteria was achieved.

- The 2013 interrupted test post survey indicates -850mV is achieved at all test point locations along the pipeline.

Historical CP Data Analysis:

The average ON-OFF shift at all test points is 225mV, calculated based on all available On/Off data from 2003, 2012 and 2013, and we consider historically adopted 1.0V on criteria, it is very likely that the adopted criteria did NOT ensure that the -850mV criteria was achieved at all test point locations. However, utilizing the worst case(most electro negative) native potential, of -660mV, the 100mV polarization criteria was likely achieved during this time frame where the 1.0V ON criteria was adopted and maintained.

Predictive Surveys:

Above grade cathodic protection and coating condition surveys have proved to be effective in locating coating holidays, however ineffective in locating disbonded coating and corrosion. The following predictive methods as described in NACE International Standard Practice SP0502 External Corrosion Direct Assessment Methodology (ECDA) have been studied:

- Close Interval Cathodic Protection Surveys
- AC Current Attenuation
- AC Voltage Gradient
- DC Voltage Gradient

Results of these studies are tabulated below:

Site Location	***Indirect Indications (ACVG/DCVG)***	***Corrosion Features Found at Coating Holidays***	***Corrsoion Features Found under Disbonded Coating***	***Corrosion Features Undetected by Indirect Assessment***
Brentlawn Ave (Lane)	3	0	4	4
7500 Broadway Avenue	1	0	1	1
Como Lake Avenue West of Mariner	5	6	7	8
E 2nd Ave.	5	5	5	5

These results indicate that the indirect survey techniques were 93% effective in finding coating holidays, however 0% effective in locating disbonded coatings with active corrosion taking place underneath.

Direct Examination Summary:

Direct Examination (Leak or Dig)	*Reason*	*Findings*	*Source*
Springer Ave. @ Braelawn (1987/11/18)	Leak	Main Pipe Corrosion	Anecdotal
E. 2nd Ave @ Commercial Dr. (1994/11/07)	Leak	Corrosion under disbonded field applied coating at girth weld	GIS (AMFM)
3434 E. 2nd Ave. (1999/08/18)	Leak	Corrosion under disbonded field applied coating at girth weld	GIS (AMFM)
Brentlawn Ave. @ Fairlawn Ave. (2001/02/01)	Leak	Corrosion under disbonded field applied coating at girth weld	Record – Form 1434 Pipe and Coating Report
Como Lake Ave @ Mariner Way (2010/02/18)	Leak	Corrosion under disbonded field applied coating at girth weld	Record – Form 1434 Pipe and Coating Report
7584 Broadway (2011/03/06)	Leak	Corrosion under field applied coating at girth weld	Record – Form 1434 Pipe and Coating Report
Lane behind Brentlawn west of Fairlawn (2011)	Integrity Inspection Dig 1	Corrosion under disbonded field applied coating at girth weld – 70% through Wall. Shop applied coating in excellent condition.	Excavation Inspection Report
Lane behind Brentlawn west of Fairlawn (2011)	Integrity Inspection Dig 2	Corrosion under disbonded field applied repair coating from 2001 Leak (Polymer Tape). Shop applied coating in excellent condition.	Excavation Inspection Report
Lane behind Brentlawn west of Fairlawn (2011)	Integrity Inspection Dig 3	No corrosion found under field applied coating. Filed applied and shop applied coating in excellent condition.	Excavation Inspection Report
West of 7584 Broadway Avenue (2011)	Integrity Inspection Dig 1	Corrosion under disbonded field applied coating at girth weld – 49% through Wall. Shop applied coating in excellent condition.	Excavation Inspection Report

West of 7584 Broadway Avenue (2011)	Integrity Inspection Dig 2	No corrosion found under field applied coating. Filed applied and shop applied coating in excellent condition. Minor disbondment noted.	Excavation Inspection Report
West of 7584 Broadway Avenue (2011)	Integrity Inspection Dig 3	No corrosion found under field applied coating. Filed applied and shop applied coating in excellent condition. Minor disbondment noted.	Excavation Inspection Report
Como Lake Avenue west of Mariner (2012)	Integrity Inspection Dig 1 (2010 Leak Site)	No corrosion found under field applied repair coating (Polymer Tape). Shop applied coating in excellent condition.	Excavation Inspection Report
Como Lake Avenue west of Mariner (2012)	Integrity Inspection Dig 2	No corrosion found under field applied coating. Shop and field applied coating in excellent condition. 4 coating holidays found in shop applied coating which corresponded to 4 active corrosion features (max depth 46%)	Excavation Inspection Report
Como Lake Avenue west of Mariner (2012)	Integrity Inspection Dig 3	Corrosion found under disbonded field applied coating. 7 Corrosion feature identified (max Depth 32%) Shop and field applied coating in good condition. 2 coating holidays found in shop applied coating which corresponded to 2 active corrosion features (max depth 34%)	Excavation Inspection Report
2525 Como Lake Avenue (2012/05/24)	Leak	Corrosion under disbonded field applied	Excavation Inspection Report

		coating at girth weld	
2nd Ave. west of Skeena (2012)	Integrity Inspection Dig 1	No corrosion found under field applied coating. Shop and field applied coating in excellent condition. 2 coating holidays found in shop applied coating which corresponded to 2 inactive corrosion features (max depth 27%)	Excavation Inspection Report
2nd Ave. west of Skeena (2012)	Integrity Inspection Dig 2 (1999 Leak)	Corrosion under disbonded field applied repair coating from 1999 Leak (Polymer Tape). Shop applied coating in excellent condition. Three leaks on the PLIDCO Repair sleeve were found and repaired.	Excavation Inspection Report
2nd Ave. west of Skeena (2012)	Integrity Inspection Dig 3	Corrosion found under disbonded field applied coating. Shop and field applied coating in excellent condition. 1 coating holiday found in shop applied coating which corresponded to 1 active corrosion feature (max depth 24%)	Excavation Inspection Report
2nd Ave. west of Skeena (2012)	Integrity Inspection Dig 4	No field coated girth weld exposed. 1 coating holiday found in shop applied coating which corresponded to 1 inactive corrosion feature (max depth 8%)	Excavation Inspection Report
7584 Broadway (2013/03)	Leak	Corrosion under disbonded field applied coating at a girth weld adjacent to previously repaired leak at 7584	Record – Form 1434 Pipe and Coating Report

		Broadway.	
Halifax @ Springer Ave (2013/07/05)	Leak	Corrosion under disbonded field applied coating at a girth weld.	BC OGC Permit Holder Post-Incident Report
Halifax (4100 Block) July 17, 2013	Leak	Corrosion under disbonded shop applied coating. The coating disbondment appeared to initiate at a field coated weld and water ingress under the coating caused further disbondment and subsequent corrosion under the shop applied coating.	BC OGC Permit Holder Post-Incident Report
4330 Halifax St. August 8, 2013	Leak	Severe Corrosion under disbonded field applied and adjacent shop applied coating. The coating disbondment appeared to initiate at a field coated weld and water ingress under the coating caused further disbondment and subsequent corrosion under the shop applied coating.	BC OGC Permit Holder Post-Incident Report
4330 Halifax St. August 20, 2013	Leak	Severe Corrosion under disbonded field applied and adjacent shop applied coating. The coating disbondment appeared to initiate at a field coated weld and water ingress under the coating caused further disbondment and subsequent corrosion under the shop applied coating.	BC OGC Permit Holder Post-Incident Report
Como Lake and Baker August 23, 2013	Leak	Isolated through wall corrosion pit under disbonded field applied coating. Two additional	BC OGC Permit Holder Post-Incident Report

		isolated pits 50% through wall.	
Halifax (4100 Block) October 9, 2013	Leak	Isolated through wall corrosion pit under disbonded field applied coating. One additional isolated pit 50% through wall.	BC OGC Permit Holder Post-Incident Report
2nd Avenue (west of Skeena	Integrity Dig October 2013 #1	No Corrosion found. No Evidence of disbonded coating at the weld. Dry trench. Debris in backfill (tires, concrete, garbage)	Record – Form 1434 Pipe and Coating Report (not received by Nov. 15, 2013)
2nd Avenue (west of Skeena	Integrity Dig October 2013 #2	No Corrosion found. No Evidence of disbonded coating at the weld. Dry trench.	Record – Form 1434 Pipe and Coating Report (not received by Nov. 15, 2013)
2233 2nd Avenue (East of Templeton St.	Integrity Dig October 2013 #1	No Corrosion found. No Evidence of disbonded coating at the weld. Dry trench.	Record – Form 1434 Pipe and Coating Report (not received by Nov. 15, 2013)
2233 2nd Avenue (East of Templeton St.	Integrity Dig October 2013 #2	Minor corrosion (12%) located 175mm from weld. Field applied weld coating disbonded at factory coating interface. Tree root growing under coating.	Record – Form 1434 Pipe and Coating Report (not received by Nov. 15, 2013)
2233 2nd Avenue (East of Templeton St.	Integrity Dig October 2013 #3	No Corrosion found. No Evidence of disbonded coating at the weld. Dry trench.	Record – Form 1434 Pipe and Coating Report (not received by Nov. 15, 2013)
Broadway & Gaglardi	Integrity Dig November 2013 #1	No Corrosion found. Field applied coating disbonded cohesively (between two layers of coal tar) with water in between.	Pending
Broadway & Gaglardi	Integrity Dig November 2013 #2	Corrosion found beneath disbonded field applied coating (34% max depth) 115mm from weld	Corrosion Control Report

Appendix 2a

FortisBC Response to General Order 2013-25

508mm Coquitlam to Vancouver IP Pipeline

Cathodic Protection Evaluation Supporting Data

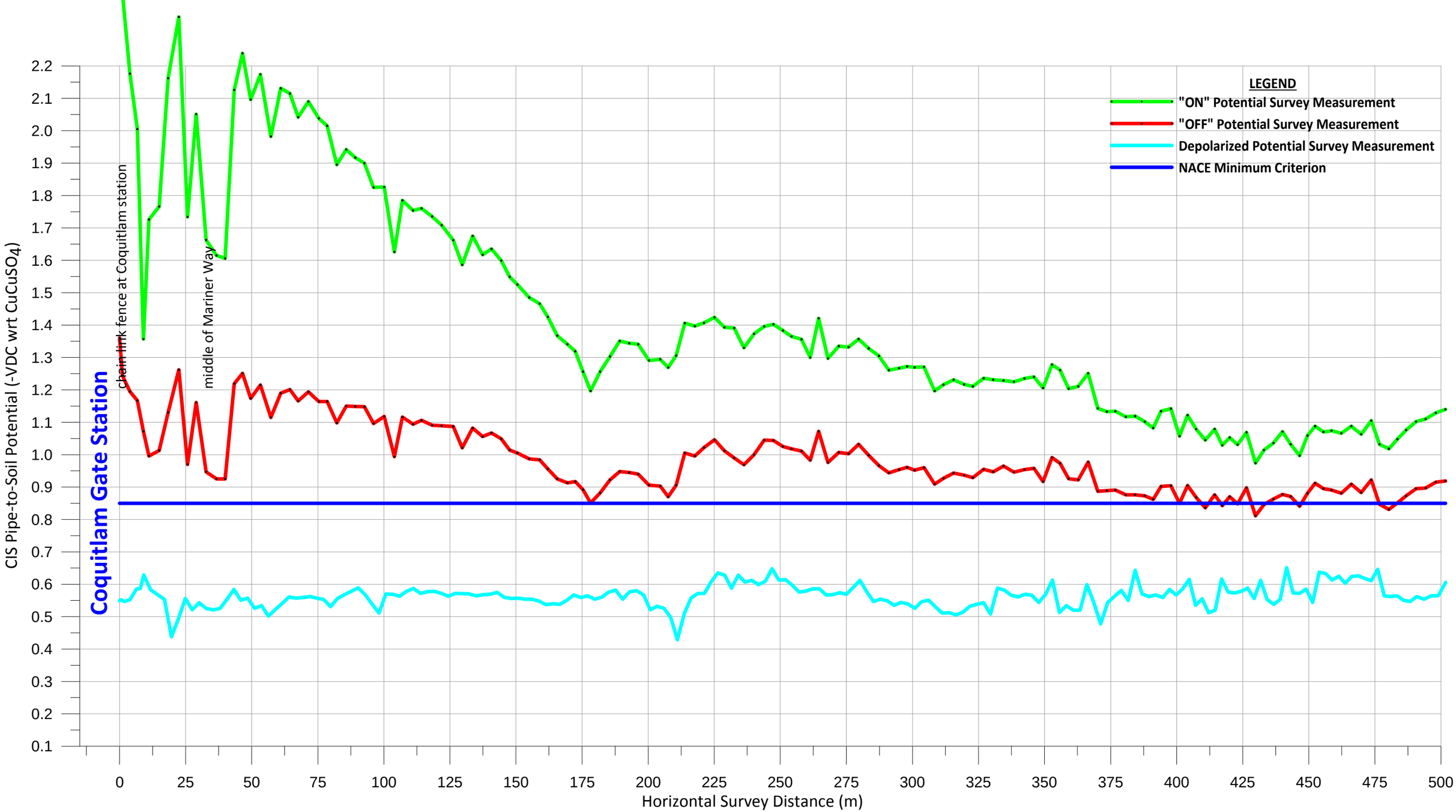
FORTIS BC
508mm (NPS 20) IP Pipeline
Coquitlam to Burnaby, Coastal (BC)

INTERRUPTED & DEPOLARIZED CIS DATA
PROFILE PLOTS

2013

SUBMITTED ON: NOVEMBER 20, 2013

COMPLETED BY: RICHARD BUKSA, P. ENG.



Notes:
The CIS/Depol data was collected after electrical continuity between the FortisBC IP & DP pipeline systems was established. The field work was completed on Nov. 7 and Nov. 12, 2013. The CIS interrupted survey was completed with an interrupt cycle of: 1.6s "ON" / 0.4s "OFF".

E-MAC CORROSION INC.
Ph. (780) 444-EMAC (3622) Fax. (780) 466-3658

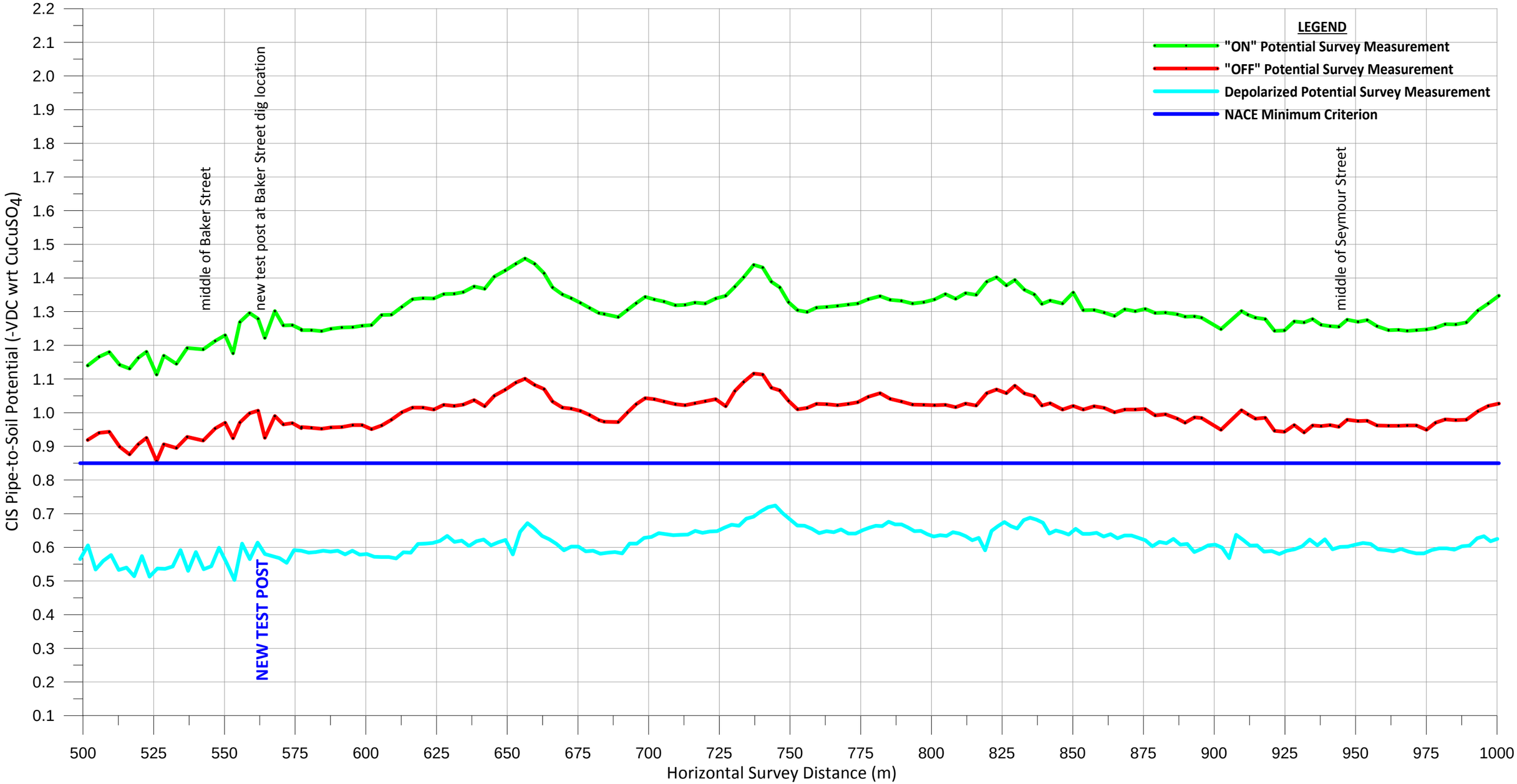
Designed By: RAB
Drawn By: RAB

Project:
Fortis BC
508mm (NPS 20) IP Pipeline
Coquitlam - Burnaby, Coastal (BC)
Interrupted & Depolarized CIS Profile
2013

FORTIS BC™

Dwg. #:	508-COQ-IP-01
Date:	November 18, 2013
Scale:	
Sheet:	1 of 17

No.	Revision / Issue	Date



Notes:
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508mm (NPS 20) IP Pipeline
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Interrupted & Depolarized CIS Profile
2013

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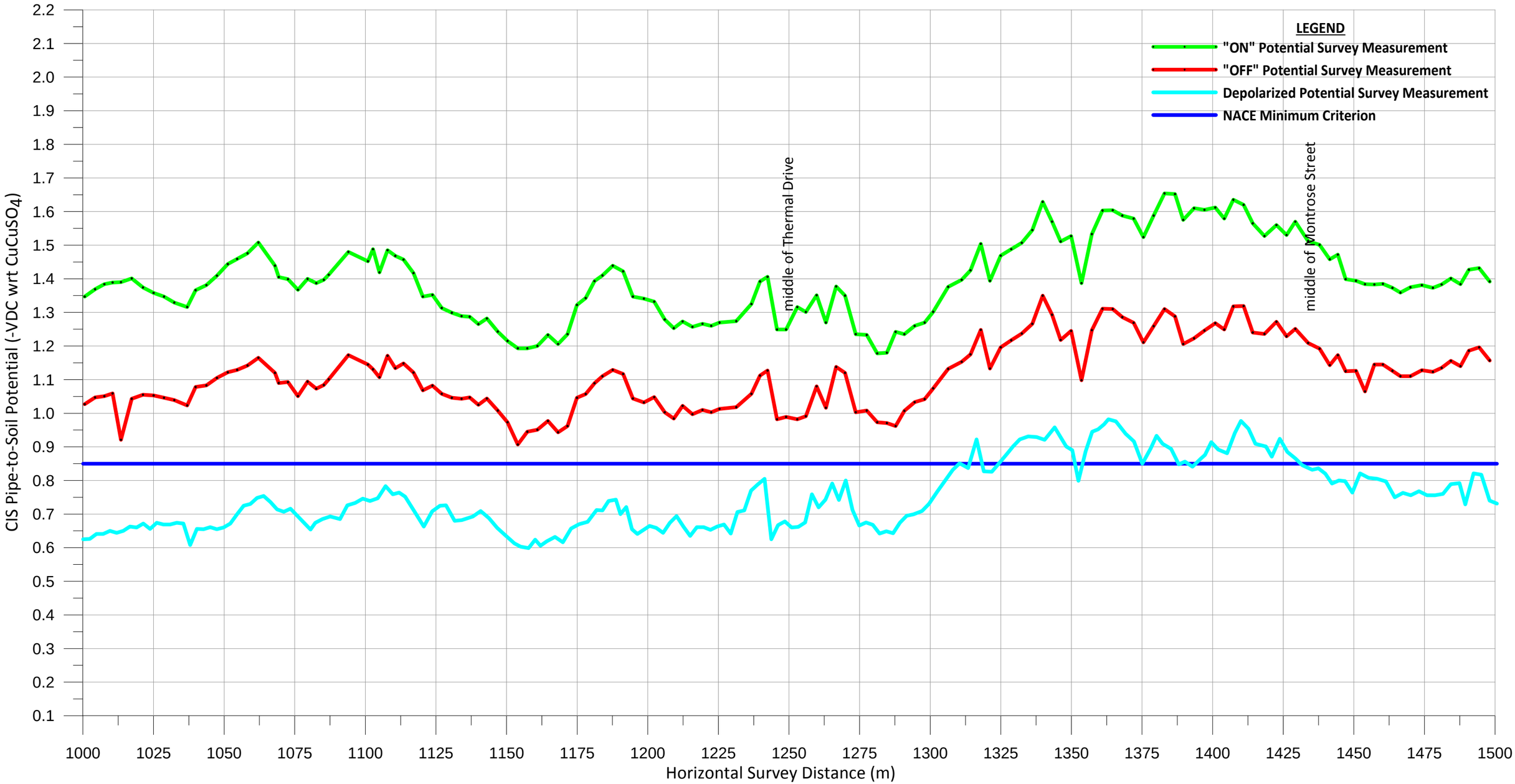
Dwg. #: 508-COQ-IP-02		Sheet: 2 of 17
Date: November 18, 2013		
Scale:		
No.	Revision / Issue	Date



Notes:
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E-MAC CORROSION INC.
Ph. (780) 444-EMAC (3622) Fax. (780) 466-3658

Designed By: RAB

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Fortis BC
508mm (NPS 20) IP Pipeline
Coquitlam - Burnaby, Coastal (BC)
Interrupted & Depolarized CIS Profile
2013

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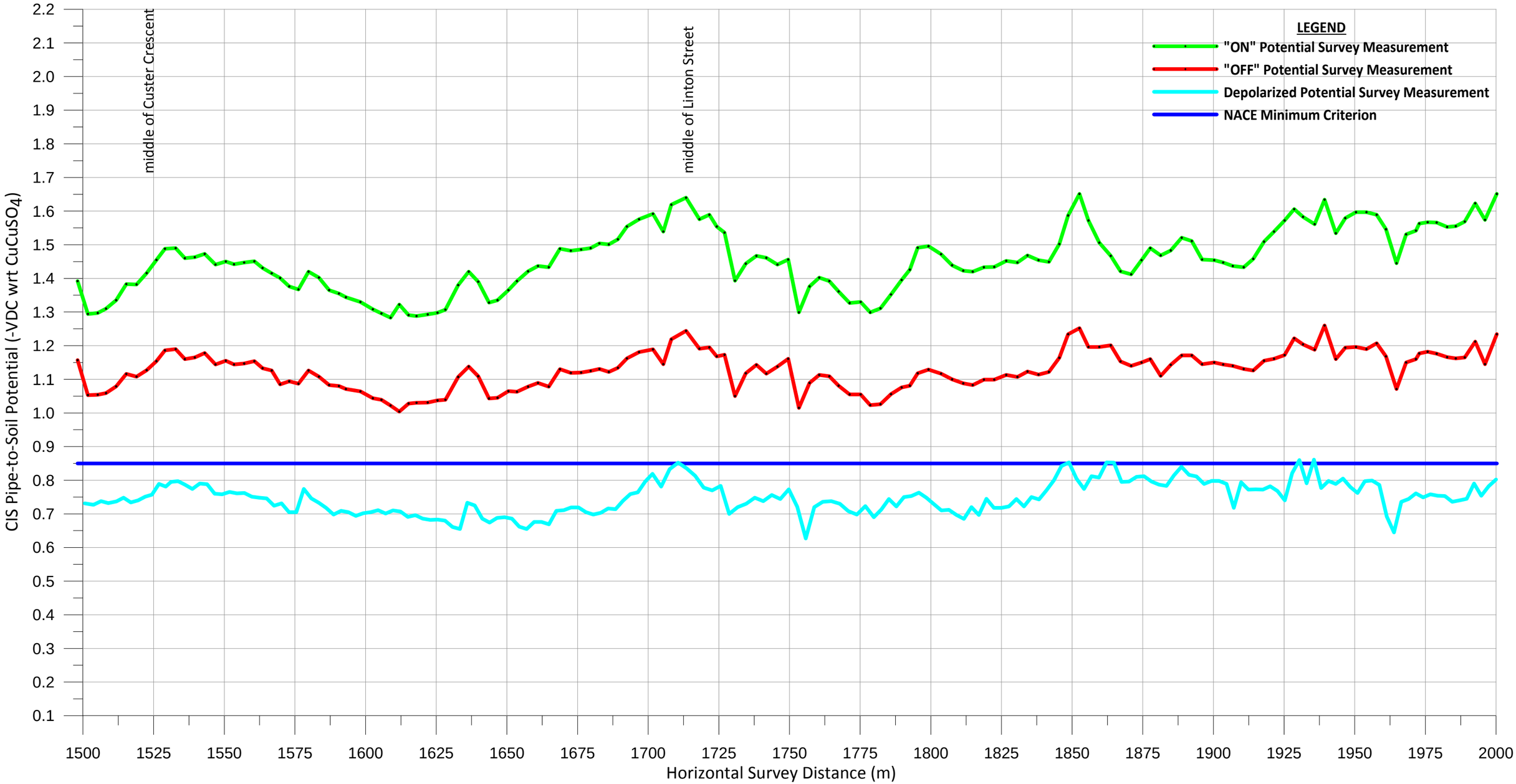
Dwg. #: 508-COQ-IP-03		Sheet: 3 of 17
Date: November 18, 2013		
Scale:		
No.	Revision / Issue	Date



Notes:
The CIS/Depol data was collected after electrical continuity between the FortisBC IP & DP pipeline systems was established. The field work was completed on Nov. 7 and Nov. 12, 2013. The CIS interrupted survey was completed with an interrupt cycle of: 1.6s "ON" / 0.4s "OFF".

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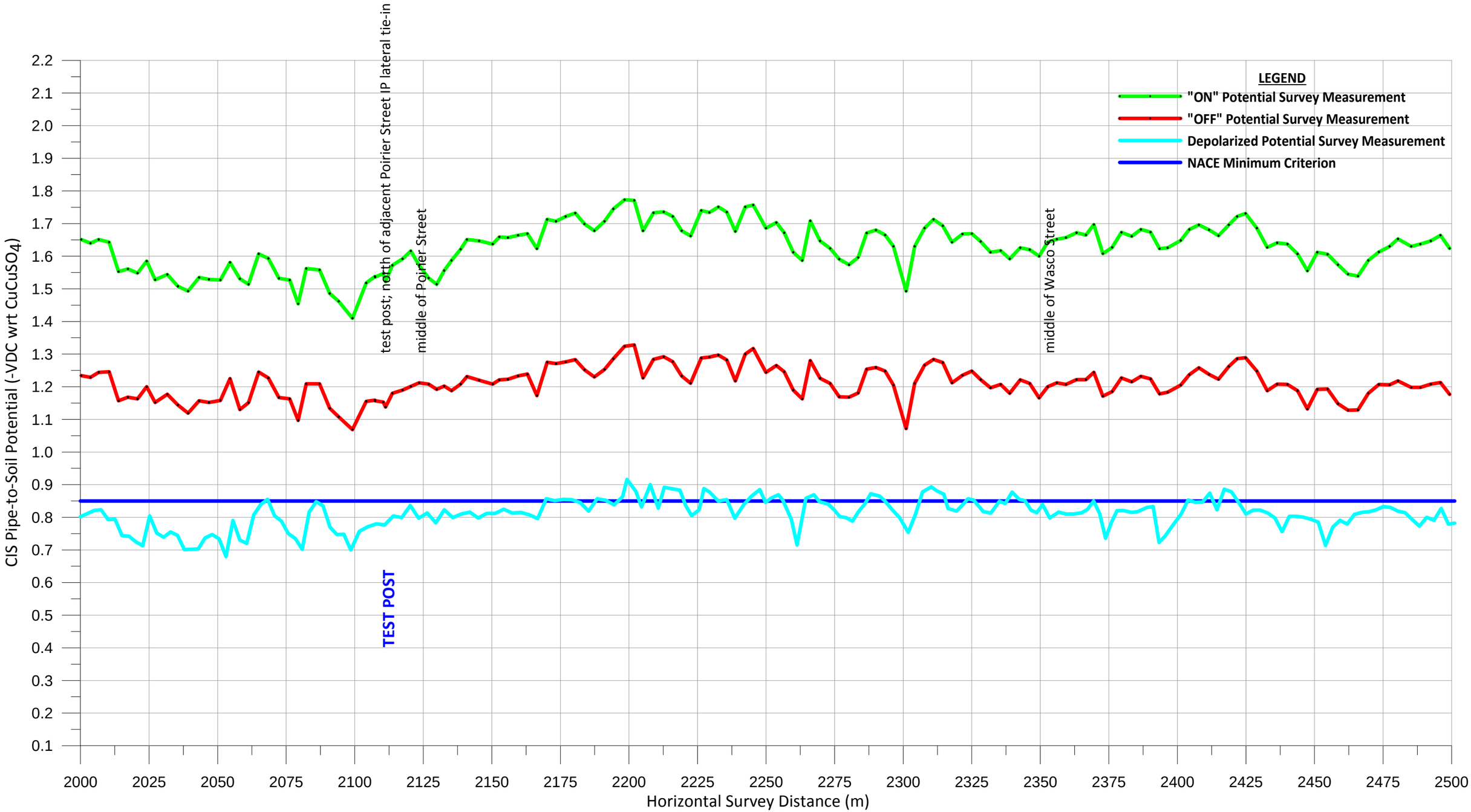
Project:
Fortis BC
508mm (NPS 20) IP Pipeline
Coquitlam - Burnaby, Coastal (BC)
Interrupted & Depolarized CIS Profile
2013

FORTIS BC™

Dwg. #: 508-COQ-IP-04		Sheet: 4 of 17
Date: November 18, 2013		
Scale:		
No.	Revision / Issue	Date



Notes:
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Designed By: RAB
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508mm (NPS 20) IP Pipeline
Coquitlam - Burnaby, Coastal (BC)
Interrupted & Depolarized CIS Profile
2013

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Dwg. #: 508-COQ-IP-05		Sheet: 5 of 17
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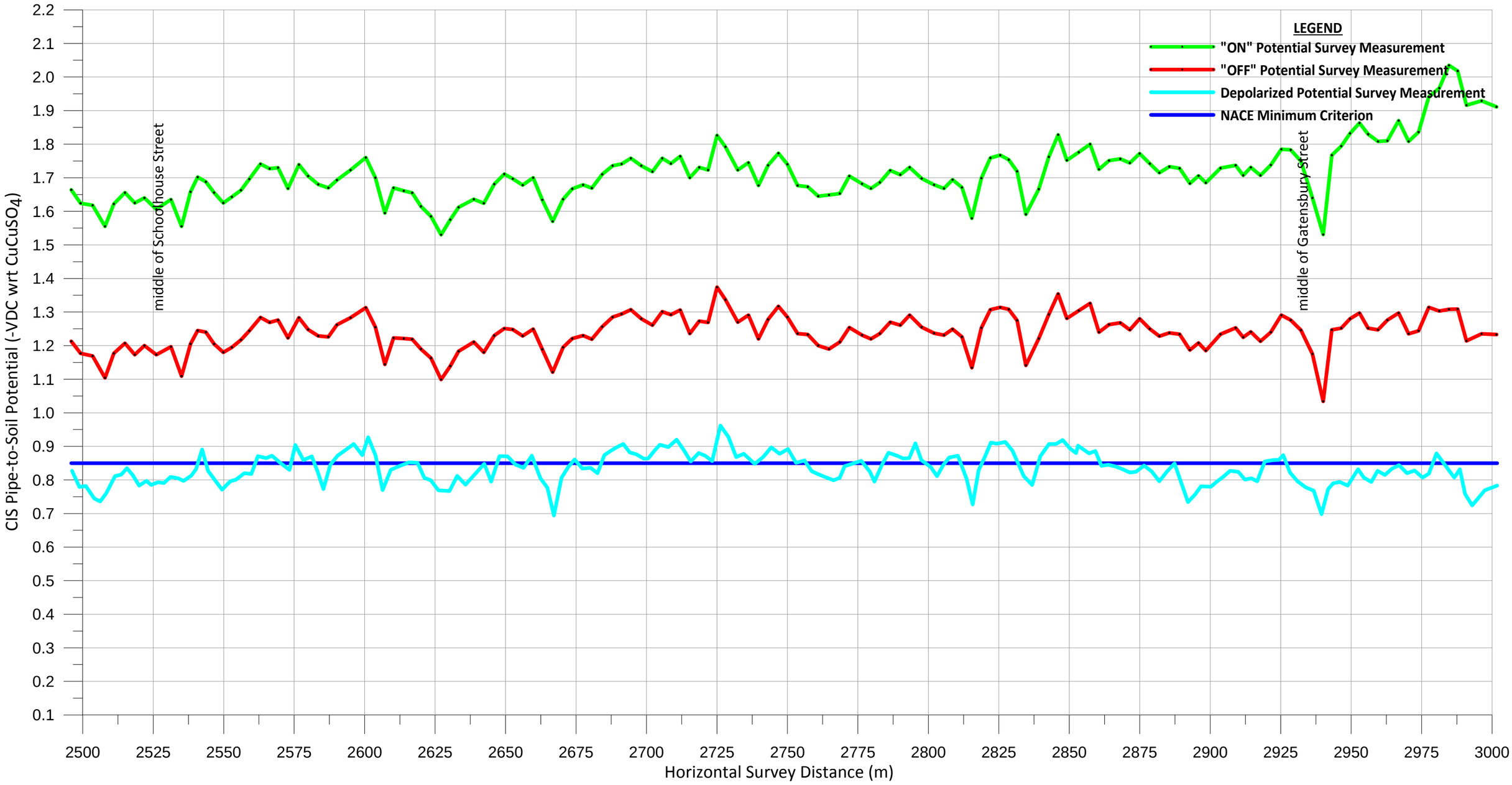
Scale:		
No.	Revision / Issue	Date



Notes:
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E-MAC CORROSION INC.
Ph. (780) 444-EMAC (3622) Fax. (780) 466-3658

Designed By: RAB
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Project:
Fortis BC
508mm (NPS 20) IP Pipeline
Coquitlam - Burnaby, Coastal (BC)
Interrupted & Depolarized CIS Profile
2013

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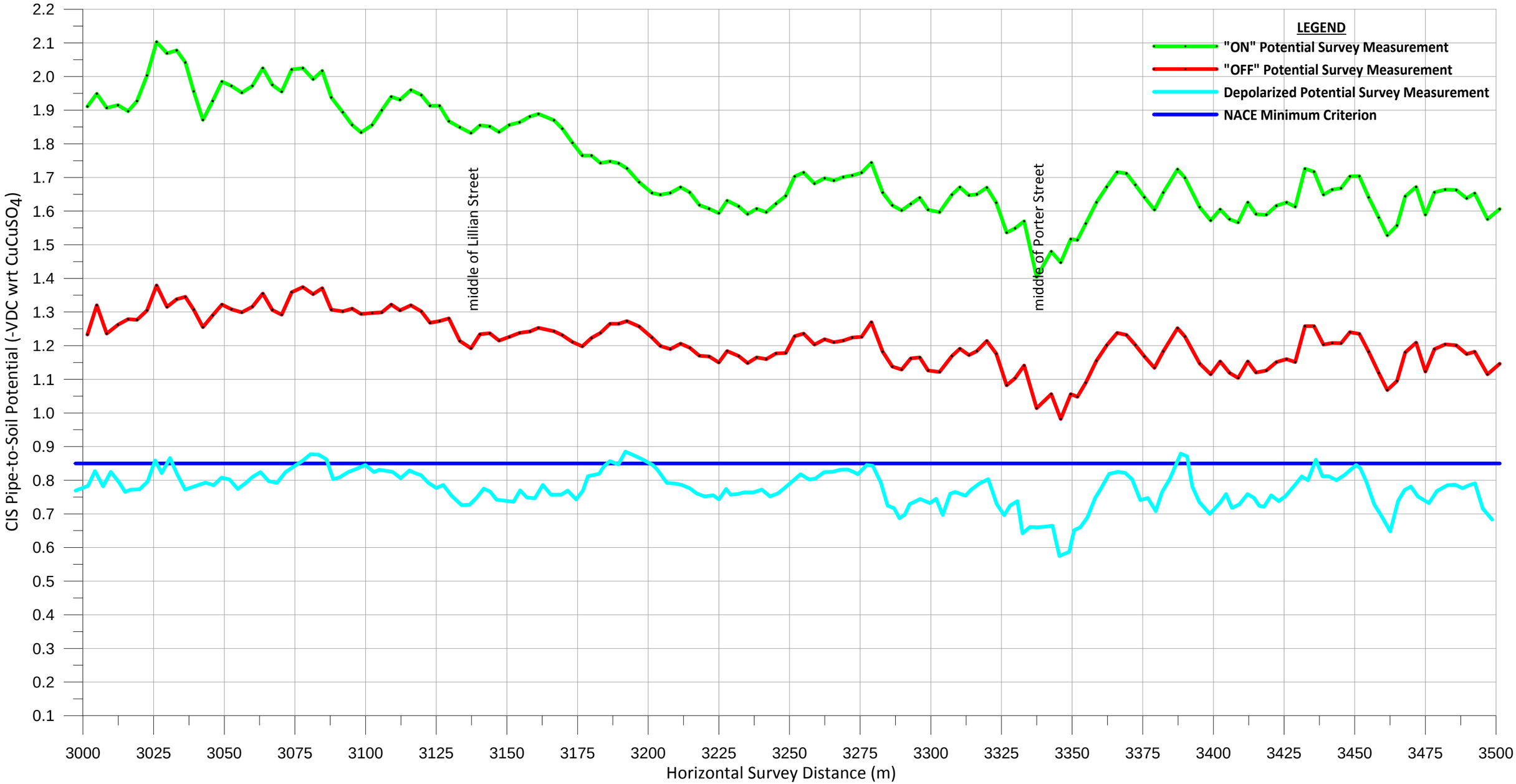
Dwg. #: 508-COQ-IP-06		Sheet: 6 of 17
Date: November 18, 2013		
Scale:		
No.	Revision / Issue	Date



Notes:
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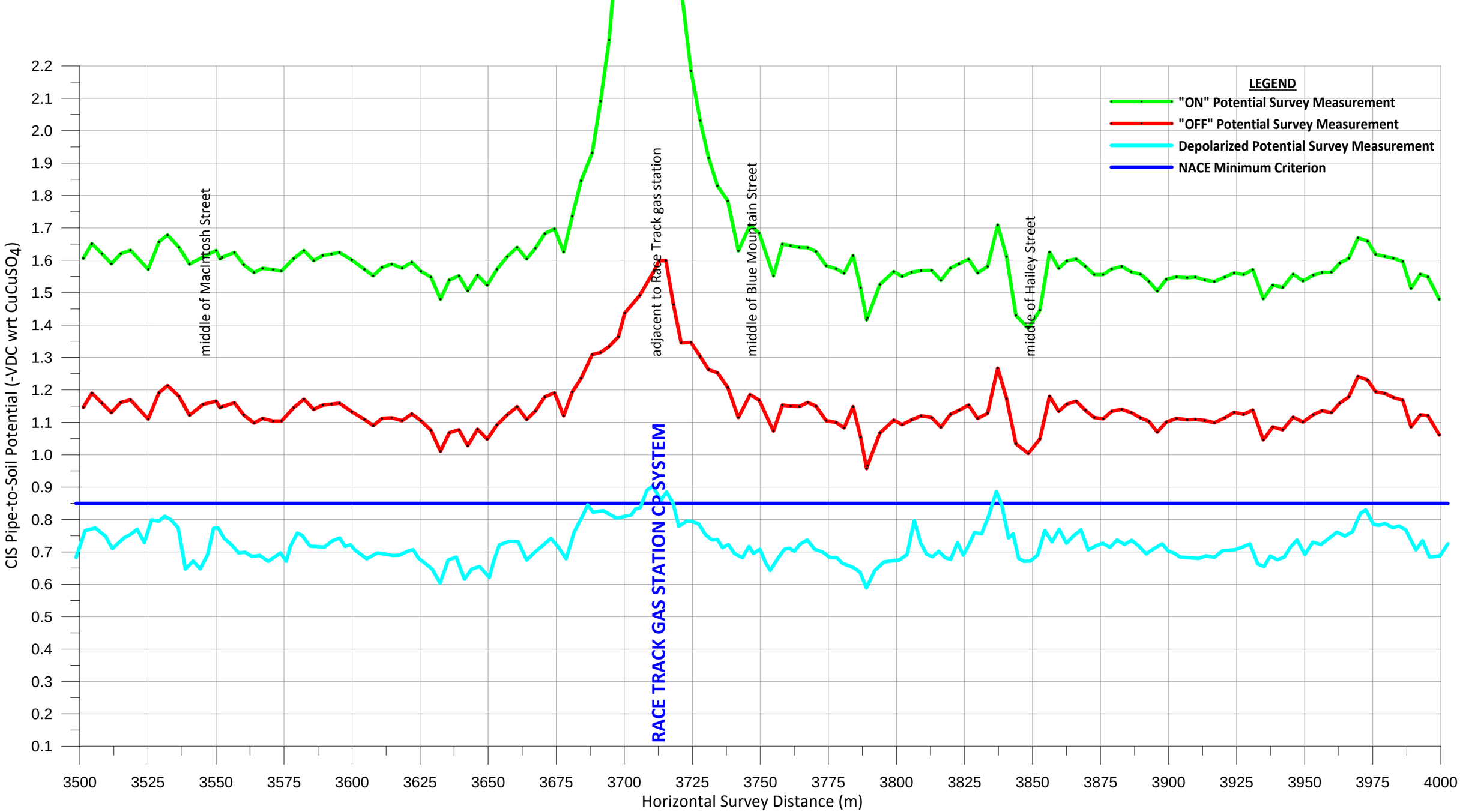
Project:
Fortis BC
508mm (NPS 20) IP Pipeline
Coquitlam - Burnaby, Coastal (BC)
Interrupted & Depolarized CIS Profile
2013

FORTIS BC™

Dwg. #: 508-COQ-IP-07	Sheet: 7 of 17
Date: November 18, 2013	
Scale:	

No.	Revision / Issue	Date



Notes:
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Project:
Fortis BC
508mm (NPS 20) IP Pipeline
Coquitlam - Burnaby, Coastal (BC)
Interrupted & Depolarized CIS Profile
2013

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Dwg. #: 508-COQ-IP-08		Sheet: 8 of 17
Date: November 18, 2013		
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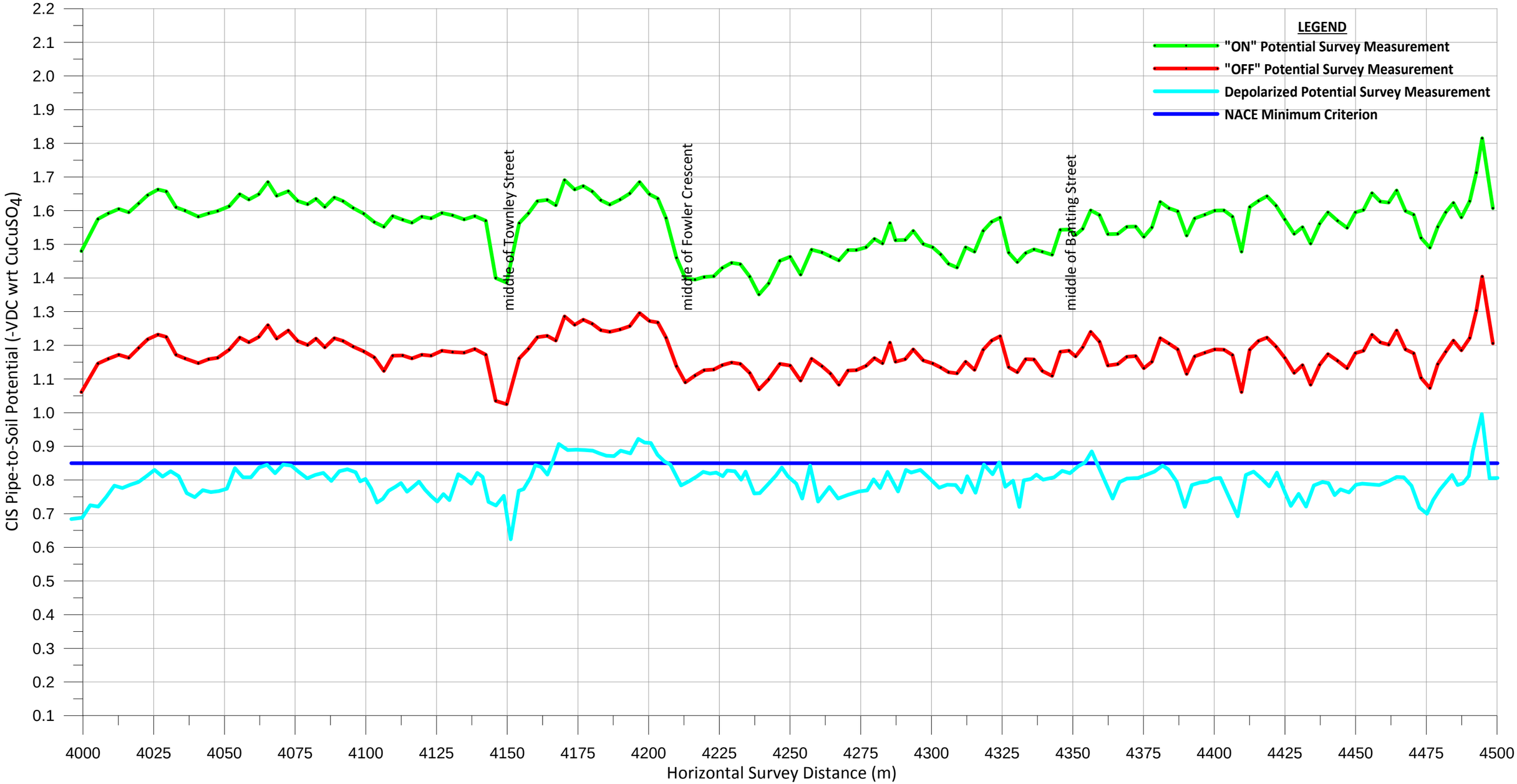
No.	Revision / Issue	Date



Notes:
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Project:
Fortis BC
508mm (NPS 20) IP Pipeline
Coquitlam - Burnaby, Coastal (BC)
Interrupted & Depolarized CIS Profile
2013

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Dwg. #: 508-COQ-IP-09	Sheet: 9 of 17
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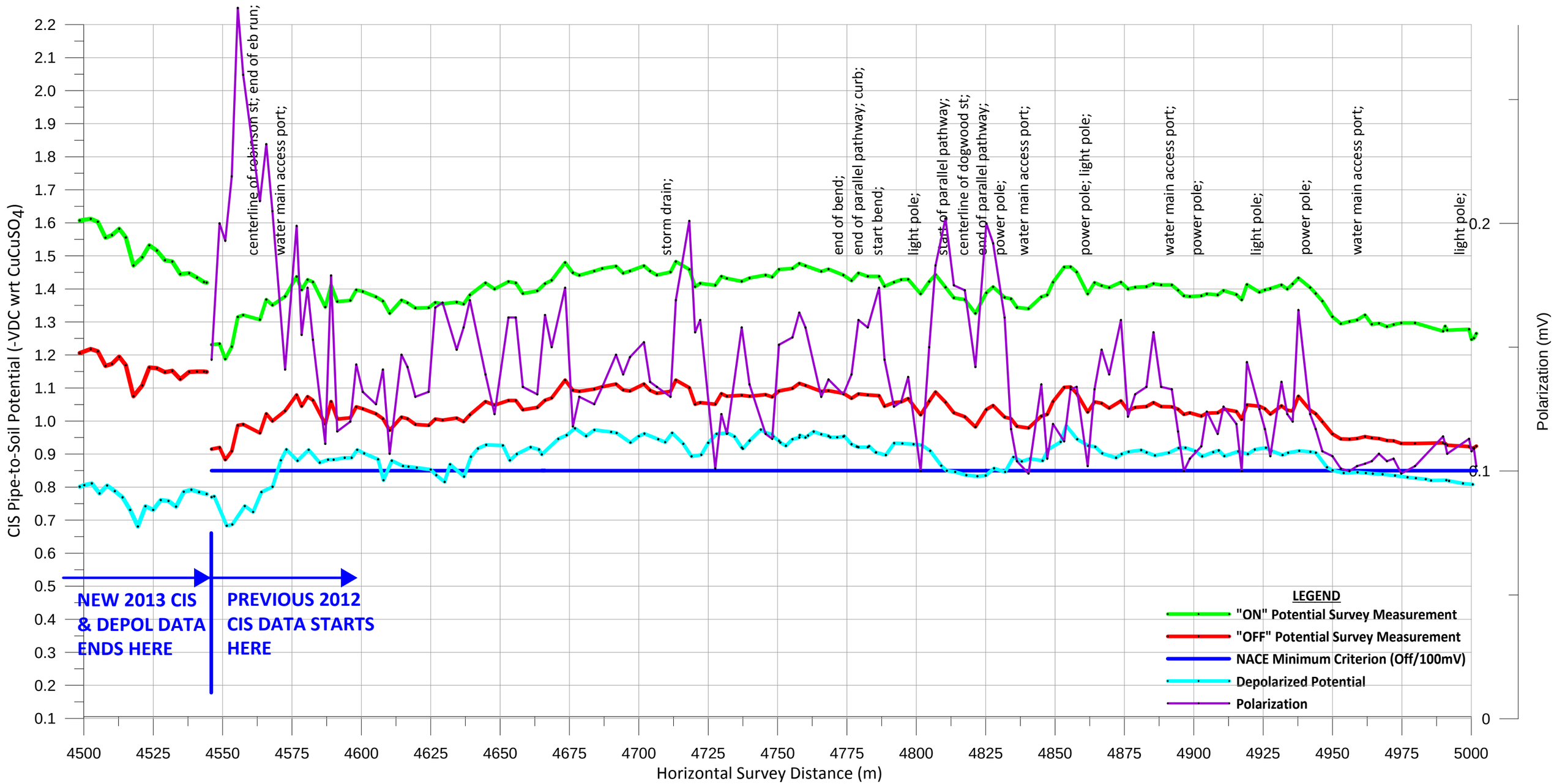
Scale:	

No.	Revision / Issue	Date



Notes:
The Coquitlam - Vancouver IP depol survey was completed in February 2013. The rectifiers were left off in order to achieve a depolarized state. The CIS data was collected in December 2012.

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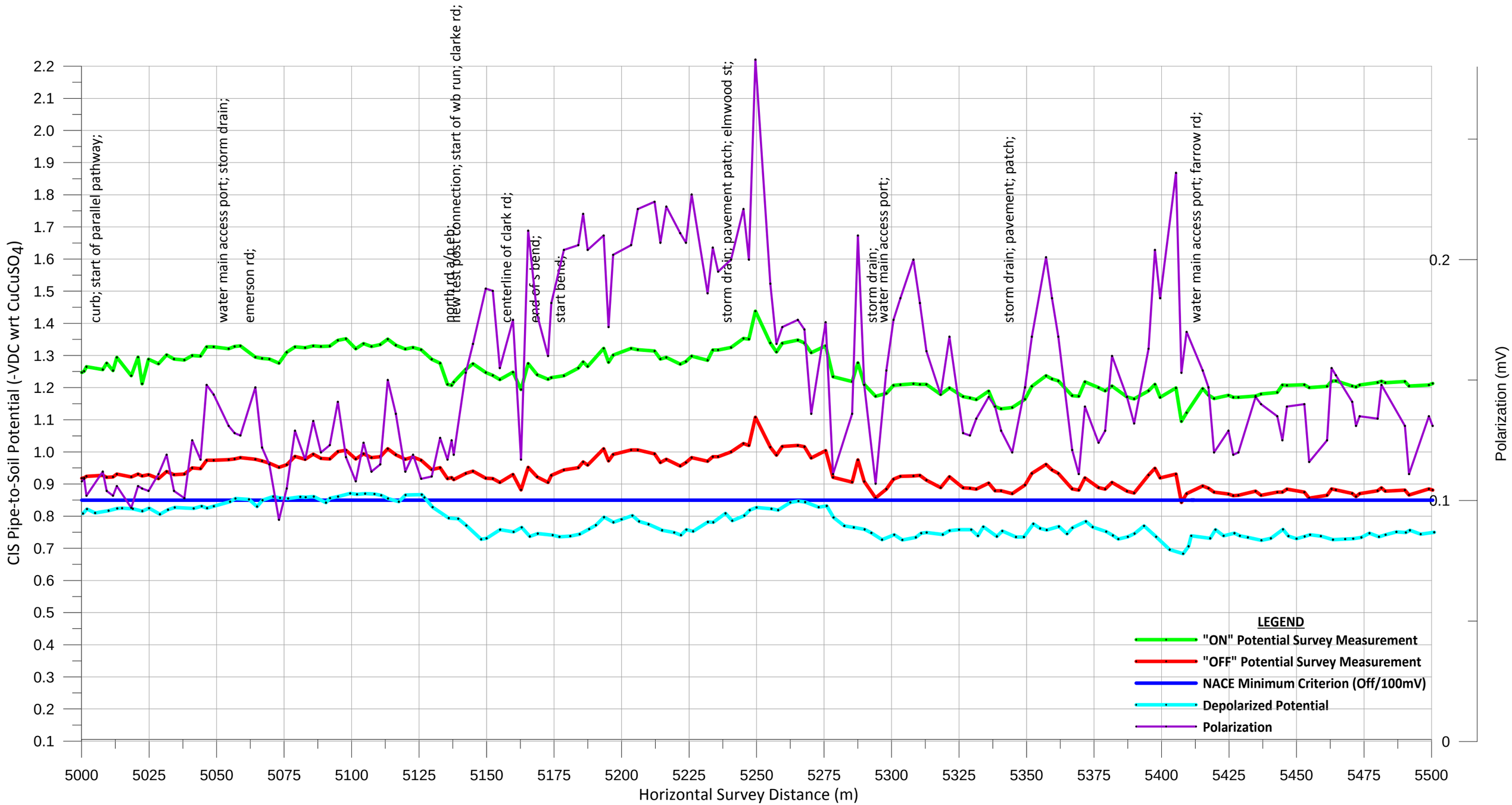
Fortis BC
508mm (NPS 20) IP Pipeline
Coquitlam - Burnaby, Coastal (BC)
Interrupted & Depolarized CIS Profile
2012

FORTIS BC

Dwg. #: 508-COQ-VAN IP-010	Sheet: 10 of 17
Date: June 18, 2013	
Scale:	

No.	Revision / Issue	Date



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E-MAC CORROSION INC.
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Project:
Fortis BC
508mm (NPS 20) IP Pipeline
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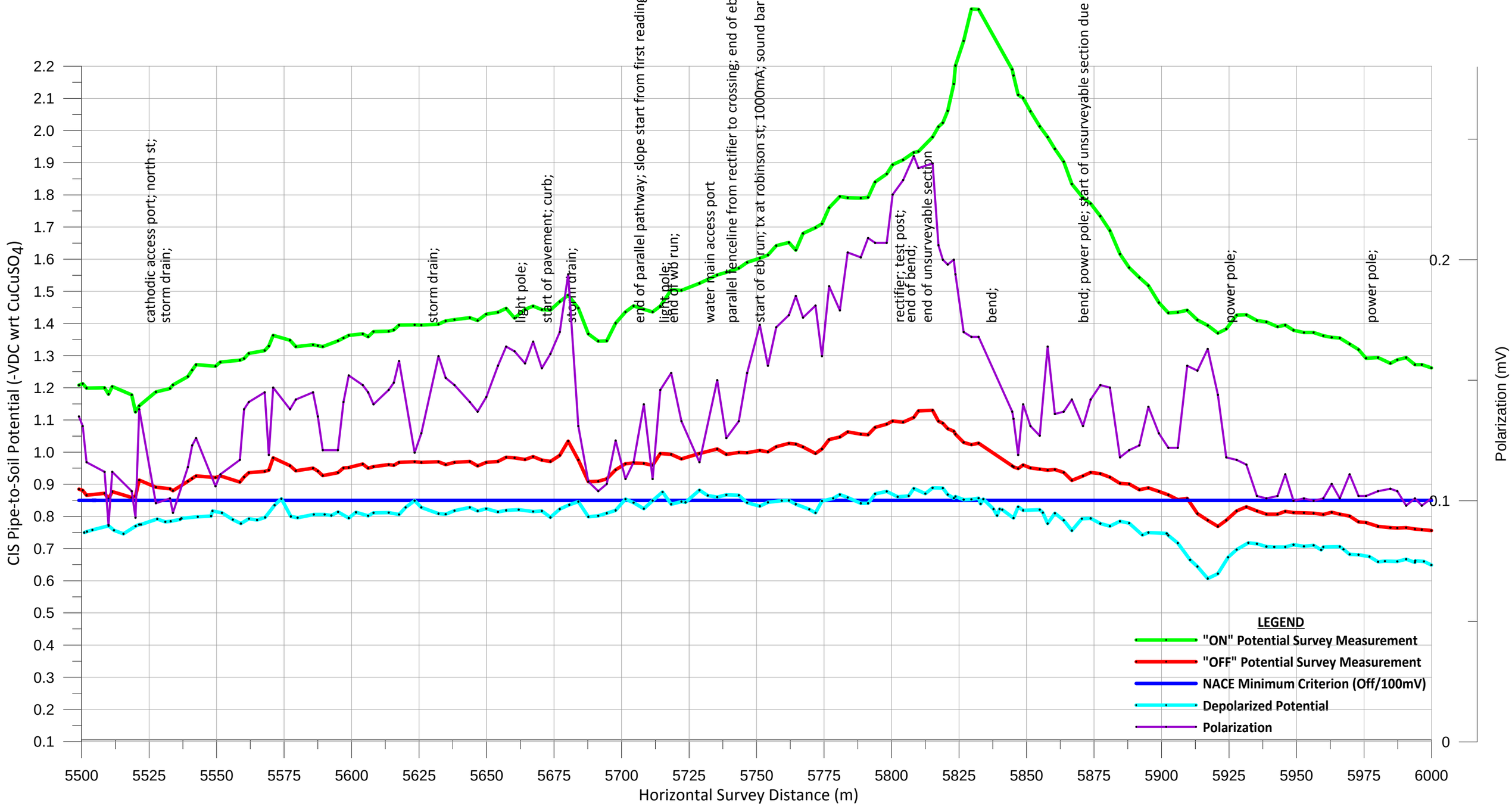
Interrupted & Depolarized CIS Profile
2012

FORTIS BC

Dwg. #: 508-COQ-VAN IP-011		Sheet: 11 of 17
Date: June 18, 2013		
Scale:		
No.	Revision / Issue	Date



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Coquitlam - Burnaby, Coastal (BC)
Interrupted & Depolarized CIS Profile
2012

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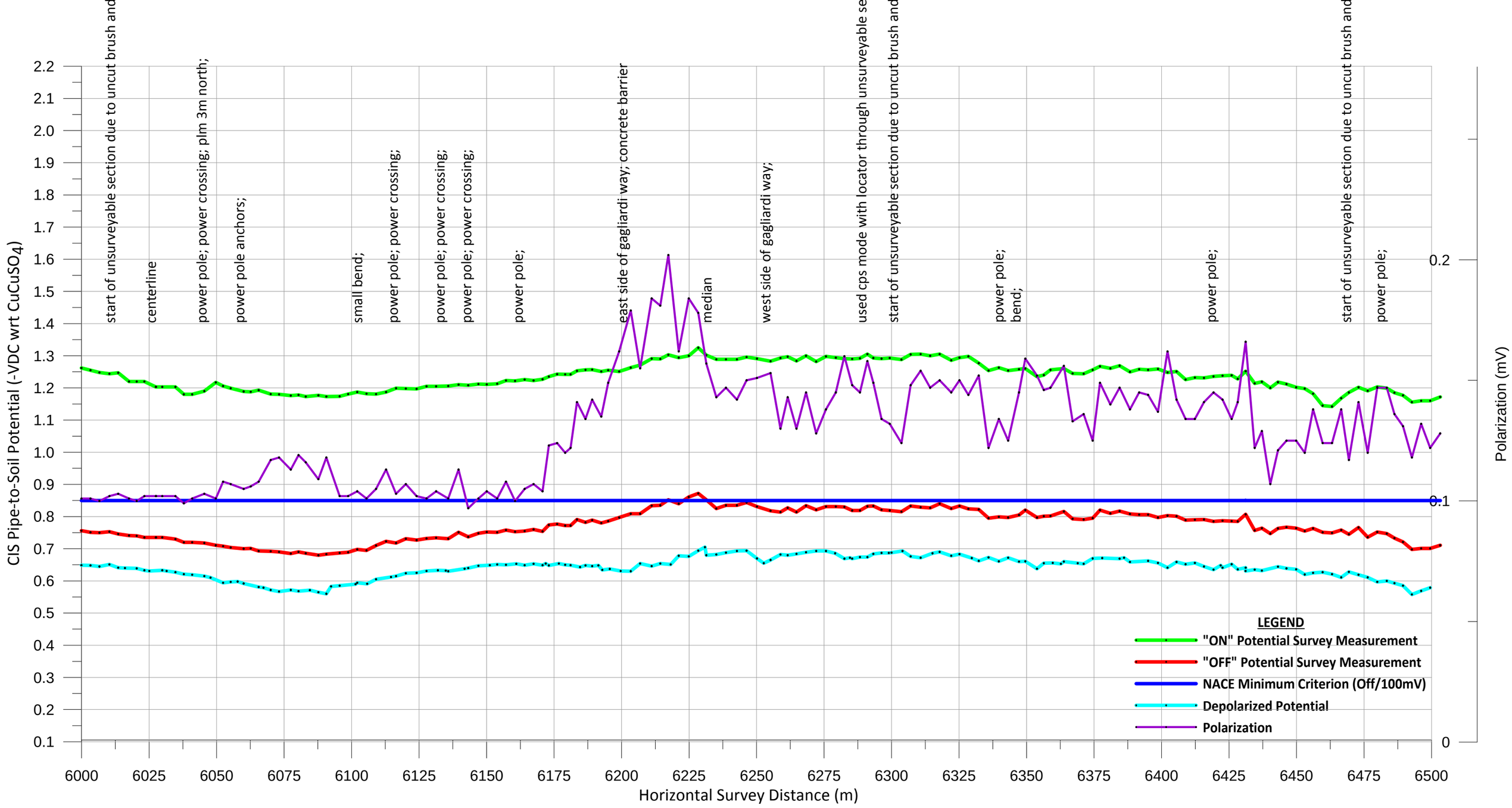
Dwg. #: 508-COQ-VAN IP-012		Sheet: 12 of 17
Date: June 18, 2013		
Scale:		
No.	Revision / Issue	Date



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Coquitlam - Burnaby, Coastal (BC)
Interrupted & Depolarized CIS Profile
2012

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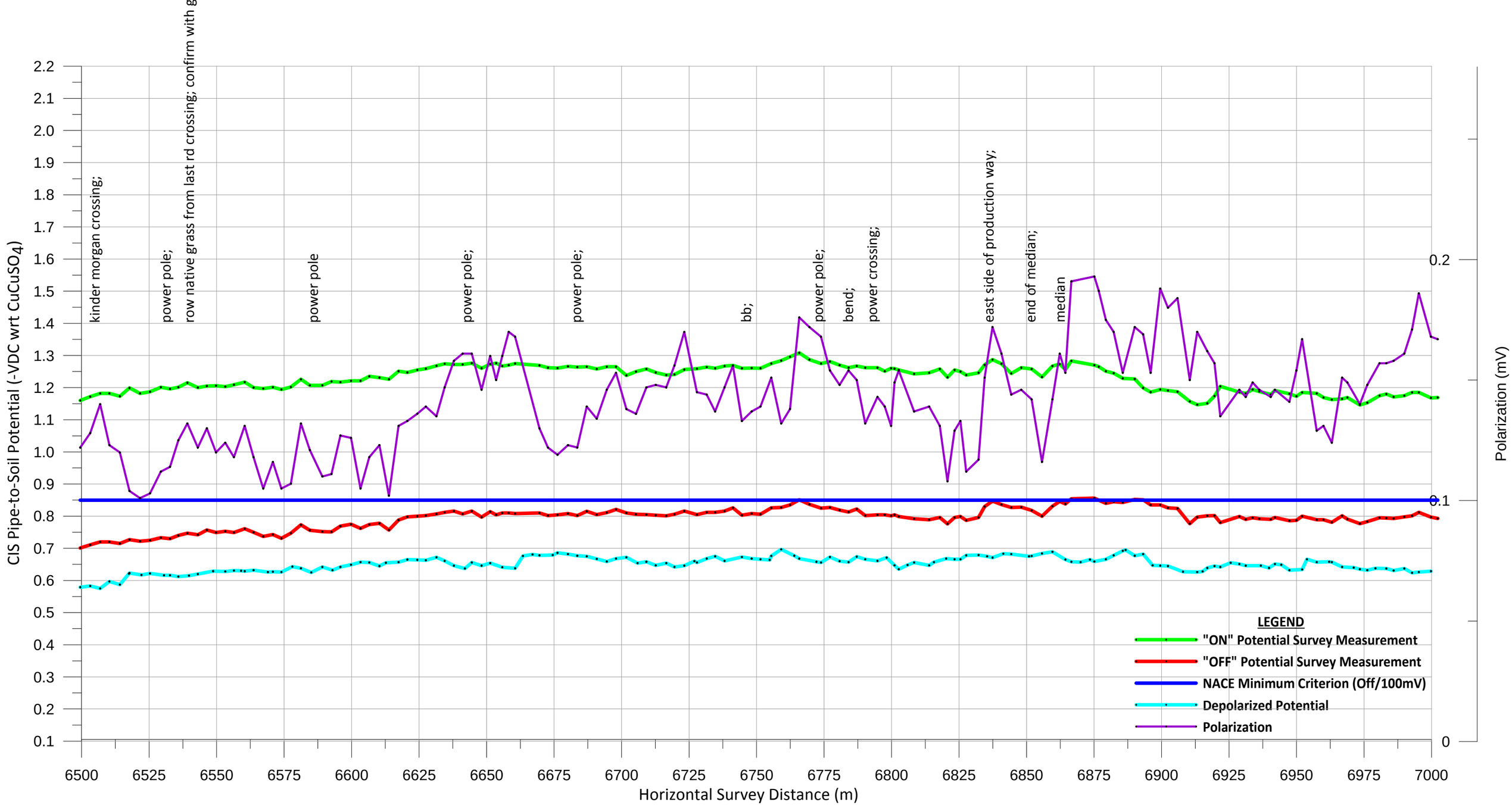
Dwg. #: 508-COQ-VAN IP-013		Sheet: 13 of 17
Date: June 18, 2013		
Scale:		
No.	Revision / Issue	Date



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Project:
Fortis BC
508mm (NPS 20) IP Pipeline
Coquitlam - Burnaby, Coastal (BC)
Interrupted & Depolarized CIS Profile
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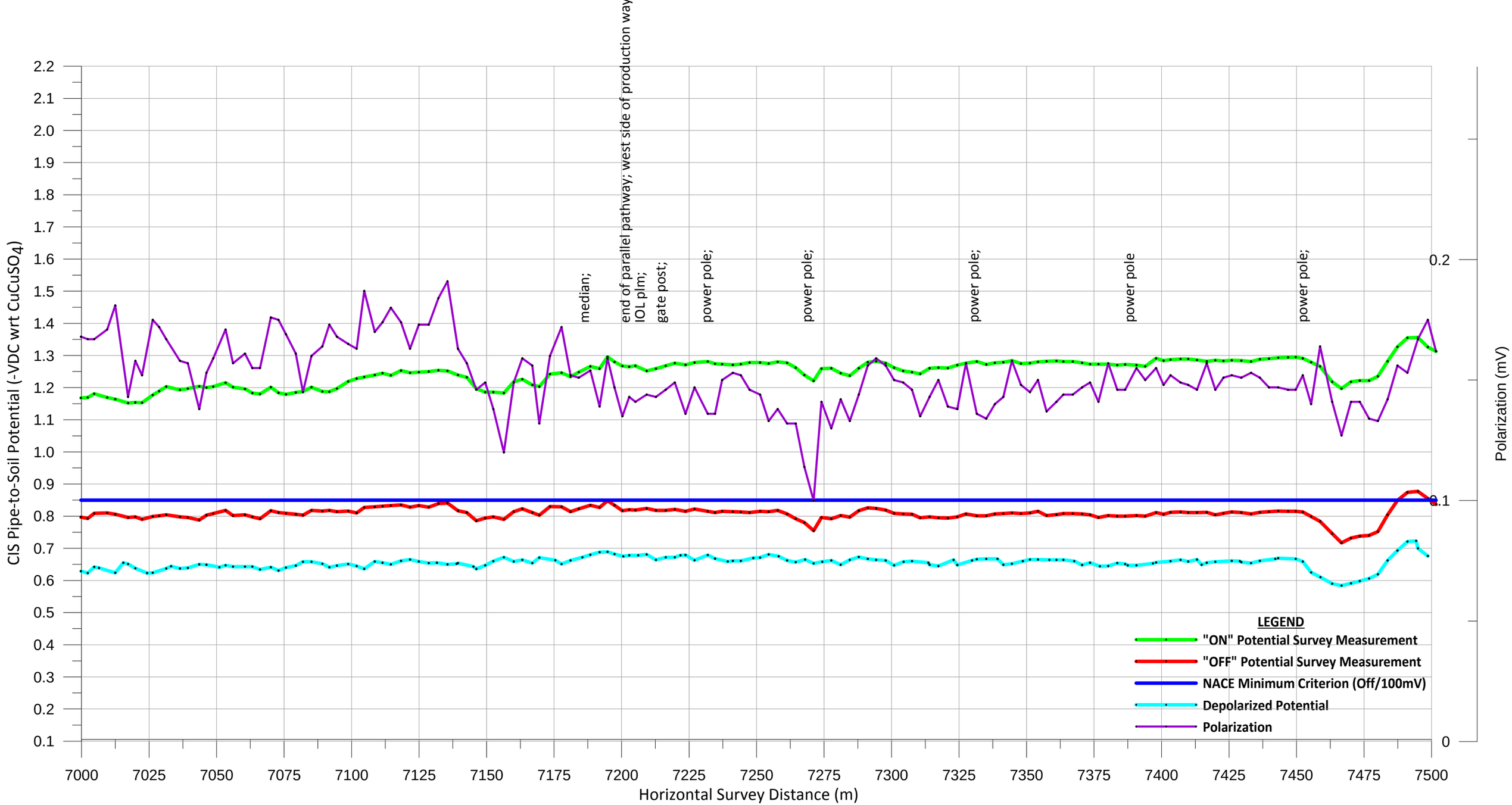
Dwg. #:	508-COQ-VAN IP-014
Date:	June 18, 2013
Scale:	
Sheet:	14 of 17

No.	Revision / Issue	Date



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Project:
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508mm (NPS 20) IP Pipeline
Coquitlam - Burnaby, Coastal (BC)
Interrupted & Depolarized CIS Profile
2012

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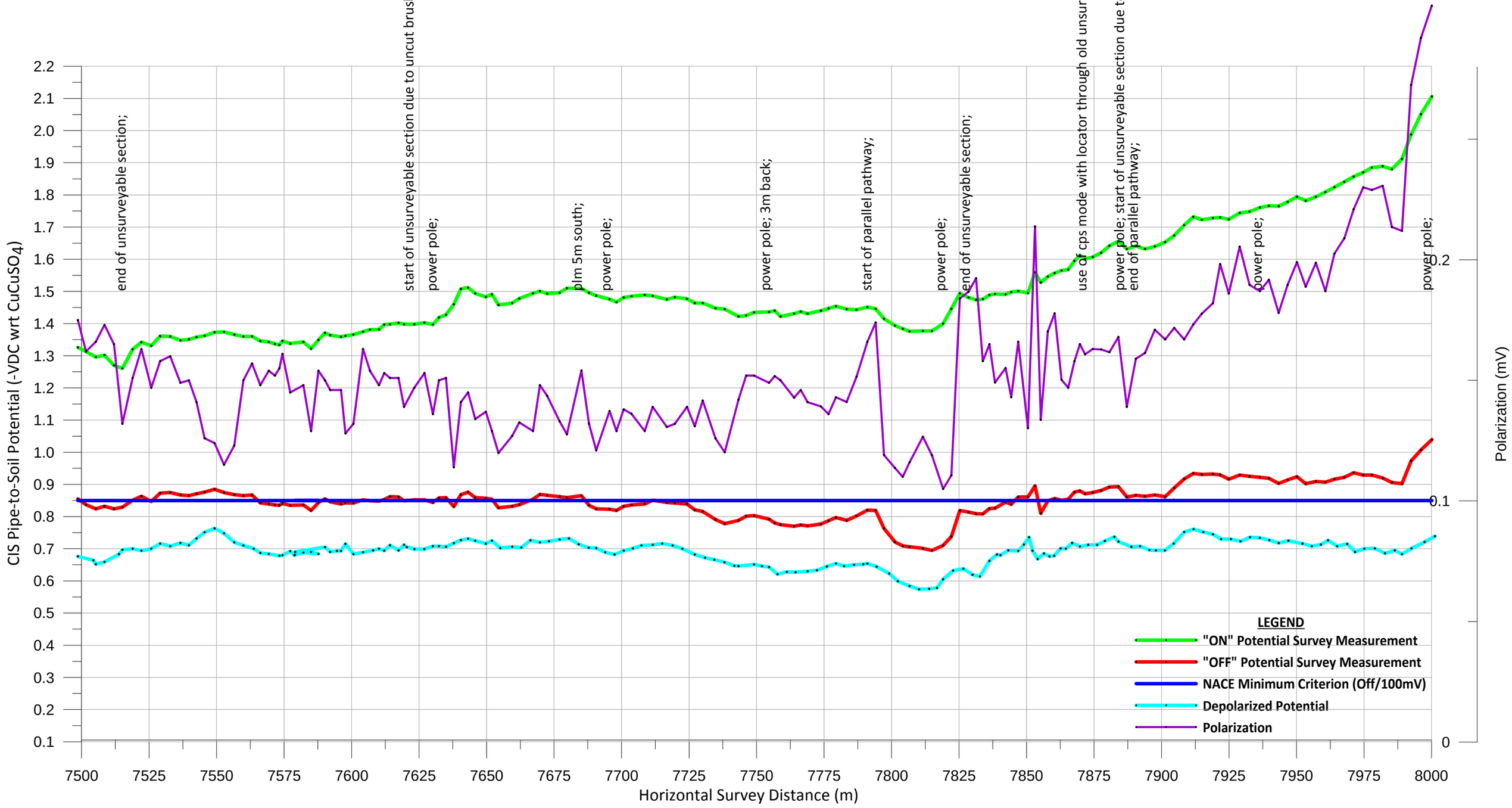
Dwg. #: 508-COQ-VAN IP-015		Sheet: 15 of 17
Date: June 18, 2013		
Scale:		
No.	Revision / Issue	Date



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508mm (NPS 20) IP Pipeline
Coquitlam - Burnaby, Coastal (BC)
Interrupted & Depolarized CIS Profile
2012

FORTIS BC

Dwg. #: 508-COQ-VAN IP-016		Sheet: 16 of 17
Date: June 18, 2013		
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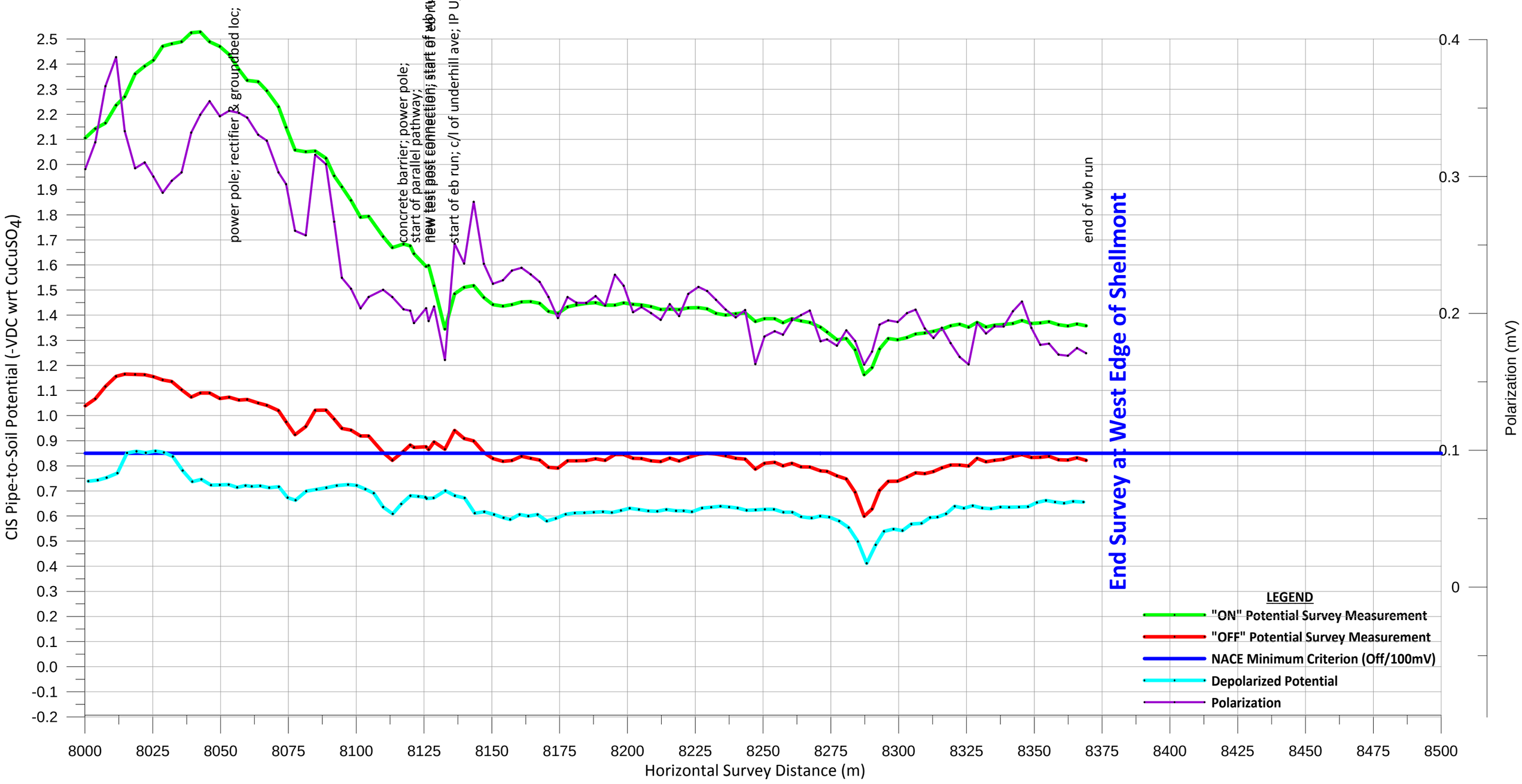
No.	Revision / Issue	Date



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Project:
Fortis BC
508mm (NPS 20) IP Pipeline
Coquitlam - Burnaby, Coastal (BC)
Interrupted & Depolarized CIS Profile
2012

FORTIS BC™

Dwg. #: 508-COQ-VAN IP-017		Sheet: 17 of 17
Date: June 18, 2013		
Scale:		
No.	Revision / Issue	Date

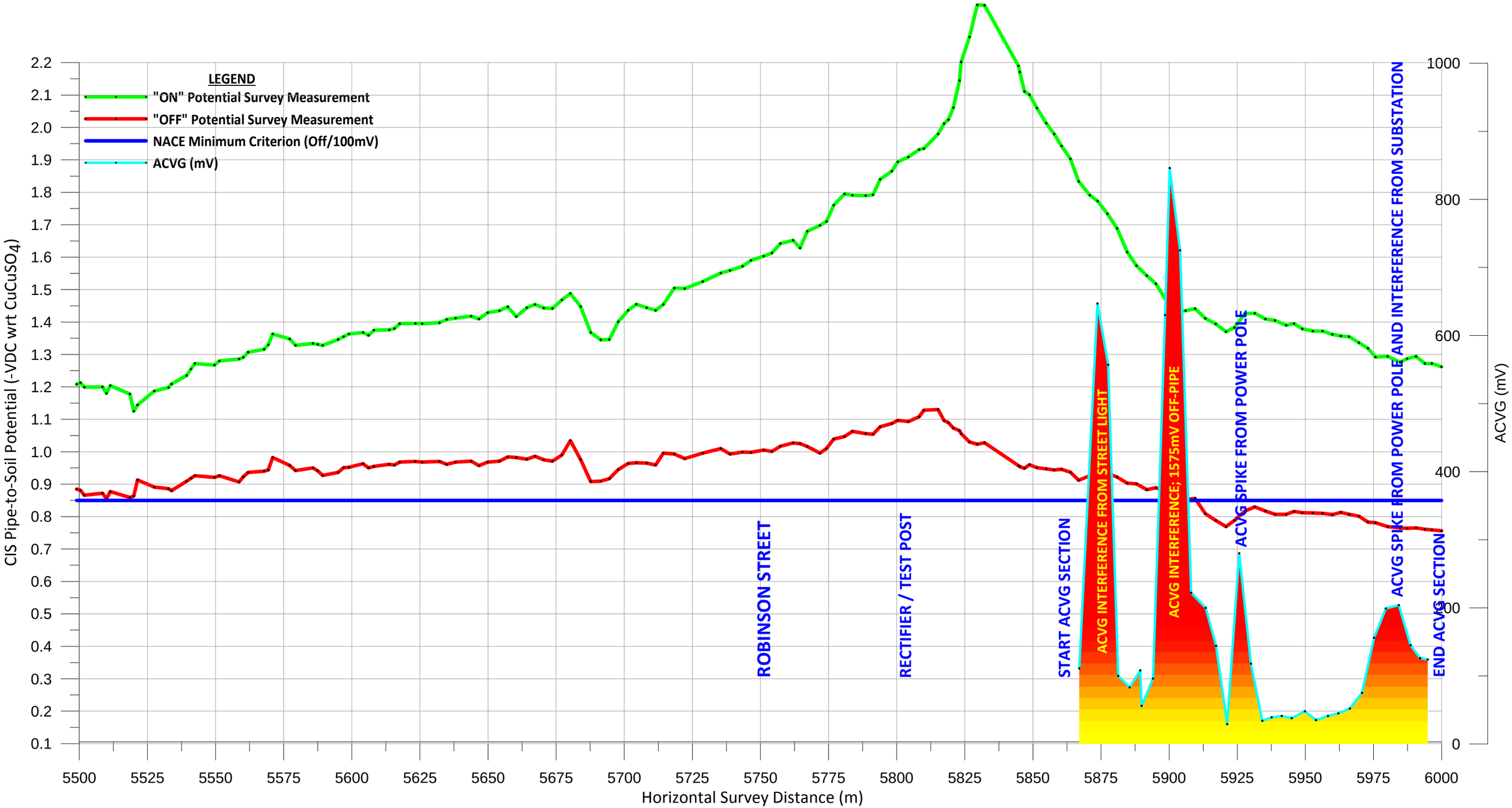
FORTIS BC
508mm (NPS 20) IP Pipeline
Coquitlam to Burnaby, Coastal (BC)

ACVG SURVEY DATA PROFILE PLOTS

2013

SUBMITTED ON: NOVEMBER 20, 2013

COMPLETED BY: RICHARD BUKSA, P. ENG.



Notes:
The Coquitlam - Burnaby IP ACVG survey was completed in February 2013. Data was collected only at locations absent of concrete or asphalt, allowing probe contact directly over the pipe.

E-MAC CORROSION INC.
Ph. (780) 444-EMAC (3622) Fax. (780) 466-3658
Designed By: RAB
Drawn By: RAB

Project:
Fortis BC
508mm (NPS 20) IP Pipeline
Coquitlam - Burnaby, Coastal (BC)
ACVG Survey Data Profile
2013

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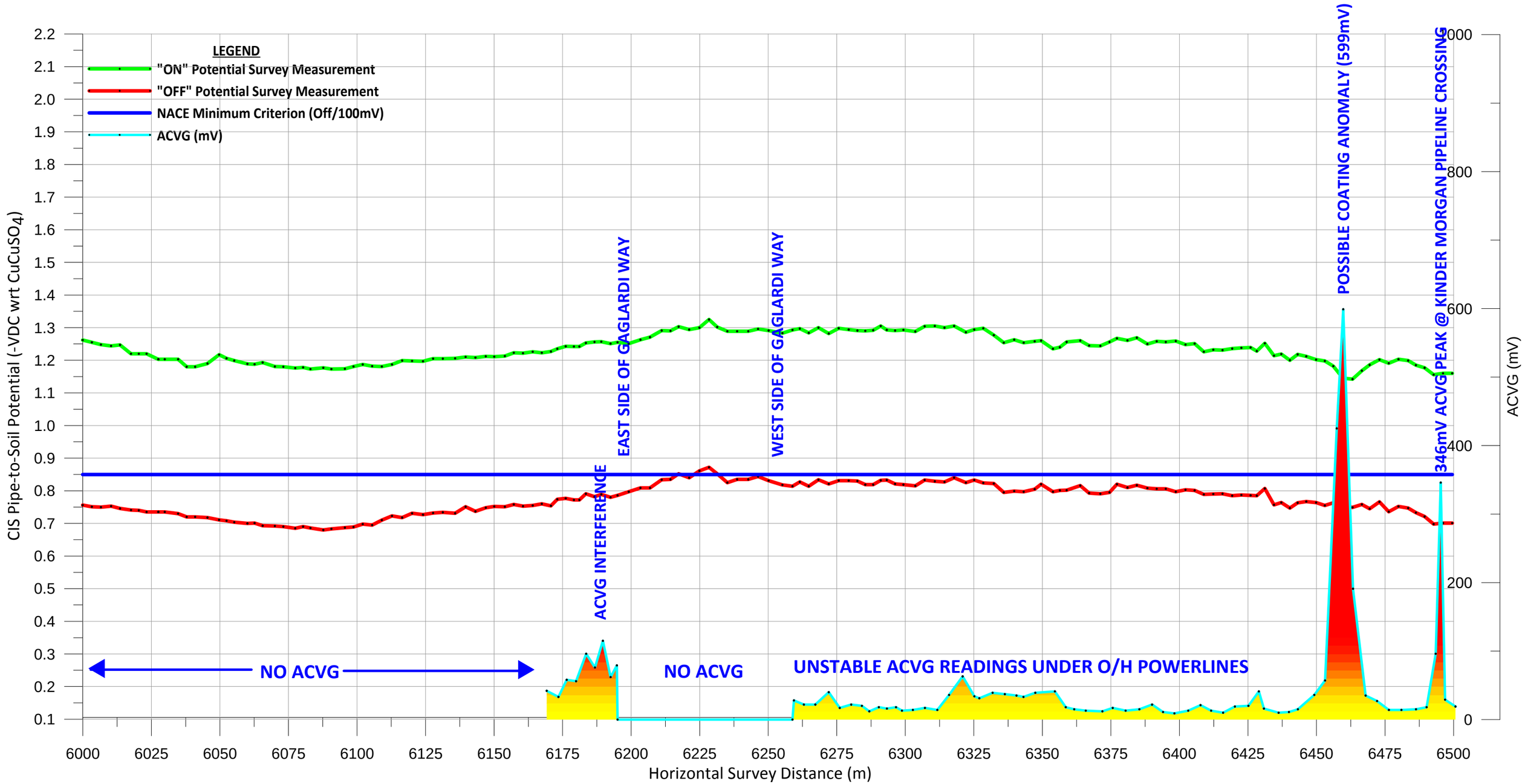
Dwg. #: 508-COQ-ACVG-01		Sheet: 1 of 6
Date: November 20, 2013		
Scale:		
No.	Revision / Issue	Date



Notes:
The Coquitlam - Burnaby IP ACVG survey was completed in February 2013. Data was collected only at locations absent of concrete or asphalt, allowing probe contact directly over the pipe.

E-MAC CORROSION INC.
Ph. (780) 444-EMAC (3622) Fax. (780) 466-3658
Designed By: RAB
Drawn By: RAB

Project:
Fortis BC
508mm (NPS 20) IP Pipeline
Coquitlam - Burnaby, Coastal (BC)
ACVG Survey Data Profile
2013

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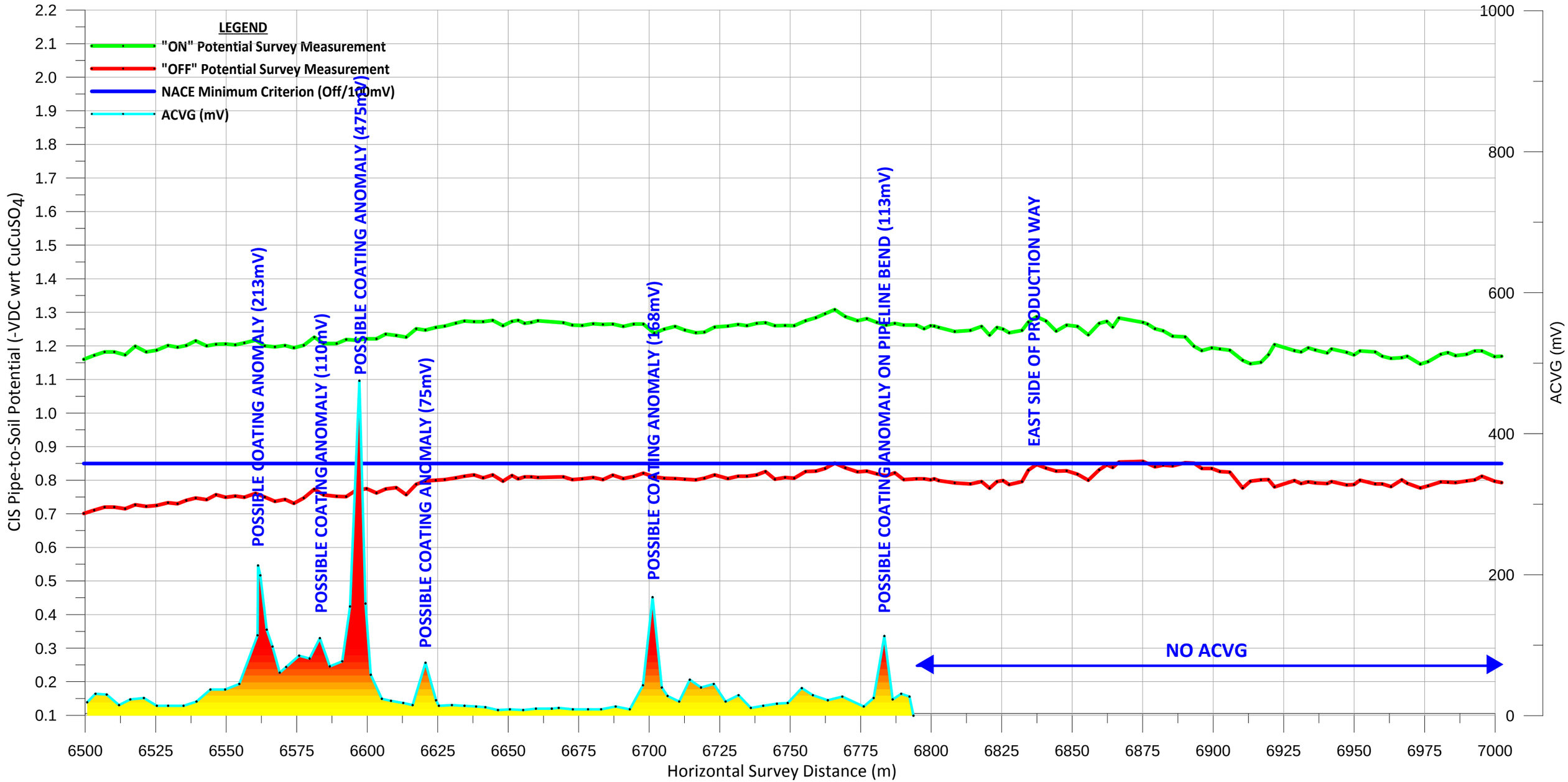
Dwg. #: 508-COQ-ACVG-02		Sheet: 2 of 6
Date: November 20, 2013		
Scale:		
No.	Revision / Issue	Date



Notes:
The Coquitlam - Burnaby IP ACVG survey was completed in February 2013. Data was collected only at locations absent of concrete or asphalt, allowing probe contact directly over the pipe.

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Drawn By: RAB

Project:
Fortis BC
508mm (NPS 20) IP Pipeline
Coquitlam - Burnaby, Coastal (BC)
ACVG Survey Data Profile
2013

FORTIS BC

Dwg. #: 508-COQ-ACVG-03		Sheet: 3 of 6
Date: November 20, 2013		
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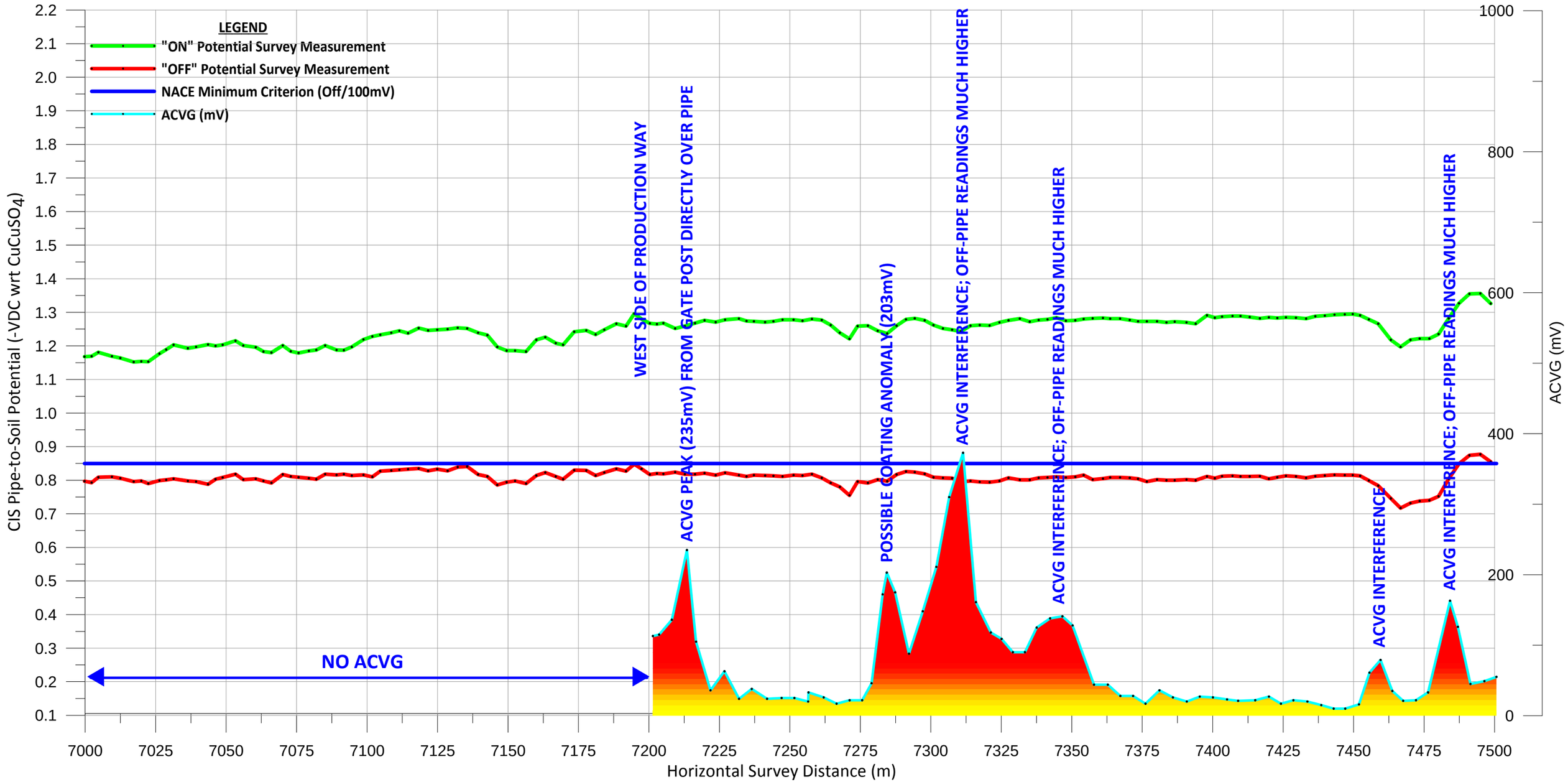
No.	Revision / Issue	Date



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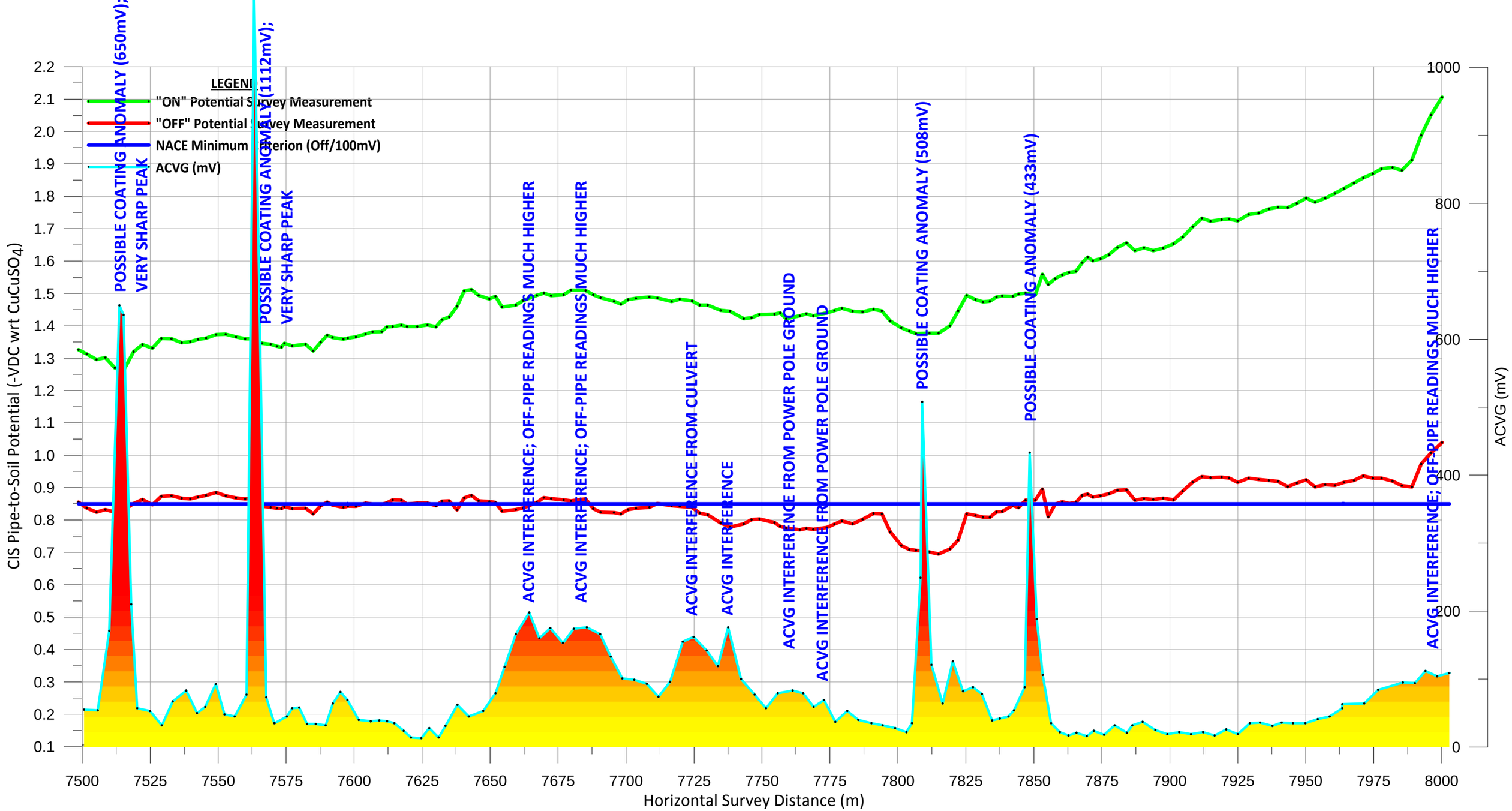
Dwg. #: 508-COQ-ACVG-04	Sheet: 4 of 6
Date: November 20, 2013	
Scale:	

No.	Revision / Issue	Date



Notes:
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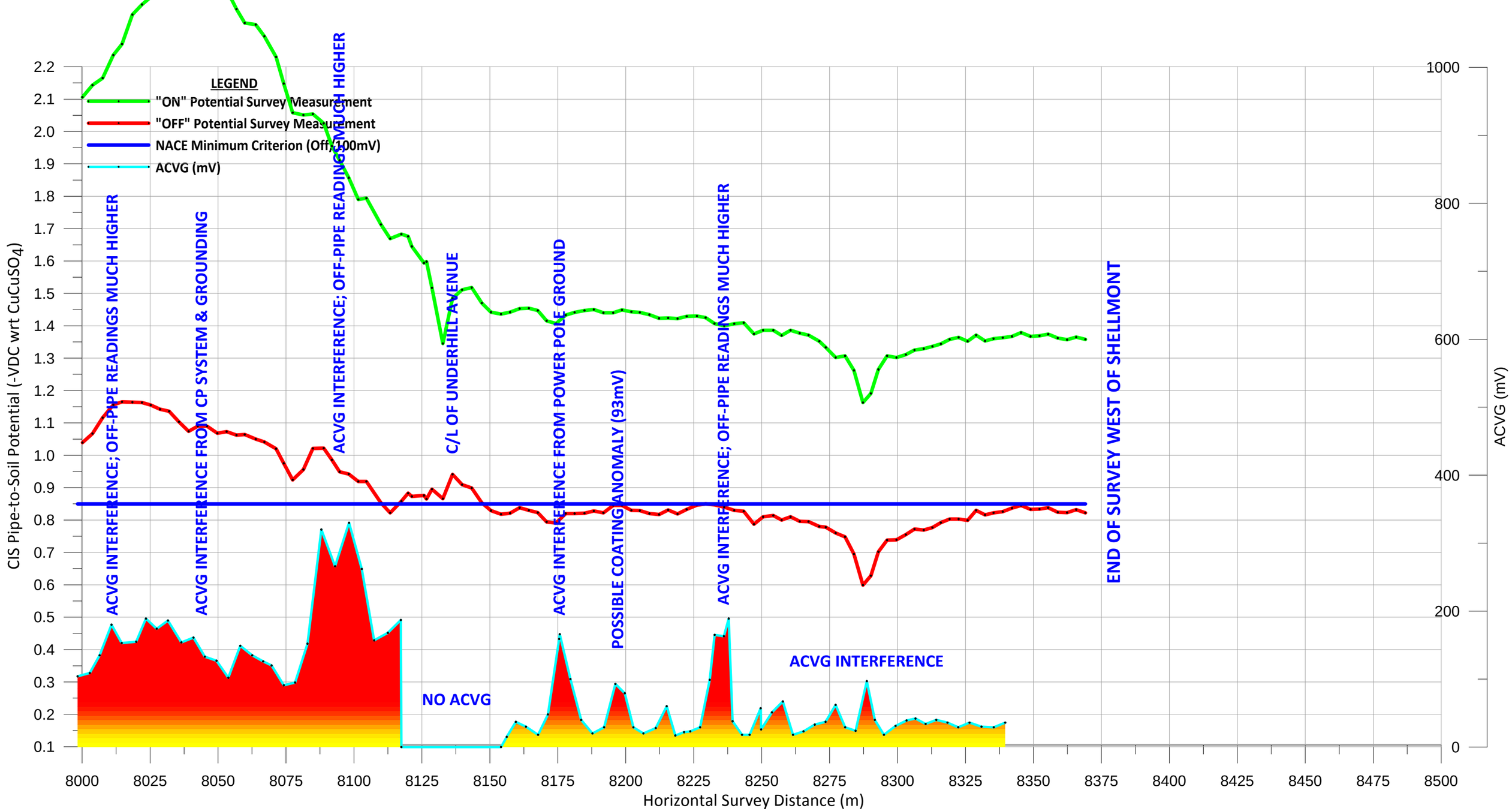
Dwg. #: 508-COQ-ACVG-05	Sheet: 5 of 6
Date: November 20, 2013	
Scale:	

No.	Revision / Issue	Date



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2013

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Dwg. #: 508-COQ-ACVG-06	Sheet: 6 of 6
Date: November 20, 2013	
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FORTIS BC
508mm (NPS 20) IP Pipeline
Coquitlam to Burnaby, Coastal (BC)
DEPTH-OF-COVER/CLOSE-INTERVAL SURVEY
2012

ECI 2012

FORTIS BC
COQUITLAM TO BURNABY, COASTAL (BC)
NPS 20 (508mm) IP PIPELINE
2012

DATE: *JANUARY 17, 2013*
WRITTEN BY: *RICHARD A. BUKSA, P.ENG*

SUMMARY

The NPS 20 (508mm) Coquitlam to Vancouver Intermediate Pressure (IP) pipeline was constructed in 1957. Corrosion control of the Coquitlam 20" IP pipeline is achieved via a protective external coating and two independent impressed current cathodic protection systems. The external coating was shop-applied coal tar enamel during the original pipe manufacturing process and some inspection reports indicate that hot coal tar enamel was field-applied to girth welds during the pipeline construction in 1957. Cold applied polymer backed tape is expected at most repair locations, as this was a common practice in the past.

The NPS 20 (508mm) Coquitlam to Vancouver pipeline extends from Coquitlam Gate station to 2nd & Woodlands station in Vancouver, with a total length of 19.5km. The scope of this survey extends from Coquitlam Gate station to Broadway & Shellmont, for a total survey length of 8.37km. Cathodic protection of this section of pipeline is supplied via an impressed current CP system located at survey distance 8050m, approximately 120m east of Underhill Avenue with 1 circuit connected to the IP pipeline. The groundbed is a lateral distance of approximately 5m from the IP pipeline and installed at a depth of 30m.

A depth-of-cover (DOC), AC current attenuation (ACCA) and GPS pipeline alignment survey were completed in August 2012 prior to the close-interval-survey (CIS), which was completed in December 2012 in order to utilize the rainy season for adequate reference electrode to ground contact. A significant portion of the pipeline runs beneath concrete/asphalt and wet ground conditions were necessary in order to obtain useful data. In addition to the data that was collected as indicated above, an interference investigation was also completed at the Coquitlam Gate station to determine the magnitude of any CP influence from the DP rectifier installed at that station.

Survey results indicate that cathodic protection potentials do not meet the -850mV (CSE) criterion on approximately 50% of the line. Based on the depth measurements obtained, the average depth is 2.20m and adequate DOC is maintained over 100% of the length of the pipeline, with the shallowest DOC measurement of 0.75m on a 2-track (or trail). During the course of the close-interval-survey (CIS), two adjacent FortisBC rectifiers intended to provide CP to the DP piping system were found to be influencing the potentials on the NPS 20 IP pipeline. The following is a description of the 2 rectifiers:

- **Rectifier 1:** Located at the Coquitlam Gate station with 1 circuit connected to the DP pipeline and was not intended to provide CP to the IP pipeline. The groundbed is a lateral distance of approximately 10m from the IP pipeline and installed at a depth of 30m.
- **Rectifier 2:** Located at survey distance 5800m approximately 200m east of Gaglardi Way near a creek, with 1 circuit connected to the DP pipeline. The groundbed is lateral distance of approximately 10m from the IP pipeline and installed at a depth of 30m.

If the IP & DP pipeline systems are indeed electrically isolated from each other, then analysis of the CIS data indicates that interference may be occurring at several locations on the IP pipeline. The relatively close proximity of both DP groundbeds to the isolated IP pipeline may be causing interference effects and continuity of the 2 systems should be considered.

Another potential source for CP interference was detected adjacent to the Race Track Gas station at 952 Como Lake Avenue, Blue Mountain Street in Coquitlam. It has been verified that an underground storage tank CP system is present at the gas station and the associated groundbed is approximately only 5m from the IP pipeline (installation depth unknown). The close proximity of this foreign groundbed could allow the NPS 20 IP pipeline within the high gradient (as observed in CIS plot data) to pick-up CP current, resulting in potentially high interference effects as the current can discharge at the surface of the pipeline on its path back to the gas station rectifier.

DISCUSSION

The Spectrum XLI survey equipment was utilized to complete the scope-of-work, which consists of a mapping-grade (sub-meter) GPS unit in conjunction with a high-output (100W) line illuminator and a Radiodetection RD7000 electromagnetic pipeline locator. All of the Fortis BC cathodic protection systems were interrupted via remote monitoring units (RMU's) with an interruption cycle of 1.6s (on) / 0.4s (off).

DEPTH-OF-COVER / GPS SURVEY

Depth-of-cover (DOC) and residual current measurements were obtained approximately every 10m with additional readings at abrupt changes in pipeline direction or land elevations. A high-output (100W) line illuminator was used to transmit a 512Hz signal to the pipeline via direct connections at various test stations in order to provide the most accurate DOC & current measurements that could be achieved. Each DOC measurement was recorded with a mapping-grade (sub-meter) GPS coordinate to provide a DOC profile and pipeline position plot. The pipeline aerial views have been included in Appendix 1, the DOC profile plots in Appendix 3, the tabulated DOC/GPS data in Appendix 4 and the ACCA plot in Appendix 5 of this report.

Results of the DOC survey data indicate that adequate cover is being maintained over the entire length of the 508mm (NPS 20) IP pipeline from the Coquitlam Gate station to the Shell Canada Shellmont station. The average pipeline DOC is 2.20m and the shallowest measurement was 0.75m on a 2-track/trail. The DOC measurements are all tabulated in Appendix 4 of this report.

CLOSE-INTERVAL-SURVEY

Analysis of the CIS data indicates that 50% of the polarized P/S "OFF" potentials do not meet the minimum criterion of -850mV. It is recommended that a depolarization CIS survey be conducted in order to further evaluate the level of cathodic protection present at these locations. Three interfering CP sources were identified during the course of the survey.

The following is a general list of IP pipeline sections where the "OFF" potentials are generally more positive than -850mV:

Approx. Start Distance (m)	Approx. End Distance (m)	Comments
0	2000	Starting at Coquitlam Gate station and ending approx. 100m from Poirier Street (approx.. 2000m total)
5900	7900	Starting after DP groundbed east of Gaglardi Way
8150	8350	Starting at Underhill Avenue and continues to the end of the survey section; Includes a sharp dip at distance 8288m

Although it is difficult to determine the exact locations where detrimental interference effects may be occurring, the CIS data indicates that the two FortisBC DP pipeline CP systems have an influence on the IP pipeline system potentials, which was designed to be electrically isolated from the DP pipeline system. It is recommended that ForticBC establish electrical continuity between the DP and IP pipeline systems in order to mitigate any possible effects from interference and enhance the CP potentials on the IP pipeline.

Analysis of the CIS data also identified another potential source for CP interference that was detected adjacent to the Race Track Gas station (approx. 3700m survey distance) at 952 Como Lake Avenue, Blue Mountain Street in Coquitlam. It has been verified that an underground storage tank CP system is present at the gas station and the associated groundbed is approximately only 5m from the IP pipeline (installation depth unknown), resulting in potential interference effects as the current can discharge at the surface of the pipeline on its path back to the gas station rectifier. Further investigation into the effects of this CP source on the IP pipeline should be considered.

AC CURRENT ATTENUATION SURVEY

In conjunction with the DOC survey, residual pipeline current measurements were recorded along with each depth reading. The general condition of the pipeline coating can be determined by monitoring the drop in current from one position to the next. A significant decrease in current may indicate that the pipeline coating condition is compromised within that associated section, providing a less resistive current path to ground via increased steel-to-electrolyte contact through the damaged coating.

Results of the ACCA survey indicate that there are several sections over the length of the pipeline where notable ACCA values correspond with either dips in CIS potentials or CIS potentials that do not meet the -850mV criterion. The following is a list of IP pipeline sections where current attenuations correspond either with dips in CIS potentials or CIS potentials that do not meet the -850mV criterion:

Approx. Start Distance (m)	Approx. End Distance (m)	Comments
180	1300	Significant current drops correlating with well-defined drops in CIS potentials that dip well below -850mV (more positive)
1400	2000	Several current drops over section with long gradual drops in CIS potentials that dip below -850mV (more positive)
3075	3350	Significant current drop correlating with a long gradual drop in CIS potentials that dip below -850mV (more positive)
4150	4400	Significant current drop correlating with several ups & downs in the CIS potentials
4500	4550	Current drop corresponding to dip in CIS potentials that go more positive than -850mV at the minimum values
5900	6100	Significant current drop over section corresponding with CIS “trough” and potentials more positive than -850mV over entire section

Approx. Start Distance (m)	Approx. End Distance (m)	Comments
6900	7500	Steady series of current drops; CIS potentials are more positive than -850mV over entire section with some CIS potential dips in the middle
8100	8369	Significant current drop correlating with CIS potentials more positive than -850mV and a sharp dip in CIS potentials centered at approximate survey distance 8290m; The section ends at the end of the CIS survey west of Shellmont

A total of approximately 3400m of ACVG survey is recommended above.

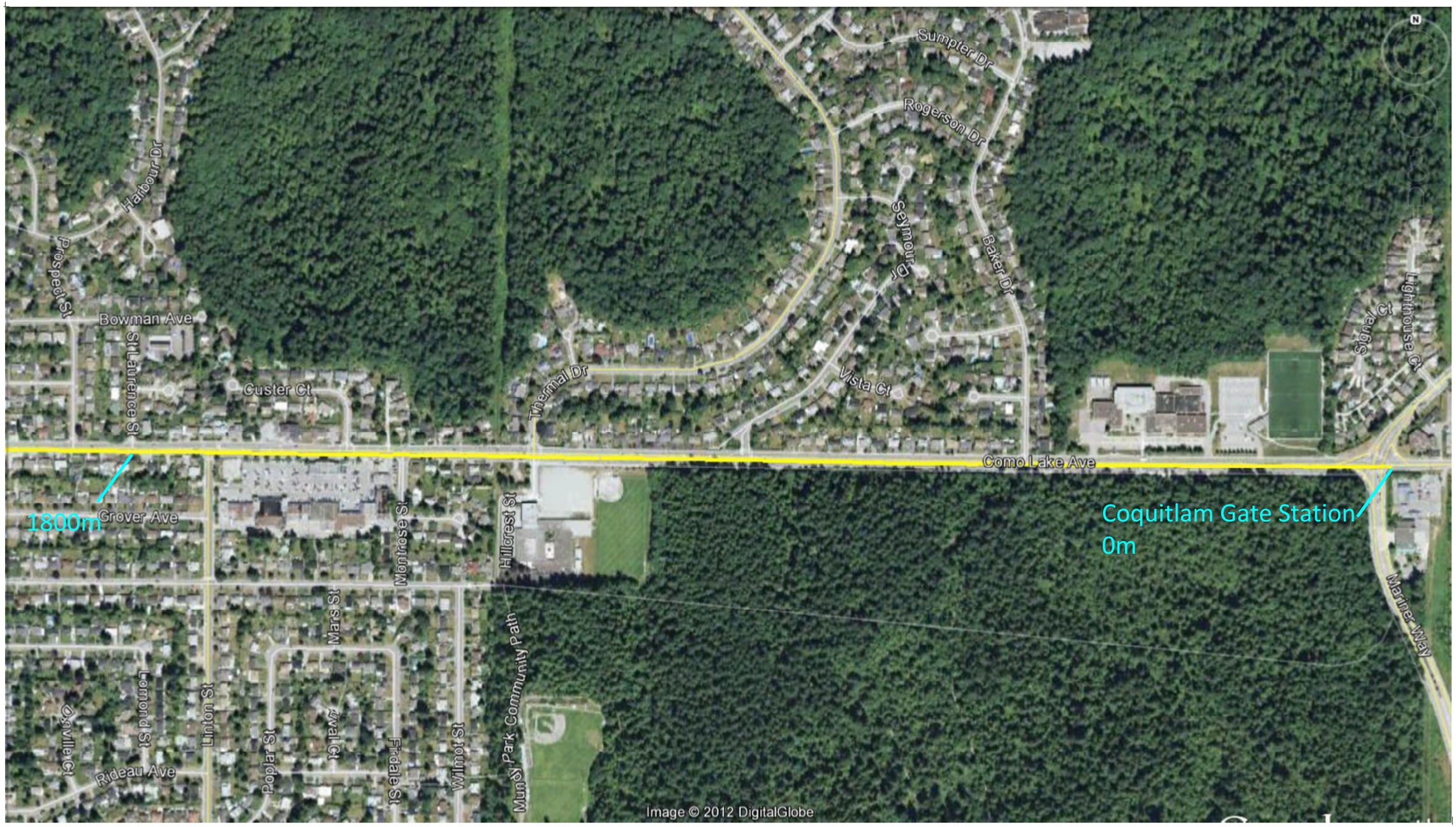
RECOMMENDATIONS

The following recommendations are based on the results of the CIS/DOC/ACCA survey:

- Consider establishing electrical continuity between the FortisBC DP & IP pipeline systems.
- Once electrical continuity has been established between the DP & IP pipeline systems, consider a CIS of the entire IP pipeline to determine if the -850mV criterion can be achieved with interference alleviated.
- Consider a depolarization CIS survey in order to determine if the 100mV polarization criterion is being achieved.
- Have an ACVG survey completed on all of the sections identified in the previous table.
- Have a cathodic protection survey completed on the underground tank structures at the Race Track Gas station to determine if the CP system output can be reduced or if alternative interference mitigation measures should be implemented.

FORTIS BC
COQUITLAM TO BURNABY, COASTAL (BC)
PROJECT DETAILS
2012

COMPANY:	Fortis BC	
PIPELINE:	508mm (NPS 20) IP PIPELINE	
DESCRIPTION:	Coquitlam to Burnaby	
PROJECT DATES:	Field:	August 2012 (DOC) December 2012 (CIS)
	Office:	January 17, 2013
PERSONNEL:	Field:	Sean Martin, Crew Leader Ryan Kochan, Sr. Tech Mike McDowell, Sr. Tech Chris Heatley, Sr. Tech
	Office:	Richard Buksa, P. Eng. Chris Heatley, Sr. Tech



Notes:
The Coquitlam - Vancouver IP CIS survey was completed in Aug and Dec 2012. The rectifiers were interrupted via aGPS time-synchronized cycle of: 1.6sec "on" / 0.4sec "off".

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Drawn By: RAB

Project:
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508mm (NPS 20) Pipeline
Coquitlam - Vancouver IP, Coastal (BC)
Pipeline Aerial View
2012

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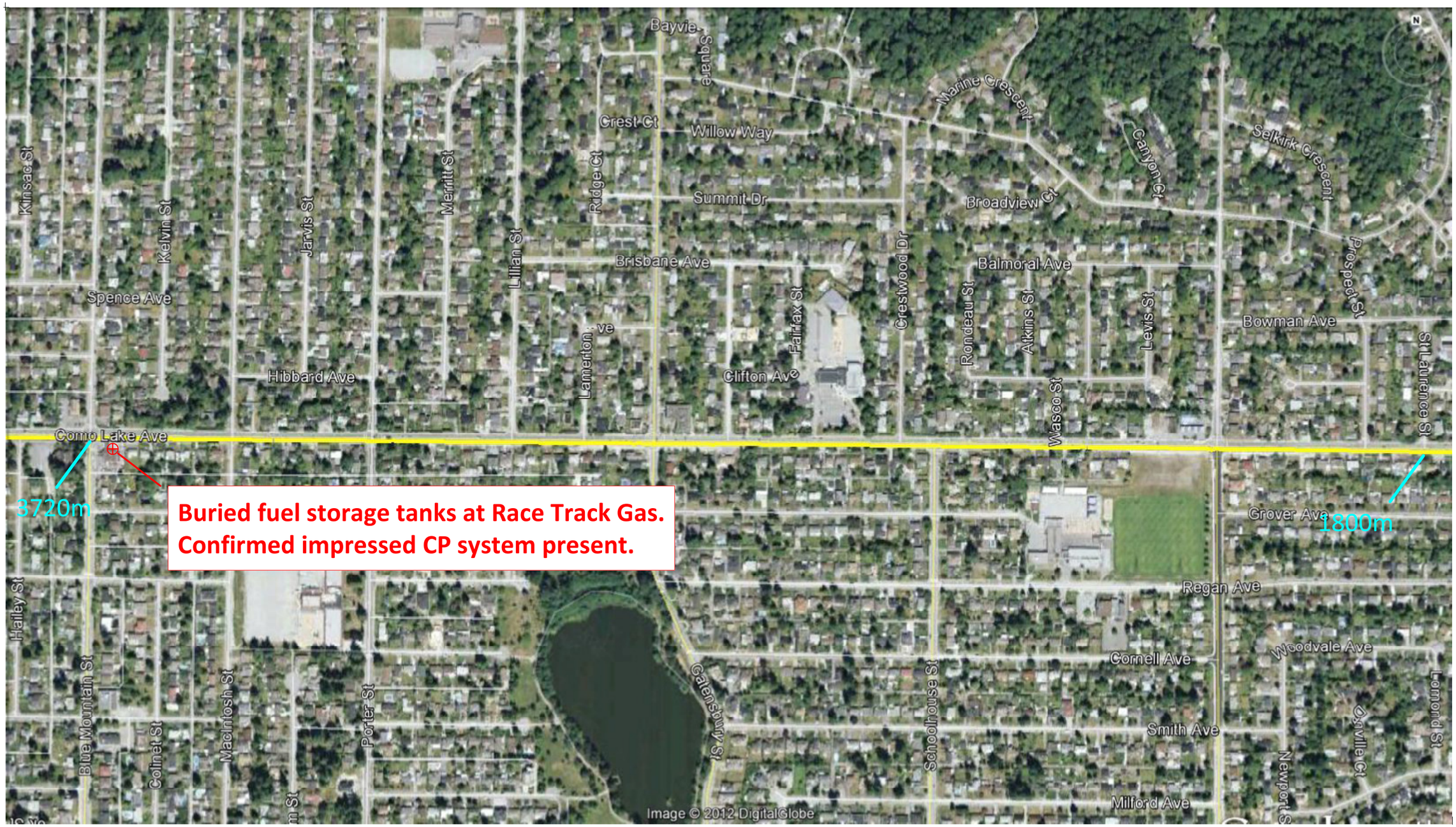
Dwg. #: 508-CVIP-AER-001		Sheet: 1 of 5
Date: December 10, 2012		
Scale:		
No.	Revision / Issue	Date



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Pipeline Aerial View
2012

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Dwg. #:	508-CVIP-AER-002
Date:	December 10, 2012
Scale:	
Sheet:	2 of 5

No.	Revision / Issue	Date

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Project:
Fortis BC
508mm (NPS 20) Pipeline
Coquitlam - Vancouver IP, Coastal (BC)
Pipeline Aerial View
2012

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Dwg. #: 508-CVIP-AER-003		Sheet: 3 of 5
Date: December 10, 2012		
Scale:		
No.	Revision / Issue	Date

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Project:
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508mm (NPS 20) Pipeline
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Pipeline Aerial View
2012

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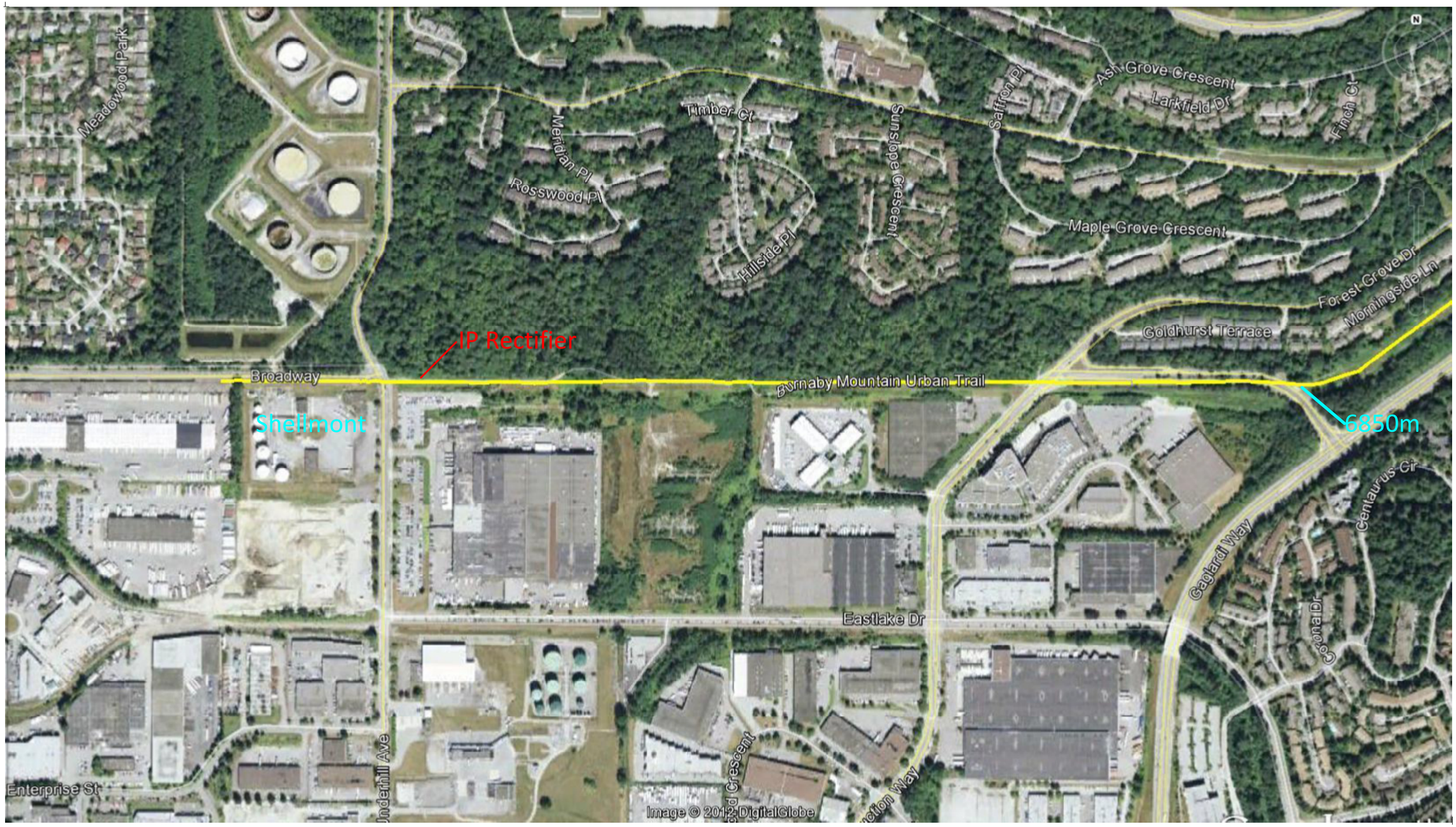
Dwg. #: 508-CVIP-AER-004		Sheet: 4 of 5
Date: December 10, 2012		
Scale:		
No.	Revision / Issue	Date



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Pipeline Aerial View
2012

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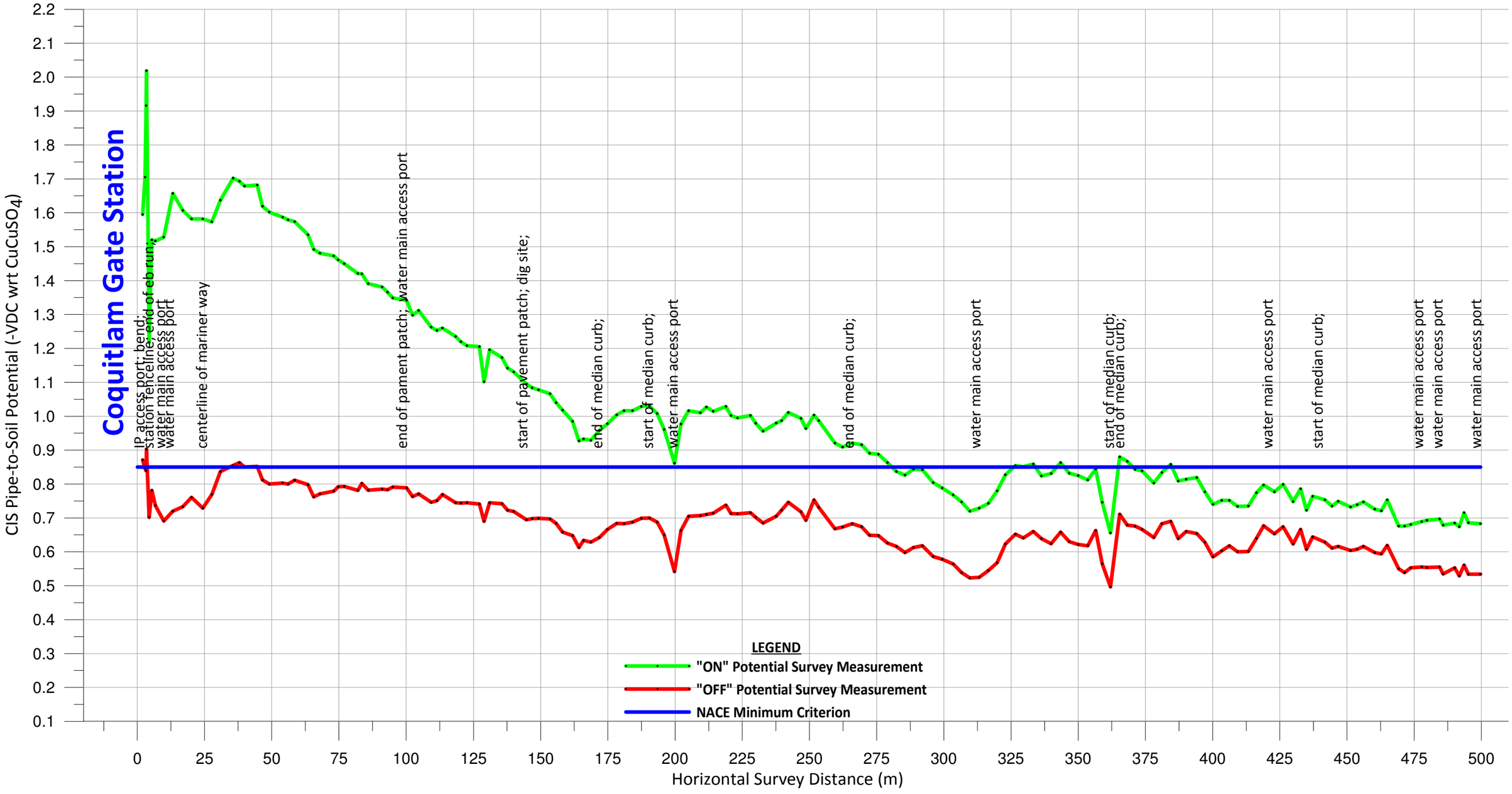
APPENDIX 2
CLOSE-INTERVAL-SURVEY (CIS) PROFILE PLOTS
508mm (NPS 20) TP Pipeline
Coquitlam to Vancouver, Coastal (BC)
2012



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Project:
Fortis BC
508mm (NPS 20) Pipeline
Coquitlam - Vancouver IP, Coastal (BC)
Close-Interval-Survey (CIS) Profile
2012

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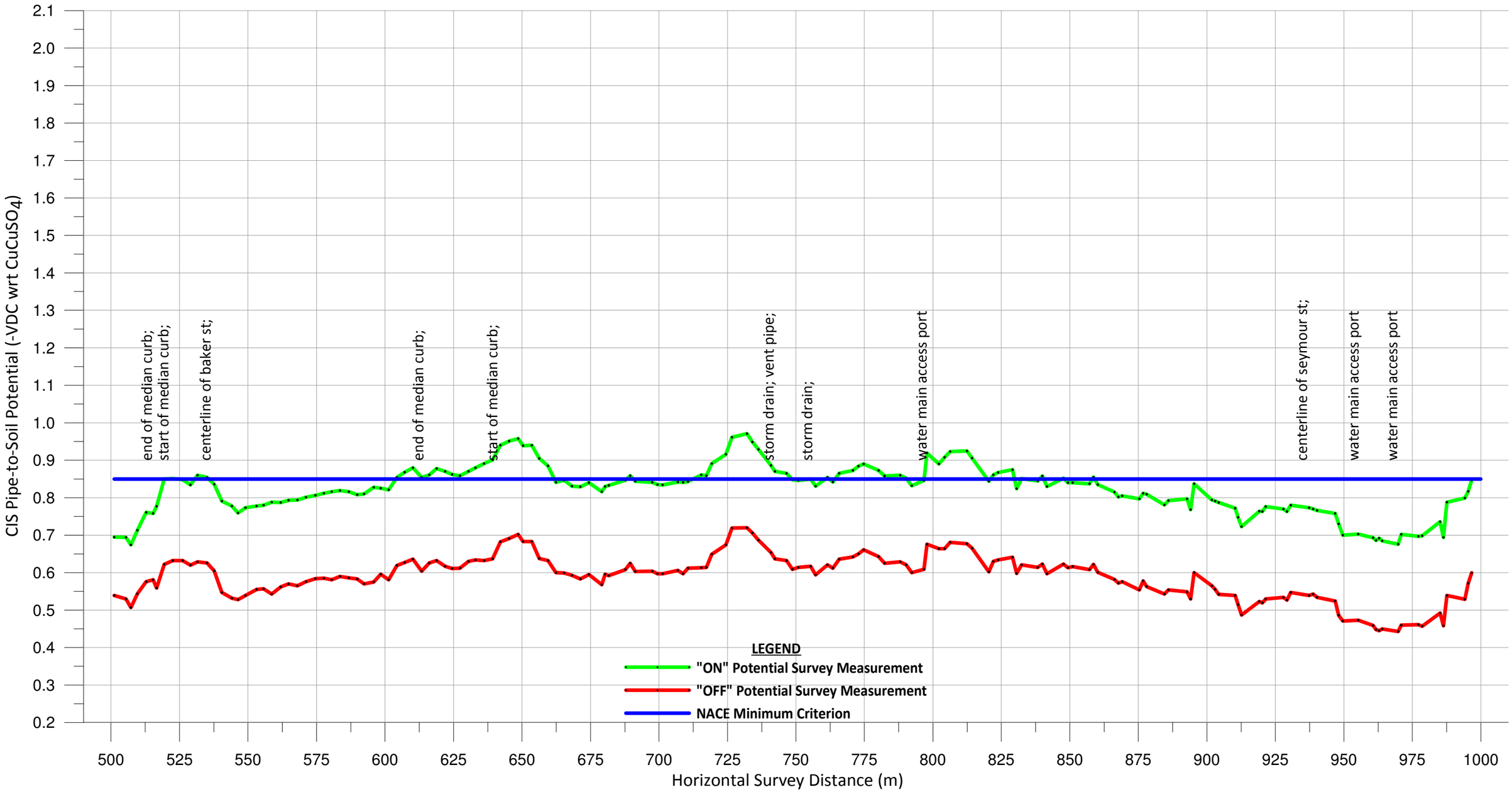
Dwg. #: 508-COQ-VAN IP-001		Sheet: 1 of 17
Date: December 6, 2012		
Scale:		
No.	Revision / Issue	Date



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Close-Interval-Survey (CIS) Profile
2012

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Dwg. #: 508-COQ-VAN IP-002	Sheet: 2 of 17
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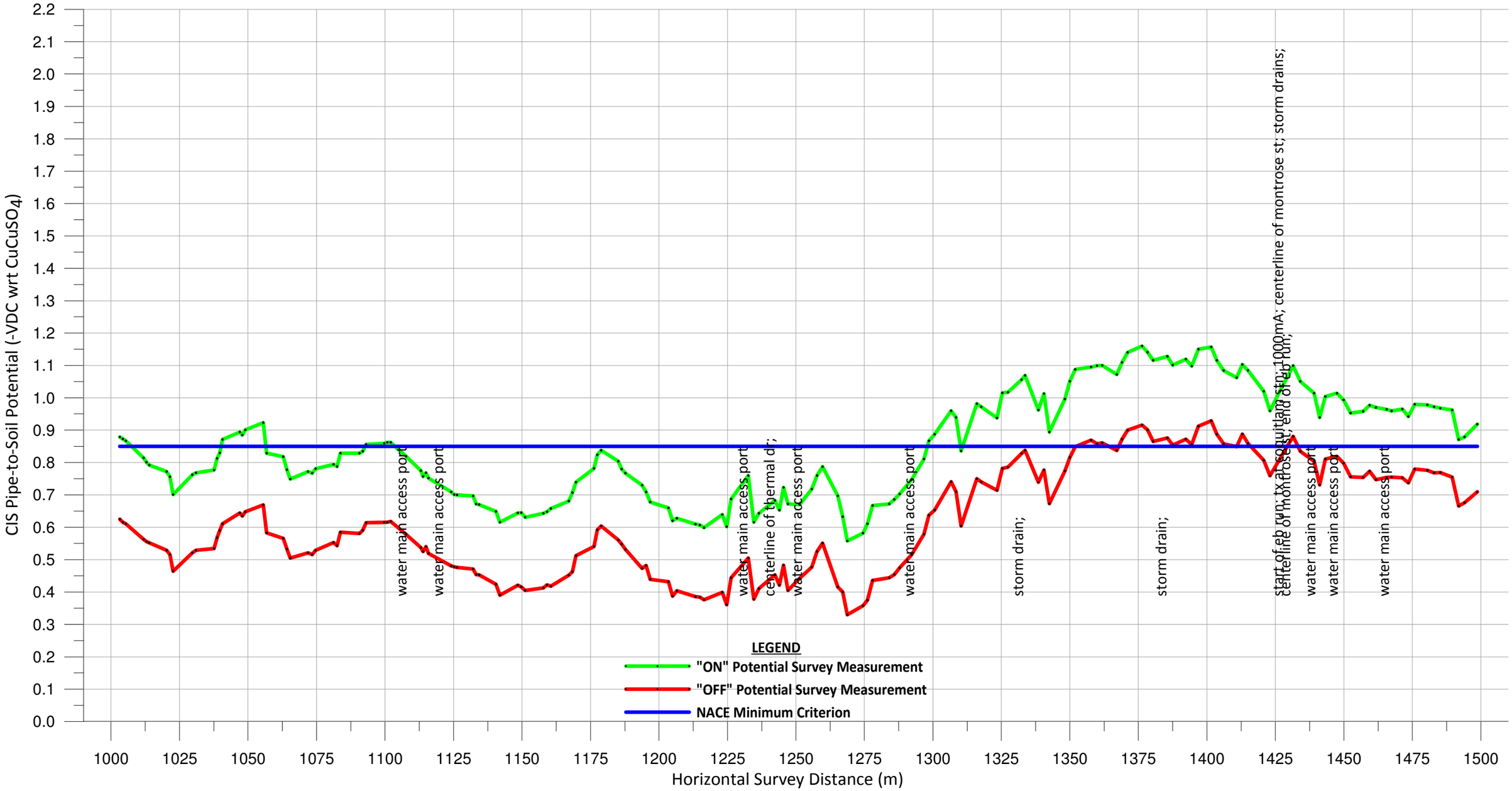
Scale:	

No.	Revision / Issue	Date



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Project:
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508mm (NPS 20) Pipeline
Coquitlam - Vancouver IP, Coastal (BC)
Close-Interval-Survey (CIS) Profile
2012

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Dwg. #: 508-COQ-VAN IP-003		Sheet: 3 of 17
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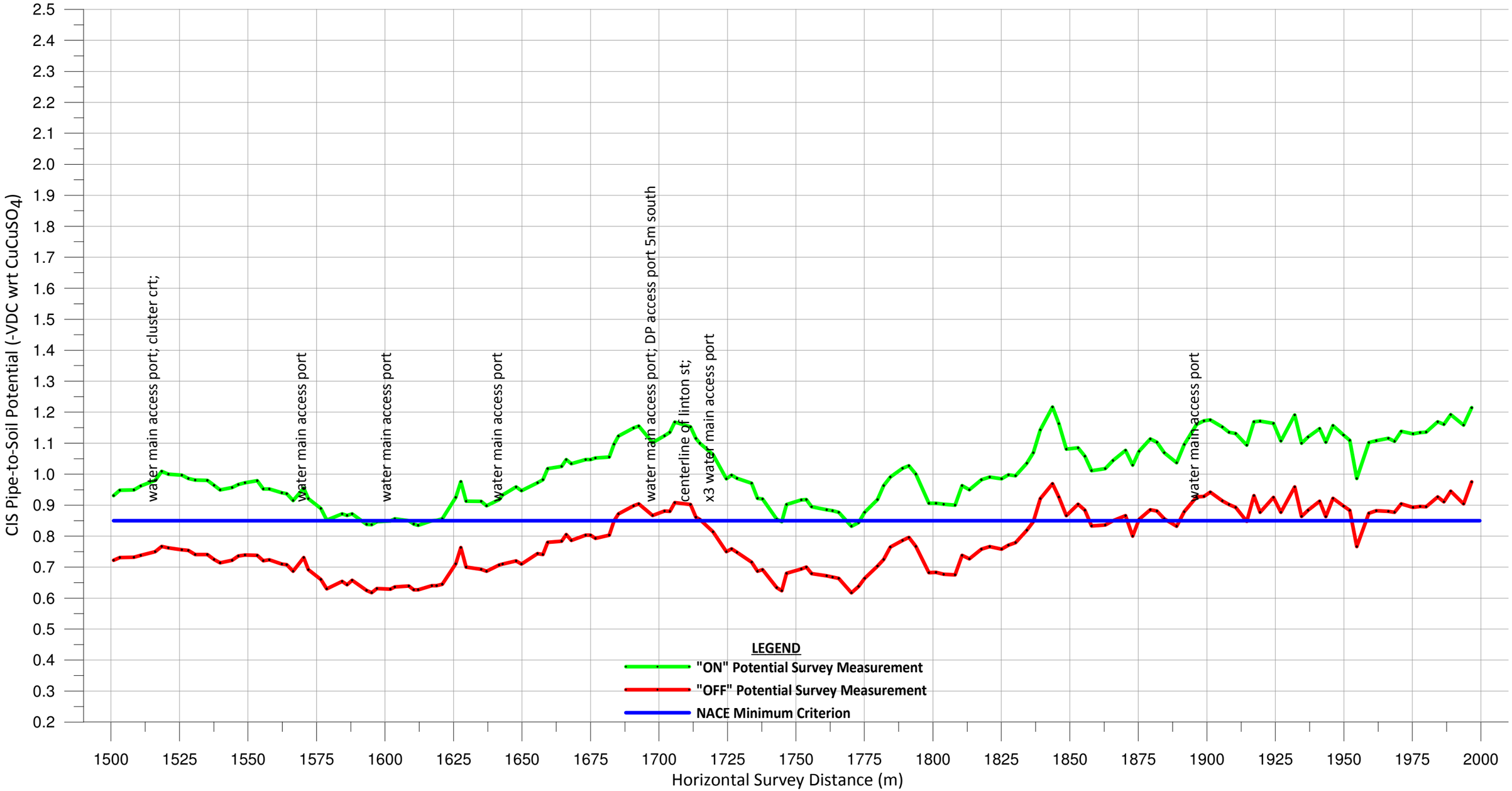
Scale:		
No.	Revision / Issue	Date



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Dwg. #: 508-COQ-VAN IP-004		Sheet: 4 of 17
Date: December 6, 2012		
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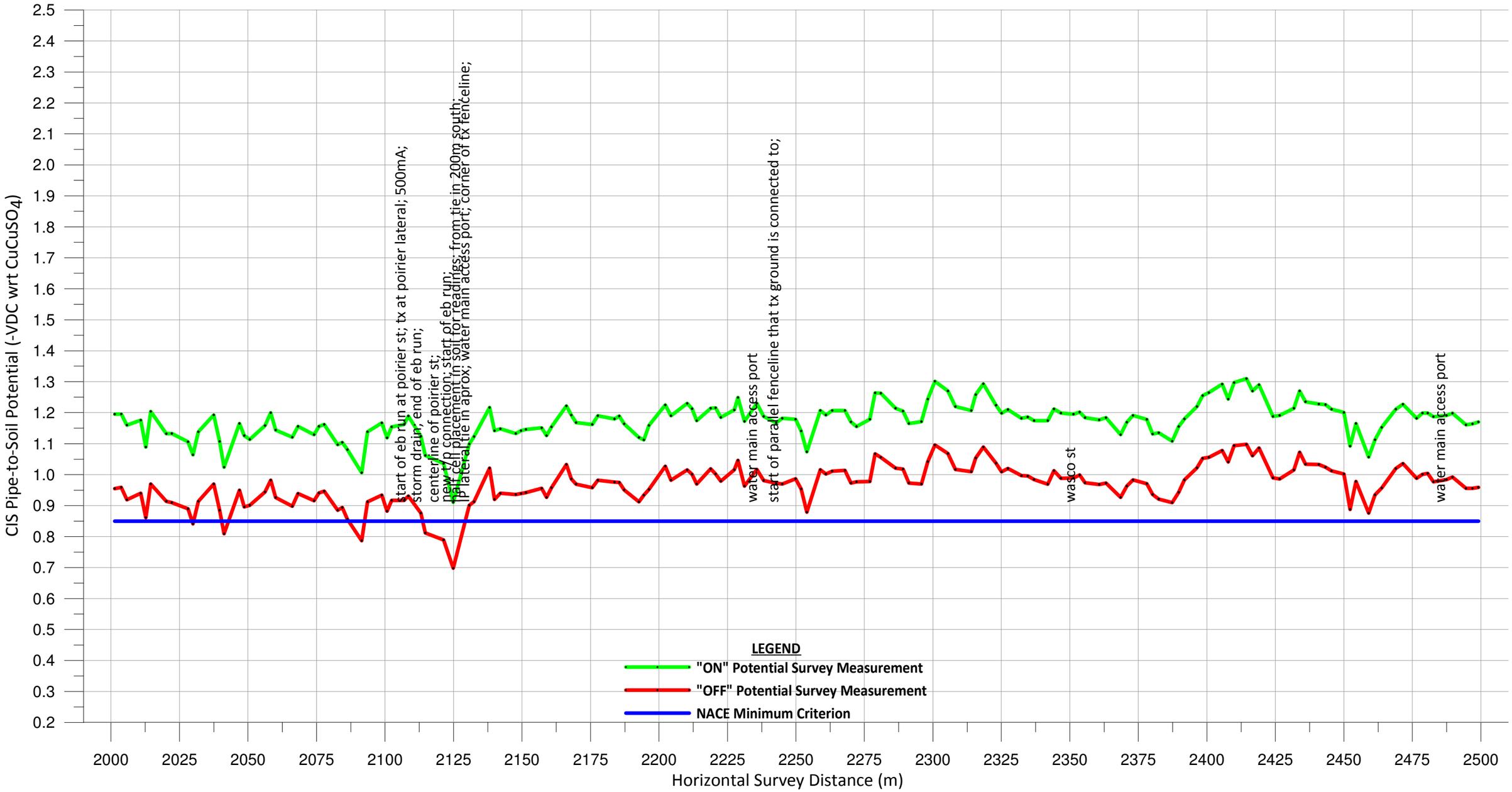
No.	Revision / Issue	Date



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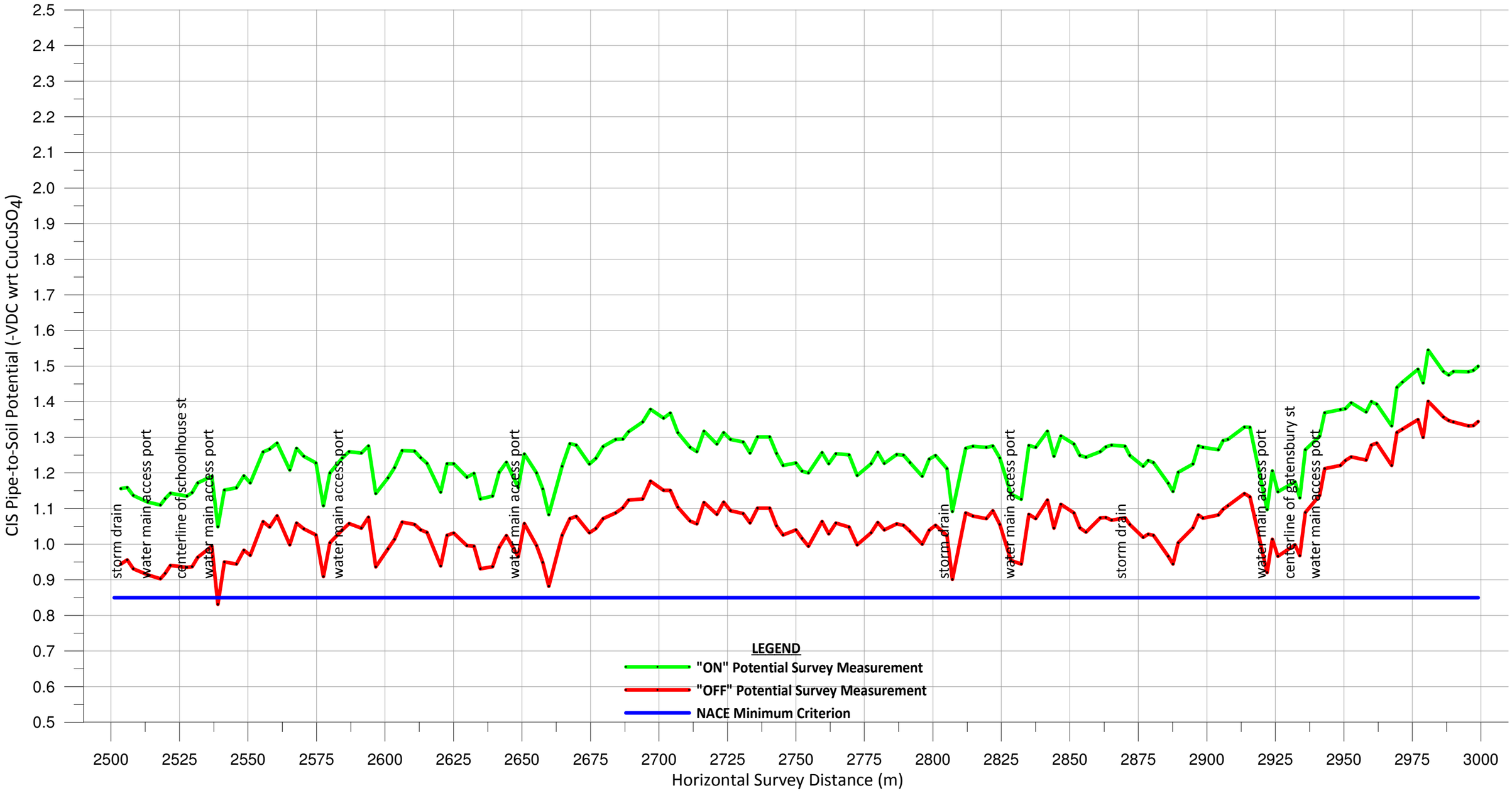
No.	Revision / Issue	Date



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Dwg. #: 508-COQ-VAN IP-006		Sheet: 6 of 17
Date: December 6, 2012		
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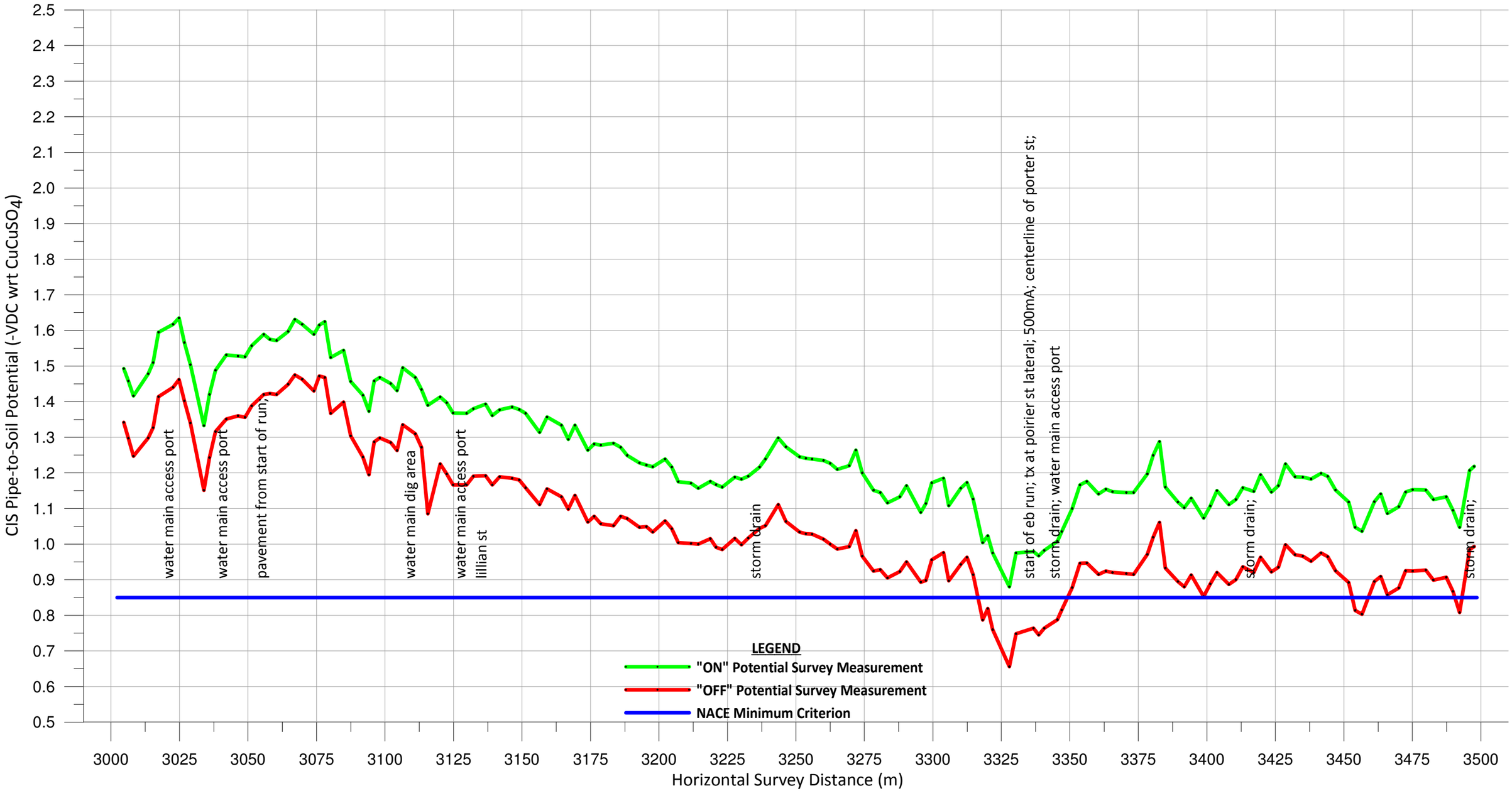
No.	Revision / Issue	Date



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Dwg. #: 508-COQ-VAN IP-007		Sheet: 7 of 17
Date: December 6, 2012		
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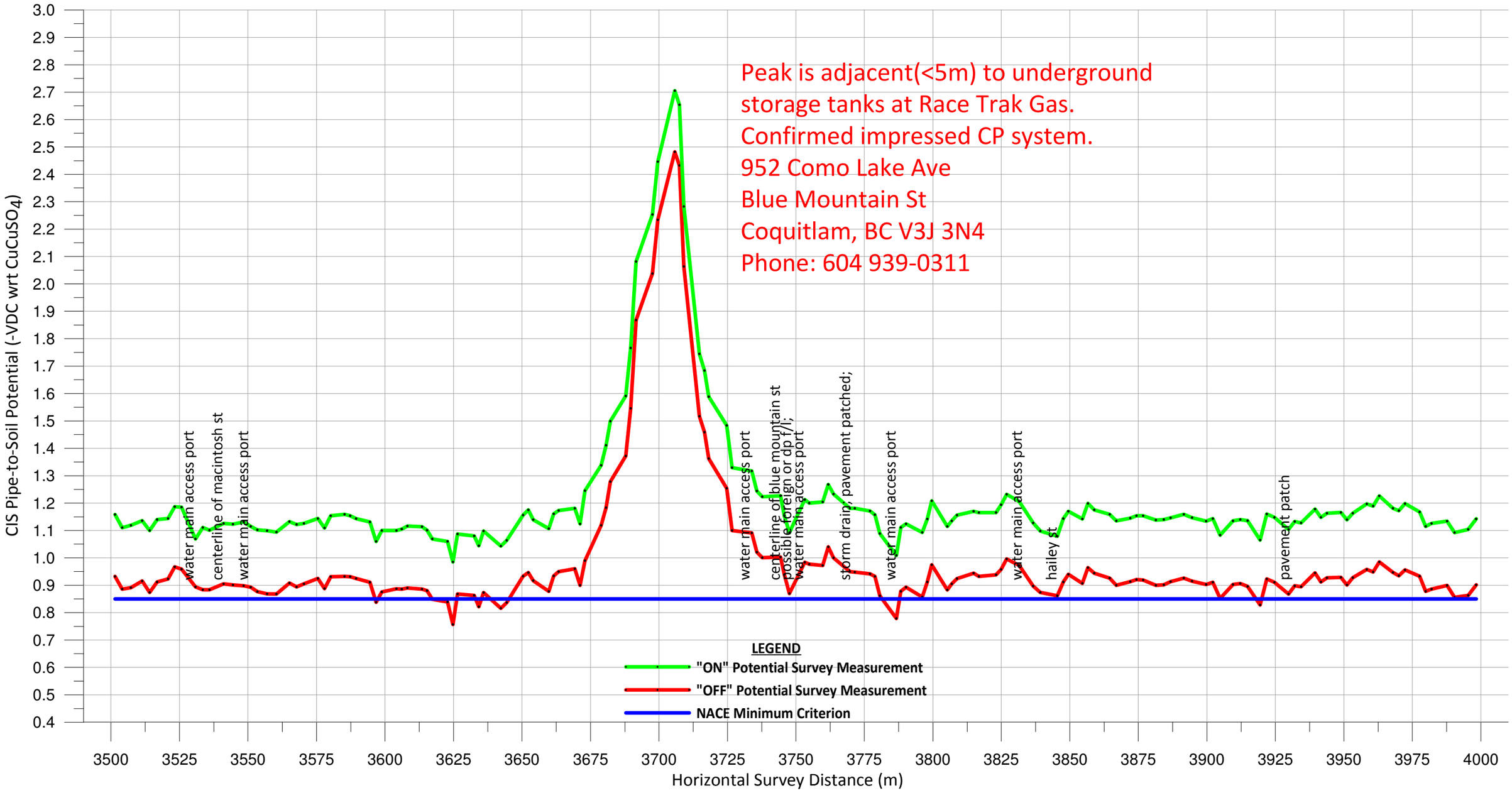
No.	Revision / Issue	Date



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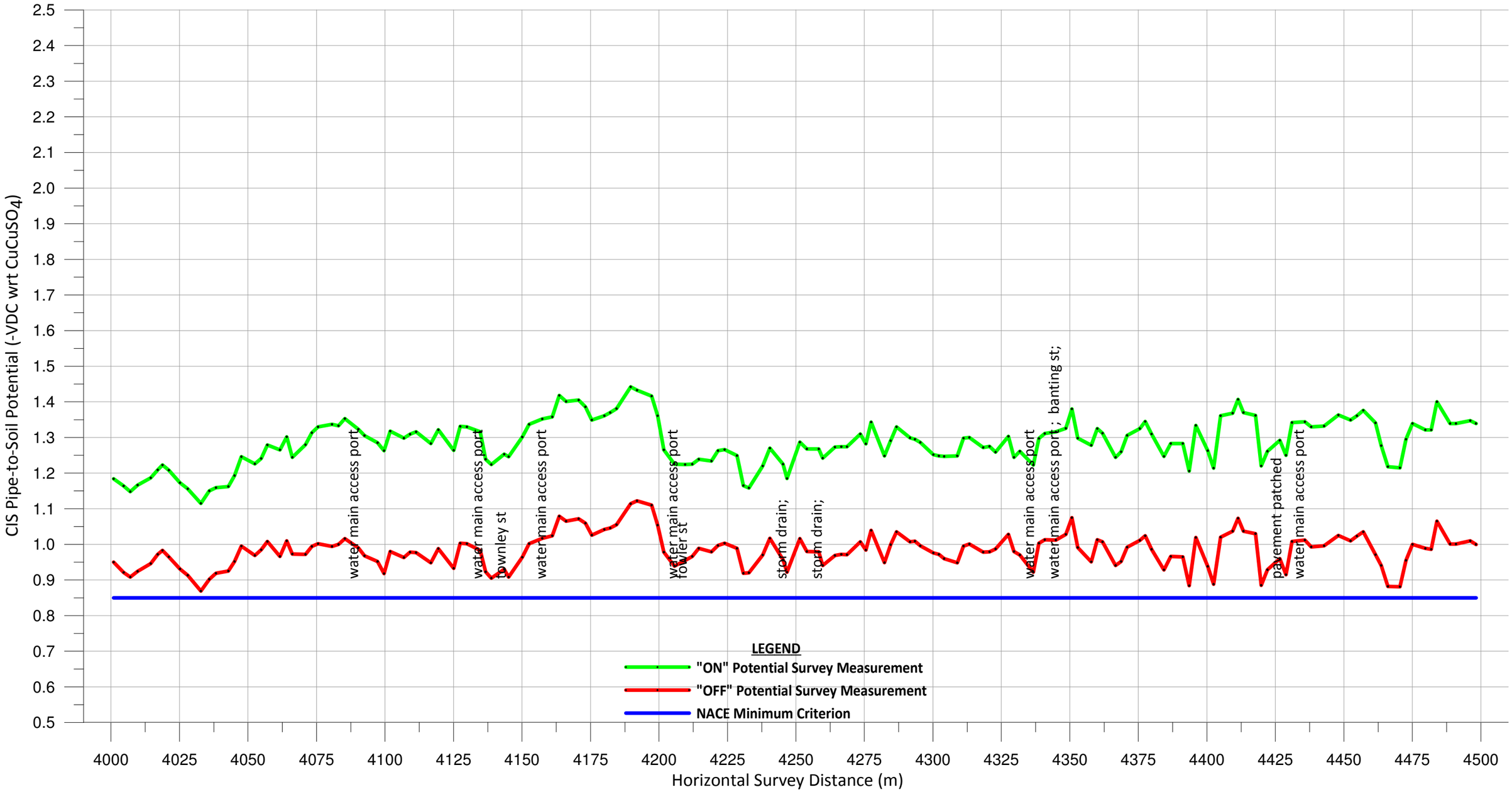
Designed By: RAB
Drawn By: RAB

Project:
Fortis BC
508mm (NPS 20) Pipeline
Coquitlam - Vancouver IP, Coastal (BC)
Close-Interval-Survey (CIS) Profile
2012

FORTIS BC™

Dwg. #:	508-COQ-VAN IP-008
Date:	December 6, 2012
Scale:	
Sheet:	8 of 17

No.	Revision / Issue	Date



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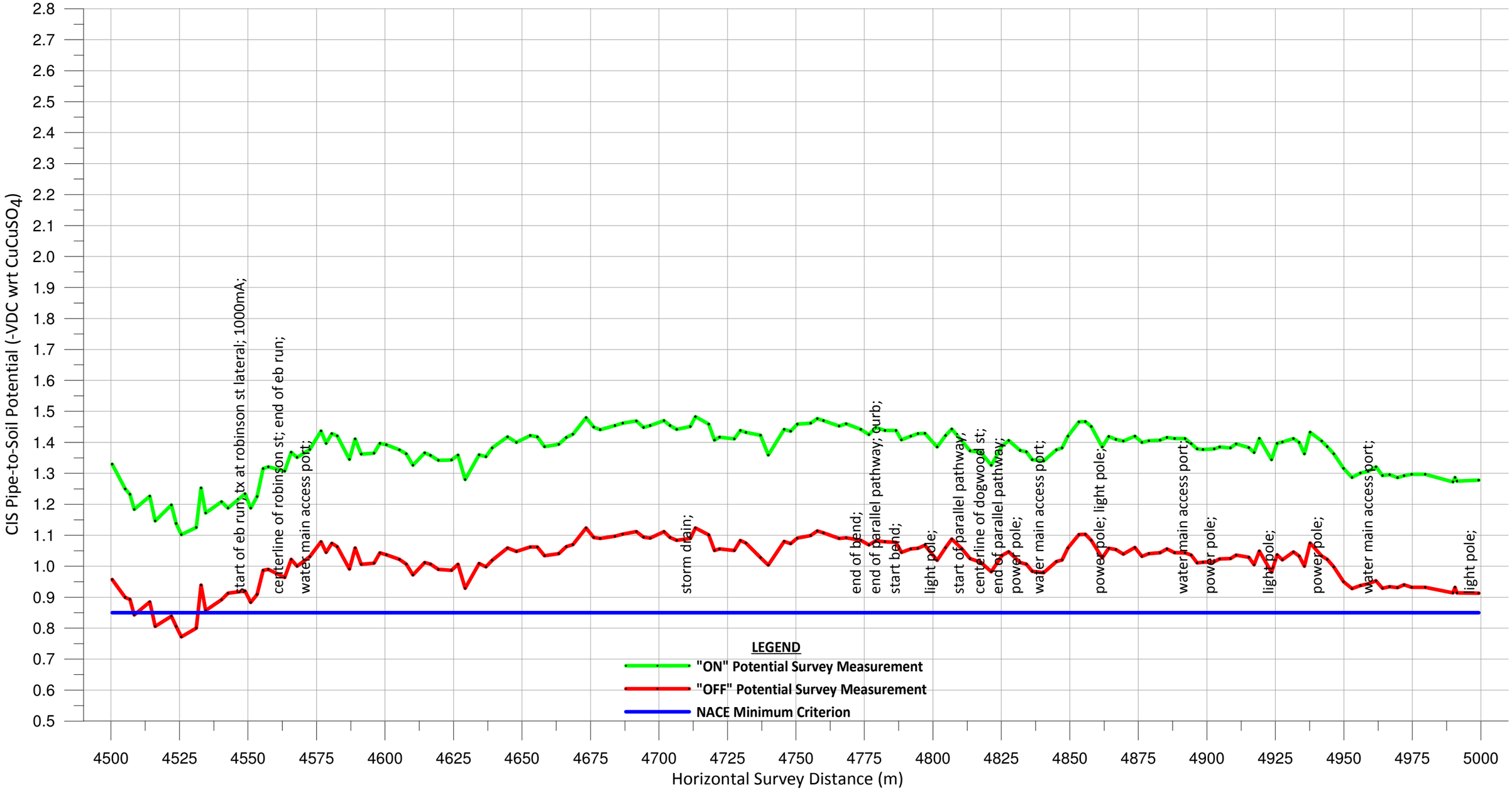
Dwg. #: 508-COQ-VAN IP-009		Sheet: 9 of 17
Date: December 6, 2012		
Scale:		
No.	Revision / Issue	Date



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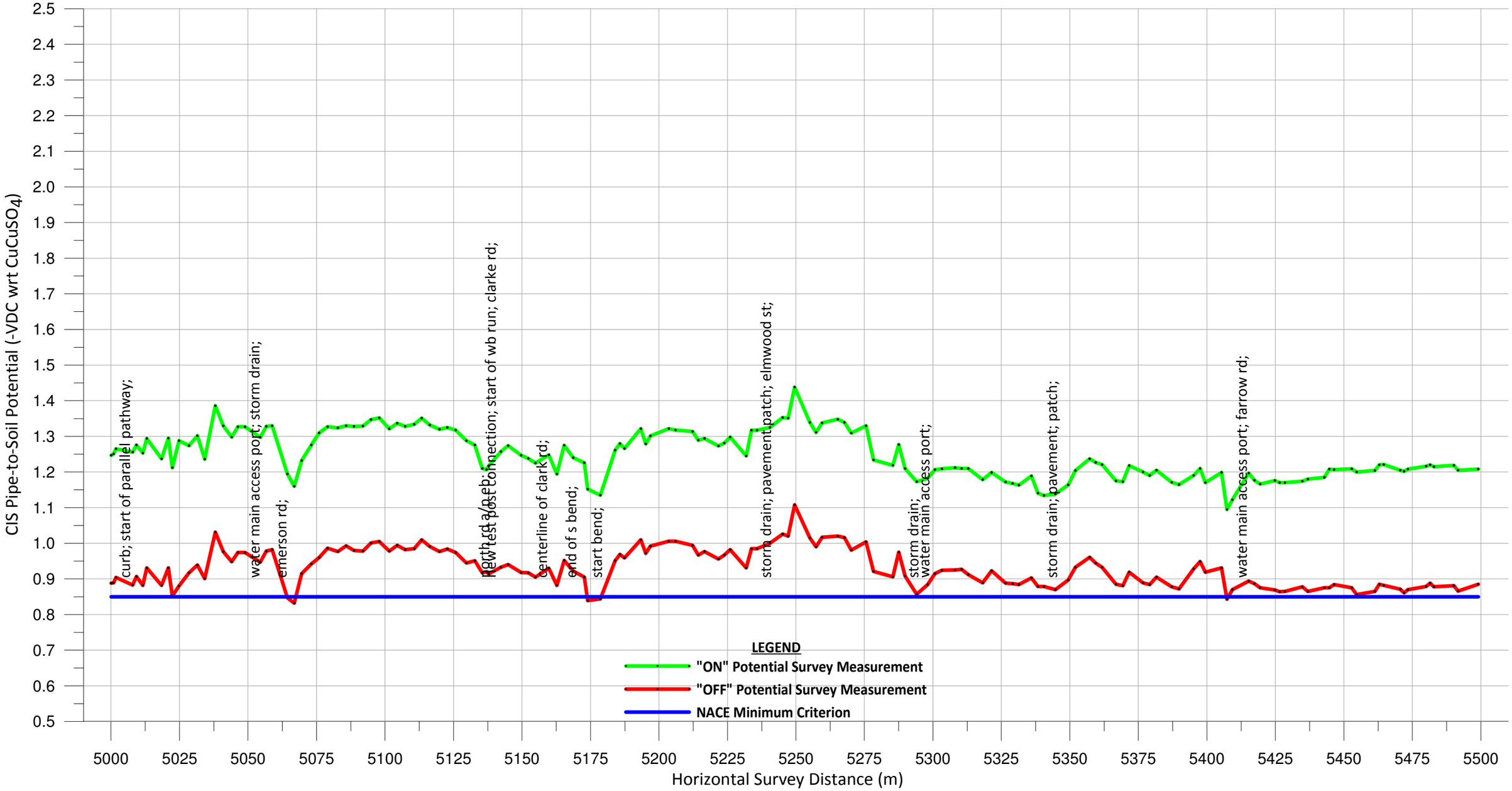
Dwg. #: 508-COQ-VAN IP-010		Sheet: 10 of 17
Date: December 6, 2012		
Scale:		
No.	Revision / Issue	Date



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Dwg. #: 508-COQ-VAN IP-011	Sheet: 11 of 17
Date: December 6, 2012	
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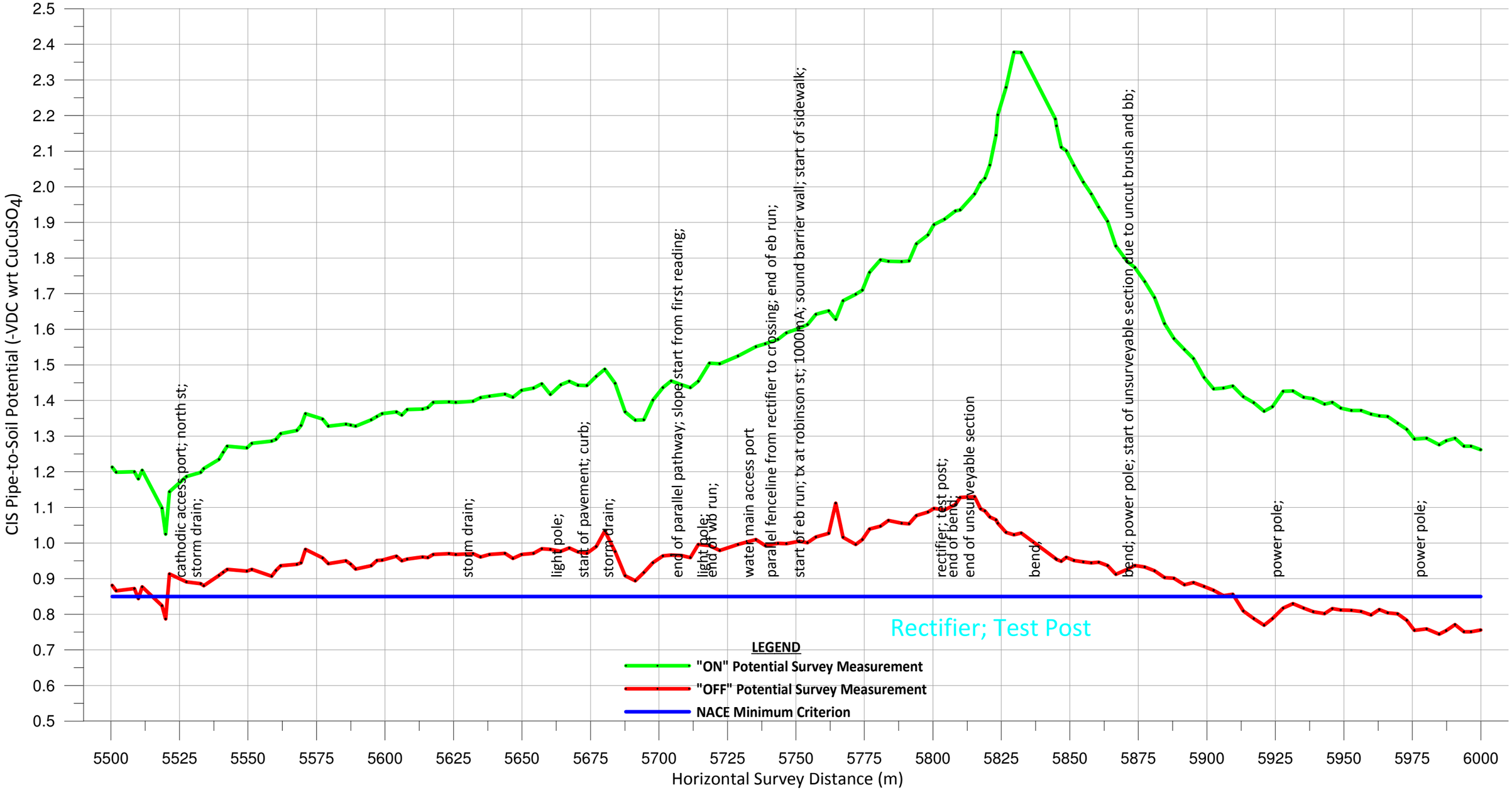
No.	Revision / Issue	Date



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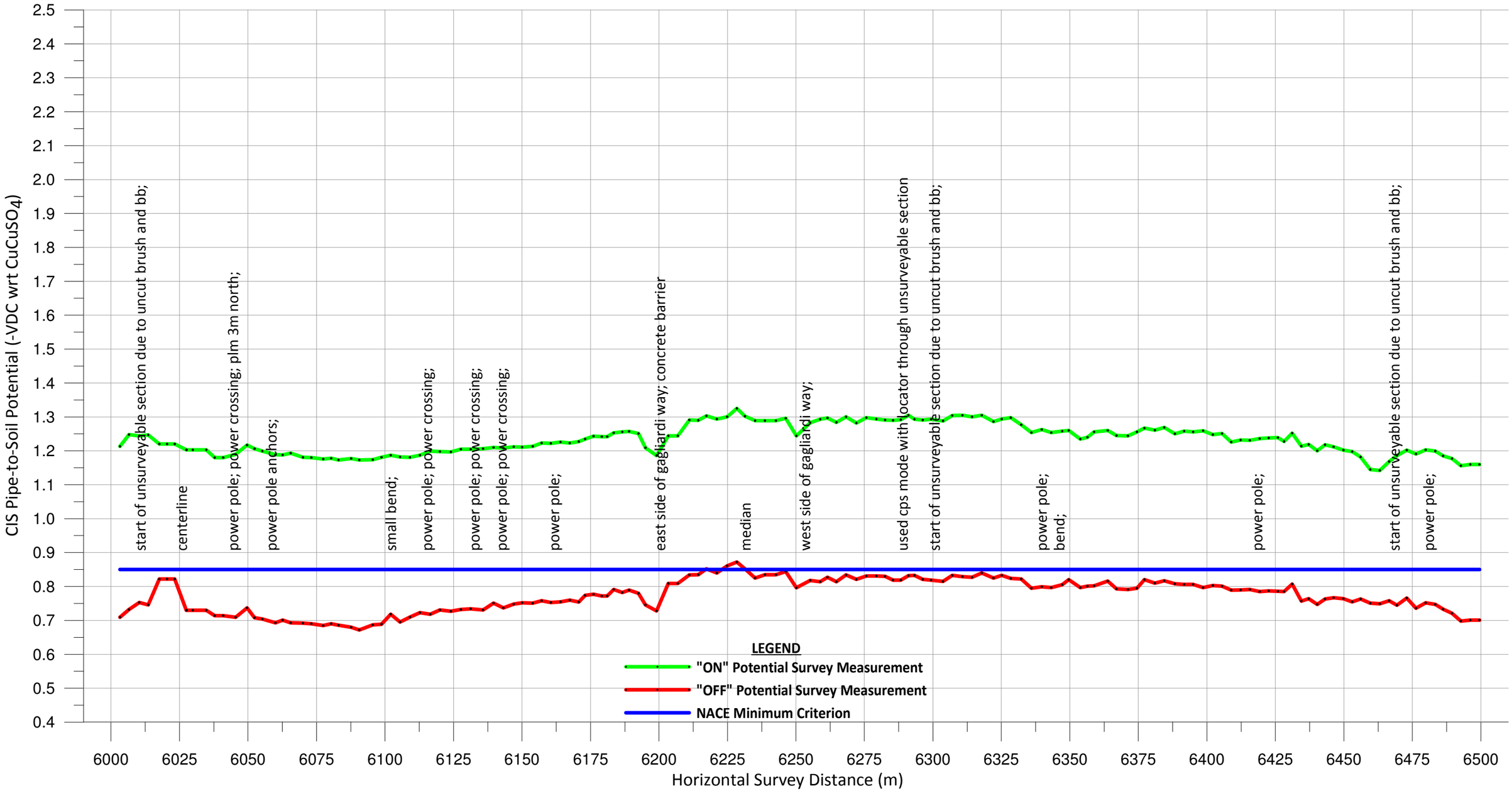
Dwg. #: 508-COQ-VAN IP-012		Sheet: 12 of 17
Date: December 6, 2012		
Scale:		
No.	Revision / Issue	Date



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Dwg. #:	508-COQ-VAN IP-013
Date:	December 6, 2012
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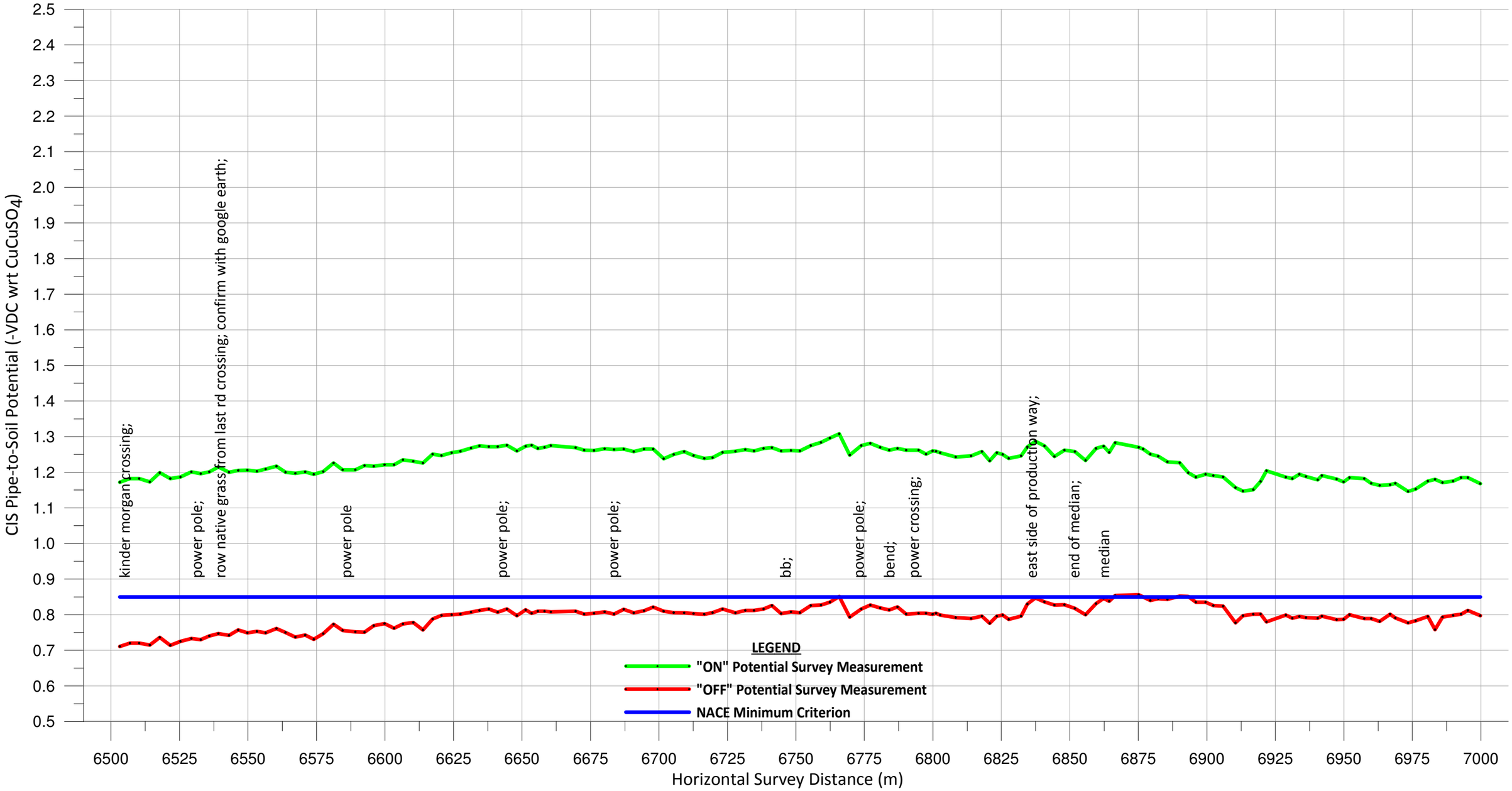
No.	Revision / Issue	Date



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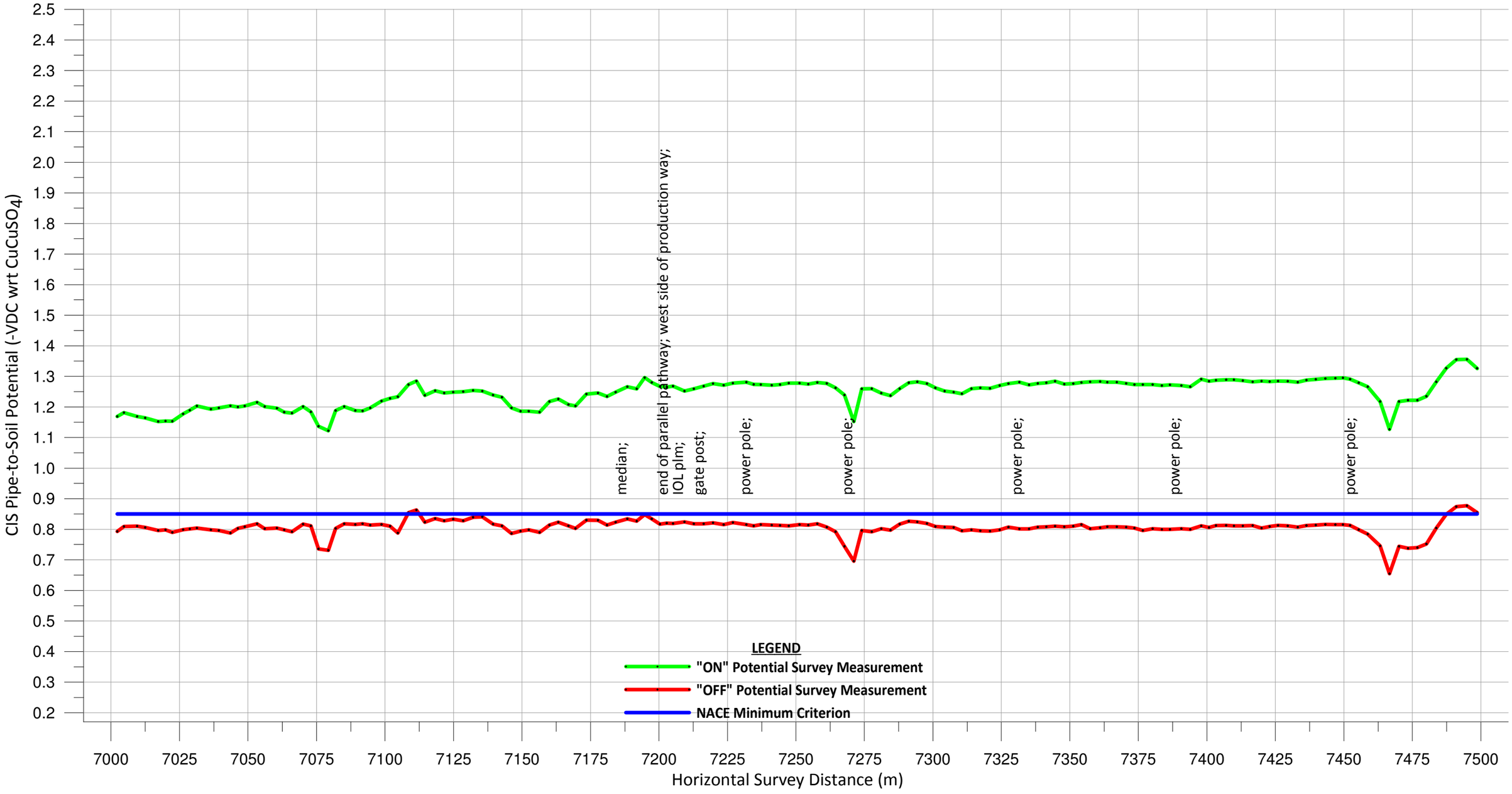
Dwg. #: 508-COQ-VAN IP-014		Sheet: 14 of 17
Date: December 6, 2012		
Scale:		
No.	Revision / Issue	Date



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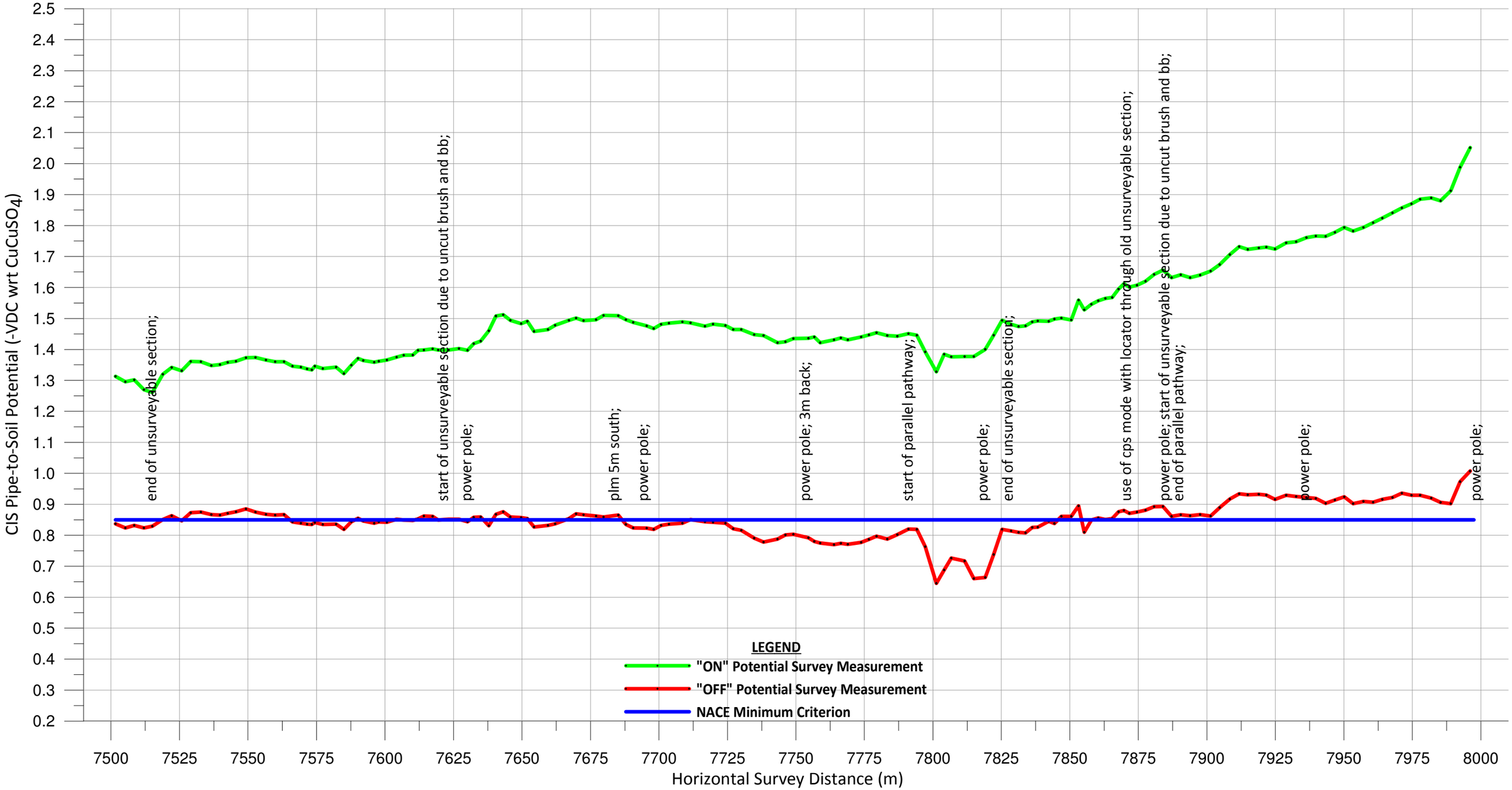
Dwg. #: 508-COQ-VAN IP-015		Sheet: 15 of 17
Date: December 6, 2012		
Scale:		
No.	Revision / Issue	Date



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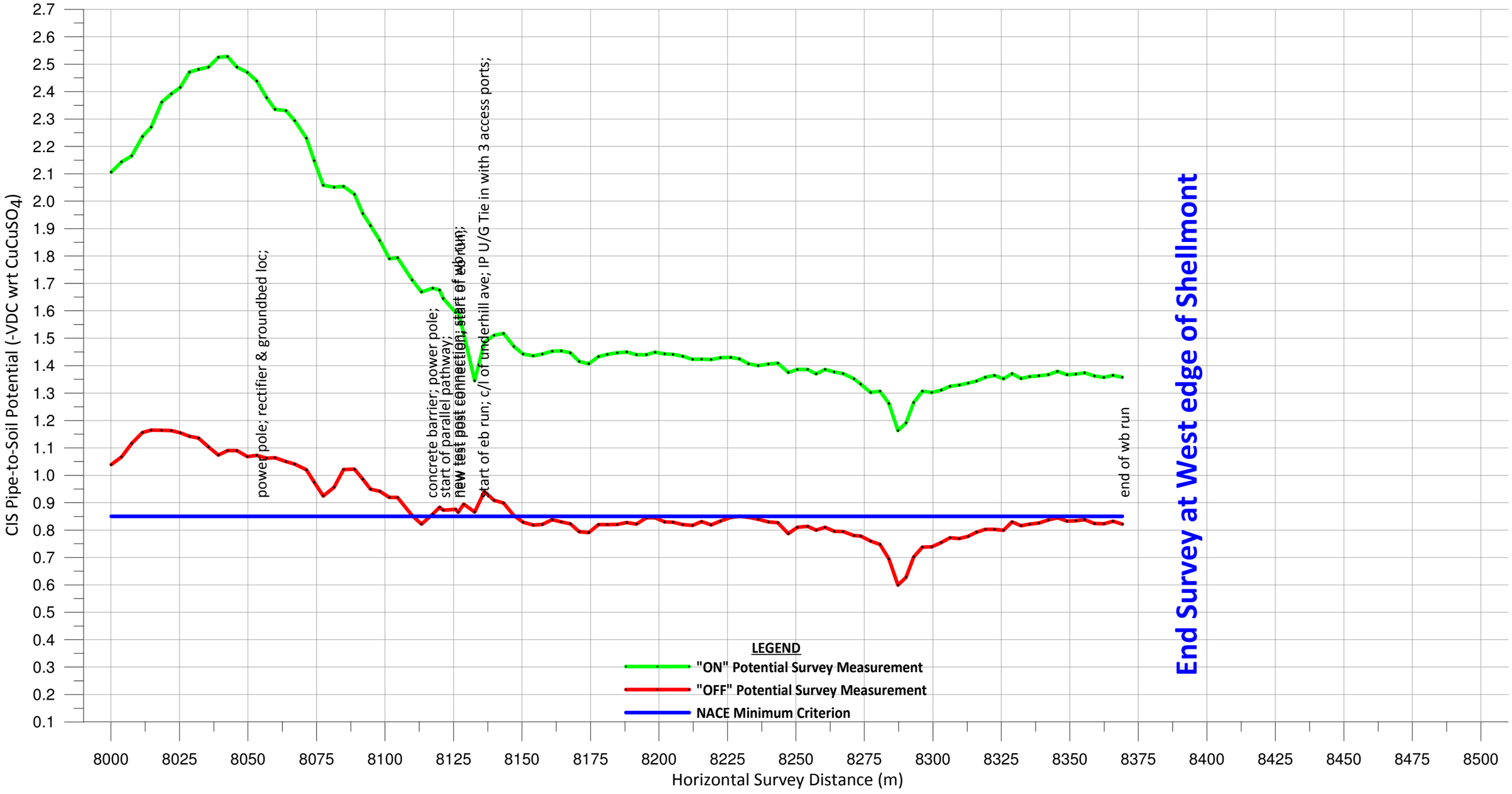
Dwg. #: 508-COQ-VAN IP-016		Sheet: 16 of 17
Date: December 6, 2012		
Scale:		
No.	Revision / Issue	Date



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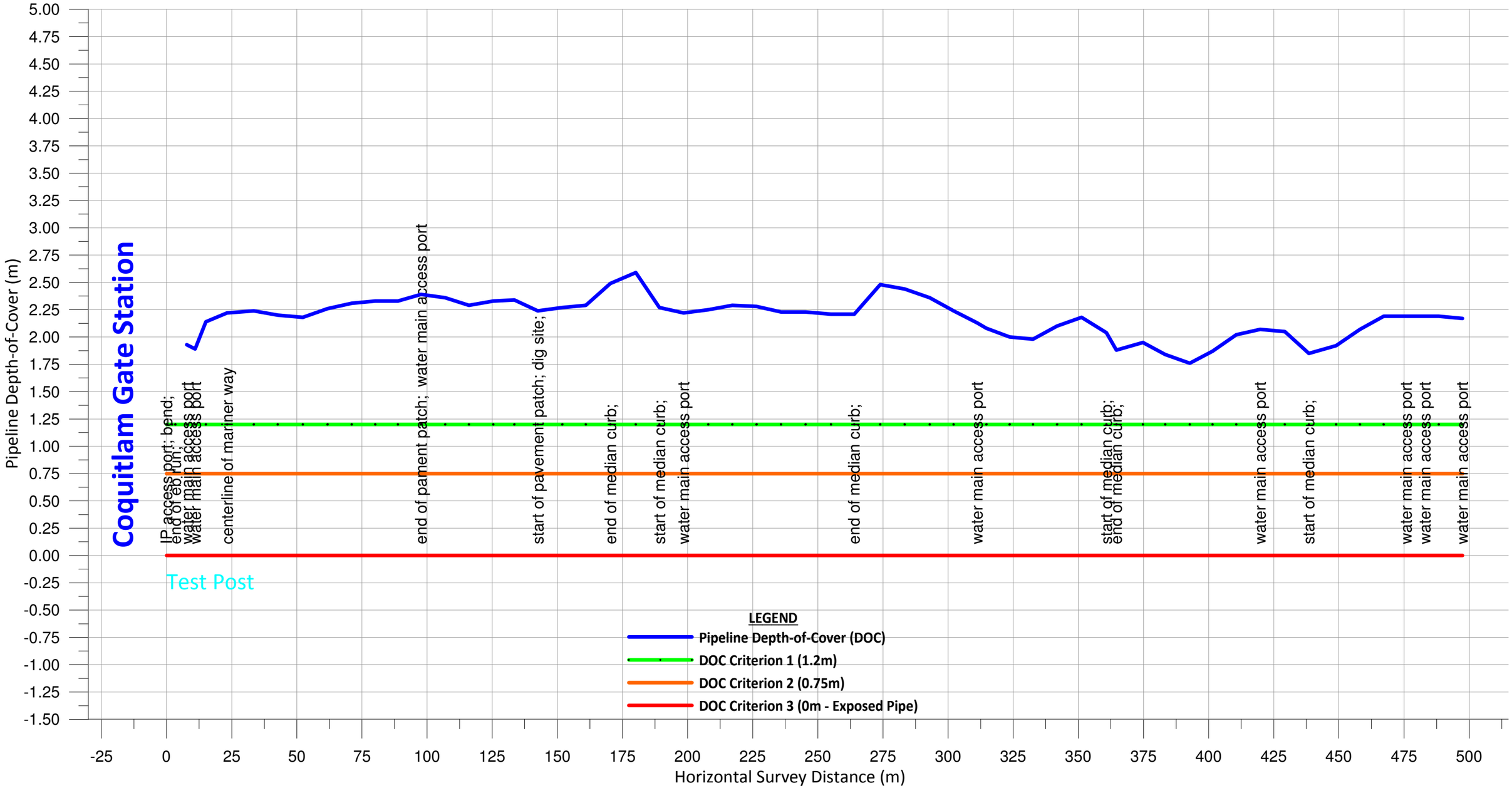
Dwg. #: 508-COQ-VAN IP-017		Sheet: 17 of 17
Date: December 6, 2012		
Scale:		
No.	Revision / Issue	Date

APPENDIX 3
DEPTH-OF-COVER (DOC) SURVEY PLOT
508mm (NPS 20) TP Pipeline
Coquitlam to Vancouver, Coastal (BC)
2012



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508mm (NPS 20) Pipeline
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Depth of Cover (DOC) Profile
2012

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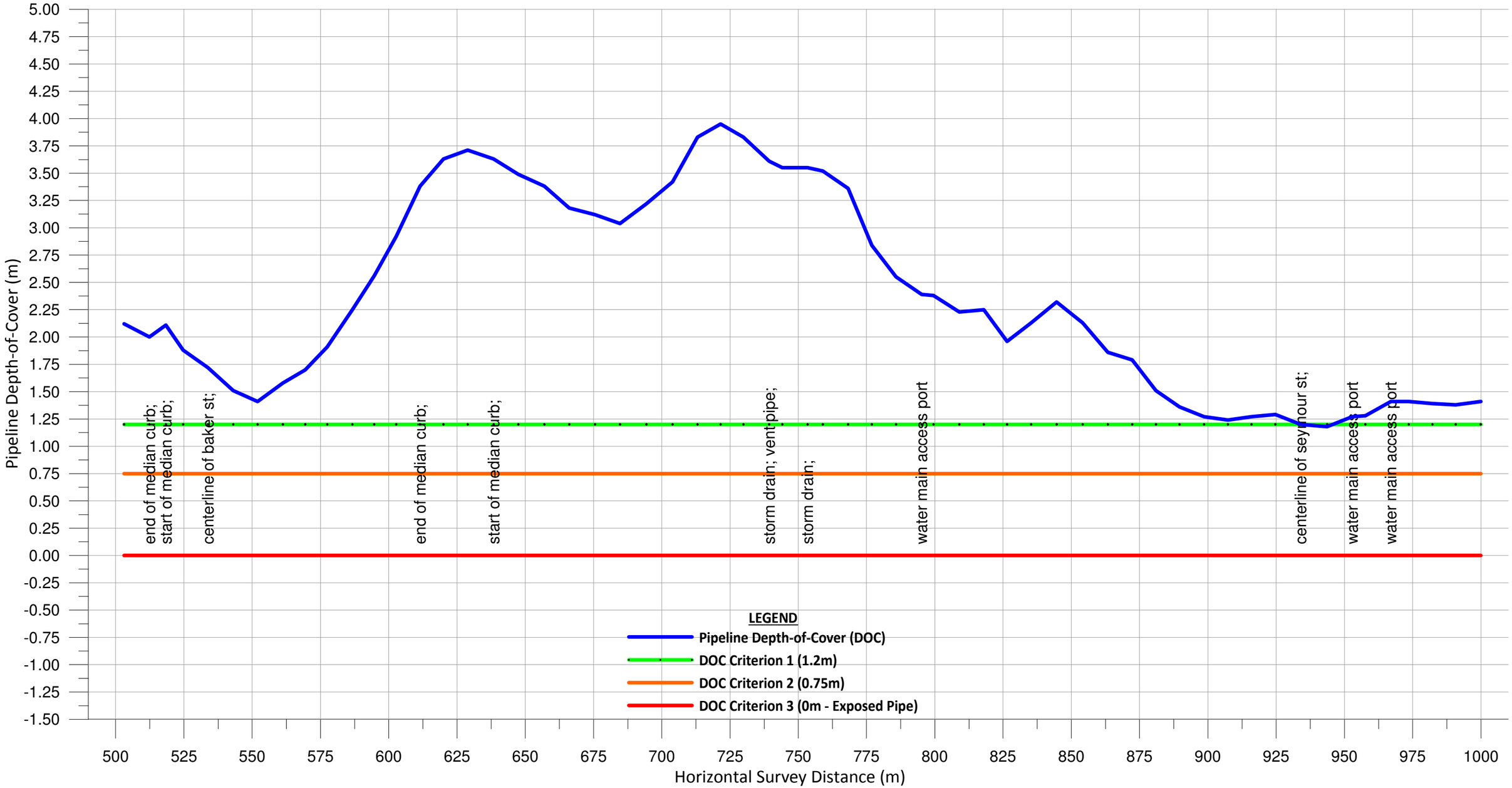
Dwg. #:	508-COQ-VAN IP-001
Date:	December 6, 2012
Scale:	
Sheet:	1 of 17

No.	Revision / Issue	Date



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Coquitlam - Vancouver IP, Coastal (BC)
Depth of Cover (DOC) Profile
2012

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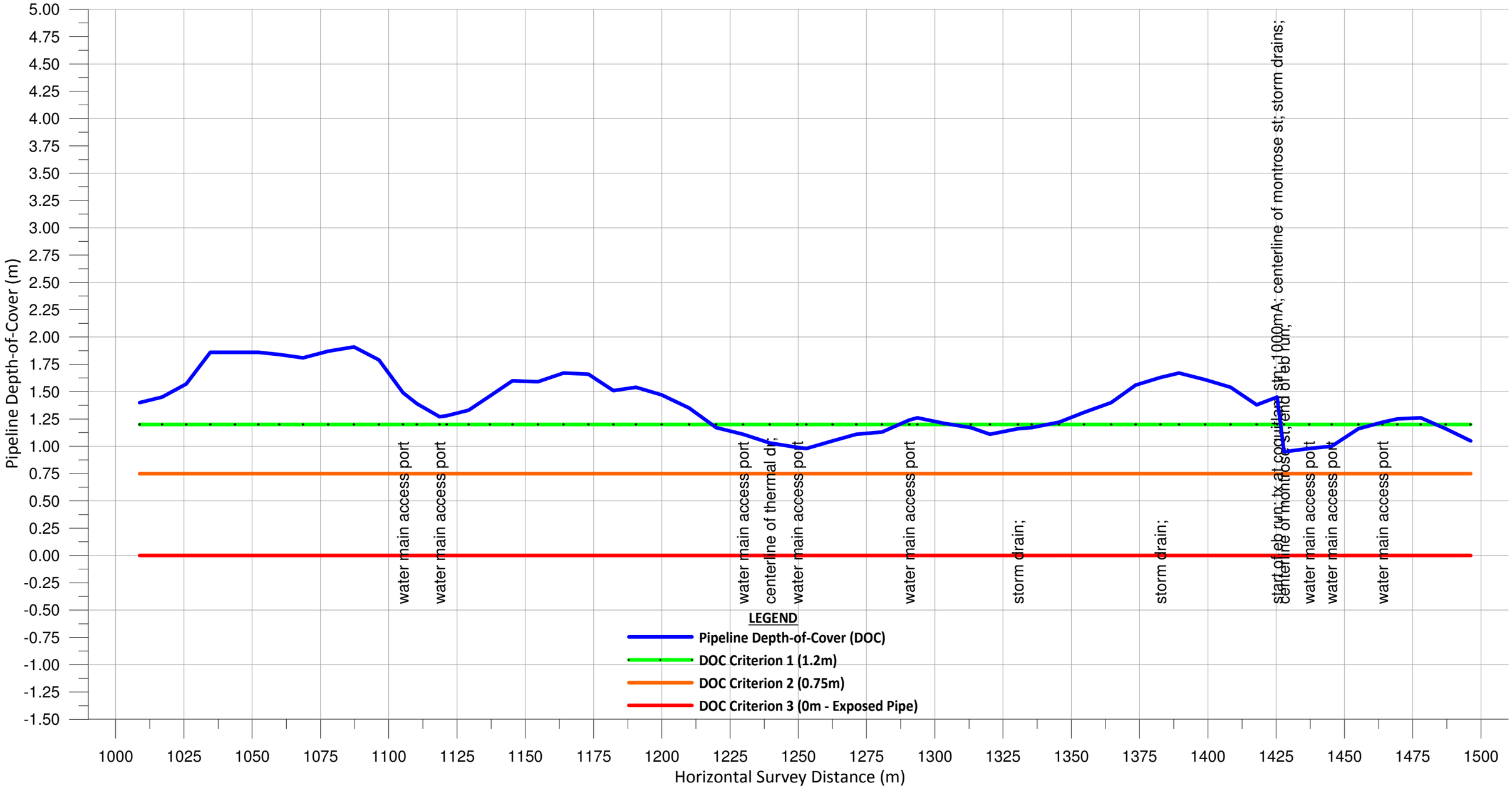
Dwg. #: 508-CV-IP-DOC-002		Sheet: 2 of 17
Date: December 6, 2012		
Scale:		
No.	Revision / Issue	Date



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Coquitlam - Vancouver IP, Coastal (BC)
Depth of Cover (DOC) Profile
2012

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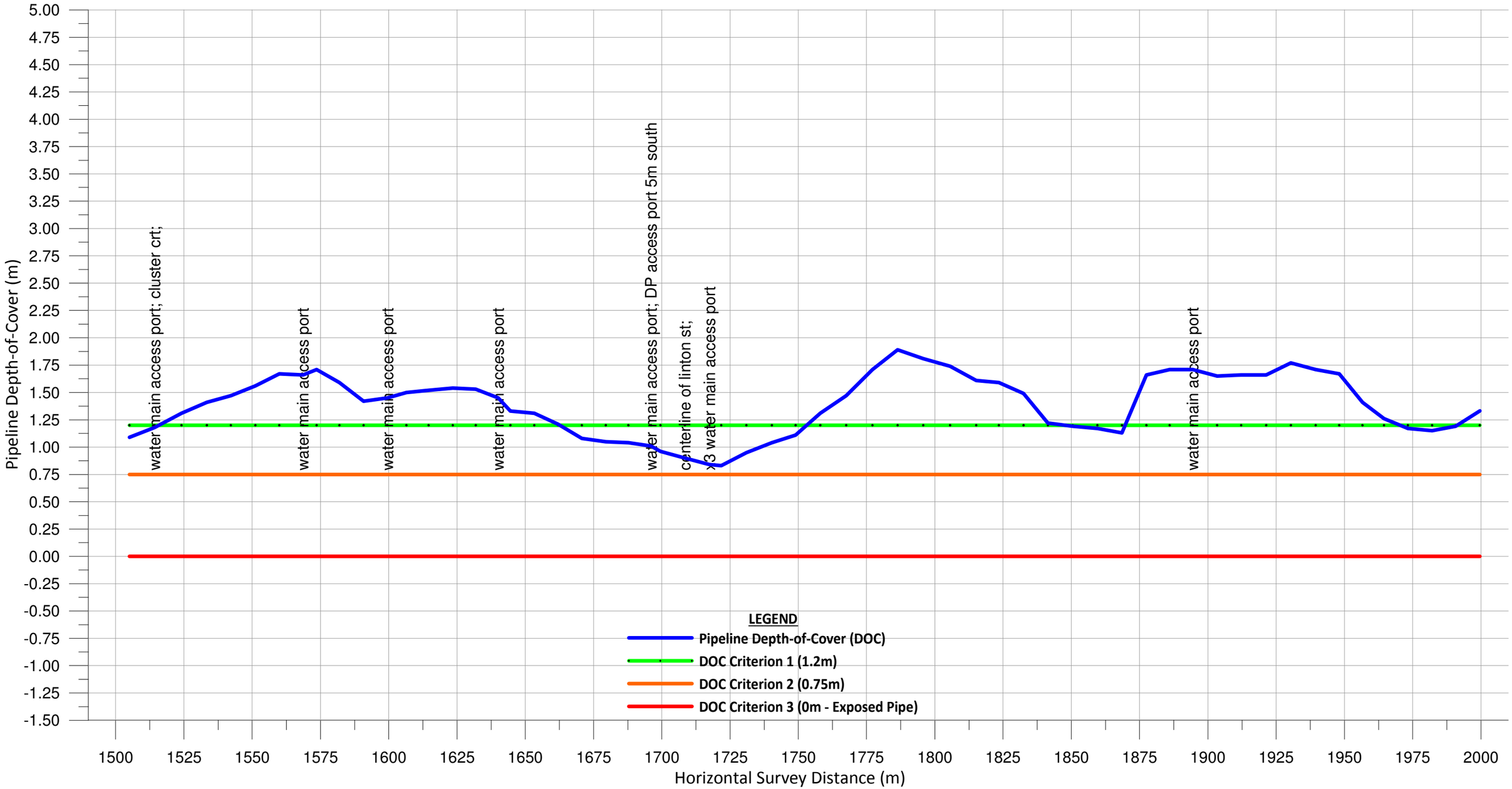
Dwg. #: 508-CV-IP-DOC-003		Sheet: 3 of 17
Date: December 6, 2012		
Scale:		
No.	Revision / Issue	Date



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Fortis BC
508mm (NPS 20) Pipeline
Coquitlam - Vancouver IP, Coastal (BC)
Depth of Cover (DOC) Profile
2012

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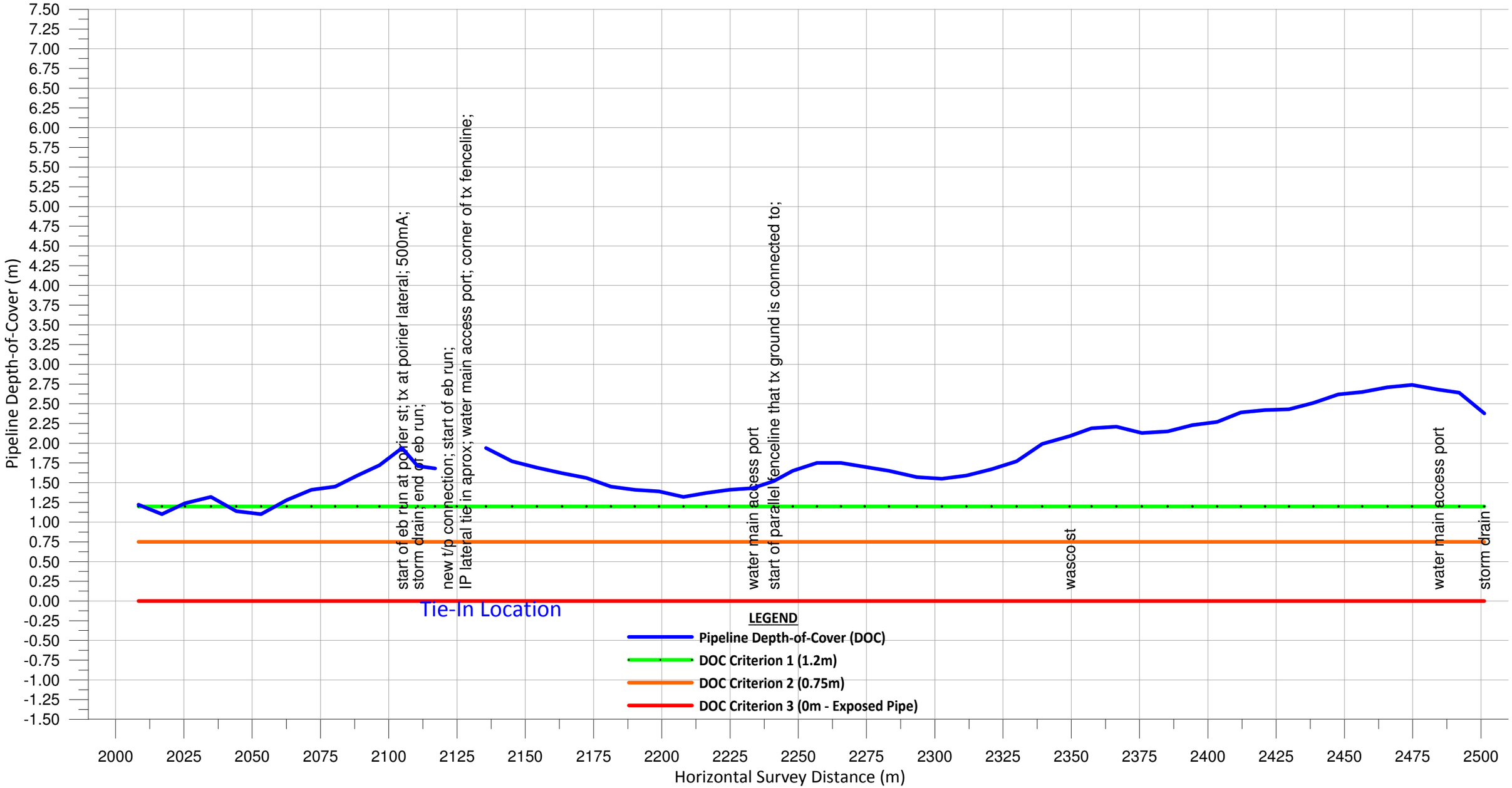
Dwg. #:	508-CV-IP-DOC-004
Date:	December 6, 2012
Scale:	
Sheet:	4 of 17

No.	Revision / Issue	Date



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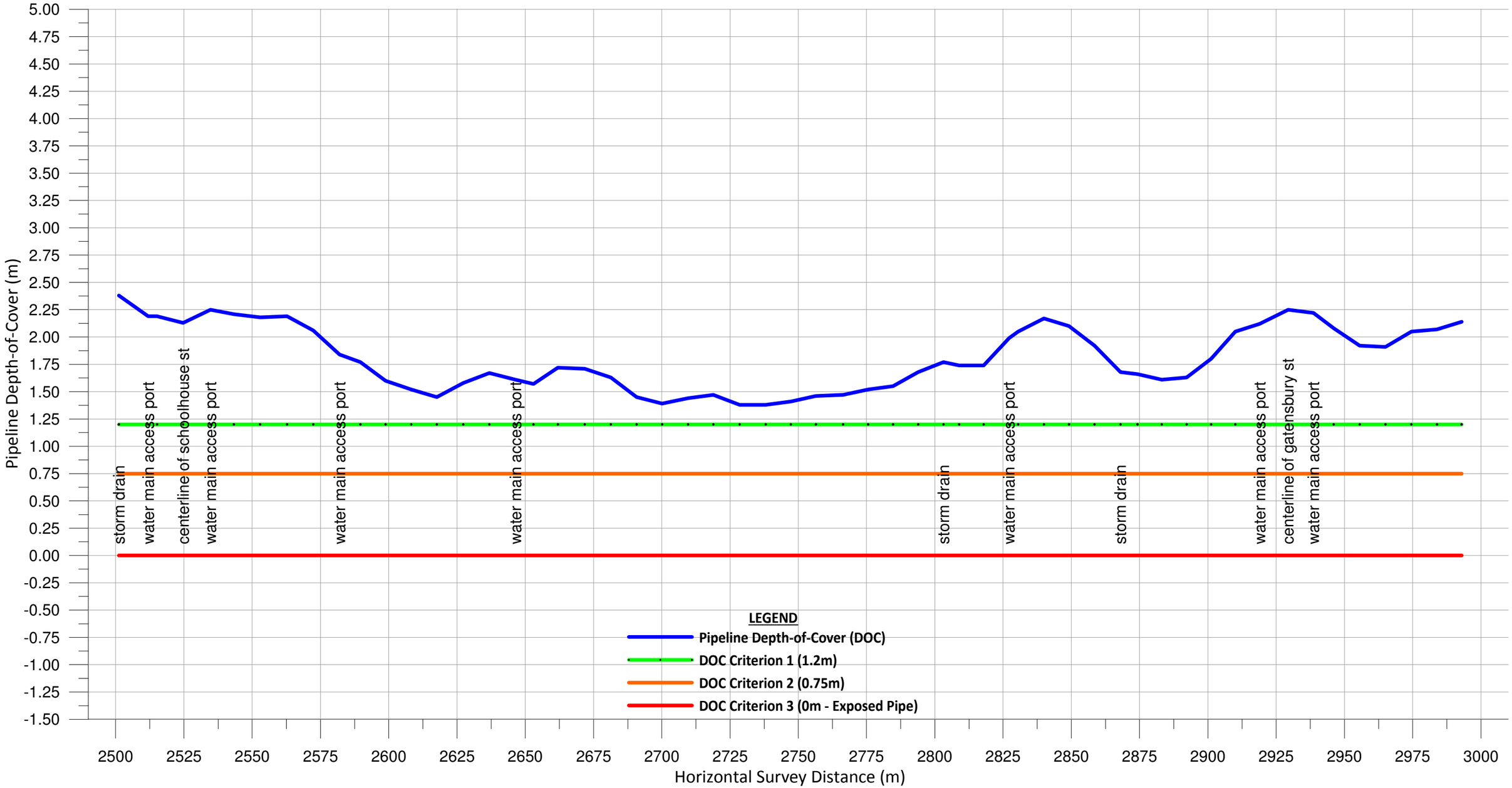
Dwg. #: 508-CV-IP-DOC-005	Sheet: 5 of 17
Date: December 6, 2012	
Scale:	

No.	Revision / Issue	Date



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2012

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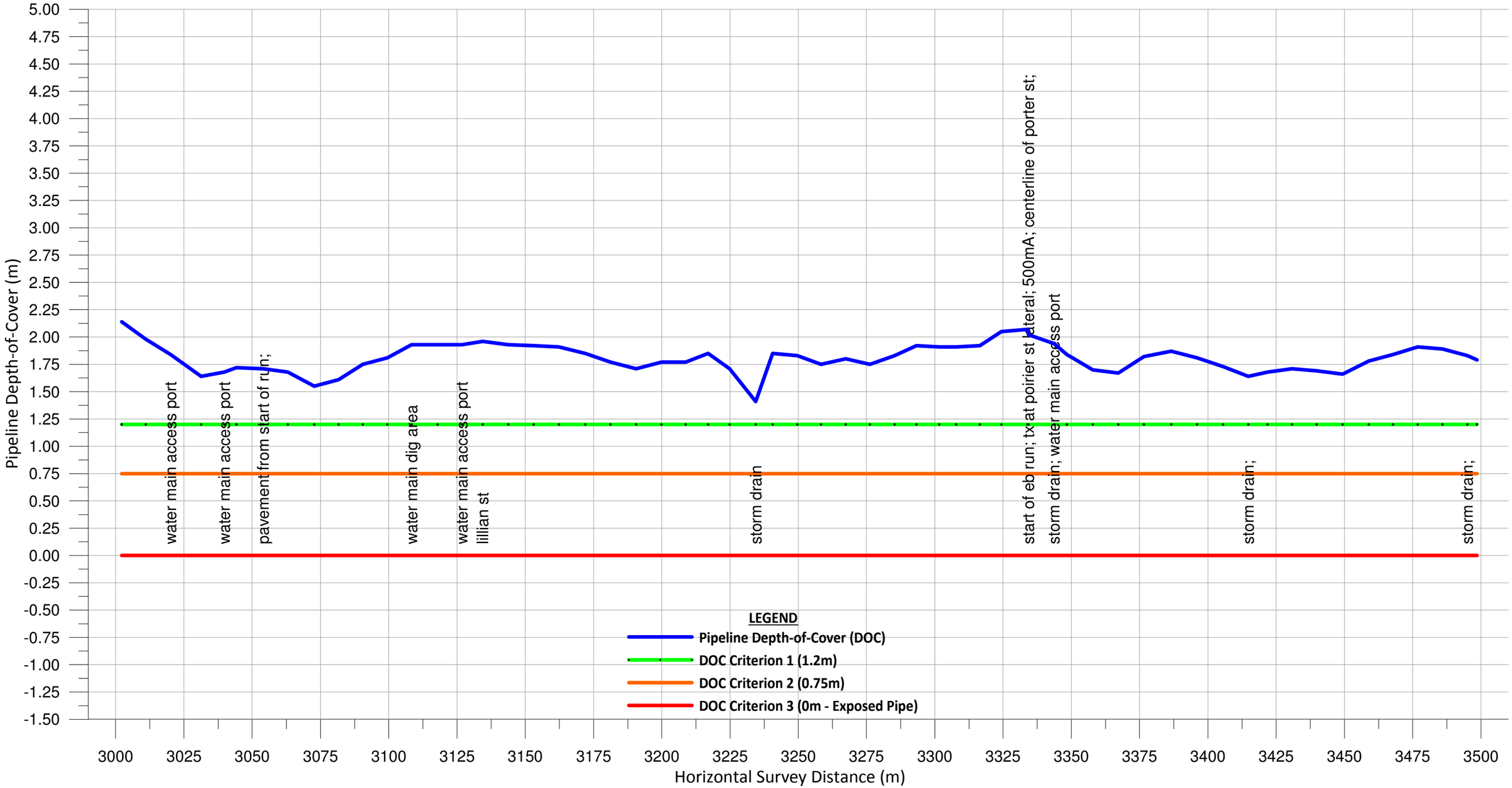
Dwg. #:	508-CV-IP-DOC-006
Date:	December 6, 2012
Scale:	
Sheet:	6 of 17

No.	Revision / Issue	Date



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Depth of Cover (DOC) Profile
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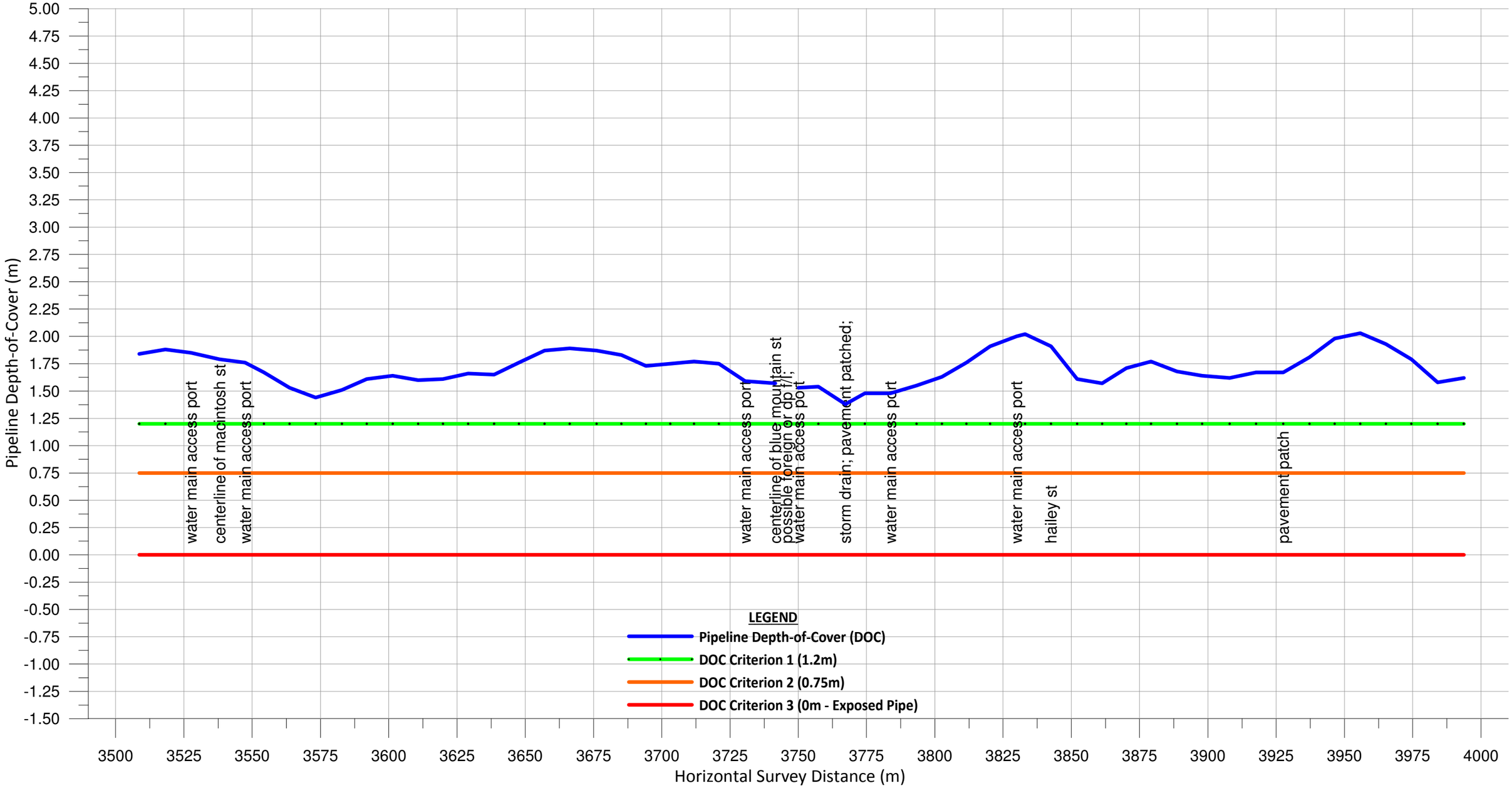
Dwg. #:	508-CV-IP-DOC-007
Date:	December 6, 2012
Scale:	
Sheet:	7 of 17

No.	Revision / Issue	Date



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2012

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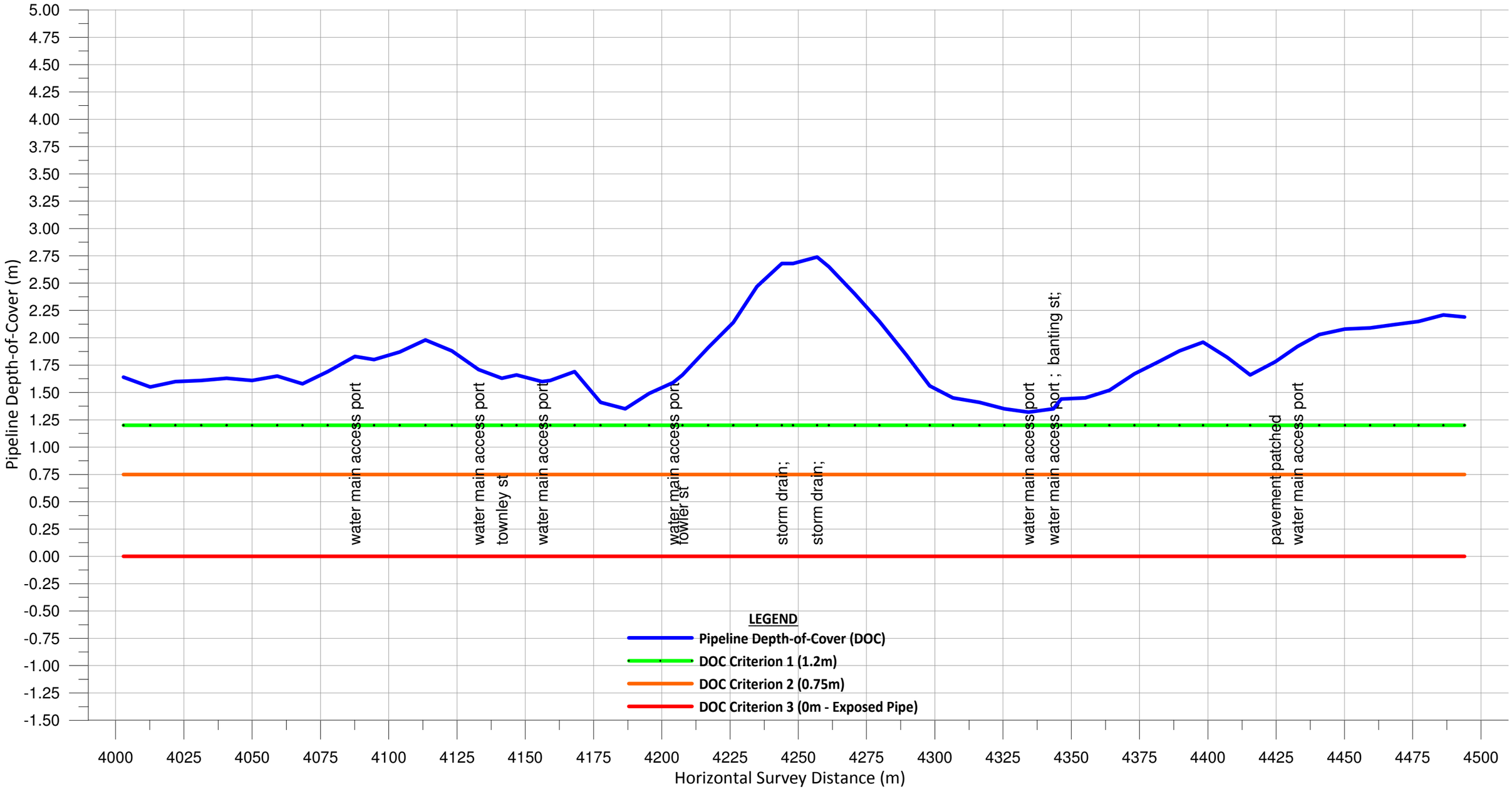
Dwg. #: 508-CV-IP-DOC-008		Sheet: 8 of 17
Date: December 6, 2012		
Scale:		
No.	Revision / Issue	Date



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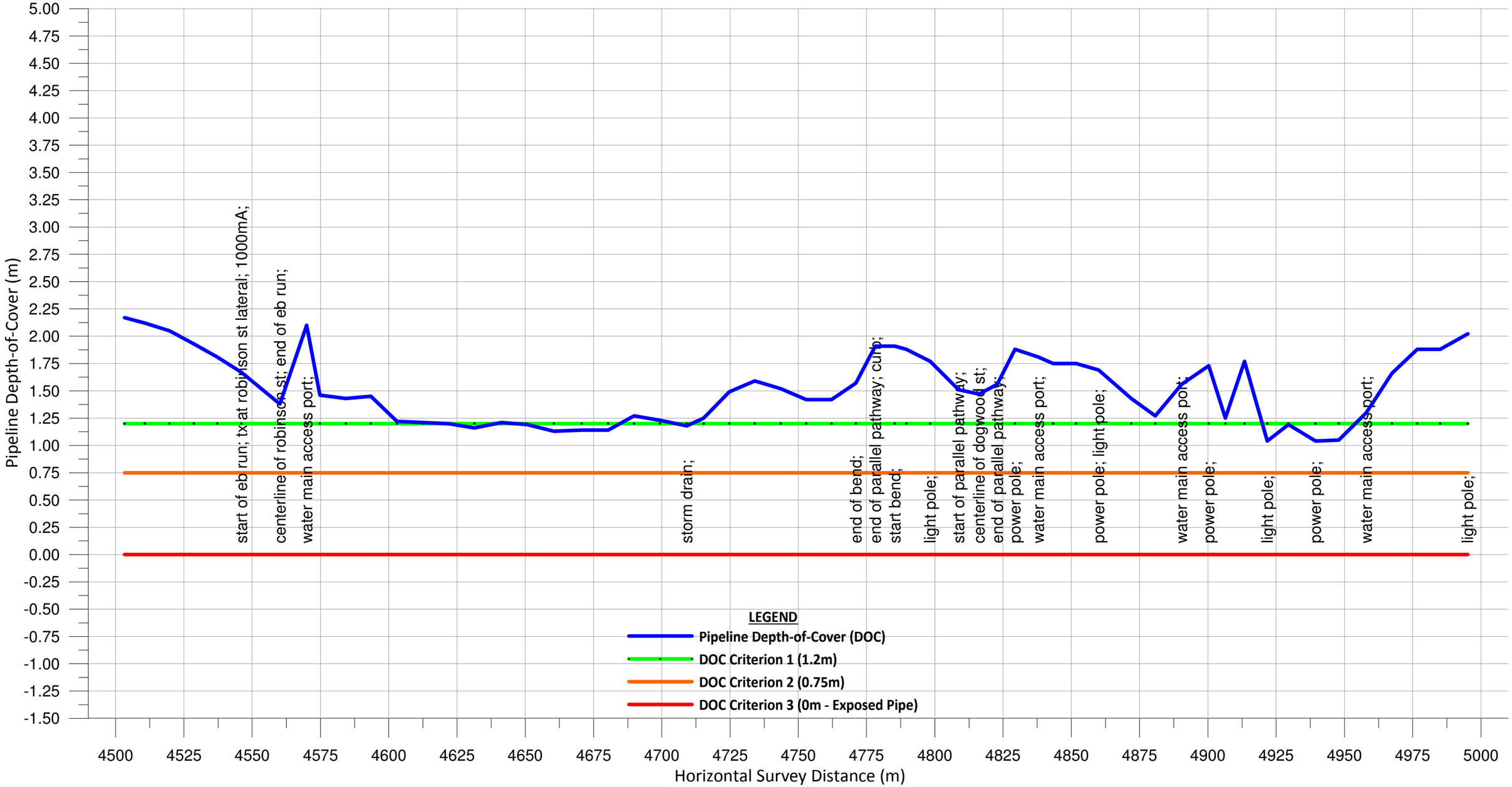
Dwg. #: 508-CV-IP-DOC-009		Sheet: 9 of 17
Date: December 6, 2012		
Scale:		
No.	Revision / Issue	Date



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Dwg. #:	508-CV-IP-DOC-010
Date:	December 6, 2012
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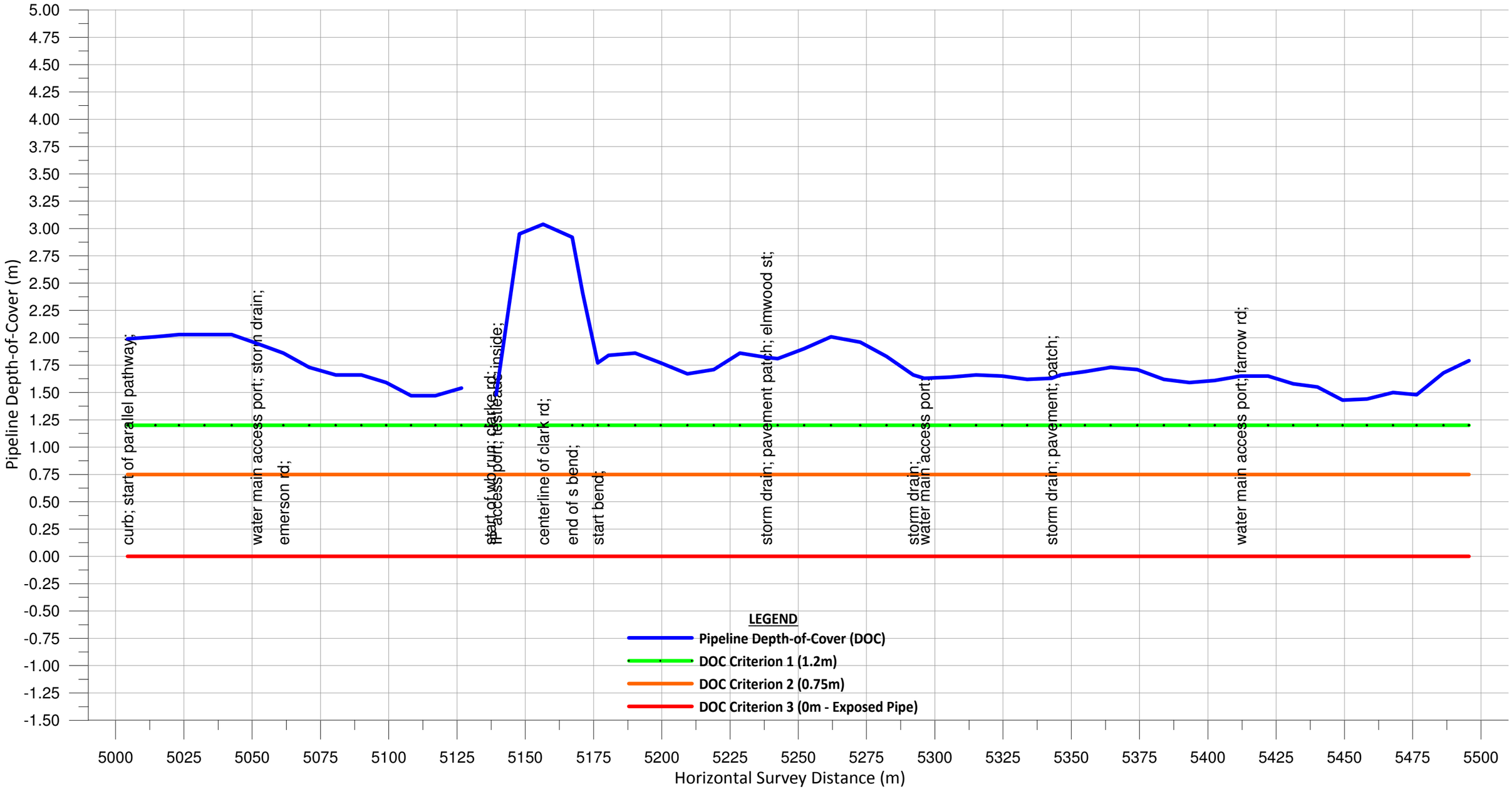

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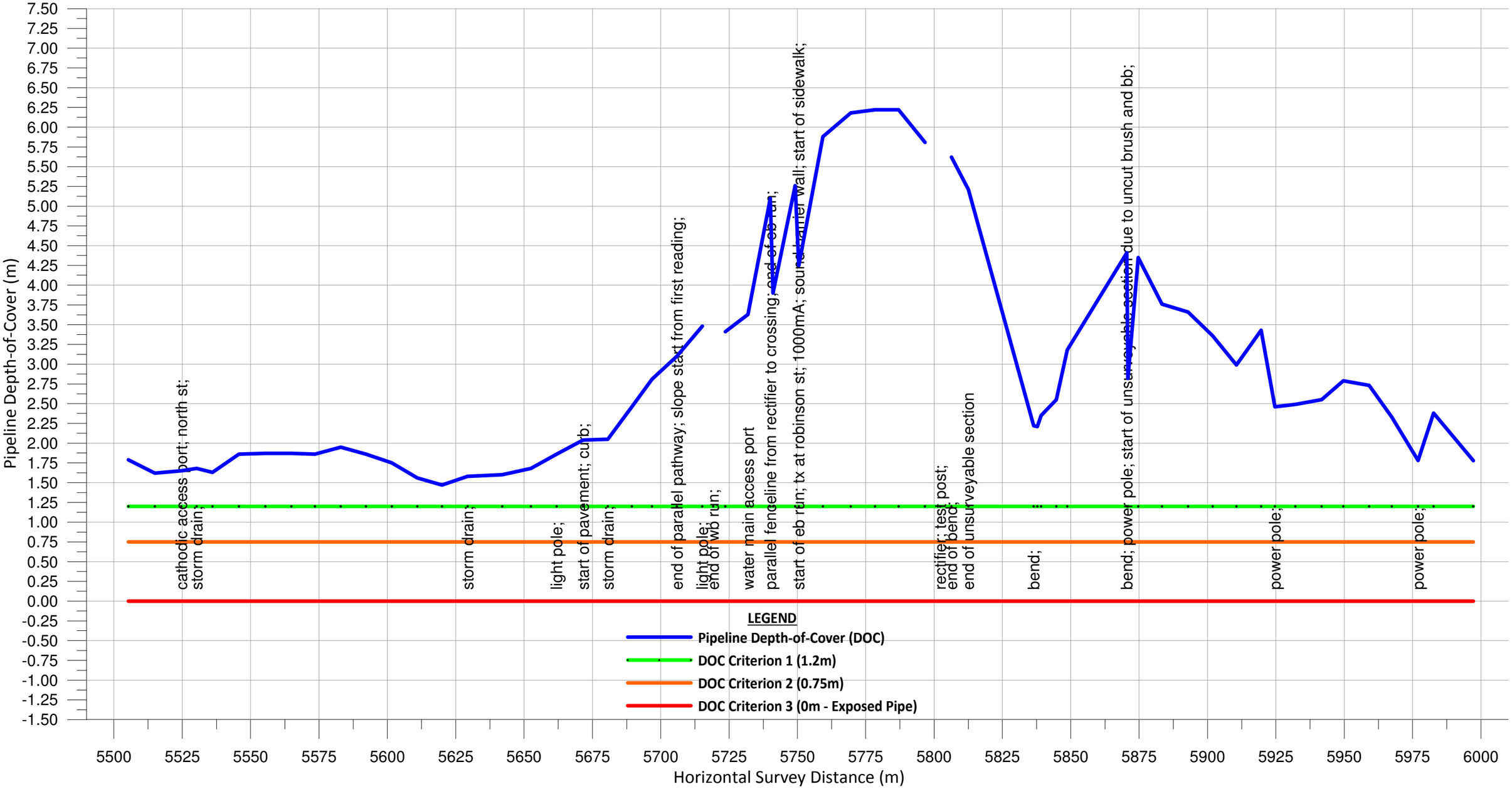
Dwg. #: 508-CV-IP-DOC-011	Sheet: 11 of 17
Date: December 6, 2012	
Scale:	

No.	Revision / Issue	Date



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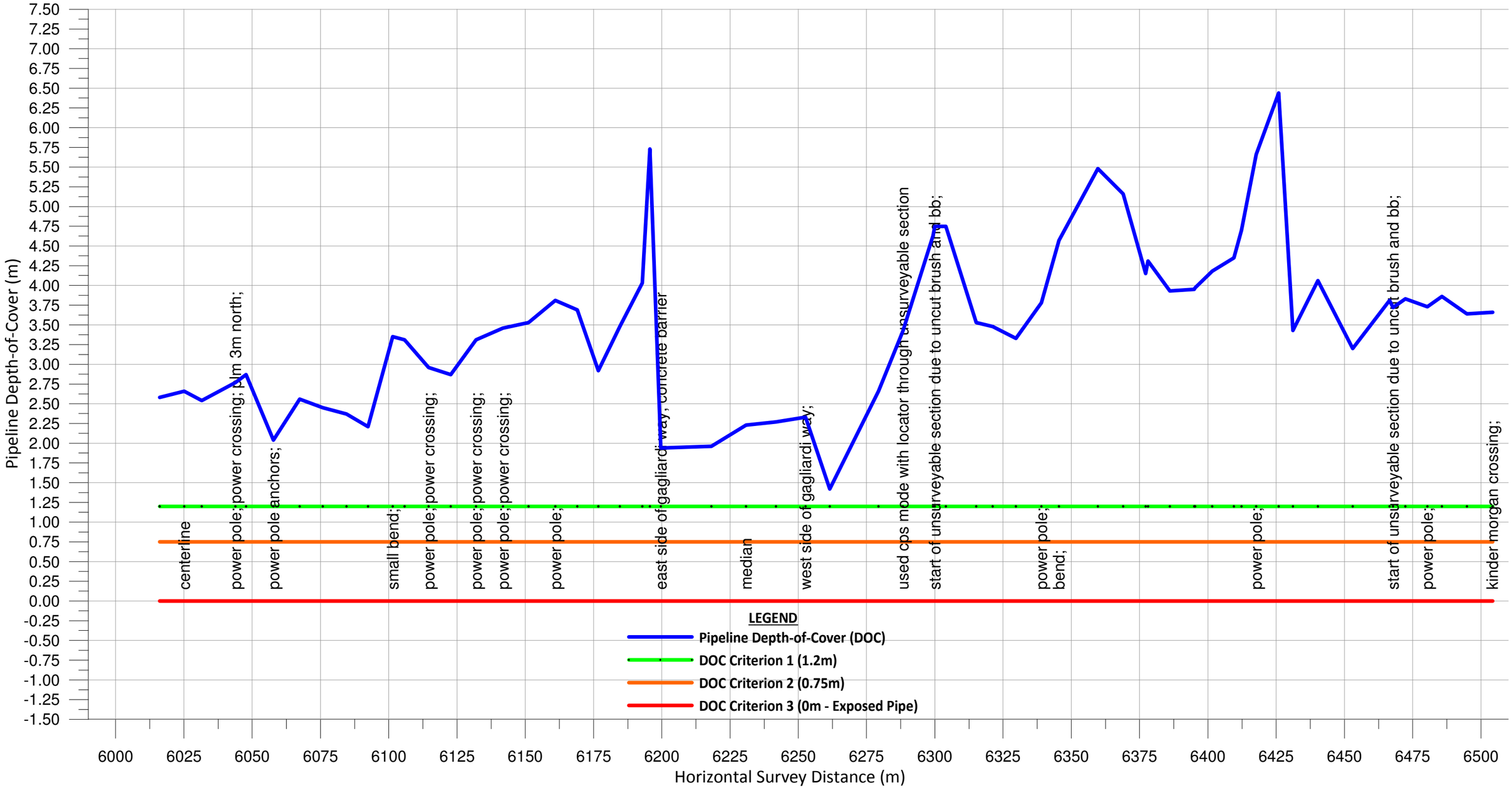
Dwg. #:	508-CV-IP-DOC-012
Date:	December 6, 2012
Scale:	
Sheet:	12 of 17

No.	Revision / Issue	Date



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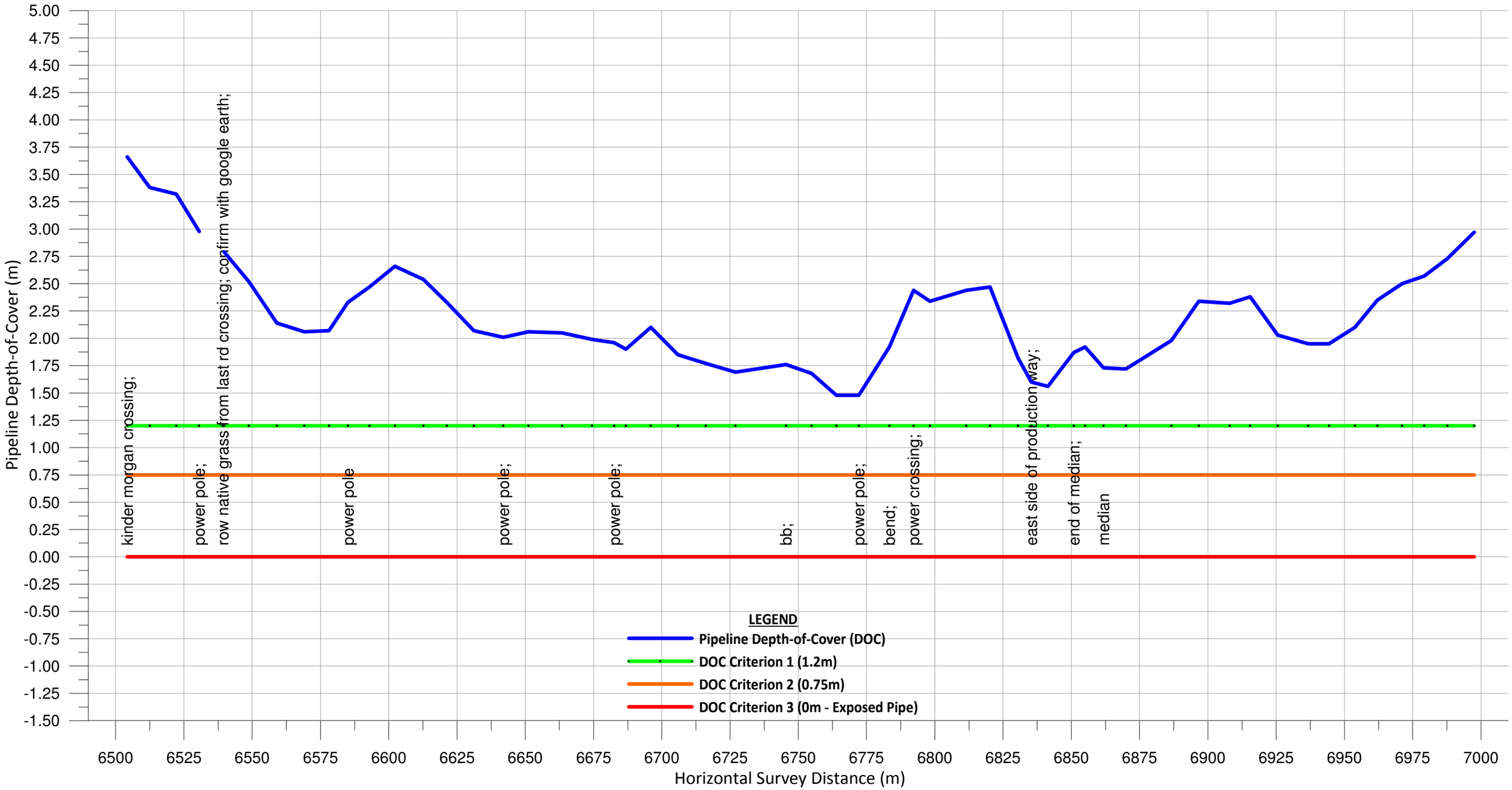
Dwg. #: 508-CV-IP-DOC-013		Sheet: 13 of 17
Date: December 6, 2012		
Scale:		
No.	Revision / Issue	Date



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E-MAC CORROSION INC.
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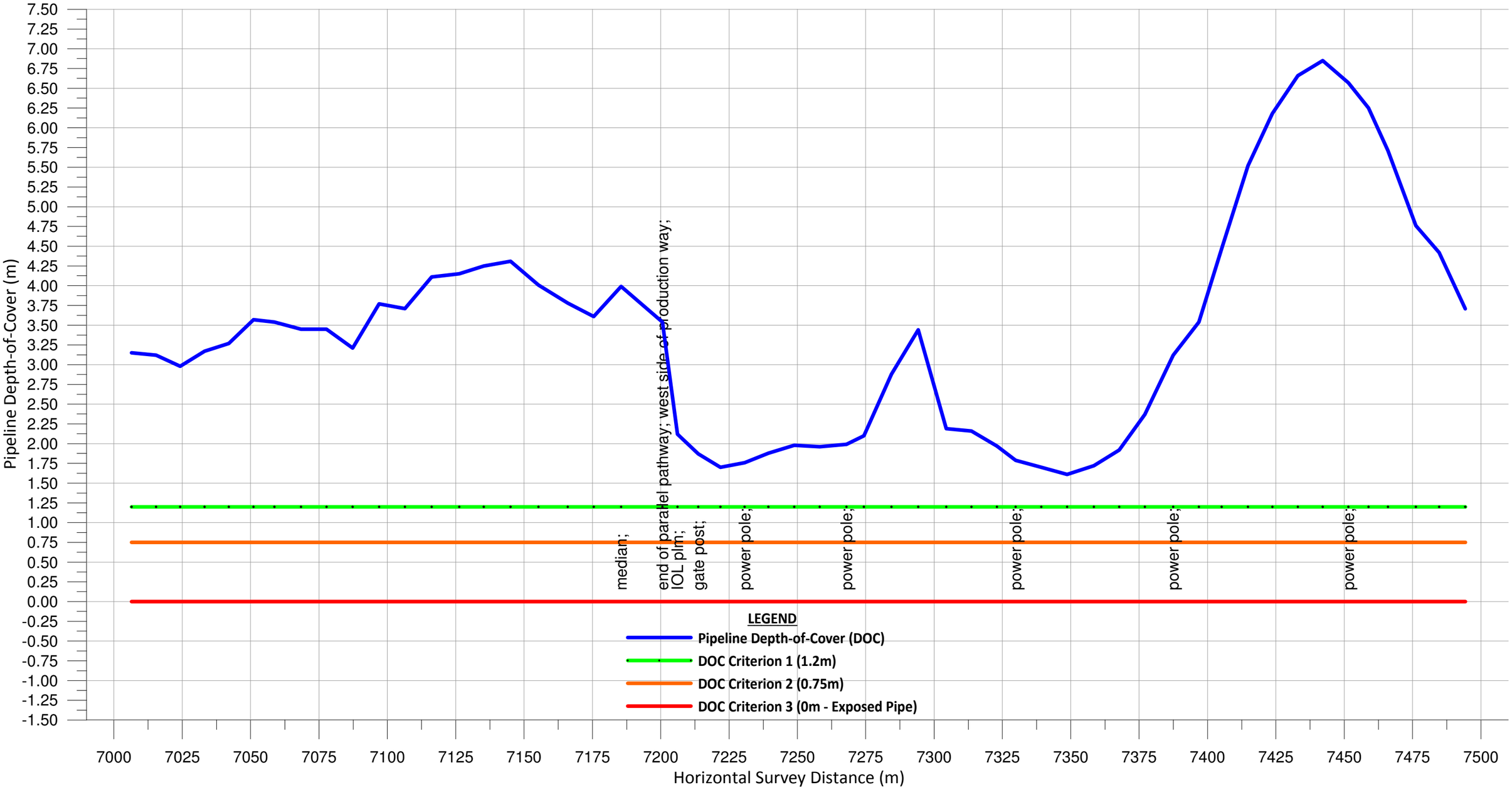
Designed By: RAB
Drawn By: RAB

Project:
Fortis BC
508mm (NPS 20) Pipeline
Coquitlam - Vancouver IP, Coastal (BC)
Depth of Cover (DOC) Profile
2012

FORTIS BC™

Dwg. #: 508-CV-IP-DOC-014		Sheet: 14 of 17
Date: December 6, 2012		
Scale:		
No.	Revision / Issue	Date



Notes:
The Coquitlam - Vancouver IP DOC survey was completed in August 2012. The rectifiers were interrupted via aGPS time-synchronized cycle of: 1.6sec "on" / 0.4sec "off".

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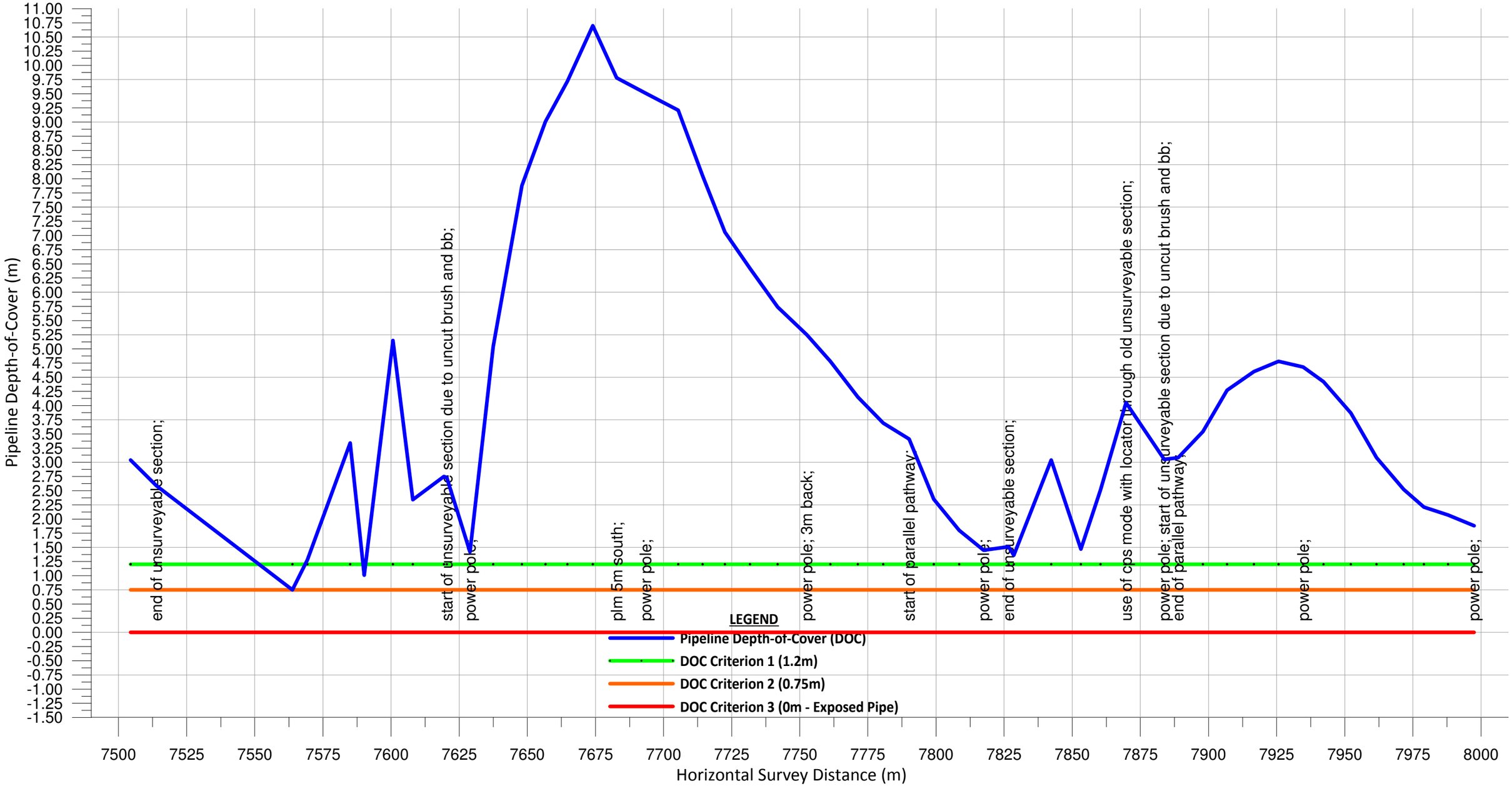
Project:
Fortis BC
508mm (NPS 20) Pipeline
Coquitlam - Vancouver IP, Coastal (BC)
Depth of Cover (DOC) Profile
2012

FORTIS BC™

Dwg. #: 508-CV-IP-DOC-015	Sheet: 15 of 17
Date: December 6, 2012	
Scale:	

No.	Revision / Issue	Date



Notes:
The Coquitlam - Vancouver IP DOC survey was completed in August 2012. The rectifiers were interrupted via aGPS time-synchronized cycle of: 1.6sec "on" / 0.4sec "off".

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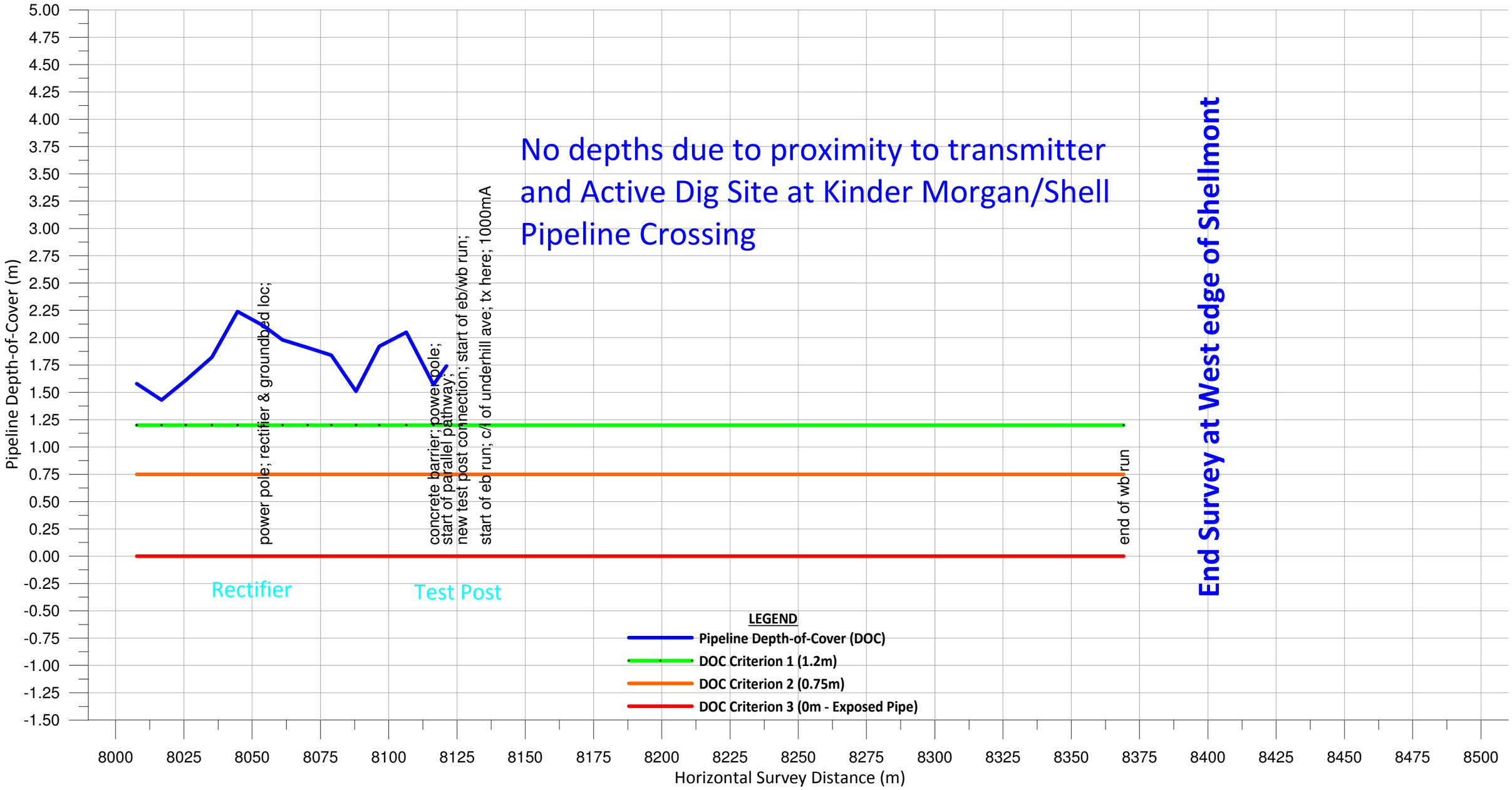
Project:
Fortis BC
508mm (NPS 20) Pipeline
Coquitlam - Vancouver IP, Coastal (BC)
Depth of Cover (DOC) Profile
2012

FORTIS BC™

Dwg. #: 508-CV-IP-DOC-016	Sheet: 16 of 17
Date: December 6, 2012	
Scale:	

No.	Revision / Issue	Date



Notes:
The Coquitlam - Vancouver IP DOC survey was completed in August 2012. The rectifiers were interrupted via aGPS time-synchronized cycle of: 1.6sec "on" / 0.4sec "off".

E-MAC CORROSION INC.
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Project:
Fortis BC
508mm (NPS 20) Pipeline
Coquitlam - Vancouver IP, Coastal (BC)
Depth of Cover (DOC) Profile
2012

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Dwg. #:	508-CV-IP-DOC-017
Date:	December 6, 2012
Scale:	
Sheet:	17 of 17

No.	Revision / Issue	Date

APPENDIX 4
TABULATED DEPTH-OF-COVER (DOC) SURVEY DATA
508mm (NPS 20) TP Pipeline
Coquitlam to Vancouver, Coastal (BC)
2012

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508mm (NPS 20) COQUITLAM - VANCOUVER
INTERMEDIATE PRESSURE PIPELINE
DEPTH-OF-COVER (DOC) SURVEY DATA
2012

CLASSIFICATIONS:
0.75m to 1.20m
Less than 0.75m
Exposed Pipe / Coating Anomaly
CP Test Stations / Valves

E-MAC CORROSION INC.

Survey Distance		WGS 84		NAD 83 Canada UTM - Zone 11		MSL Ground Elevation	Residual Current	Pipeline Depth-of-	
Horizontal (m)	3D Ground (m)	Latitude DD.ddddddd	Longitude DD.ddddddd	Northing (m)	Easting (m)	(m)	(mA)	Cover (m)	Notes / Comments
0.0	0.0	49.26314142	-122.81741283	5456724.67	513284.39	170.93	412	1.86	IP access port; bend; Start survey at Coquitlam Gate Station
2.1	2.1	49.26314122	-122.81744150	5456724.65	513282.30	171.03	680	1.79	
3.4	3.4	49.26314112	-122.81745900	5456724.63	513281.03	171.49			end of eb run; Chain Link Fence
3.4	3.5	49.26314111	-122.81745961	5456724.63	513280.98	171.53			
7.8	8.0	49.26314075	-122.81751942	5456724.58	513276.63	170.78	540	1.93	water main access port;
11.0	11.2	49.26314392	-122.81756342	5456724.92	513273.43	170.93	534	1.89	water main access port;
15.1	15.3	49.26314542	-122.81762008	5456725.08	513269.31	170.93	555	2.14	
23.3	23.5	49.26314083	-122.81773200	5456724.55	513261.17	170.78	531	2.22	centerline of mariner way;
33.5	33.7	49.26314092	-122.81787250	5456724.54	513250.94	170.28	530	2.24	
42.7	42.9	49.26314317	-122.81799867	5456724.76	513241.76	169.73	525	2.20	
52.3	52.6	49.26314342	-122.81813100	5456724.77	513232.14	169.23	523	2.18	
61.8	62.0	49.26314333	-122.81826108	5456724.74	513222.67	168.73	530	2.26	
71.1	71.4	49.26314217	-122.81838875	5456724.59	513213.38	168.13	534	2.31	
80.1	80.4	49.26314242	-122.81851333	5456724.59	513204.32	167.58	535	2.33	
88.8	89.2	49.26314142	-122.81863317	5456724.46	513195.60	167.03	533	2.33	
97.6	98.0	49.26314200	-122.81875408	5456724.50	513186.80	166.53	535	2.39	end of pament patch; water main access port;
107.0	107.3	49.26314450	-122.81888233	5456724.76	513177.47	166.13	528	2.36	
116.1	116.4	49.26314400	-122.81900742	5456724.68	513168.37	165.93	524	2.29	
125.4	125.8	49.26314425	-122.81913583	5456724.69	513159.03	165.93	525	2.33	
133.5	133.9	49.26314617	-122.81924692	5456724.88	513150.95	166.13	522	2.34	
142.5	142.9	49.26314683	-122.81937050	5456724.93	513141.95	166.03	512	2.24	start of pavement patch; dig site;
151.9	152.3	49.26314792	-122.81949975	5456725.03	513132.55	165.93	505	2.27	
161.0	161.3	49.26314908	-122.81962433	5456725.14	513123.48	166.13	500	2.29	
170.4	170.7	49.26314733	-122.81975350	5456724.92	513114.09	166.03	497	2.49	end of median curb;
180.1	180.5	49.26314750	-122.81988775	5456724.92	513104.32	165.93	501	2.59	
189.2	189.6	49.26314750	-122.82001217	5456724.90	513095.27	165.68	488	2.27	start of median curb;
198.4	198.8	49.26314825	-122.82013958	5456724.96	513086.00	165.73	479	2.22	water main access port;
208.0	208.4	49.26315083	-122.82027050	5456725.22	513076.47	165.73	479	2.25	
217.2	217.5	49.26315100	-122.82039675	5456725.22	513067.29	165.53	475	2.29	
226.5	226.8	49.26315183	-122.82052442	5456725.29	513058.00	165.33	470	2.28	
235.9	236.3	49.26315333	-122.82065383	5456725.43	513048.58	165.03	464	2.23	
245.3	245.6	49.26315350	-122.82078275	5456725.43	513039.20	164.73	461	2.23	
255.0	255.4	49.26315583	-122.82091708	5456725.67	513029.43	164.43	457	2.21	
264.0	264.4	49.26315425	-122.82104008	5456725.47	513020.48	164.28	451	2.21	end of median curb;
273.9	274.4	49.26315442	-122.82117700	5456725.46	513010.52	163.88	450	2.48	
283.4	283.8	49.26315308	-122.82130667	5456725.29	513001.08	163.33	449	2.44	

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FORTIS BC
508mm (NPS 20) COQUITLAM - VANCOUVER
INTERMEDIATE PRESSURE PIPELINE
DEPTH-OF-COVER (DOC) SURVEY DATA
2012

CLASSIFICATIONS:
0.75m to 1.20m
Less than 0.75m
Exposed Pipe / Coating Anomaly
CP Test Stations / Valves

E-MAC CORROSION INC.

Survey Distance		WGS 84		NAD 83 Canada UTM - Zone 11		MSL Ground Elevation	Residual Current	Pipeline Depth-of-Cover	Notes / Comments
Horizontal (m)	3D Ground (m)	Latitude DD.ddddddd	Longitude DD.ddddddd	Northing (m)	Easting (m)	(m)	(mA)	(m)	
292.9	293.4	49.26315408	-122.82143792	5456725.38	512991.53	163.03	434	2.36	
302.2	302.6	49.26315683	-122.82156467	5456725.67	512982.31	162.93	420	2.24	
311.1	311.6	49.26315908	-122.82168817	5456725.89	512973.33	162.53	415	2.13	water main access port;
314.7	315.1	49.26315850	-122.82173717	5456725.82	512969.76	162.43	408	2.08	
323.6	324.0	49.26315842	-122.82185908	5456725.79	512960.89	162.13	404	2.00	
332.6	333.0	49.26315942	-122.82198325	5456725.88	512951.86	161.93	400	1.98	
341.8	342.3	49.26316033	-122.82210992	5456725.96	512942.64	161.73	394	2.10	
351.2	351.7	49.26316100	-122.82223892	5456726.01	512933.25	161.58	389	2.18	
360.8	361.2	49.26316033	-122.82237050	5456725.92	512923.68	161.03	385	2.04	start of median curb;
364.6	365.0	49.26316183	-122.82242233	5456726.07	512919.91	161.13	384	1.88	end of median curb;
374.8	375.3	49.26316333	-122.82256275	5456726.22	512909.69	161.03	380	1.95	
383.4	383.8	49.26316375	-122.82268067	5456726.24	512901.11	160.83	372	1.84	
392.7	393.2	49.26316392	-122.82280942	5456726.24	512891.75	160.63	366	1.76	
401.5	402.0	49.26316450	-122.82292975	5456726.28	512882.99	160.63	361	1.87	
410.6	411.1	49.26316600	-122.82305525	5456726.43	512873.86	160.48	355	2.02	
419.8	420.3	49.26316692	-122.82318175	5456726.51	512864.66	160.33	345	2.07	water main access port;
429.3	429.8	49.26316667	-122.82331183	5456726.46	512855.19	160.23	335	2.05	
438.4	438.9	49.26316583	-122.82343775	5456726.35	512846.03	159.93	328	1.85	start of median curb;
448.9	449.4	49.26316500	-122.82358192	5456726.23	512835.54	159.93	324	1.92	
458.1	458.6	49.26316725	-122.82370758	5456726.46	512826.40	159.98	316	2.07	
467.2	467.7	49.26316742	-122.82383308	5456726.46	512817.27	160.03	312	2.19	
475.8	476.3	49.26316867	-122.82395125	5456726.57	512808.67	160.13	305	2.19	water main access port;
483.0	483.5	49.26316983	-122.82405050	5456726.69	512801.45	160.23	300	2.19	water main access port;
488.3	488.8	49.26317050	-122.82412317	5456726.75	512796.16	160.28	299	2.19	
497.4	497.9	49.26317017	-122.82424758	5456726.69	512787.11	160.43	293	2.17	water main access port;
503.1	503.6	49.26317133	-122.82432625	5456726.81	512781.38	160.63	289	2.12	
512.4	512.9	49.26317325	-122.82445350	5456727.00	512772.13	160.83	283	2.00	end of median curb;
518.4	518.9	49.26317449	-122.82453641	5456727.12	512766.09	161.03	280	2.11	start of median curb;
524.7	525.2	49.26317575	-122.82462283	5456727.25	512759.81	161.13	278	1.88	
533.8	534.3	49.26317408	-122.82474775	5456727.04	512750.72	161.58	268	1.72	centerline of baker st;
543.1	543.6	49.26317667	-122.82487542	5456727.31	512741.43	161.83	260	1.51	
552.0	552.5	49.26317800	-122.82499767	5456727.43	512732.53	162.03	258	1.41	
561.3	561.8	49.26317942	-122.82512533	5456727.57	512723.24	162.23	256	1.58	
569.4	570.0	49.26318033	-122.82523775	5456727.65	512715.07	162.43	254	1.70	
577.5	578.1	49.26318283	-122.82534850	5456727.91	512707.01	162.63	253	1.91	
586.7	587.3	49.26318267	-122.82547500	5456727.87	512697.80	163.03	252	2.25	

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508mm (NPS 20) COQUITLAM - VANCOUVER
INTERMEDIATE PRESSURE PIPELINE
DEPTH-OF-COVER (DOC) SURVEY DATA
2012

CLASSIFICATIONS:
0.75m to 1.20m
Less than 0.75m
Exposed Pipe / Coating Anomaly
CP Test Stations / Valves

E-MAC CORROSION INC.

Survey Distance		WGS 84		NAD 83 Canada UTM - Zone 11		MSL Ground Elevation	Residual Current	Pipeline Depth-of-	
Horizontal (m)	3D Ground (m)	Latitude DD.ddddddd	Longitude DD.ddddddd	Northing (m)	Easting (m)	(m)	(mA)	Cover (m)	Notes / Comments
594.7	595.2	49.26318192	-122.82558425	5456727.77	512689.85	163.43	250	2.56	
602.7	603.3	49.26318100	-122.82569550	5456727.65	512681.76	163.53	250	2.92	
611.4	612.0	49.26318167	-122.82581508	5456727.71	512673.06	163.48	247	3.38	end of median curb;
620.1	620.7	49.26318283	-122.82593367	5456727.82	512664.43	164.83	248	3.63	
628.9	629.6	49.26318650	-122.82605492	5456728.20	512655.61	165.73	239	3.71	
638.4	639.2	49.26318850	-122.82618592	5456728.40	512646.08	166.43	232	3.63	start of median curb;
647.5	648.3	49.26318917	-122.82631008	5456728.46	512637.04	167.33	218	3.49	
657.0	657.9	49.26319075	-122.82644133	5456728.61	512627.49	168.33	208	3.38	
666.1	667.1	49.26319000	-122.82656658	5456728.51	512618.38	169.23	204	3.18	
675.5	676.5	49.26318742	-122.82669575	5456728.20	512608.98	170.08	199	3.12	
684.7	685.7	49.26318683	-122.82682175	5456728.11	512599.82	170.83	194	3.04	
694.4	695.4	49.26319150	-122.82695475	5456728.61	512590.14	171.68	184	3.22	
703.9	705.0	49.26318892	-122.82708575	5456728.30	512580.61	172.33	174	3.42	
713.1	714.1	49.26318800	-122.82721133	5456728.18	512571.47	172.83	176	3.83	
721.5	722.6	49.26319108	-122.82732775	5456728.50	512563.00	173.23	167	3.95	
729.9	730.9	49.26319408	-122.82744217	5456728.81	512554.68	173.53	155	3.83	
739.3	740.4	49.26319700	-122.82757183	5456729.12	512545.24	173.73	125	3.61	storm drain; vent pipe;
744.1	745.2	49.26319783	-122.82763825	5456729.20	512540.41	173.73	120	3.55	
753.4	754.5	49.26320042	-122.82776517	5456729.46	512531.17	173.63	116	3.55	storm drain;
759.0	760.0	49.26320025	-122.82784192	5456729.43	512525.59	173.53	117	3.52	
768.2	769.3	49.26320458	-122.82796867	5456729.89	512516.37	173.43	117	3.36	
776.9	778.0	49.26320550	-122.82808808	5456729.98	512507.68	173.13	102	2.84	
785.8	786.9	49.26320625	-122.82821008	5456730.04	512498.80	172.73	105	2.55	
795.2	796.3	49.26320667	-122.82833925	5456730.06	512489.40	172.33	112	2.39	water main access port;
799.5	800.6	49.26320675	-122.82839883	5456730.06	512485.07	172.13	118	2.38	
809.0	810.1	49.26321217	-122.82852892	5456730.64	512475.60	171.63	124	2.23	
817.9	819.0	49.26321258	-122.82865175	5456730.67	512466.67	171.13	124	2.25	
826.4	827.5	49.26321217	-122.82876850	5456730.61	512458.17	170.73	118	1.96	
835.3	836.4	49.26321450	-122.82889008	5456730.84	512449.33	170.43	135	2.13	
844.6	845.7	49.26321433	-122.82901800	5456730.80	512440.02	170.23	145	2.32	
854.1	855.3	49.26321758	-122.82914933	5456731.14	512430.46	170.23	140	2.13	
863.3	864.5	49.26321792	-122.82927583	5456731.16	512421.26	170.03	134	1.86	
872.3	873.4	49.26322217	-122.82939858	5456731.61	512412.33	169.93	134	1.79	
881.0	882.1	49.26322275	-122.82951800	5456731.66	512403.64	169.83	137	1.51	
889.6	890.7	49.26322483	-122.82963642	5456731.87	512395.02	169.83	143	1.36	
898.6	899.7	49.26322525	-122.82975958	5456731.90	512386.06	169.73	145	1.27	

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508mm (NPS 20) COQUITLAM - VANCOUVER
INTERMEDIATE PRESSURE PIPELINE
DEPTH-OF-COVER (DOC) SURVEY DATA
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CLASSIFICATIONS:
0.75m to 1.20m
Less than 0.75m
Exposed Pipe / Coating Anomaly
CP Test Stations / Valves

E-MAC CORROSION INC.

Survey Distance		WGS 84		NAD 83 Canada UTM - Zone 11		MSL Ground Elevation	Residual Current	Pipeline Depth-of-Cover	Notes / Comments
Horizontal (m)	3D Ground (m)	Latitude DD.ddddddd	Longitude DD.ddddddd	Northing (m)	Easting (m)	(m)	(mA)	(m)	
907.3	908.5	49.26323008	-122.82987983	5456732.41	512377.31	169.83	143	1.24	
916.0	917.1	49.26323358	-122.82999883	5456732.78	512368.65	169.83	136	1.27	
924.7	925.9	49.26323292	-122.83011925	5456732.69	512359.89	169.73	138	1.29	
934.0	935.2	49.26323492	-122.83024708	5456732.89	512350.59	169.48	139	1.20	centerline of seymour st;
943.6	944.8	49.26323650	-122.83037892	5456733.05	512341.00	169.18	137	1.18	
952.9	954.0	49.26323800	-122.83050592	5456733.19	512331.76	168.63	136	1.27	water main access port;
957.7	958.8	49.26323833	-122.83057142	5456733.22	512326.99	168.33	136	1.28	
967.0	968.2	49.26323675	-122.83070000	5456733.02	512317.64	167.63	132	1.41	water main access port;
973.6	974.8	49.26323733	-122.83079042	5456733.07	512311.06	167.13	131	1.41	
982.3	983.5	49.26323758	-122.83090975	5456733.08	512302.38	166.43	137	1.39	
990.8	992.1	49.26324233	-122.83102633	5456733.59	512293.89	165.73	129	1.38	
999.9	1001.3	49.26324283	-122.83115233	5456733.62	512284.73	164.83	133	1.41	
1008.7	1010.1	49.26324650	-122.83127333	5456734.01	512275.92	164.13	125	1.40	
1017.0	1018.4	49.26324625	-122.83138633	5456733.97	512267.70	163.48	123	1.45	
1025.9	1027.3	49.26324758	-122.83150867	5456734.09	512258.80	162.93	116	1.57	
1034.6	1036.1	49.26324750	-122.83162933	5456734.07	512250.02	162.53	109	1.86	
1043.7	1045.1	49.26324933	-122.83175317	5456734.25	512241.01	162.13	103	1.86	
1052.3	1053.8	49.26325100	-122.83187158	5456734.42	512232.39	161.83	96	1.86	
1059.9	1061.5	49.26324967	-122.83197683	5456734.25	512224.74	161.73	97	1.84	
1068.6	1070.1	49.26325283	-122.83209600	5456734.58	512216.07	161.73	97	1.81	
1077.8	1079.3	49.26325258	-122.83222233	5456734.53	512206.87	161.63	96	1.87	
1087.3	1088.8	49.26325650	-122.83235200	5456734.95	512197.44	161.73	95	1.91	
1096.4	1098.0	49.26325625	-122.83247833	5456734.90	512188.25	161.93	92	1.79	
1105.2	1106.8	49.26325675	-122.83259908	5456734.94	512179.46	162.13	92	1.49	water main access port;
1110.3	1111.8	49.26325775	-122.83266842	5456735.04	512174.42	162.43	92	1.39	
1118.6	1120.2	49.26325890	-122.83278271	5456735.15	512166.10	162.63	89	1.27	water main access port;
1121.2	1122.8	49.26325925	-122.83281858	5456735.18	512163.49	162.73	88	1.28	
1129.3	1130.9	49.26325942	-122.83292975	5456735.18	512155.40	162.83	88	1.33	
1137.1	1138.7	49.26325600	-122.83303683	5456734.78	512147.61	162.93	83	1.46	
1145.3	1146.9	49.26325483	-122.83314992	5456734.64	512139.39	163.08	80	1.60	
1154.6	1156.2	49.26325800	-122.83327767	5456734.97	512130.09	163.03	71	1.59	
1164.0	1165.6	49.26325942	-122.83340708	5456735.10	512120.68	162.83	71	1.67	
1173.1	1174.7	49.26326300	-122.83353183	5456735.48	512111.60	162.83	63	1.66	
1182.2	1183.8	49.26326433	-122.83365708	5456735.61	512102.48	162.83	57	1.51	
1190.6	1192.1	49.26326467	-122.83377158	5456735.63	512094.15	162.73	65	1.54	
1200.0	1201.5	49.26326717	-122.83390067	5456735.89	512084.76	162.63	66	1.47	

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508mm (NPS 20) COQUITLAM - VANCOUVER
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DEPTH-OF-COVER (DOC) SURVEY DATA
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Less than 0.75m
Exposed Pipe / Coating Anomaly
CP Test Stations / Valves

E-MAC CORROSION INC.

Survey Distance		WGS 84		NAD 83 Canada UTM - Zone 11		MSL Ground Elevation	Residual Current	Pipeline Depth-of-Cover	Notes / Comments
Horizontal (m)	3D Ground (m)	Latitude DD.ddddddd	Longitude DD.ddddddd	Northing (m)	Easting (m)	(m)	(mA)	(m)	
1210.0	1211.6	49.26327067	-122.83403867	5456736.25	512074.72	162.53	70	1.35	
1219.9	1221.5	49.26327367	-122.83417442	5456736.57	512064.84	162.33	76	1.17	
1229.8	1231.3	49.26327367	-122.83431008	5456736.54	512054.97	162.38	79	1.11	water main access port;
1239.5	1241.1	49.26327633	-122.83444450	5456736.82	512045.19	162.23	82	1.03	centerline of thermal dr;
1249.7	1251.2	49.26327808	-122.83458350	5456736.99	512035.08	162.03	87	0.99	water main access port;
1252.9	1254.5	49.26327917	-122.83462808	5456737.10	512031.83	162.03	87	0.98	
1262.6	1264.1	49.26328175	-122.83476067	5456737.37	512022.19	161.73	83	1.05	
1271.3	1272.9	49.26328417	-122.83488050	5456737.62	512013.47	161.73	81	1.11	
1280.6	1282.2	49.26328433	-122.83500933	5456737.62	512004.10	161.53	77	1.13	
1290.6	1292.2	49.26328542	-122.83514650	5456737.72	511994.12	161.23	74	1.24	water main access port;
1293.6	1295.2	49.26328542	-122.83518692	5456737.71	511991.17	161.23	74	1.26	
1303.4	1305.0	49.26328858	-122.83532242	5456738.04	511981.32	160.93	74	1.21	
1313.2	1314.8	49.26329117	-122.83545617	5456738.31	511971.58	160.63	74	1.17	
1320.2	1321.8	49.26329000	-122.83555267	5456738.16	511964.56	160.23	75	1.11	
1330.4	1332.1	49.26329000	-122.83569342	5456738.14	511954.32	159.93	73	1.16	storm drain;
1335.4	1337.1	49.26328833	-122.83576192	5456737.94	511949.34	159.63	73	1.17	
1345.4	1347.1	49.26329142	-122.83589950	5456738.26	511939.33	159.23	68	1.22	
1354.6	1356.2	49.26329467	-122.83602492	5456738.61	511930.20	158.83	70	1.31	
1364.6	1366.2	49.26329267	-122.83616258	5456738.36	511920.19	158.93	65	1.40	
1373.6	1375.2	49.26329525	-122.83628592	5456738.63	511911.21	158.73	64	1.56	
1382.7	1384.3	49.26329633	-122.83641117	5456738.73	511902.10	158.63	64	1.63	storm drain;
1389.4	1391.1	49.26329175	-122.83650367	5456738.21	511895.37	158.73	64	1.67	
1399.0	1400.7	49.26329375	-122.83663525	5456738.41	511885.80	158.93	63	1.61	
1408.3	1410.0	49.26329558	-122.83676275	5456738.59	511876.52	159.03	70	1.54	
1417.9	1419.5	49.26330192	-122.83689408	5456739.28	511866.96	159.23	70	1.38	
1425.3	1427.0	49.26330033	-122.83699683	5456739.08	511859.49	159.48	69	1.45	start of eb run; tx at coquitlam stn; 1000mA; c/l of montrose st
1427.9	1429.6	49.26330053	-122.83703191	5456739.10	511856.94	159.43	28	0.95	centerline of montrose st; end of eb run;
1437.1	1438.8	49.26330133	-122.83715833	5456739.17	511847.74	159.38	28	0.98	water main access port;
1445.3	1447.0	49.26329850	-122.83727108	5456738.84	511839.54	159.63	29	1.00	water main access port;
1455.2	1456.9	49.26330017	-122.83740658	5456739.00	511829.68	159.73	35	1.16	
1464.0	1465.7	49.26330100	-122.83752733	5456739.07	511820.89	159.83	40	1.22	water main access port;
1469.4	1471.1	49.26330233	-122.83760208	5456739.21	511815.45	159.83	42	1.25	
1478.0	1479.7	49.26330433	-122.83771992	5456739.42	511806.88	159.93	43	1.26	
1487.1	1488.9	49.26330575	-122.83784592	5456739.55	511797.71	160.03	43	1.16	
1496.2	1497.9	49.26330917	-122.83797025	5456739.91	511788.66	160.23	44	1.05	
1505.1	1506.8	49.26330975	-122.83809217	5456739.96	511779.79	160.33	46	1.09	

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Exposed Pipe / Coating Anomaly
CP Test Stations / Valves

E-MAC CORROSION INC.

Survey Distance		WGS 84		NAD 83 Canada UTM - Zone 11		MSL Ground Elevation	Residual Current	Pipeline Depth-of-Cover	Notes / Comments
Horizontal (m)	3D Ground (m)	Latitude DD.ddddddd	Longitude DD.ddddddd	Northing (m)	Easting (m)	(m)	(mA)	(m)	
1514.3	1516.0	49.26331033	-122.83821850	5456740.00	511770.60	160.43	46	1.18	water main access port; cluster crt;
1524.1	1525.8	49.26331042	-122.83835383	5456739.99	511760.76	160.53	47	1.31	
1533.4	1535.1	49.26331008	-122.83848125	5456739.94	511751.49	160.73	46	1.41	
1542.2	1543.9	49.26331092	-122.83860283	5456740.01	511742.64	160.93	44	1.47	
1551.1	1552.9	49.26331092	-122.83872533	5456739.99	511733.73	161.03	44	1.56	
1559.9	1561.7	49.26331025	-122.83884658	5456739.90	511724.91	161.13	45	1.67	
1568.6	1570.3	49.26330958	-122.83896517	5456739.81	511716.28	161.13	45	1.66	water main access port;
1573.6	1575.3	49.26331100	-122.83903433	5456739.95	511711.25	161.23	50	1.71	
1581.9	1583.6	49.26331708	-122.83914783	5456740.61	511702.99	161.23	50	1.59	
1590.8	1592.5	49.26331775	-122.83926958	5456740.67	511694.13	161.53	52	1.42	
1599.6	1601.3	49.26331642	-122.83939075	5456740.50	511685.31	161.83	52	1.45	water main access port;
1606.5	1608.2	49.26331833	-122.83948542	5456740.70	511678.42	161.98	52	1.50	
1614.6	1616.3	49.26332067	-122.83959667	5456740.94	511670.33	162.23	52	1.52	
1623.5	1625.2	49.26332167	-122.83971925	5456741.03	511661.41	162.48	55	1.54	
1631.9	1633.7	49.26332383	-122.83983492	5456741.25	511653.00	162.93	56	1.53	
1640.1	1641.9	49.26332342	-122.83994742	5456741.19	511644.81	163.33	57	1.45	water main access port;
1644.6	1646.4	49.26332475	-122.84000908	5456741.33	511640.32	163.53	58	1.33	
1653.3	1655.1	49.26332642	-122.84012900	5456741.50	511631.60	163.93	62	1.31	
1662.0	1663.8	49.26332700	-122.84024850	5456741.54	511622.90	164.33	65	1.21	
1670.7	1672.5	49.26332958	-122.84036808	5456741.81	511614.20	164.73	67	1.08	
1679.5	1681.3	49.26333108	-122.84048842	5456741.96	511605.45	165.13	69	1.05	
1687.8	1689.6	49.26333333	-122.84060283	5456742.19	511597.12	165.43	70	1.04	
1696.1	1697.9	49.26333483	-122.84071658	5456742.34	511588.85	165.53	74	1.01	water main access port; DP access port 5m south;
1699.5	1701.4	49.26333467	-122.84076442	5456742.32	511585.37	165.63	73	0.96	
1708.4	1710.3	49.26333575	-122.84088633	5456742.42	511576.50	165.73	75	0.90	centerline of linton st;
1717.4	1719.3	49.26333692	-122.84101033	5456742.53	511567.47	165.73	87	0.84	x3 water main access port;
1721.8	1723.6	49.26333775	-122.84107000	5456742.61	511563.13	165.73	89	0.83	
1731.0	1732.8	49.26333858	-122.84119633	5456742.69	511553.94	165.53	88	0.95	
1740.3	1742.2	49.26333933	-122.84132492	5456742.75	511544.58	165.23	86	1.04	
1749.0	1750.9	49.26334283	-122.84144392	5456743.12	511535.93	164.93	81	1.11	
1758.0	1759.9	49.26334250	-122.84156825	5456743.06	511526.88	164.73	75	1.31	
1767.5	1769.4	49.26333658	-122.84169817	5456742.39	511517.43	164.33	70	1.47	
1777.1	1779.0	49.26333792	-122.84183042	5456742.51	511507.81	164.13	70	1.71	
1786.4	1788.3	49.26333933	-122.84195733	5456742.65	511498.57	163.93	71	1.89	
1795.7	1797.6	49.26334067	-122.84208592	5456742.78	511489.22	163.63	73	1.81	
1805.6	1807.6	49.26334067	-122.84222200	5456742.76	511479.32	163.43	74	1.74	

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Exposed Pipe / Coating Anomaly
CP Test Stations / Valves

E-MAC CORROSION INC.

Survey Distance		WGS 84		NAD 83 Canada UTM - Zone 11		MSL Ground Elevation	Residual Current	Pipeline Depth-of-Cover	Notes / Comments
Horizontal (m)	3D Ground (m)	Latitude DD.dddddd	Longitude DD.dddddd	Northing (m)	Easting (m)	(m)	(mA)	(m)	
1815.1	1817.0	49.26334383	-122.84235233	5456743.09	511469.83	163.23	74	1.61	
1823.5	1825.4	49.26334500	-122.84246692	5456743.21	511461.50	163.13	80	1.59	
1832.5	1834.4	49.26334658	-122.84259100	5456743.36	511452.47	163.03	85	1.49	
1841.4	1843.3	49.26334992	-122.84271317	5456743.71	511443.58	163.03	87	1.22	
1850.5	1852.4	49.26335150	-122.84283833	5456743.87	511434.47	162.93	101	1.19	
1859.6	1861.5	49.26335217	-122.84296283	5456743.93	511425.41	162.73	103	1.17	
1868.5	1870.4	49.26335300	-122.84308575	5456744.00	511416.47	162.63	104	1.13	
1877.5	1879.4	49.26335300	-122.84320933	5456743.98	511407.48	162.53	117	1.66	
1886.0	1887.9	49.26335392	-122.84332633	5456744.07	511398.97	162.53	111	1.71	
1894.5	1896.4	49.26335508	-122.84344317	5456744.18	511390.47	162.43	110	1.71	water main access port;
1903.4	1905.4	49.26335733	-122.84356558	5456744.41	511381.56	162.43	117	1.65	
1912.2	1914.2	49.26335783	-122.84368675	5456744.45	511372.74	162.43	120	1.66	
1921.3	1923.3	49.26335950	-122.84381200	5456744.61	511363.63	162.43	121	1.66	
1930.4	1932.4	49.26336058	-122.84393667	5456744.72	511354.56	162.63	122	1.77	
1939.5	1941.5	49.26336167	-122.84406142	5456744.82	511345.48	162.93	121	1.71	
1948.1	1950.1	49.26336383	-122.84418000	5456745.04	511336.85	163.33	127	1.67	
1956.6	1958.6	49.26336650	-122.84429642	5456745.32	511328.38	163.73	125	1.41	
1964.5	1966.5	49.26336650	-122.84440492	5456745.30	511320.49	164.13	125	1.26	
1973.3	1975.3	49.26336750	-122.84452550	5456745.40	511311.72	164.73	132	1.17	
1982.1	1984.2	49.26336833	-122.84464717	5456745.47	511302.86	165.33	127	1.15	
1990.7	1992.8	49.26336925	-122.84476550	5456745.56	511294.25	165.73	131	1.19	
1999.5	2001.6	49.26337025	-122.84488658	5456745.65	511285.44	166.13	132	1.33	
2008.3	2010.4	49.26337633	-122.84500725	5456746.31	511276.66	166.43	130	1.22	
2016.9	2019.0	49.26337750	-122.84512483	5456746.42	511268.11	166.58	120	1.10	
2025.4	2027.5	49.26337825	-122.84524133	5456746.49	511259.63	166.63	120	1.24	
2034.9	2037.0	49.26337725	-122.84537192	5456746.35	511250.13	166.58	135	1.32	
2044.2	2046.2	49.26337867	-122.84549933	5456746.49	511240.86	166.43	140	1.14	
2053.2	2055.3	49.26337858	-122.84562400	5456746.47	511231.79	166.13	146	1.10	
2062.6	2064.7	49.26337775	-122.84575317	5456746.35	511222.39	165.83	143	1.28	
2071.7	2073.8	49.26337800	-122.84587792	5456746.36	511213.32	165.43	144	1.41	
2080.4	2082.5	49.26337900	-122.84599742	5456746.46	511204.62	165.03	137	1.45	
2088.5	2090.6	49.26337825	-122.84610850	5456746.36	511196.54	164.63	133	1.59	
2096.6	2098.8	49.26337783	-122.84622033	5456746.29	511188.40	164.43	129	1.72	
2104.9	2107.0	49.26337875	-122.84633358	5456746.38	511180.16	164.23	135	1.94	start of eb run at poirier st; tx at poirier lateral; 500mA;
2110.6	2112.8	49.26338292	-122.84641283	5456746.83	511174.40	163.83	122	1.71	storm drain; end of eb run;
2116.9	2119.1	49.26338600	-122.84649917	5456747.16	511168.12	163.58	121	1.68	

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E-MAC CORROSION INC.

Survey Distance		WGS 84		NAD 83 Canada UTM - Zone 11		MSL Ground Elevation	Residual Current	Pipeline Depth-of-Cover	Notes / Comments
Horizontal (m)	3D Ground (m)	Latitude DD.ddddddd	Longitude DD.ddddddd	Northing (m)	Easting (m)	(m)	(mA)	(m)	
2121.4	2123.5	49.26336667	-122.84655258	5456745.00	511164.23	163.56			new t/p connection; start of eb run;
2124.9	2127.1	49.26337764	-122.84659802	5456746.22	511160.93	163.23			
2128.2	2130.4	49.26338792	-122.84664050	5456747.35	511157.83	162.93			IP lateral tie in aprox; water main access port; corner of tx fenceline;
2135.6	2137.8	49.26338900	-122.84674267	5456747.46	511150.40	162.48	190	1.94	
2145.2	2147.4	49.26339142	-122.84687408	5456747.71	511140.84	161.93	190	1.77	
2154.3	2156.5	49.26339383	-122.84699942	5456747.96	511131.72	161.53	164	1.69	
2163.5	2165.8	49.26339275	-122.84712625	5456747.82	511122.49	161.23	158	1.62	
2172.4	2174.7	49.26339342	-122.84724842	5456747.87	511113.60	160.98	154	1.56	
2181.4	2183.6	49.26339433	-122.84737167	5456747.96	511104.63	160.83	147	1.45	
2190.1	2192.3	49.26339608	-122.84749092	5456748.14	511095.96	160.63	147	1.41	
2199.0	2201.2	49.26339567	-122.84761342	5456748.07	511087.05	160.58	147	1.39	
2207.9	2210.2	49.26339692	-122.84773617	5456748.19	511078.11	160.73	143	1.32	
2216.3	2218.6	49.26339858	-122.84785167	5456748.36	511069.71	160.83	144	1.37	
2224.7	2227.0	49.26339667	-122.84796700	5456748.13	511061.32	160.93	137	1.41	
2233.2	2235.5	49.26339700	-122.84808392	5456748.15	511052.81	161.03	131	1.43	water main access port;
2241.0	2243.3	49.26339958	-122.84819075	5456748.42	511045.04	161.23	134	1.52	start of parallel fenceline that tx ground is connected to;
2248.0	2250.2	49.26340275	-122.84828658	5456748.76	511038.07	161.33	128	1.65	
2256.9	2259.1	49.26340383	-122.84840875	5456748.86	511029.18	161.53	124	1.75	
2265.6	2267.9	49.26340417	-122.84852933	5456748.88	511020.41	161.63	124	1.75	
2274.3	2276.6	49.26340575	-122.84864883	5456749.04	511011.71	161.53	124	1.70	
2283.2	2285.5	49.26340608	-122.84877067	5456749.06	511002.85	161.43	127	1.65	
2293.4	2295.7	49.26340567	-122.84891100	5456748.99	510992.64	161.23	127	1.57	
2302.6	2304.9	49.26340633	-122.84903733	5456749.05	510983.44	161.23	134	1.55	
2311.6	2313.9	49.26340683	-122.84916092	5456749.09	510974.45	161.13	135	1.59	
2320.8	2323.1	49.26340500	-122.84928742	5456748.86	510965.25	161.03	140	1.67	
2329.9	2332.2	49.26340508	-122.84941283	5456748.86	510956.12	161.03	142	1.77	
2339.3	2341.5	49.26340458	-122.84954142	5456748.78	510946.77	161.08	148	1.99	
2349.4	2351.6	49.26340383	-122.84967983	5456748.68	510936.70	160.93	147	2.09	wasco st;
2357.4	2359.7	49.26340500	-122.84979050	5456748.79	510928.65	161.03	147	2.19	
2366.5	2368.8	49.26340533	-122.84991558	5456748.81	510919.55	161.13	147	2.21	
2375.8	2378.1	49.26340592	-122.85004358	5456748.86	510910.23	161.33	148	2.13	
2385.3	2387.6	49.26340692	-122.85017375	5456748.95	510900.76	161.63	145	2.15	
2394.3	2396.6	49.26340725	-122.85029825	5456748.97	510891.71	161.83	140	2.23	
2403.4	2405.7	49.26340833	-122.85042258	5456749.07	510882.66	162.03	137	2.27	
2412.1	2414.4	49.26340933	-122.85054192	5456749.17	510873.98	162.23	139	2.39	
2420.9	2423.2	49.26341033	-122.85066358	5456749.26	510865.12	162.33	137	2.42	

FORTIS BC

FORTIS BC
508mm (NPS 20) COQUITLAM - VANCOUVER
INTERMEDIATE PRESSURE PIPELINE
DEPTH-OF-COVER (DOC) SURVEY DATA
2012

CLASSIFICATIONS:
0.75m to 1.20m
Less than 0.75m
Exposed Pipe / Coating Anomaly
CP Test Stations / Valves

E-MAC CORROSION INC.

Survey Distance		WGS 84		NAD 83 Canada UTM - Zone 11		MSL Ground Elevation	Residual Current	Pipeline Depth-of-Cover	Notes / Comments
Horizontal (m)	3D Ground (m)	Latitude DD.ddddddd	Longitude DD.ddddddd	Northing (m)	Easting (m)	(m)	(mA)	(m)	
2429.7	2431.9	49.26341158	-122.85078367	5456749.38	510856.39	162.33	136	2.43	
2438.6	2440.9	49.26341208	-122.85090683	5456749.42	510847.43	162.33	137	2.51	
2447.8	2450.0	49.26341150	-122.85103242	5456749.34	510838.29	162.33	138	2.62	
2456.5	2458.8	49.26341300	-122.85115300	5456749.48	510829.52	162.33	139	2.65	
2465.8	2468.1	49.26341258	-122.85128017	5456749.42	510820.26	162.33	140	2.71	
2474.7	2477.0	49.26341375	-122.85140317	5456749.53	510811.31	162.33	142	2.74	
2484.4	2486.7	49.26341492	-122.85153650	5456749.64	510801.61	162.13	145	2.68	water main access port;
2492.0	2494.3	49.26341658	-122.85164058	5456749.81	510794.04	162.13	145	2.64	
2501.2	2503.5	49.26341717	-122.85176642	5456749.86	510784.88	162.13	123	2.38	storm drain;
2511.9	2514.2	49.26341842	-122.85191367	5456749.98	510774.17	162.03	123	2.19	water main access port;
2515.1	2517.4	49.26342033	-122.85195800	5456750.19	510770.95	161.93	125	2.19	
2524.7	2527.0	49.26341950	-122.85208958	5456750.07	510761.37	161.83	130	2.13	centerline of schoolhouse st;
2534.7	2537.0	49.26341900	-122.85222692	5456750.00	510751.38	161.83	133	2.25	water main access port;
2543.3	2545.6	49.26342117	-122.85234500	5456750.22	510742.79	161.83	133	2.21	
2552.9	2555.2	49.26342050	-122.85247717	5456750.13	510733.17	161.73	131	2.18	
2562.7	2565.0	49.26342267	-122.85261242	5456750.35	510723.33	161.63	129	2.19	
2572.4	2574.7	49.26342408	-122.85274483	5456750.49	510713.70	161.43	122	2.06	
2582.0	2584.3	49.26342467	-122.85287733	5456750.54	510704.06	161.33	106	1.84	water main access port;
2589.7	2591.9	49.26342583	-122.85298233	5456750.65	510696.42	161.33	104	1.77	
2598.8	2601.1	49.26342750	-122.85310825	5456750.82	510687.26	161.23	97	1.60	
2608.3	2610.6	49.26342758	-122.85323808	5456750.81	510677.81	160.93	82	1.52	
2617.6	2619.9	49.26343100	-122.85336608	5456751.17	510668.50	161.03	76	1.45	
2627.3	2629.6	49.26343108	-122.85349983	5456751.16	510658.77	160.93	75	1.58	
2636.8	2639.1	49.26343183	-122.85363058	5456751.23	510649.25	160.73	72	1.67	
2646.4	2648.7	49.26343342	-122.85376208	5456751.38	510639.68	160.53	68	1.61	water main access port;
2653.0	2655.3	49.26343350	-122.85385283	5456751.38	510633.08	160.43	67	1.57	
2662.0	2664.3	49.26343392	-122.85397600	5456751.41	510624.12	160.23	65	1.72	
2671.7	2674.1	49.26343442	-122.85411042	5456751.45	510614.34	160.13	63	1.71	
2681.3	2683.6	49.26343483	-122.85424183	5456751.47	510604.78	160.03	66	1.63	
2690.8	2693.1	49.26343633	-122.85437233	5456751.62	510595.28	159.78	68	1.45	
2700.1	2702.4	49.26343558	-122.85449975	5456751.52	510586.01	159.63	68	1.39	
2709.6	2711.9	49.26343617	-122.85463075	5456751.57	510576.48	159.43	68	1.44	
2718.9	2721.2	49.26343783	-122.85475825	5456751.74	510567.21	159.33	68	1.47	
2728.5	2730.8	49.26343917	-122.85489042	5456751.87	510557.59	159.13	68	1.38	
2738.1	2740.4	49.26344058	-122.85502208	5456752.00	510548.01	158.83	68	1.38	
2747.3	2749.6	49.26344133	-122.85514817	5456752.07	510538.84	158.53	67	1.41	

FORTIS BC

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508mm (NPS 20) COQUITLAM - VANCOUVER
INTERMEDIATE PRESSURE PIPELINE
DEPTH-OF-COVER (DOC) SURVEY DATA
2012

CLASSIFICATIONS:
0.75m to 1.20m
Less than 0.75m
Exposed Pipe / Coating Anomaly
CP Test Stations / Valves

E-MAC CORROSION INC.

Survey Distance		WGS 84		NAD 83 Canada UTM - Zone 11		MSL Ground Elevation	Residual Current	Pipeline Depth-of-	
Horizontal (m)	3D Ground (m)	Latitude DD.ddddddd	Longitude DD.ddddddd	Northing (m)	Easting (m)	(m)	(mA)	Cover (m)	Notes / Comments
2756.4	2758.7	49.26344150	-122.85527392	5456752.07	510529.69	158.23	66	1.46	
2766.4	2768.7	49.26344075	-122.85541117	5456751.97	510519.70	157.83	68	1.47	
2775.6	2778.0	49.26344275	-122.85553817	5456752.17	510510.46	157.53	68	1.52	
2784.7	2787.1	49.26344308	-122.85566275	5456752.19	510501.40	157.13	68	1.55	
2793.9	2796.3	49.26344400	-122.85578908	5456752.28	510492.21	156.73	67	1.68	
2803.2	2805.6	49.26344475	-122.85591692	5456752.34	510482.91	156.33	67	1.77	storm drain;
2808.9	2811.3	49.26344550	-122.85599500	5456752.42	510477.22	156.13	66	1.74	
2817.9	2820.3	49.26344458	-122.85611908	5456752.30	510468.20	155.83	66	1.74	
2827.2	2829.6	49.26344267	-122.85624683	5456752.07	510458.90	155.33	67	1.99	water main access port;
2830.5	2833.0	49.26344458	-122.85629283	5456752.27	510455.56	155.23	66	2.05	
2840.0	2842.4	49.26344158	-122.85642200	5456751.92	510446.16	154.83	68	2.17	
2849.1	2851.6	49.26344400	-122.85654800	5456752.17	510436.99	154.53	67	2.10	
2858.5	2861.0	49.26344567	-122.85667700	5456752.34	510427.60	154.13	65	1.92	
2868.0	2870.4	49.26344583	-122.85680700	5456752.34	510418.15	153.83	55	1.68	storm drain;
2874.3	2876.7	49.26344758	-122.85689367	5456752.52	510411.84	153.63	53	1.66	
2883.1	2885.6	49.26344792	-122.85701542	5456752.54	510402.98	153.33	49	1.61	
2892.2	2894.7	49.26344883	-122.85714067	5456752.63	510393.87	153.03	47	1.63	
2901.2	2903.7	49.26345050	-122.85726342	5456752.80	510384.94	152.83	46	1.80	
2910.1	2912.6	49.26345158	-122.85738567	5456752.90	510376.04	152.63	46	2.05	
2919.0	2921.5	49.26345083	-122.85750825	5456752.80	510367.13	152.23	46	2.12	water main access port;
2929.4	2931.9	49.26345217	-122.85765100	5456752.93	510356.74	151.83	50	2.25	centerline of gatensbury st;
2938.7	2941.2	49.26345267	-122.85777883	5456752.97	510347.44	151.43	50	2.22	water main access port;
2946.1	2948.6	49.26345592	-122.85788067	5456753.31	510340.03	151.13	49	2.08	
2955.6	2958.1	49.26345375	-122.85801083	5456753.06	510330.56	150.83	48	1.92	
2965.0	2967.5	49.26345417	-122.85814042	5456753.08	510321.13	150.43	47	1.91	
2974.5	2977.1	49.26345525	-122.85827133	5456753.19	510311.61	150.23	45	2.05	
2983.9	2986.4	49.26345825	-122.85839975	5456753.50	510302.26	150.28	44	2.07	
2992.9	2995.4	49.26346058	-122.85852358	5456753.75	510293.25	150.03	43	2.14	
3002.2	3004.7	49.26346083	-122.85865158	5456753.76	510283.94	149.93	43	2.14	
3011.0	3013.5	49.26346083	-122.85877225	5456753.74	510275.16	149.73	40	1.98	
3020.1	3022.6	49.26346117	-122.85889742	5456753.76	510266.05	149.53	39	1.84	water main access port;
3031.3	3033.8	49.26346392	-122.85905158	5456754.04	510254.84	149.48	38	1.64	
3039.8	3042.3	49.26345983	-122.85916767	5456753.57	510246.39	149.33	37	1.68	water main access port;
3044.2	3046.7	49.26346092	-122.85922850	5456753.69	510241.96	149.23	37	1.72	
3054.0	3056.6	49.26346267	-122.85936375	5456753.86	510232.12	148.93	36	1.71	pavement from start of run;
3063.0	3065.6	49.26346308	-122.85948717	5456753.89	510223.14	148.73	36	1.68	

FORTIS BC

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INTERMEDIATE PRESSURE PIPELINE
DEPTH-OF-COVER (DOC) SURVEY DATA
2012

CLASSIFICATIONS:
0.75m to 1.20m
Less than 0.75m
Exposed Pipe / Coating Anomaly
CP Test Stations / Valves

E-MAC CORROSION INC.

Survey Distance		WGS 84		NAD 83 Canada UTM - Zone 11		MSL Ground Elevation	Residual Current	Pipeline Depth-of-Cover	Notes / Comments
Horizontal (m)	3D Ground (m)	Latitude DD.ddddddd	Longitude DD.ddddddd	Northing (m)	Easting (m)	(m)	(mA)	(m)	
3072.7	3075.3	49.26346383	-122.85962025	5456753.96	510213.46	148.53	36	1.55	
3081.6	3084.2	49.26346433	-122.85974275	5456754.00	510204.55	148.33	36	1.61	
3090.5	3093.0	49.26346542	-122.85986450	5456754.10	510195.69	148.33	35	1.75	
3099.5	3102.0	49.26346650	-122.85998800	5456754.20	510186.71	148.23	32	1.81	
3108.3	3110.9	49.26346725	-122.86010983	5456754.27	510177.84	148.23	31	1.93	water main dig area;
3117.9	3120.5	49.26346908	-122.86024133	5456754.46	510168.27	148.13	31	1.93	
3126.7	3129.3	49.26347017	-122.86036300	5456754.56	510159.42	148.08	30	1.93	water main access port;
3134.4	3137.0	49.26346875	-122.86046808	5456754.39	510151.78	148.03	31	1.96	lillian st;
3143.8	3146.4	49.26347083	-122.86059725	5456754.60	510142.38	148.03	31	1.93	
3153.1	3155.7	49.26347158	-122.86072508	5456754.67	510133.08	147.93	30	1.92	
3162.3	3164.9	49.26347308	-122.86085192	5456754.82	510123.85	147.93	30	1.91	
3172.0	3174.5	49.26347383	-122.86098442	5456754.89	510114.21	147.93	29	1.85	
3181.2	3183.8	49.26347417	-122.86111200	5456754.91	510104.93	147.93	27	1.77	
3190.6	3193.2	49.26347442	-122.86124050	5456754.92	510095.58	147.83	24	1.71	
3199.9	3202.5	49.26347467	-122.86136808	5456754.93	510086.29	147.83	23	1.77	
3208.8	3211.3	49.26347442	-122.86149000	5456754.88	510077.42	147.88	22	1.77	
3217.0	3219.5	49.26347558	-122.86160283	5456755.00	510069.21	147.93	21	1.85	
3224.9	3227.5	49.26347708	-122.86171158	5456755.15	510061.30	147.93	20	1.71	
3234.4	3237.0	49.26347792	-122.86184258	5456755.23	510051.77	148.03	16	1.41	storm drain;
3240.6	3243.2	49.26347933	-122.86192783	5456755.37	510045.57	148.23	19	1.85	
3249.7	3252.3	49.26347942	-122.86205233	5456755.36	510036.51	148.33	19	1.83	
3258.4	3261.0	49.26347992	-122.86217175	5456755.40	510027.82	148.43	18	1.75	
3267.4	3270.0	49.26348242	-122.86229550	5456755.67	510018.82	148.43	18	1.80	
3276.2	3278.8	49.26348175	-122.86241708	5456755.58	510009.97	148.83	18	1.75	
3285.3	3287.9	49.26348242	-122.86254158	5456755.63	510000.91	149.23	18	1.83	
3293.3	3295.9	49.26348517	-122.86265142	5456755.92	509992.92	149.33	17	1.92	
3301.6	3304.3	49.26349017	-122.86276592	5456756.47	509984.59	149.93	17	1.91	
3307.8	3310.5	49.26348625	-122.86285092	5456756.02	509978.41	149.83	17	1.91	
3316.5	3319.1	49.26348058	-122.86296975	5456755.37	509969.76	150.23	17	1.92	
3324.3	3327.0	49.26348208	-122.86307767	5456755.53	509961.91	150.53	16	2.05	
3333.9	3336.6	49.26348800	-122.86320942	5456756.17	509952.32	150.23	178	2.07	
3334.3	3337.1	49.26348500	-122.86321167	5456755.83	509952.16	150.43	160	2.02	start of eb run; tx at poirier st lateral; 500mA; centerline of porter st;
3343.7	3346.4	49.26349008	-122.86333958	5456756.38	509942.85	150.33	175	1.94	storm drain; water main access port;
3348.4	3351.1	49.26348950	-122.86340442	5456756.31	509938.14	150.43	178	1.84	
3357.8	3360.6	49.26348933	-122.86353467	5456756.27	509928.66	150.63	180	1.70	
3367.2	3369.9	49.26348983	-122.86366333	5456756.31	509919.30	150.83	181	1.67	

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0.75m to 1.20m
Less than 0.75m
Exposed Pipe / Coating Anomaly
CP Test Stations / Valves

E-MAC CORROSION INC.

Survey Distance		WGS 84		NAD 83 Canada UTM - Zone 11		MSL Ground Elevation	Residual Current	Pipeline Depth-of-Cover	Notes / Comments
Horizontal (m)	3D Ground (m)	Latitude DD.ddddddd	Longitude DD.ddddddd	Northing (m)	Easting (m)	(m)	(mA)	(m)	
3376.6	3379.3	49.26349042	-122.86379250	5456756.36	509909.90	150.83	183	1.82	
3386.6	3389.4	49.26349142	-122.86392992	5456756.45	509899.90	151.03	184	1.87	
3396.0	3398.8	49.26349142	-122.86405950	5456756.43	509890.47	151.13	183	1.81	
3405.5	3408.3	49.26349275	-122.86418967	5456756.57	509881.00	150.83	183	1.73	
3414.8	3417.6	49.26349308	-122.86431758	5456756.59	509871.70	150.73	178	1.64	storm drain;
3421.9	3424.6	49.26349333	-122.86441483	5456756.60	509864.62	151.08	184	1.68	
3430.8	3433.6	49.26349400	-122.86453725	5456756.66	509855.71	151.43	185	1.71	
3439.8	3442.6	49.26349617	-122.86466175	5456756.88	509846.66	151.13	186	1.69	
3449.3	3452.1	49.26349858	-122.86479192	5456757.14	509837.19	151.08	183	1.66	
3459.0	3461.7	49.26349892	-122.86492458	5456757.16	509827.53	151.18	185	1.78	
3467.8	3470.6	49.26349933	-122.86504567	5456757.19	509818.72	151.73	185	1.84	
3476.9	3479.7	49.26349900	-122.86517050	5456757.13	509809.64	151.93	185	1.91	
3486.0	3488.7	49.26349950	-122.86529533	5456757.17	509800.56	151.83	184	1.89	
3495.1	3497.8	49.26349917	-122.86542042	5456757.12	509791.46	151.88	185	1.83	storm drain;
3498.5	3501.3	49.26350017	-122.86546833	5456757.22	509787.97	151.93	184	1.79	
3508.7	3511.5	49.26350083	-122.86560767	5456757.28	509777.83	151.83	184	1.84	
3518.2	3521.0	49.26350200	-122.86573867	5456757.39	509768.30	151.78	182	1.88	
3527.6	3530.4	49.26350283	-122.86586733	5456757.47	509758.94	151.63	181	1.85	water main access port;
3538.0	3540.8	49.26350500	-122.86601108	5456757.69	509748.48	151.63	180	1.79	centerline of macintosh st;
3547.4	3550.2	49.26350442	-122.86614000	5456757.61	509739.10	151.43	183	1.76	water main access port;
3554.3	3557.1	49.26350517	-122.86623442	5456757.68	509732.23	151.13	182	1.67	
3563.7	3566.5	49.26350775	-122.86636367	5456757.95	509722.83	150.78	180	1.53	
3573.2	3576.0	49.26350858	-122.86649475	5456758.03	509713.29	150.33	178	1.44	
3582.9	3585.7	49.26350817	-122.86662758	5456757.96	509703.63	149.88	181	1.51	
3592.0	3594.8	49.26350858	-122.86675208	5456757.99	509694.57	149.43	181	1.61	
3601.4	3604.3	49.26350792	-122.86688225	5456757.90	509685.10	148.93	181	1.64	
3610.8	3613.6	49.26350867	-122.86701092	5456757.97	509675.74	148.43	182	1.60	
3619.8	3622.7	49.26351233	-122.86713542	5456758.36	509666.68	148.13	179	1.61	
3629.1	3632.0	49.26351175	-122.86726233	5456758.28	509657.45	147.63	181	1.66	
3638.6	3641.5	49.26351142	-122.86739283	5456758.23	509647.95	147.13	181	1.65	
3647.7	3650.6	49.26351242	-122.86751758	5456758.32	509638.87	146.68	181	1.76	
3657.1	3660.0	49.26351317	-122.86764683	5456758.39	509629.47	146.23	179	1.87	
3666.3	3669.2	49.26351467	-122.86777375	5456758.54	509620.24	146.03	180	1.89	
3676.2	3679.1	49.26351508	-122.86790925	5456758.57	509610.38	145.73	180	1.87	
3685.2	3688.2	49.26351650	-122.86803408	5456758.71	509601.30	145.53	180	1.83	
3694.2	3697.1	49.26351842	-122.86815725	5456758.91	509592.33	145.43	179	1.73	

FORTIS BC

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508mm (NPS 20) COQUITLAM - VANCOUVER
INTERMEDIATE PRESSURE PIPELINE
DEPTH-OF-COVER (DOC) SURVEY DATA
2012

CLASSIFICATIONS:
0.75m to 1.20m
Less than 0.75m
Exposed Pipe / Coating Anomaly
CP Test Stations / Valves

E-MAC CORROSION INC.

Survey Distance		WGS 84		NAD 83 Canada UTM - Zone 11		MSL Ground Elevation	Residual Current	Pipeline Depth-of-Cover	Notes / Comments
Horizontal (m)	3D Ground (m)	Latitude DD.ddddddd	Longitude DD.ddddddd	Northing (m)	Easting (m)	(m)	(mA)	(m)	
3703.2	3706.1	49.26351875	-122.86828033	5456758.93	509583.38	145.43	182	1.75	
3711.8	3714.8	49.26352025	-122.86839950	5456759.08	509574.71	145.53	184	1.77	
3720.9	3723.8	49.26351908	-122.86852433	5456758.94	509565.63	145.63	183	1.75	
3730.5	3733.4	49.26351842	-122.86865600	5456758.84	509556.05	145.88	178	1.59	water main access port;
3741.5	3744.5	49.26352033	-122.86880783	5456759.04	509545.00	145.73	175	1.57	centerline of blue mountain st;
3745.8	3748.7	49.26352033	-122.86886572	5456759.03	509540.79	145.73			possible foreign or dp f/l;
3750.1	3753.1	49.26352033	-122.86892567	5456759.02	509536.43	145.73	173	1.53	water main access port;
3757.4	3760.3	49.26352133	-122.86902558	5456759.12	509529.16	145.63	173	1.54	
3767.2	3770.2	49.26352133	-122.86916092	5456759.11	509519.31	145.43	171	1.38	storm drain; pavement patched;
3774.4	3777.4	49.26352250	-122.86925958	5456759.22	509512.13	145.33	177	1.48	
3783.8	3786.7	49.26352367	-122.86938858	5456759.34	509502.75	145.18	175	1.48	water main access port;
3793.3	3796.3	49.26352425	-122.86951950	5456759.38	509493.22	144.83	176	1.55	
3802.6	3805.6	49.26352558	-122.86964658	5456759.52	509483.97	144.33	178	1.63	
3811.6	3814.6	49.26352833	-122.86977067	5456759.81	509474.95	143.63	178	1.76	
3820.3	3823.3	49.26352758	-122.86988958	5456759.71	509466.29	142.93	180	1.91	
3829.9	3833.0	49.26352867	-122.87002233	5456759.81	509456.64	142.13	180	2.00	water main access port;
3833.1	3836.2	49.26352933	-122.87006583	5456759.88	509453.47	141.83	181	2.02	
3842.6	3845.7	49.26352883	-122.87019633	5456759.81	509443.98	141.03	181	1.91	hailey st;
3852.1	3855.3	49.26352817	-122.87032758	5456759.72	509434.43	140.13	175	1.61	
3861.3	3864.5	49.26353017	-122.87045325	5456759.93	509425.28	139.38	177	1.57	
3870.1	3873.4	49.26352667	-122.87057500	5456759.52	509416.43	138.73	180	1.71	
3879.2	3882.4	49.26353033	-122.87069925	5456759.91	509407.39	138.13	181	1.77	
3888.6	3891.9	49.26353233	-122.87082925	5456760.12	509397.93	137.23	180	1.68	
3897.9	3901.2	49.26353225	-122.87095650	5456760.09	509388.67	136.53	179	1.64	
3907.9	3911.3	49.26353392	-122.87109442	5456760.26	509378.63	135.63	179	1.62	
3917.6	3921.0	49.26353392	-122.87122775	5456760.25	509368.93	135.03	181	1.67	
3927.6	3931.0	49.26353742	-122.87136442	5456760.62	509358.99	134.03	179	1.67	pavement patch;
3937.3	3940.7	49.26353933	-122.87149733	5456760.81	509349.32	133.33	180	1.81	
3946.4	3949.9	49.26354033	-122.87162342	5456760.91	509340.15	132.63	180	1.98	
3955.8	3959.3	49.26354117	-122.87175217	5456760.99	509330.78	132.03	181	2.03	
3965.2	3968.7	49.26354150	-122.87188150	5456761.01	509321.37	131.43	180	1.93	
3974.5	3978.1	49.26354150	-122.87200933	5456760.99	509312.07	130.83	183	1.79	
3984.2	3987.7	49.26354225	-122.87214225	5456761.06	509302.40	130.43	181	1.58	
3993.7	3997.3	49.26354250	-122.87227333	5456761.07	509292.86	130.03	180	1.62	
4002.9	4006.4	49.26354275	-122.87239900	5456761.08	509283.72	129.73	182	1.64	
4012.6	4016.2	49.26354358	-122.87253333	5456761.16	509273.94	129.33	182	1.55	

FORTIS BC

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508mm (NPS 20) COQUITLAM - VANCOUVER
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2012

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Less than 0.75m
Exposed Pipe / Coating Anomaly
CP Test Stations / Valves

E-MAC CORROSION INC.

Survey Distance		WGS 84		NAD 83 Canada UTM - Zone 11		MSL Ground Elevation	Residual Current	Pipeline Depth-of-Cover	Notes / Comments
Horizontal (m)	3D Ground (m)	Latitude DD.ddddddd	Longitude DD.ddddddd	Northing (m)	Easting (m)	(m)	(mA)	(m)	
4021.9	4025.4	49.26354417	-122.87265992	5456761.21	509264.73	128.93	182	1.60	
4031.3	4034.9	49.26354642	-122.87279033	5456761.44	509255.24	128.53	179	1.61	
4040.6	4044.2	49.26354467	-122.87291750	5456761.23	509245.99	127.73	180	1.63	
4050.0	4053.6	49.26354608	-122.87304617	5456761.37	509236.63	127.48	180	1.61	
4059.1	4062.8	49.26354633	-122.87317242	5456761.39	509227.45	127.38	182	1.65	
4068.5	4072.1	49.26354833	-122.87330033	5456761.59	509218.14	127.03	179	1.58	
4077.6	4081.3	49.26354842	-122.87342658	5456761.59	509208.95	126.73	180	1.69	
4087.6	4091.2	49.26354950	-122.87356342	5456761.69	509199.00	126.33	183	1.83	water main access port;
4094.6	4098.3	49.26354975	-122.87365983	5456761.71	509191.98	126.03	180	1.80	
4104.0	4107.7	49.26354925	-122.87378917	5456761.64	509182.57	125.73	183	1.87	
4113.4	4117.1	49.26355008	-122.87391875	5456761.71	509173.15	125.43	187	1.98	
4123.1	4126.8	49.26355133	-122.87405183	5456761.84	509163.46	125.13	185	1.88	
4132.9	4136.6	49.26355208	-122.87418592	5456761.90	509153.71	124.93	183	1.71	water main access port;
4141.4	4145.1	49.26355492	-122.87430317	5456762.20	509145.18	124.93	178	1.63	townley st;
4146.8	4150.5	49.26355450	-122.87437717	5456762.15	509139.79	124.73	181	1.66	
4156.1	4159.8	49.26355575	-122.87450525	5456762.27	509130.47	124.43	182	1.60	water main access port;
4159.2	4162.9	49.26355525	-122.87454717	5456762.21	509127.42	124.23	182	1.61	
4168.1	4171.8	49.26355508	-122.87466925	5456762.18	509118.54	123.83	188	1.69	
4177.6	4181.3	49.26355558	-122.87480000	5456762.22	509109.03	123.63	206	1.41	
4186.6	4190.4	49.26355783	-122.87492467	5456762.45	509099.96	123.53	212	1.35	
4195.3	4199.1	49.26355858	-122.87504425	5456762.52	509091.26	123.33	239	1.49	
4204.2	4207.9	49.26355933	-122.87516575	5456762.59	509082.42	123.23	241	1.59	water main access port;
4207.6	4211.3	49.26355858	-122.87521250	5456762.50	509079.02	123.33	245	1.66	fowler st;
4216.9	4220.7	49.26355900	-122.87534108	5456762.53	509069.66	123.03	257	1.91	
4226.1	4229.9	49.26356017	-122.87546750	5456762.65	509060.46	122.83	264	2.14	
4234.9	4238.6	49.26355942	-122.87558733	5456762.55	509051.74	122.53	274	2.47	
4244.0	4247.8	49.26356142	-122.87571258	5456762.76	509042.63	122.33	290	2.68	storm drain;
4248.1	4251.9	49.26356308	-122.87576917	5456762.94	509038.51	122.28	294	2.68	
4256.9	4260.7	49.26356308	-122.87588975	5456762.92	509029.74	122.13	309	2.74	storm drain;
4261.2	4265.0	49.26356383	-122.87594908	5456763.00	509025.42	122.03	307	2.65	
4270.7	4274.5	49.26356483	-122.87608008	5456763.09	509015.89	121.93	311	2.40	
4279.7	4283.5	49.26356575	-122.87620308	5456763.18	509006.94	122.03	313	2.15	
4289.7	4293.5	49.26356583	-122.87634083	5456763.17	508996.92	122.03	316	1.84	
4298.1	4301.9	49.26356633	-122.87645700	5456763.22	508988.47	122.13	318	1.56	
4306.6	4310.4	49.26356775	-122.87657325	5456763.36	508980.01	122.23	323	1.45	
4316.3	4320.1	49.26356867	-122.87670683	5456763.44	508970.29	122.53	333	1.41	

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CLASSIFICATIONS:
0.75m to 1.20m
Less than 0.75m
Exposed Pipe / Coating Anomaly
CP Test Stations / Valves

E-MAC CORROSION INC.

Survey Distance		WGS 84		NAD 83 Canada UTM - Zone 11		MSL Ground Elevation	Residual Current	Pipeline Depth-of-Cover	Notes / Comments
Horizontal (m)	3D Ground (m)	Latitude DD.ddddddd	Longitude DD.ddddddd	Northing (m)	Easting (m)	(m)	(mA)	(m)	
4325.5	4329.3	49.26356925	-122.87683308	5456763.49	508961.11	122.73	342	1.35	
4334.3	4338.1	49.26357208	-122.87695375	5456763.80	508952.33	122.93	362	1.32	water main access port;
4343.4	4347.3	49.26357225	-122.87707942	5456763.80	508943.18	123.08	362	1.35	water main access port; banting st;
4346.3	4350.1	49.26357000	-122.87711792	5456763.54	508940.38	123.23	380	1.44	
4355.1	4358.9	49.26357258	-122.87723925	5456763.82	508931.56	123.43	382	1.45	
4363.9	4367.8	49.26357225	-122.87736100	5456763.77	508922.70	123.63	405	1.52	
4373.1	4376.9	49.26357400	-122.87748642	5456763.95	508913.57	124.13	412	1.67	
4381.9	4385.8	49.26357408	-122.87760808	5456763.94	508904.72	124.63	424	1.78	
4389.6	4393.5	49.26357308	-122.87771383	5456763.82	508897.03	125.13	436	1.88	
4398.2	4402.1	49.26357500	-122.87783242	5456764.02	508888.40	125.73	447	1.96	
4407.1	4411.0	49.26357592	-122.87795375	5456764.10	508879.57	126.53	443	1.82	
4415.5	4419.4	49.26357633	-122.87806958	5456764.14	508871.14	126.98	439	1.66	
4424.6	4428.6	49.26357733	-122.87819483	5456764.23	508862.03	127.43	466	1.78	pavement patched;
4432.8	4436.8	49.26357733	-122.87830767	5456764.22	508853.82	128.23	453	1.92	water main access port;
4440.8	4444.7	49.26357692	-122.87841683	5456764.16	508845.88	128.83	457	2.03	
4450.2	4454.2	49.26357808	-122.87854675	5456764.28	508836.43	129.43	458	2.08	
4459.4	4463.4	49.26357942	-122.87867333	5456764.41	508827.22	130.13	461	2.09	
4468.3	4472.3	49.26357992	-122.87879467	5456764.45	508818.39	130.63	465	2.12	
4477.2	4481.2	49.26357983	-122.87891708	5456764.43	508809.48	131.13	463	2.15	
4486.3	4490.3	49.26358025	-122.87904225	5456764.46	508800.38	131.53	463	2.21	
4493.9	4498.0	49.26358108	-122.87914767	5456764.54	508792.71	132.23	455	2.19	
4503.3	4507.4	49.26358017	-122.87927567	5456764.42	508783.39	132.63	441	2.17	
4510.7	4514.7	49.26358142	-122.87937725	5456764.55	508776.00	132.73	435	2.12	
4519.7	4523.8	49.26358125	-122.87950200	5456764.52	508766.93	133.03	435	2.05	
4528.6	4532.7	49.26358525	-122.87962425	5456764.95	508758.03	133.13	435	1.93	
4537.2	4541.3	49.26358617	-122.87974225	5456765.03	508749.45	133.38	430	1.81	
4546.0	4550.1	49.26358317	-122.87986300	5456764.69	508740.66	133.83	404	1.67	start of eb run; tx at robinson st lateral; 1000mA;
4560.1	4564.3	49.26358400	-122.88005742	5456764.76	508726.52	133.33	227	1.38	centerline of robinson st; end of eb run;
4570.0	4574.1	49.26357417	-122.88019142	5456763.65	508716.77	133.78	252	2.10	water main access port;
4574.8	4579.0	49.26357317	-122.88025808	5456763.53	508711.92	133.93	252	1.46	
4584.3	4588.5	49.26356567	-122.88038783	5456762.68	508702.48	133.83	268	1.43	
4593.5	4597.7	49.26356150	-122.88051367	5456762.20	508693.32	133.58	254	1.45	
4603.0	4607.2	49.26355542	-122.88064458	5456761.51	508683.80	133.38	175	1.22	
4612.7	4616.9	49.26354742	-122.88077742	5456760.61	508674.14	133.03	166	1.21	
4621.8	4626.0	49.26354492	-122.88090225	5456760.32	508665.06	132.53	163	1.20	
4631.4	4635.6	49.26353875	-122.88103333	5456759.61	508655.52	132.03	163	1.16	

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Exposed Pipe / Coating Anomaly
CP Test Stations / Valves

E-MAC CORROSION INC.

Survey Distance		WGS 84		NAD 83 Canada UTM - Zone 11		MSL Ground Elevation	Residual Current	Pipeline Depth-of-Cover	Notes / Comments
Horizontal (m)	3D Ground (m)	Latitude DD.ddddddd	Longitude DD.ddddddd	Northing (m)	Easting (m)	(m)	(mA)	(m)	
4641.3	4645.5	49.26353158	-122.88116942	5456758.80	508645.62	131.63	155	1.21	
4650.7	4655.0	49.26352483	-122.88129817	5456758.04	508636.25	131.03	163	1.19	
4660.5	4664.8	49.26351767	-122.88143267	5456757.23	508626.47	130.33	165	1.13	
4670.6	4674.9	49.26351042	-122.88157142	5456756.40	508616.38	129.63	168	1.14	
4680.4	4684.7	49.26350275	-122.88170450	5456755.54	508606.69	129.03	158	1.14	
4689.9	4694.2	49.26349550	-122.88183483	5456754.72	508597.21	128.43	161	1.27	
4699.4	4703.7	49.26348733	-122.88196467	5456753.79	508587.77	127.83	151	1.23	
4709.1	4713.5	49.26348117	-122.88209833	5456753.09	508578.04	127.33	160	1.18	storm drain;
4715.3	4719.7	49.26347675	-122.88218358	5456752.59	508571.84	126.93	161	1.25	
4724.7	4729.2	49.26347008	-122.88231225	5456751.84	508562.48	126.43	166	1.49	
4734.1	4738.5	49.26346308	-122.88244025	5456751.04	508553.17	125.73	166	1.59	
4743.6	4748.1	49.26345658	-122.88257050	5456750.31	508543.70	125.13	166	1.52	
4752.9	4757.4	49.26344967	-122.88269808	5456749.52	508534.42	124.43	165	1.42	
4762.1	4766.7	49.26344233	-122.88282467	5456748.69	508525.21	123.83	163	1.42	
4771.1	4775.6	49.26343417	-122.88294700	5456747.77	508516.31	123.23	169	1.57	end of bend;
4778.2	4782.8	49.26340517	-122.88303483	5456744.54	508509.92	122.73	172	1.91	end of parallel pathway; curb; Pedestrian Path
4785.3	4790.0	49.26338150	-122.88312567	5456741.90	508503.32	122.43	212	1.91	start bend;
4789.6	4794.2	49.26338150	-122.88318358	5456741.89	508499.10	122.23	221	1.88	
4798.3	4802.9	49.26337625	-122.88330350	5456741.29	508490.38	121.73	219	1.77	light pole;
4808.7	4813.4	49.26336825	-122.88344633	5456740.39	508479.99	121.13	221	1.51	start of parallel pathway; Pedestrian Path
4816.3	4820.9	49.26336200	-122.88354908	5456739.68	508472.51	120.73	225	1.47	centerline of dogwood st;
4822.9	4827.6	49.26335442	-122.88363983	5456738.83	508465.91	120.18	235	1.56	end of parallel pathway; Pedestrian Path
4829.4	4834.1	49.26334875	-122.88372833	5456738.19	508459.48	120.13	234	1.88	power pole; Overhead Cables
4837.9	4842.6	49.26334242	-122.88384525	5456737.47	508450.97	119.83	235	1.81	water main access port;
4843.3	4848.2	49.26333600	-122.88391902	5456736.75	508445.60	118.46	236	1.75	
4851.8	4856.7	49.26333335	-122.88403502	5456736.44	508437.16	117.46	245	1.75	
4860.0	4864.9	49.26332435	-122.88414767	5456735.43	508428.97	117.46	255	1.69	power pole; light pole; Overhead Cables
4871.9	4876.9	49.26331823	-122.88431104	5456734.73	508417.08	116.46	237	1.43	
4880.8	4885.7	49.26331196	-122.88443204	5456734.02	508408.28	116.46	200	1.27	
4890.4	4895.4	49.26330413	-122.88456400	5456733.13	508398.68	115.46	229	1.56	water main access port;
4900.3	4905.4	49.26329180	-122.88469925	5456731.75	508388.84	115.46	235	1.73	power pole; Overhead Cables
4906.4	4911.5	49.26328647	-122.88478249	5456731.15	508382.79	114.46	202	1.25	
4913.4	4918.5	49.26327750	-122.88487796	5456730.14	508375.84	114.46	202	1.77	
4921.8	4926.9	49.26326997	-122.88499227	5456729.29	508367.53	114.46	151	1.04	light pole;
4929.5	4934.7	49.26326557	-122.88509798	5456728.79	508359.84	113.46	173	1.19	
4939.4	4944.6	49.26326054	-122.88523379	5456728.21	508349.96	113.46	141	1.04	power pole; Overhead Cables

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508mm (NPS 20) COQUITLAM - VANCOUVER
INTERMEDIATE PRESSURE PIPELINE
DEPTH-OF-COVER (DOC) SURVEY DATA
2012

CLASSIFICATIONS:
0.75m to 1.20m
Less than 0.75m
Exposed Pipe / Coating Anomaly
CP Test Stations / Valves

E-MAC CORROSION INC.

Survey Distance		WGS 84		NAD 83 Canada UTM - Zone 11		MSL Ground Elevation	Residual Current	Pipeline Depth-of-Cover	Notes / Comments
Horizontal (m)	3D Ground (m)	Latitude DD.ddddddd	Longitude DD.ddddddd	Northing (m)	Easting (m)	(m)	(mA)	(m)	
4947.9	4953.1	49.26326028	-122.88535099	5456728.17	508341.43	112.96	133	1.05	
4958.0	4963.3	49.26326342	-122.88548981	5456728.51	508331.33	112.46	164	1.30	water main access port;
4967.4	4972.6	49.26325646	-122.88561792	5456727.72	508322.01	112.46	190	1.66	
4976.7	4982.0	49.26322632	-122.88573758	5456724.35	508313.31	111.46	219	1.88	
4985.1	4990.4	49.26321366	-122.88585106	5456722.93	508305.06	111.46	222	1.88	
4995.2	5000.5	49.26321177	-122.88598924	5456722.71	508295.00	110.46	242	2.02	light pole;
5004.3	5009.7	49.26320998	-122.88611554	5456722.50	508285.81	110.46	249	1.99	curb; start of parallel pathway; Pedestrian Path
5014.6	5020.0	49.26320474	-122.88625562	5456721.90	508275.62	109.46	251	2.01	
5023.2	5028.6	49.26320398	-122.88637422	5456721.80	508266.99	109.46	250	2.03	
5032.5	5038.1	49.26319817	-122.88650200	5456721.14	508257.70	111.13	249	2.03	
5042.5	5048.0	49.26319233	-122.88663858	5456720.48	508247.76	110.83	260	2.03	
5051.6	5057.1	49.26318850	-122.88676358	5456720.04	508238.67	110.33	246	1.95	water main access port; storm drain;
5061.4	5067.0	49.26317983	-122.88689825	5456719.06	508228.87	110.03	254	1.86	emerson rd;
5070.9	5076.5	49.26317208	-122.88702817	5456718.18	508219.42	110.03	254	1.73	
5080.6	5086.2	49.26316517	-122.88716092	5456717.40	508209.76	110.03	243	1.66	
5090.0	5095.6	49.26315758	-122.88728958	5456716.54	508200.40	109.93	252	1.66	
5099.1	5104.7	49.26315033	-122.88741408	5456715.72	508191.35	109.93	250	1.59	
5108.2	5113.8	49.26314183	-122.88753842	5456714.77	508182.30	109.93	248	1.47	
5117.1	5122.7	49.26313550	-122.88766067	5456714.05	508173.41	110.03	247	1.47	
5126.6	5132.2	49.26312733	-122.88779008	5456713.13	508163.99	110.23	242	1.54	
5135.5	5141.2	49.26310726	-122.88790938	5456710.88	508155.32	109.04			
5137.1	5142.8	49.26310375	-122.88793017	5456710.49	508153.81	108.83			start of wb run; clarke rd;
5137.8	5143.5	49.26311053	-122.88793080	5456711.24	508153.76	108.98			
5139.3	5145.0	49.26312383	-122.88793217	5456712.72	508153.66	109.28	211	1.48	IP access port; testleads inside;
5147.8	5153.8	49.26311792	-122.88804917	5456712.05	508145.15	108.93	263	2.95	
5156.6	5162.5	49.26311183	-122.88816858	5456711.36	508136.46	108.73	255	3.04	centerline of clark rd;
5167.2	5173.1	49.26310358	-122.88831417	5456710.43	508125.87	108.93	246	2.92	end of s bend;
5171.0	5177.0	49.26311958	-122.88836075	5456712.20	508122.48	109.03	212	2.41	
5176.5	5182.5	49.26313692	-122.88843158	5456714.12	508117.32	108.83	201	1.77	start bend;
5180.6	5186.6	49.26313483	-122.88848683	5456713.88	508113.30	108.73	211	1.84	
5190.2	5196.2	49.26312650	-122.88861933	5456712.94	508103.66	108.63	210	1.86	
5199.7	5205.7	49.26312067	-122.88874858	5456712.28	508094.26	108.48	207	1.77	
5209.4	5215.4	49.26311133	-122.88888142	5456711.23	508084.60	108.43	205	1.67	
5219.0	5225.0	49.26310467	-122.88901350	5456710.47	508074.99	108.13	203	1.71	
5228.6	5234.6	49.26309725	-122.88914442	5456709.64	508065.46	108.03	202	1.86	
5238.3	5244.3	49.26309042	-122.88927708	5456708.86	508055.81	107.83	198	1.82	storm drain; pavement patch; elmwood st;

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CP Test Stations / Valves

E-MAC CORROSION INC.

Survey Distance		WGS 84		NAD 83 Canada UTM - Zone 11		MSL Ground Elevation	Residual Current	Pipeline Depth-of-Cover	Notes / Comments
Horizontal (m)	3D Ground (m)	Latitude DD.ddddddd	Longitude DD.ddddddd	Northing (m)	Easting (m)	(m)	(mA)	(m)	
5242.5	5248.5	49.26308800	-122.88933475	5456708.59	508051.62	107.63	188	1.81	
5252.1	5258.2	49.26308367	-122.88946708	5456708.09	508041.99	106.98	187	1.90	
5262.0	5268.1	49.26307342	-122.88960208	5456706.94	508032.17	106.33	189	2.01	
5272.7	5278.8	49.26306075	-122.88974775	5456705.51	508021.57	105.53	196	1.96	
5282.3	5288.4	49.26305450	-122.88987917	5456704.81	508012.01	104.78	193	1.83	
5292.1	5298.2	49.26305083	-122.89001392	5456704.38	508002.21	104.08	174	1.66	storm drain;
5296.1	5302.3	49.26304583	-122.89006900	5456703.82	507998.20	103.73	168	1.63	water main access port;
5305.5	5311.7	49.26303808	-122.89019767	5456702.95	507988.84	103.23	165	1.64	
5315.1	5321.3	49.26303200	-122.89032892	5456702.26	507979.29	102.53	167	1.66	
5324.7	5330.9	49.26302358	-122.89045975	5456701.31	507969.78	102.03	166	1.65	
5333.8	5340.1	49.26301700	-122.89058533	5456700.56	507960.64	101.43	169	1.62	
5342.8	5349.0	49.26301258	-122.89070800	5456700.06	507951.72	100.83	173	1.63	storm drain; pavement; patch;
5346.0	5352.3	49.26301033	-122.89075275	5456699.80	507948.46	100.43	176	1.66	
5354.9	5361.2	49.26300300	-122.89087458	5456698.98	507939.60	99.98	175	1.69	
5364.4	5370.7	49.26299775	-122.89100475	5456698.38	507930.13	99.53	177	1.73	
5374.2	5380.5	49.26298925	-122.89113783	5456697.42	507920.45	99.13	176	1.71	
5383.9	5390.2	49.26298092	-122.89127075	5456696.48	507910.78	98.83	174	1.62	
5393.3	5399.6	49.26297508	-122.89139950	5456695.82	507901.41	98.33	174	1.59	
5402.5	5408.9	49.26296900	-122.89152650	5456695.13	507892.17	98.03	174	1.61	
5412.0	5418.4	49.26296033	-122.89165642	5456694.15	507882.72	97.83	172	1.65	water main access port; farrow rd;
5422.0	5428.4	49.26295008	-122.89179267	5456693.00	507872.81	97.38	175	1.65	
5431.2	5437.6	49.26294683	-122.89191958	5456692.62	507863.58	96.93	172	1.58	
5440.1	5446.5	49.26293875	-122.89204100	5456691.71	507854.74	96.53	170	1.55	
5449.4	5455.7	49.26293242	-122.89216750	5456690.99	507845.54	96.03	169	1.43	
5458.3	5464.7	49.26292508	-122.89228967	5456690.17	507836.65	95.53	167	1.44	
5467.8	5474.2	49.26291642	-122.89241992	5456689.19	507827.18	94.93	168	1.50	
5476.4	5482.9	49.26291267	-122.89253842	5456688.76	507818.56	94.43	166	1.48	
5486.3	5492.7	49.26290433	-122.89267317	5456687.82	507808.75	94.03	163	1.68	
5495.6	5502.0	49.26289992	-122.89280083	5456687.32	507799.47	93.63	161	1.79	
5505.3	5511.7	49.26289233	-122.89293358	5456686.46	507789.81	93.33	159	1.79	
5515.0	5521.4	49.26288167	-122.89306567	5456685.26	507780.20	92.63	147	1.62	
5524.6	5531.2	49.26287400	-122.89319800	5456684.39	507770.57	91.63	123	1.65	cathodic access port; north st;
5530.3	5536.8	49.26287558	-122.89327533	5456684.56	507764.95	91.43	105	1.68	storm drain;
5536.0	5542.5	49.26287375	-122.89335433	5456684.35	507759.20	91.33	105	1.63	
5545.7	5552.3	49.26287325	-122.89348775	5456684.28	507749.49	90.43	108	1.86	
5555.4	5562.0	49.26287467	-122.89362058	5456684.42	507739.83	89.53	105	1.87	

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Horizontal (m)	3D Ground (m)	Latitude DD.ddddddd	Longitude DD.ddddddd	Northing (m)	Easting (m)	(m)	(mA)	(m)	
5564.9	5571.5	49.26287442	-122.89375067	5456684.38	507730.36	88.53	105	1.87	
5573.5	5580.3	49.26287283	-122.89386975	5456684.19	507721.70	87.53	105	1.86	
5583.0	5589.9	49.26287475	-122.89399983	5456684.39	507712.23	86.13	110	1.95	
5592.2	5599.1	49.26287442	-122.89412642	5456684.34	507703.03	84.93	106	1.86	
5601.7	5608.6	49.26287317	-122.89425633	5456684.19	507693.57	83.83	111	1.75	
5611.0	5618.0	49.26287942	-122.89438417	5456684.87	507684.27	82.93	117	1.56	
5620.0	5627.1	49.26288408	-122.89450808	5456685.38	507675.25	81.93	118	1.47	
5629.4	5636.5	49.26288725	-122.89463667	5456685.72	507665.90	80.73	111	1.58	storm drain;
5642.0	5649.4	49.26288783	-122.89477200	5456685.77	507656.05	79.53	117	1.60	
5652.5	5660.3	49.26288592	-122.89489717	5456685.54	507646.95	78.38	118	1.68	
5661.9	5670.1	49.26288742	-122.89501875	5456685.70	507638.10	77.13	120	1.86	light pole;
5671.6	5680.6	49.26288758	-122.89514958	5456685.70	507628.58	76.13	117	2.04	start of pavement; curb; Paved Road
5680.6	5691.0	49.26289067	-122.89527292	5456686.03	507619.61	75.13	111	2.05	storm drain;
5689.4	5700.8	49.26289408	-122.89539325	5456686.40	507610.85	74.13	119	2.46	
5696.8	5709.2	49.26289475	-122.89549425	5456686.47	507603.50	73.13	149	2.81	
5705.9	5719.3	49.26289758	-122.89561967	5456686.77	507594.38	72.63	150	3.10	end of parallel pathway; slope start from first reading;
5715.2	5730.1	49.26289975	-122.89574600	5456687.00	507585.19	71.63	145	3.48	light pole;
5719.2	5734.9	49.26290643	-122.89580003	5456687.73	507581.25	68.98			end of wb run;
5723.7	5739.6	49.26290292	-122.89586125	5456687.34	507576.80	70.63	140	3.41	
5731.9	5748.0	49.26290608	-122.89597492	5456687.68	507568.53	69.73	128	3.63	water main access port;
5740.1	5757.1	49.26289950	-122.89608650	5456686.94	507560.41	67.23	128	5.10	parallel fenceline from rectifier to crossing; end of eb run
5741.1	5760.1	49.26290808	-122.89609058	5456687.89	507560.11	68.93	128	3.90	
5749.2	5769.1	49.26290108	-122.89620125	5456687.10	507552.06	66.33	34	5.26	
5750.5	5771.1	49.26291267	-122.89620375	5456688.39	507551.88	66.83	34	4.25	start of eb run; tx at robinson st; 1000mA; sound barrier wall
5759.3	5780.6	49.26290192	-122.89632417	5456687.18	507543.12	65.13	35	5.88	
5769.5	5790.9	49.26290600	-122.89646425	5456687.62	507532.93	63.93	35	6.18	
5778.4	5799.8	49.26291308	-122.89658542	5456688.40	507524.11	63.33	34	6.22	
5787.0	5808.4	49.26291575	-122.89670367	5456688.68	507515.51	62.53	35	6.22	
5796.7	5818.1	49.26292083	-122.89683642	5456689.23	507505.85	61.78	35	5.81	
5802.3	5824.1	49.26292239	-122.89691334	5456689.40	507500.25	59.43			rectifier; test post;
5806.4	5828.7	49.26292358	-122.89696983	5456689.52	507496.14	61.43	35	5.62	end of bend;
5812.5	5834.9	49.26291267	-122.89705283	5456688.30	507490.10	60.83	35	5.21	end of unsurveyable section;
5836.4	5859.1	49.26277106	-122.89730025	5456672.54	507472.12	53.86	35	2.22	bend; Pipeline Marker
5837.8	5860.8	49.26276723	-122.89731772	5456672.11	507470.85	52.86	35	2.21	Pedestrian Path
5839.1	5862.1	49.26276578	-122.89733595	5456671.95	507469.53	52.86	35	2.35	Pipe Fence
5844.7	5867.8	49.26279467	-122.89739885	5456675.15	507464.95	54.05	35	2.55	Creek

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E-MAC CORROSION INC.

Survey Distance		WGS 84		NAD 83 Canada UTM - Zone 11		MSL Ground Elevation	Residual Current	Pipeline Depth-of-	
Horizontal (m)	3D Ground (m)	Latitude DD.ddddddd	Longitude DD.ddddddd	Northing (m)	Easting (m)	(m)	(mA)	Cover (m)	Notes / Comments
5848.7	5871.8	49.26281543	-122.89744418	5456677.45	507461.64	54.90	35	3.18	Pipeline Marker
5870.5	5893.9	49.26292767	-122.89768917	5456689.91	507443.80	59.53	35	4.41	bend; power pole; unsurveyable section: uncut brush and bb; plm
5870.9	5895.5	49.26292759	-122.89769459	5456689.90	507443.41	59.52	35	2.82	
5874.7	5899.6	49.26292658	-122.89774708	5456689.78	507439.59	59.43	35	4.35	
5883.3	5908.3	49.26292517	-122.89786600	5456689.61	507430.94	59.63	37	3.76	
5892.9	5917.9	49.26292683	-122.89799750	5456689.78	507421.37	59.93	38	3.66	
5901.9	5926.9	49.26292867	-122.89812108	5456689.98	507412.38	60.03	30	3.36	
5910.6	5935.6	49.26292875	-122.89824025	5456689.97	507403.71	60.28	25	2.99	
5919.6	5944.7	49.26292717	-122.89836450	5456689.79	507394.67	60.33	27	3.43	Pipeline Marker
5924.7	5949.8	49.26292883	-122.89843375	5456689.96	507389.63	60.43	25	2.46	power pole;
5932.1	5957.3	49.26293192	-122.89853642	5456690.30	507382.16	60.63	28	2.49	
5941.7	5966.9	49.26292892	-122.89866808	5456689.95	507372.58	61.83	28	2.55	
5949.7	5974.9	49.26293125	-122.89877767	5456690.20	507364.61	62.53	28	2.79	
5959.1	5984.4	49.26293400	-122.89890692	5456690.49	507355.20	62.93	29	2.73	
5967.4	5992.7	49.26294000	-122.89902017	5456691.15	507346.96	63.23	28	2.33	
5977.0	6002.3	49.26294025	-122.89915250	5456691.16	507337.33	63.53	27	1.78	power pole; Pipeline Marker
5982.7	6008.0	49.26294033	-122.89923083	5456691.16	507331.63	64.33	28	2.38	2-Track or Trail
5997.2	6022.5	49.26295592	-122.89942817	5456692.88	507317.27	64.63	29	1.78	Chain Link Fence
6010.0	6035.3	49.26294650	-122.89960350	5456691.81	507304.52	65.93	30	2.21	start of unsurveyable section: uncut brush and bb;
6016.1	6041.5	49.26293925	-122.89968683	5456691.00	507298.46	66.43	27	2.58	
6025.1	6050.5	49.26294100	-122.89981050	5456691.18	507289.46	67.33	29	2.66	centerline; Paved Road
6031.5	6056.9	49.26294050	-122.89989867	5456691.12	507283.05	67.38	30	2.54	
6043.8	6069.3	49.26294475	-122.90006792	5456691.58	507270.73	69.13	19	2.77	power pole/crossing; plm 3m north; Pipeline Marker; Overhead Cables
6047.8	6073.3	49.26294450	-122.90012208	5456691.54	507266.79	69.43	19	2.87	
6057.8	6083.4	49.26294442	-122.90025975	5456691.52	507256.77	69.93	19	2.04	power pole anchors;
6067.4	6093.0	49.26294683	-122.90039142	5456691.78	507247.19	70.13	17	2.56	
6075.8	6101.4	49.26294892	-122.90050742	5456692.00	507238.75	70.43	18	2.45	
6084.6	6110.2	49.26295117	-122.90062758	5456692.23	507230.01	70.53	18	2.37	
6092.4	6118.0	49.26295192	-122.90073533	5456692.31	507222.17	70.33	18	2.21	
6101.5	6127.1	49.26297525	-122.90085458	5456694.89	507213.49	70.33	24	3.35	small bend; Gravel Road
6105.8	6131.5	49.26297075	-122.90091375	5456694.38	507209.19	70.23	30	3.31	
6114.6	6140.3	49.26296700	-122.90103500	5456693.96	507200.37	70.03	30	2.96	power pole; power crossing; Overhead Cables
6122.7	6148.4	49.26296733	-122.90114600	5456693.98	507192.29	69.83	39	2.87	
6132.0	6157.7	49.26297150	-122.90127317	5456694.43	507183.04	69.63	41	3.31	power pole; power crossing; Overhead Cables
6141.8	6167.6	49.26296892	-122.90140892	5456694.13	507173.16	69.23	46	3.46	power pole; power crossing;
6151.2	6176.9	49.26296975	-122.90153775	5456694.21	507163.79	68.93	49	3.53	2-Track or Trail

FORTIS BC

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508mm (NPS 20) COQUITLAM - VANCOUVER
INTERMEDIATE PRESSURE PIPELINE
DEPTH-OF-COVER (DOC) SURVEY DATA
2012

CLASSIFICATIONS:
0.75m to 1.20m
Less than 0.75m
Exposed Pipe / Coating Anomaly
CP Test Stations / Valves

E-MAC CORROSION INC.

Survey Distance		WGS 84		NAD 83 Canada UTM - Zone 11		MSL Ground Elevation	Residual Current	Pipeline Depth-of-	
Horizontal (m)	3D Ground (m)	Latitude DD.ddddddd	Longitude DD.ddddddd	Northing (m)	Easting (m)	(m)	(mA)	Cover (m)	Notes / Comments
6161.0	6186.7	49.26297592	-122.90167175	5456694.89	507154.04	68.93	49	3.81	power pole;
6169.1	6194.9	49.26297350	-122.90178308	5456694.61	507145.94	69.53	45	3.69	Pipeline Marker
6176.8	6202.7	49.26297833	-122.90188833	5456695.14	507138.28	67.33	42	2.92	
6184.6	6211.3	49.26297608	-122.90199650	5456694.87	507130.41	64.33	48	3.48	
6192.9	6220.5	49.26297383	-122.90210983	5456694.61	507122.16	60.83	57	4.03	Pipeline Marker
6195.6	6224.6	49.26296700	-122.90214600	5456693.85	507119.53	59.43	85	5.73	
6199.7	6229.8	49.26297983	-122.90219767	5456695.27	507115.77	58.88	43	1.94	east side of gagliardi way; concrete barrier; Paved Road
6218.2	6248.3	49.26298350	-122.90245208	5456695.66	507097.26	58.93	45	1.96	
6230.9	6261.0	49.26298350	-122.90262675	5456695.64	507084.55	58.93	45	2.23	median;
6241.8	6272.0	49.26298333	-122.90277683	5456695.61	507073.63	58.73	45	2.27	
6252.7	6282.9	49.26298442	-122.90292650	5456695.71	507062.74	58.23	47	2.33	west side of gagliardi way; Paved Road
6261.5	6291.8	49.26298526	-122.90304800	5456695.80	507053.90	59.86	43	1.42	
6279.3	6309.7	49.26298702	-122.90329295	5456695.97	507036.08	63.13	52	2.66	
6288.3	6318.7	49.26298791	-122.90341580	5456696.06	507027.14	64.78	55	3.42	used cps mode with locator through unsurveyable section;
6299.3	6329.8	49.26298900	-122.90356744	5456696.16	507016.11	66.81	56	4.63	
6300.0	6330.5	49.26298908	-122.90357667	5456696.17	507015.44	66.93	52	4.75	start of unsurveyable section: uncut brush and bb;
6304.1	6334.9	49.26299333	-122.90363217	5456696.64	507011.40	66.98	54	4.75	Pipeline Marker
6315.2	6346.1	49.26299450	-122.90378517	5456696.76	507000.27	66.63	61	3.53	Chain Link Fence
6321.2	6352.3	49.26299633	-122.90386742	5456696.95	506994.28	68.23	51	3.48	
6329.7	6360.9	49.26299958	-122.90398450	5456697.30	506985.76	69.18	50	3.33	
6339.0	6370.4	49.26300700	-122.90411233	5456698.11	506976.46	71.18	52	3.78	power pole;
6345.5	6376.9	49.26301842	-122.90419867	5456699.38	506970.18	72.88	53	4.57	bend; Pedestrian Path; Pipeline Marker
6359.7	6393.5	49.26295208	-122.90436617	5456691.99	506958.00	65.23	61	5.48	Pipeline Marker
6369.0	6402.9	49.26290308	-122.90446925	5456686.53	506950.51	66.33	59	5.16	
6377.2	6411.1	49.26285666	-122.90455764	5456681.36	506944.09	65.56	51	4.15	
6378.0	6412.0	49.26285200	-122.90456650	5456680.84	506943.44	65.48	56	4.31	
6386.1	6420.1	49.26280983	-122.90465658	5456676.15	506936.89	64.43	56	3.93	
6395.0	6429.0	49.26276043	-122.90475313	5456670.64	506929.88	64.48	50	3.95	Pipeline Marker
6395.4	6429.3	49.26275842	-122.90475700	5456670.42	506929.59	64.48	57	3.97	Pipeline Marker
6401.6	6435.6	49.26272558	-122.90482650	5456666.76	506924.54	64.03	58	4.18	
6409.5	6443.6	49.26268408	-122.90491508	5456662.14	506918.10	63.13	60	4.35	
6412.3	6446.5	49.26266940	-122.90494623	5456660.51	506915.84	62.82	52	4.70	
6417.7	6452.1	49.26264108	-122.90500633	5456657.35	506911.47	62.23	62	5.66	power pole;
6426.0	6460.4	49.26259562	-122.90509572	5456652.29	506904.97	61.90	63	6.44	Pipeline Marker
6431.1	6466.3	49.26256697	-122.90515209	5456649.10	506900.88	61.69	52	3.43	Creek
6440.3	6475.5	49.26251663	-122.90525111	5456643.50	506893.68	61.33	52	4.06	

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Exposed Pipe / Coating Anomaly
CP Test Stations / Valves

E-MAC CORROSION INC.

Survey Distance		WGS 84		NAD 83 Canada UTM - Zone 11		MSL Ground Elevation	Residual Current	Pipeline Depth-of-Cover	Notes / Comments
Horizontal (m)	3D Ground (m)	Latitude DD.ddddddd	Longitude DD.ddddddd	Northing (m)	Easting (m)	(m)	(mA)	(m)	
6453.1	6488.3	49.26244608	-122.90538991	5456635.64	506883.59	60.82	48	3.20	
6466.6	6501.8	49.26237162	-122.90553639	5456627.35	506872.94	60.28	54	3.81	Pipeline Marker
6467.8	6503.1	49.26236450	-122.90555025	5456626.56	506871.93	60.23	63	3.72	start of unsurveyable section: uncut brush and bb; Pipeline Marker
6472.3	6507.6	49.26234408	-122.90560333	5456624.28	506868.07	60.33	63	3.83	
6480.4	6515.6	49.26229758	-122.90568825	5456619.10	506861.90	60.33	64	3.73	power pole;
6485.7	6521.0	49.26227017	-122.90574892	5456616.05	506857.49	60.43	66	3.86	
6494.9	6530.1	49.26222233	-122.90585083	5456610.72	506850.08	60.28	62	3.64	
6504.2	6539.5	49.26217225	-122.90595467	5456605.15	506842.54	60.43	65	3.66	kinder morgan crossing; Below Ground Pipe
6512.5	6547.7	49.26212642	-122.90604350	5456600.04	506836.08	60.23	62	3.38	
6522.2	6557.4	49.26207508	-122.90615133	5456594.33	506828.24	59.68	60	3.32	
6530.5	6565.8	49.26202658	-122.90623900	5456588.93	506821.87	59.98	60	2.98	power pole;
6539.2	6574.5	49.26198350	-122.90633814	5456584.13	506814.66	59.75			row native grass from last rd crossing; confirm with google earth;
6539.8	6575.1	49.26198058	-122.90634492	5456583.80	506814.17	59.73	60	2.79	
6548.7	6584.0	49.26193108	-122.90644142	5456578.29	506807.15	59.13	59	2.52	
6559.1	6594.4	49.26187525	-122.90655567	5456572.07	506798.85	58.58	57	2.14	
6569.0	6604.3	49.26181900	-122.90666208	5456565.81	506791.11	58.23	56	2.06	
6578.1	6613.4	49.26177450	-122.90676642	5456560.86	506783.53	57.98	56	2.07	
6585.1	6620.4	49.26173742	-122.90684392	5456556.73	506777.90	57.73	57	2.33	power pole;
6592.9	6628.3	49.26169267	-122.90692783	5456551.74	506771.80	57.33	58	2.47	
6602.3	6637.6	49.26164700	-122.90703525	5456546.66	506763.99	57.13	58	2.66	
6612.7	6648.1	49.26159050	-122.90715008	5456540.37	506755.64	56.78	58	2.54	
6621.3	6656.6	49.26154275	-122.90724258	5456535.05	506748.92	56.63	58	2.33	
6631.2	6666.5	49.26148708	-122.90734842	5456528.85	506741.22	56.03	58	2.07	
6641.9	6677.3	49.26143300	-122.90747125	5456522.83	506732.29	55.33	58	2.01	power pole; Pipeline Marker
6651.2	6686.5	49.26138468	-122.90757430	5456517.45	506724.80	55.03	58	2.06	
6663.5	6698.9	49.26131916	-122.90771074	5456510.15	506714.88	55.13	57	2.05	
6674.5	6709.9	49.26126058	-122.90783269	5456503.63	506706.02	54.68	57	1.99	
6682.5	6717.9	49.26121733	-122.90792158	5456498.81	506699.56	54.33	57	1.96	power pole;
6686.8	6722.2	49.26119517	-122.90797000	5456496.34	506696.04	54.33	57	1.90	
6696.0	6731.4	49.26114617	-122.90807175	5456490.89	506688.64	54.48	58	2.10	
6705.9	6741.3	49.26109375	-122.90818158	5456485.05	506680.66	53.93	58	1.85	
6716.1	6751.5	49.26103558	-122.90828958	5456478.57	506672.81	53.53	58	1.77	
6727.0	6762.4	49.26097283	-122.90840442	5456471.59	506664.46	53.23	57	1.69	Pipeline Marker
6745.5	6781.0	49.26092975	-122.90865075	5456466.78	506646.54	52.63	58	1.76	bb;
6754.8	6790.3	49.26090115	-122.90877098	5456463.59	506637.80	52.43	58	1.68	
6764.0	6799.4	49.26087485	-122.90888976	5456460.65	506629.16	52.98	58	1.48	

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E-MAC CORROSION INC.

Survey Distance		WGS 84		NAD 83 Canada UTM - Zone 11		MSL Ground Elevation	Residual Current	Pipeline Depth-of-Cover	Notes / Comments
Horizontal (m)	3D Ground (m)	Latitude DD.ddddddd	Longitude DD.ddddddd	Northing (m)	Easting (m)	(m)	(mA)	(m)	
6772.2	6807.6	49.26085120	-122.90899655	5456458.01	506621.39	53.23	57	1.48	power pole;
6783.4	6818.8	49.26081892	-122.90914250	5456454.41	506610.78	53.88	61	1.92	bend; Pipeline Marker
6792.2	6827.7	49.26080677	-122.90926284	5456453.05	506602.02	55.06	60	2.44	power crossing; Pipeline Marker; Overhead Cables
6798.2	6834.3	49.26080458	-122.90934430	5456452.80	506596.10	57.73	58	2.34	2-Track or Trail
6811.5	6850.1	49.26079972	-122.90952716	5456452.24	506582.79	49.36	57	2.44	Pipeline Marker
6820.2	6859.2	49.26080651	-122.90964675	5456452.99	506574.09	52.03	55	2.47	
6830.5	6869.7	49.26081453	-122.90978720	5456453.87	506563.87	53.46	53	1.82	Pedestrian Path; Pipeline Marker
6835.4	6874.6	49.26081837	-122.90985437	5456454.29	506558.98	53.46	53	1.60	east side of production way;
6841.4	6881.1	49.26082275	-122.90993625	5456454.77	506553.02	56.13	52	1.56	
6850.9	6890.7	49.26082655	-122.91006735	5456455.18	506543.48	57.18	53	1.87	end of median;
6855.1	6894.9	49.26082820	-122.91012428	5456455.36	506539.34	56.48	53	1.92	Pipeline Marker
6861.8	6901.7	49.26083088	-122.91021672	5456455.65	506532.62	55.83	53	1.73	median;
6870.0	6912.1	49.26083414	-122.91032949	5456456.00	506524.41	62.31	54	1.72	
6886.7	6928.9	49.26084077	-122.91055854	5456456.72	506507.74	63.98	54	1.98	
6896.7	6938.9	49.26084475	-122.91069600	5456457.15	506497.74	64.08	58	2.34	
6908.0	6950.7	49.26084257	-122.91085071	5456456.89	506486.48	60.56	62	2.32	
6915.5	6958.4	49.26084127	-122.91095449	5456456.74	506478.93	62.23	73	2.38	
6925.6	6969.0	49.26083959	-122.91109284	5456456.54	506468.87	65.18	63	2.03	
6936.8	6980.8	49.26083771	-122.91124677	5456456.32	506457.67	61.46	70	1.95	
6944.3	6988.8	49.26083642	-122.91135075	5456456.17	506450.10	64.13	70	1.95	
6953.9	6998.3	49.26083358	-122.91148133	5456455.84	506440.60	64.23	74	2.10	
6962.1	7006.6	49.26083117	-122.91159467	5456455.56	506432.36	64.83	78	2.35	
6971.1	7015.7	49.26082850	-122.91171883	5456455.26	506423.32	63.63	81	2.50	
6979.2	7023.8	49.26082692	-122.91182950	5456455.07	506415.27	64.03	87	2.57	
6987.7	7032.3	49.26082708	-122.91194700	5456455.08	506406.72	64.63	88	2.73	
6997.5	7042.1	49.26083025	-122.91208092	5456455.42	506396.98	65.13	99	2.97	
7006.5	7051.1	49.26082942	-122.91220400	5456455.32	506388.02	65.93	99	3.15	
7015.4	7060.1	49.26083008	-122.91232742	5456455.38	506379.04	66.63	101	3.12	
7024.3	7068.9	49.26082892	-122.91244867	5456455.24	506370.22	67.03	101	2.98	
7033.2	7077.8	49.26083075	-122.91257092	5456455.43	506361.32	67.33	113	3.17	
7042.0	7086.7	49.26082833	-122.91269233	5456455.16	506352.49	67.88	120	3.27	
7051.0	7095.7	49.26083167	-122.91281667	5456455.52	506343.44	68.33	127	3.57	
7058.7	7103.4	49.26082800	-122.91292142	5456455.10	506335.82	68.83	127	3.54	
7068.4	7113.1	49.26082575	-122.91305533	5456454.84	506326.08	69.18	131	3.45	
7077.7	7122.4	49.26082558	-122.91318333	5456454.81	506316.77	69.63	126	3.45	
7087.3	7132.0	49.26082675	-122.91331433	5456454.93	506307.23	70.03	115	3.21	

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Survey Distance		WGS 84		NAD 83 Canada UTM - Zone 11		MSL Ground Elevation	Residual Current	Pipeline Depth-of-	
Horizontal (m)	3D Ground (m)	Latitude DD.ddddddd	Longitude DD.ddddddd	Northing (m)	Easting (m)	(m)	(mA)	Cover (m)	Notes / Comments
7097.0	7141.7	49.26082608	-122.91344817	5456454.84	506297.50	70.33	141	3.77	
7106.4	7151.1	49.26082500	-122.91357733	5456454.71	506288.10	70.73	143	3.71	
7116.2	7160.9	49.26082767	-122.91371200	5456455.00	506278.30	71.13	157	4.11	
7126.3	7171.0	49.26082717	-122.91385058	5456454.93	506268.22	71.43	161	4.15	
7135.2	7180.0	49.26082283	-122.91397342	5456454.44	506259.28	71.63	168	4.25	
7145.1	7189.8	49.26082358	-122.91410900	5456454.51	506249.42	71.93	171	4.31	
7155.2	7200.0	49.26082325	-122.91424833	5456454.46	506239.28	72.23	180	4.01	
7166.0	7210.8	49.26082775	-122.91439592	5456454.95	506228.54	72.53	178	3.78	
7175.5	7220.3	49.26082750	-122.91452600	5456454.91	506219.07	72.93	173	3.61	
7185.5	7230.3	49.26083267	-122.91466342	5456455.47	506209.07	73.48	187	3.99	median;
7200.6	7245.4	49.26082717	-122.91487142	5456454.84	506193.94	73.73	180	3.54	end of parallel pathway; west side of production way; plm
7206.1	7251.0	49.26083167	-122.91494700	5456455.34	506188.44	73.03	174	2.12	IOL plm; Pipeline Marker
7213.7	7259.1	49.26082939	-122.91505128	5456455.08	506180.85	70.11	181	1.87	gate post; Pipe Fence
7221.8	7267.6	49.26082917	-122.91516250	5456455.04	506172.76	72.78	176	1.70	
7230.7	7276.5	49.26083083	-122.91528383	5456455.22	506163.93	72.73	176	1.76	power pole;
7239.4	7285.2	49.26083183	-122.91540333	5456455.32	506155.24	72.93	178	1.88	
7248.8	7294.6	49.26083075	-122.91553317	5456455.19	506145.79	73.43	177	1.98	
7258.2	7304.0	49.26082758	-122.91566192	5456454.83	506136.42	73.73	175	1.96	
7268.0	7313.8	49.26082775	-122.91579658	5456454.83	506126.63	73.33	180	1.99	power pole;
7274.3	7320.2	49.26082967	-122.91588392	5456455.04	506120.27	72.83	190	2.10	
7284.4	7330.3	49.26083375	-122.91602183	5456455.48	506110.24	72.43	210	2.88	
7294.2	7340.1	49.26083125	-122.91615642	5456455.19	506100.44	72.63	215	3.44	
7304.5	7350.6	49.26082967	-122.91629808	5456455.01	506090.14	73.38	190	2.19	
7313.6	7359.8	49.26082608	-122.91642383	5456454.60	506080.99	74.43	190	2.16	
7323.0	7369.2	49.26082575	-122.91655200	5456454.55	506071.66	75.43	189	1.97	Pipeline Marker
7329.8	7376.1	49.26082458	-122.91664617	5456454.41	506064.81	76.13	188	1.79	power pole;
7339.2	7385.6	49.26082567	-122.91677558	5456454.52	506055.39	76.73	190	1.70	
7348.6	7395.0	49.26082608	-122.91690483	5456454.56	506045.99	77.43	190	1.61	
7358.4	7404.8	49.26082708	-122.91703925	5456454.66	506036.21	78.38	190	1.72	
7367.7	7414.1	49.26082617	-122.91716667	5456454.55	506026.94	79.18	191	1.92	
7377.1	7423.6	49.26082533	-122.91729633	5456454.45	506017.51	80.03	195	2.37	
7387.5	7433.9	49.26082708	-122.91743842	5456454.63	506007.17	81.03	205	3.12	power pole;
7396.8	7443.3	49.26082975	-122.91756717	5456454.91	505997.80	81.83	208	3.54	
7405.2	7451.6	49.26083183	-122.91768175	5456455.14	505989.46	82.93	221	4.47	
7414.8	7461.3	49.26083092	-122.91781433	5456455.02	505979.81	84.13	231	5.52	
7423.7	7470.2	49.26082700	-122.91793642	5456454.58	505970.93	84.93	240	6.18	

FORTIS BC

FORTIS BC
508mm (NPS 20) COQUITLAM - VANCOUVER
INTERMEDIATE PRESSURE PIPELINE
DEPTH-OF-COVER (DOC) SURVEY DATA
2012

CLASSIFICATIONS:
0.75m to 1.20m
Less than 0.75m
Exposed Pipe / Coating Anomaly
CP Test Stations / Valves

E-MAC CORROSION INC.

Survey Distance		WGS 84		NAD 83 Canada UTM - Zone 11		MSL Ground Elevation	Residual Current	Pipeline Depth-of-Cover	Notes / Comments
Horizontal (m)	3D Ground (m)	Latitude DD.dddddd	Longitude DD.dddddd	Northing (m)	Easting (m)	(m)	(mA)	(m)	
7433.0	7479.5	49.26082683	-122.91806458	5456454.55	505961.61	85.33	245	6.66	
7442.1	7488.6	49.26082875	-122.91818958	5456454.75	505952.51	85.73	249	6.85	
7451.5	7498.0	49.26083033	-122.91831875	5456454.92	505943.11	86.23	245	6.57	power pole;
7458.9	7505.4	49.26082800	-122.91841942	5456454.65	505935.79	86.23	245	6.25	Pipeline Marker
7466.0	7512.5	49.26083325	-122.91851750	5456455.23	505928.65	86.13	234	5.71	
7476.2	7522.8	49.26083067	-122.91865725	5456454.93	505918.48	86.03	224	4.76	
7484.7	7531.3	49.26083000	-122.91877458	5456454.85	505909.95	85.73	222	4.42	
7494.3	7540.8	49.26083025	-122.91890567	5456454.86	505900.41	85.63	214	3.71	
7504.4	7551.0	49.26083092	-122.91904467	5456454.93	505890.30	85.23	205	3.04	
7513.9	7560.4	49.26082775	-122.91917492	5456454.57	505880.82	84.88	205	2.59	end of unsurveyable section;
7563.8	7610.4	49.26081775	-122.91986067	5456453.40	505830.93	85.13	188	0.75	2-Track or Trail
7569.3	7616.1	49.26081892	-122.91993665	5456453.53	505825.40	84.32	200	1.28	Pipeline Marker
7585.0	7632.3	49.26082226	-122.92015188	5456453.88	505809.74	82.04	200	3.34	Pipeline Marker
7590.1	7637.7	49.26082336	-122.92022278	5456454.00	505804.58	81.29	200	1.01	Base of Hill; Creek
7600.7	7649.7	49.26082559	-122.92036732	5456454.23	505794.06	79.75	200	5.15	Pipeline Marker; Crest of Hill
7608.0	7657.2	49.26082717	-122.92046817	5456454.40	505786.72	78.68	200	2.34	2-Track or Trail
7619.4	7669.6	49.26083617	-122.92062440	5456455.39	505775.35	83.90	200	2.75	Pipeline Marker
7620.5	7670.8	49.26083700	-122.92063858	5456455.48	505774.32	84.38	197	2.73	start of unsurveyable section: uncut brush and bb; Pipeline Marker
7629.0	7679.9	49.26082692	-122.92075450	5456454.35	505765.89	86.33	187	1.42	power pole;
7637.5	7689.0	49.26082342	-122.92087158	5456453.95	505757.37	86.63	220	5.04	
7648.0	7699.6	49.26082658	-122.92101633	5456454.29	505746.84	88.73	245	7.88	
7656.7	7708.2	49.26083500	-122.92113450	5456455.22	505738.24	89.73	245	9.01	
7664.7	7716.3	49.26083883	-122.92124500	5456455.64	505730.20	90.53	242	9.72	
7674.0	7725.6	49.26083658	-122.92137250	5456455.38	505720.92	90.78	249	10.70	
7682.8	7734.5	49.26084250	-122.92149308	5456456.03	505712.15	90.83	233	9.78	plm 5m south; Pipeline Marker
7693.4	7745.1	49.26083875	-122.92163908	5456455.60	505701.53	90.38	233	9.51	power pole;
7705.4	7757.1	49.26084143	-122.92180328	5456455.89	505689.58	89.53	229	9.21	
7714.4	7766.0	49.26084342	-122.92192683	5456456.10	505680.59	88.53	227	8.05	
7722.5	7774.2	49.26084092	-122.92203825	5456455.81	505672.48	87.98	215	7.06	
7731.7	7783.4	49.26083708	-122.92216533	5456455.38	505663.24	87.93	215	6.42	
7741.9	7793.6	49.26084191	-122.92230461	5456455.90	505653.10	87.23	211	5.74	
7752.6	7804.4	49.26084692	-122.92245108	5456456.45	505642.44	85.13	208	5.25	power pole; 3m back;
7761.2	7813.1	49.26084757	-122.92257029	5456456.51	505633.77	84.73	202	4.78	
7771.3	7823.1	49.26084825	-122.92270867	5456456.58	505623.70	83.88	196	4.15	
7780.7	7832.6	49.26084033	-122.92283683	5456455.69	505614.38	84.63	196	3.69	
7790.1	7842.0	49.26084156	-122.92296670	5456455.81	505604.93	83.93	198	3.41	start of parallel pathway; Pedestrian Path

FORTIS BC

FORTIS BC
508mm (NPS 20) COQUITLAM - VANCOUVER
INTERMEDIATE PRESSURE PIPELINE
DEPTH-OF-COVER (DOC) SURVEY DATA
2012

CLASSIFICATIONS:
0.75m to 1.20m
Less than 0.75m
Exposed Pipe / Coating Anomaly
CP Test Stations / Valves

E-MAC CORROSION INC.

Survey Distance		WGS 84		NAD 83 Canada UTM - Zone 11		MSL Ground Elevation	Residual Current	Pipeline Depth-of-	
Horizontal (m)	3D Ground (m)	Latitude DD.ddddddd	Longitude DD.ddddddd	Northing (m)	Easting (m)	(m)	(mA)	Cover (m)	Notes / Comments
7799.1	7851.1	49.26084267	-122.92309067	5456455.93	505595.91	83.23	189	2.35	
7808.5	7860.4	49.26084026	-122.92321910	5456455.65	505586.56	82.43	183	1.80	
7817.5	7869.4	49.26083792	-122.92334225	5456455.38	505577.60	81.83	178	1.45	power pole; Pipeline Marker
7826.6	7878.7	49.26082948	-122.92346755	5456454.43	505568.49	80.13	176	1.51	end of unsurveyable section;
7828.5	7880.6	49.26082773	-122.92349350	5456454.24	505566.60	80.19	177	1.36	
7842.2	7894.4	49.26082697	-122.92368215	5456454.14	505552.87	80.62	179	3.04	Pipeline Marker
7853.2	7905.5	49.26082636	-122.92383203	5456454.06	505541.97	80.97	181	1.47	Creek
7860.4	7912.8	49.26082596	-122.92393137	5456454.01	505534.74	81.19	185	2.51	
7869.8	7922.2	49.26082544	-122.92406026	5456453.94	505525.36	81.49	188	4.05	use of cps mode with locator through old unsurveyable section; plm
7883.7	7936.3	49.26082530	-122.92425258	5456453.91	505511.37	81.93	188	3.05	power pole; start of unsurveyable section: uncut brush and bb; plm
7888.8	7941.4	49.26082525	-122.92432242	5456453.90	505506.29	82.33	186	3.08	end of parallel pathway;
7897.9	7950.5	49.26082365	-122.92444729	5456453.71	505497.20	82.98	185	3.54	
7906.8	7959.3	49.26082208	-122.92456925	5456453.53	505488.33	83.63	186	4.27	
7916.7	7969.2	49.26081192	-122.92470392	5456452.39	505478.53	83.63	186	4.60	
7925.7	7978.3	49.26081408	-122.92482817	5456452.62	505469.49	83.73	198	4.78	
7934.8	7987.3	49.26082169	-122.92495208	5456453.46	505460.47	83.78	197	4.68	power pole;
7942.2	7994.8	49.26082800	-122.92505417	5456454.15	505453.05	83.53	190	4.42	
7952.2	8004.8	49.26082728	-122.92519156	5456454.06	505443.05	82.68	191	3.87	
7961.7	8014.2	49.26082658	-122.92532158	5456453.98	505433.59	81.73	190	3.08	
7971.7	8024.2	49.26082624	-122.92545873	5456453.93	505423.61	80.93	193	2.52	Pipeline Marker
7979.0	8031.6	49.26082600	-122.92555992	5456453.89	505416.25	80.43	194	2.21	
7987.9	8040.5	49.26081958	-122.92568175	5456453.17	505407.38	79.83	195	2.07	
7997.4	8050.0	49.26082081	-122.92581233	5456453.30	505397.88	79.23	195	1.88	power pole;
8007.7	8060.3	49.26082217	-122.92595408	5456453.44	505387.57	78.53	197	1.58	
8016.8	8069.4	49.26082375	-122.92607875	5456453.61	505378.50	77.93	197	1.43	
8025.6	8078.2	49.26082517	-122.92619942	5456453.76	505369.72	77.63	208	1.61	
8035.3	8087.9	49.26082650	-122.92633250	5456453.90	505360.04	77.43	215	1.82	
8044.6	8097.3	49.26082683	-122.92646125	5456453.92	505350.67	77.23	233	2.24	
8054.2	8106.8	49.26082892	-122.92659225	5456454.15	505341.14	76.93	222	2.11	power pole; rectifier & groundbed loc;
8061.1	8113.7	49.26083267	-122.92668717	5456454.56	505334.23	76.83	245	1.98	
8070.3	8122.9	49.26083100	-122.92681375	5456454.36	505325.02	76.73	235	1.91	
8078.9	8131.6	49.26082983	-122.92693258	5456454.22	505316.37	76.53	240	1.84	
8088.0	8140.6	49.26082991	-122.92705673	5456454.22	505307.34	76.23	240	1.51	
8096.5	8149.2	49.26083039	-122.92717450	5456454.27	505298.77	76.28	252	1.92	
8106.4	8159.1	49.26083092	-122.92731000	5456454.32	505288.91	76.33	274	2.05	
8116.4	8169.1	49.26083177	-122.92744728	5456454.40	505278.92	76.83	258	1.57	concrete barrier; power pole;

FORTIS BC

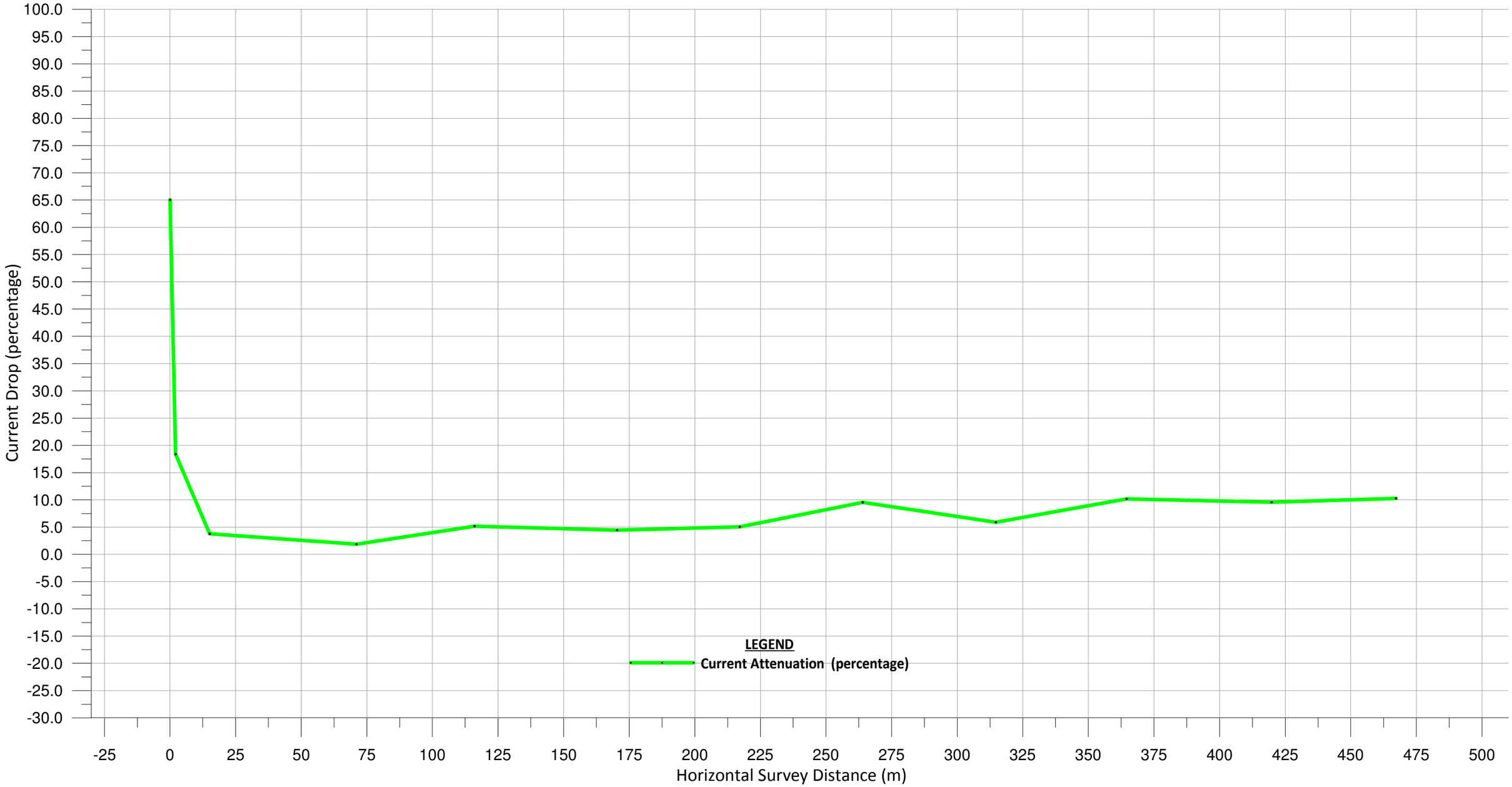
FORTIS BC
508mm (NPS 20) COQUITLAM - VANCOUVER
INTERMEDIATE PRESSURE PIPELINE
DEPTH-OF-COVER (DOC) SURVEY DATA
2012

CLASSIFICATIONS:
0.75m to 1.20m
Less than 0.75m
Exposed Pipe / Coating Anomaly
CP Test Stations / Valves

E-MAC CORROSION INC.

Survey Distance		WGS 84		NAD 83 Canada UTM - Zone 11		MSL Ground Elevation	Residual Current	Pipeline Depth-of-	
Horizontal (m)	3D Ground (m)	Latitude DD.ddddddd	Longitude DD.ddddddd	Northing (m)	Easting (m)	(m)	(mA)	Cover (m)	Notes / Comments
8121.1	8173.8	49.26083215	-122.92751173	5456454.44	505274.23	77.33	258	1.74	start of parallel pathway; Pedestrian Path
8125.8	8178.5	49.26083254	-122.92757608	5456454.48	505269.55	77.43			
8126.7	8179.4	49.26083261	-122.92758882	5456454.49	505268.62	77.53			new test post connection; start of eb/wb run;
8135.3	8188.0	49.26083332	-122.92770654	5456454.56	505260.06	77.83	390	1.85	start of eb run; c/l of underhill ave; tx here; 1000mA;
8369.1	8422.0	49.26083900	-122.93091817	5456454.97	505026.38	80.53			End Survey at West edge of Shellmont

APPENDIX 5
AC CURRENT ATTENUATION (ACCA) SURVEY DATA
508mm (NPS 20) TP Pipeline
Coquitlam to Vancouver, Coastal (BC)
2012



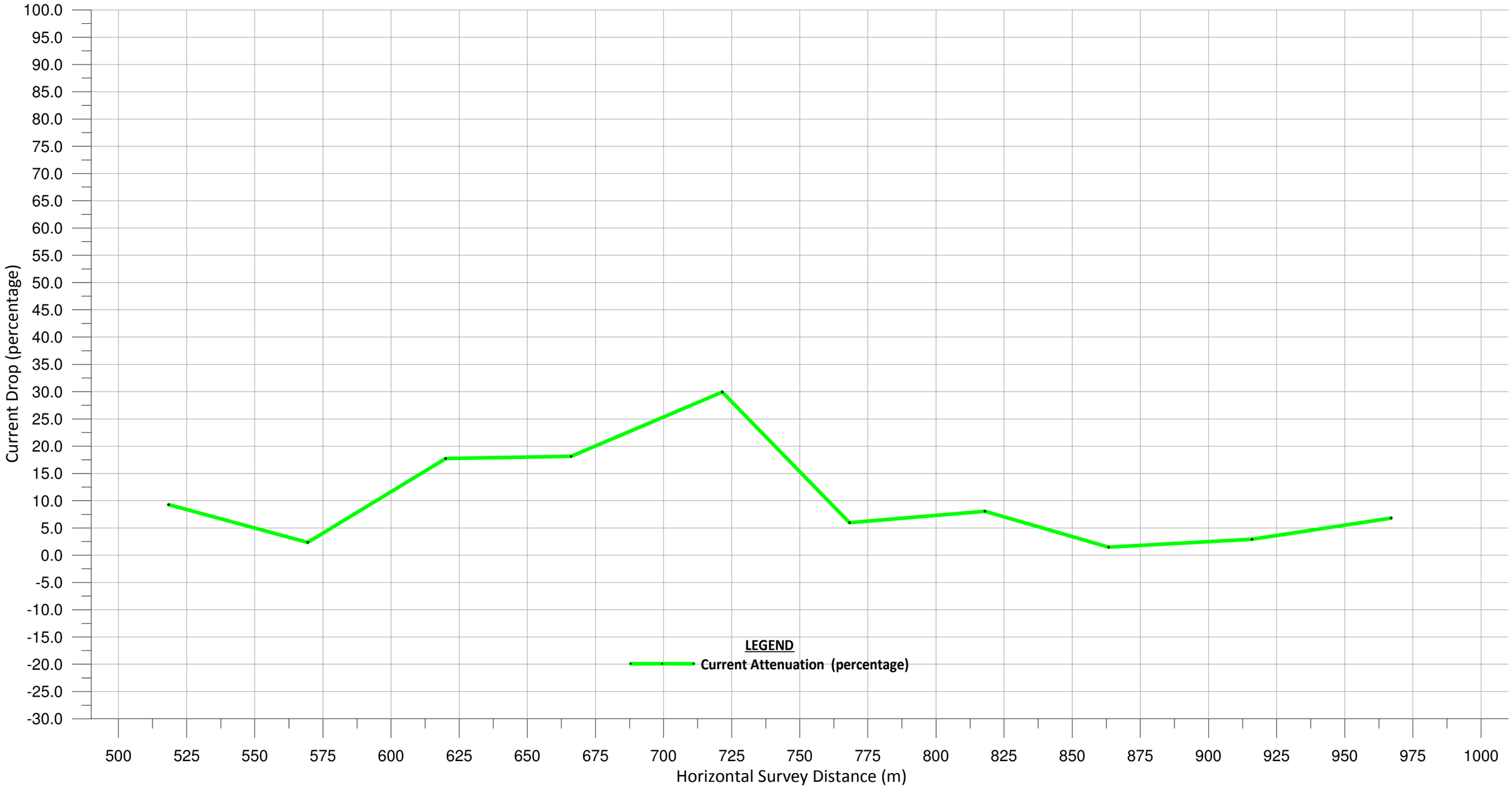
Notes:
The Coquitlam - Vancouver IP ACCA survey was completed in August 2012. The current was supplied utilizing a Spectrum XLI 100 watt 512 Hz Transmitter.

E-MAC CORROSION INC.
Ph. (780) 444-EMAC (3622) Fax. (780) 466-3658
Designed By: RAB
Drawn By: RAB

Project:
Fortis BC
508mm (NPS 20) Pipeline
Coquitlam - Vancouver IP, Coastal (BC)
AC Current Attenuation Profile
2012

FORTIS BC™

Dwg. #: 508-CVIP-ACCA-001		Sheet: 1 of 17
Date: December 6, 2012		
Scale:		
No.	Revision / Issue	Date



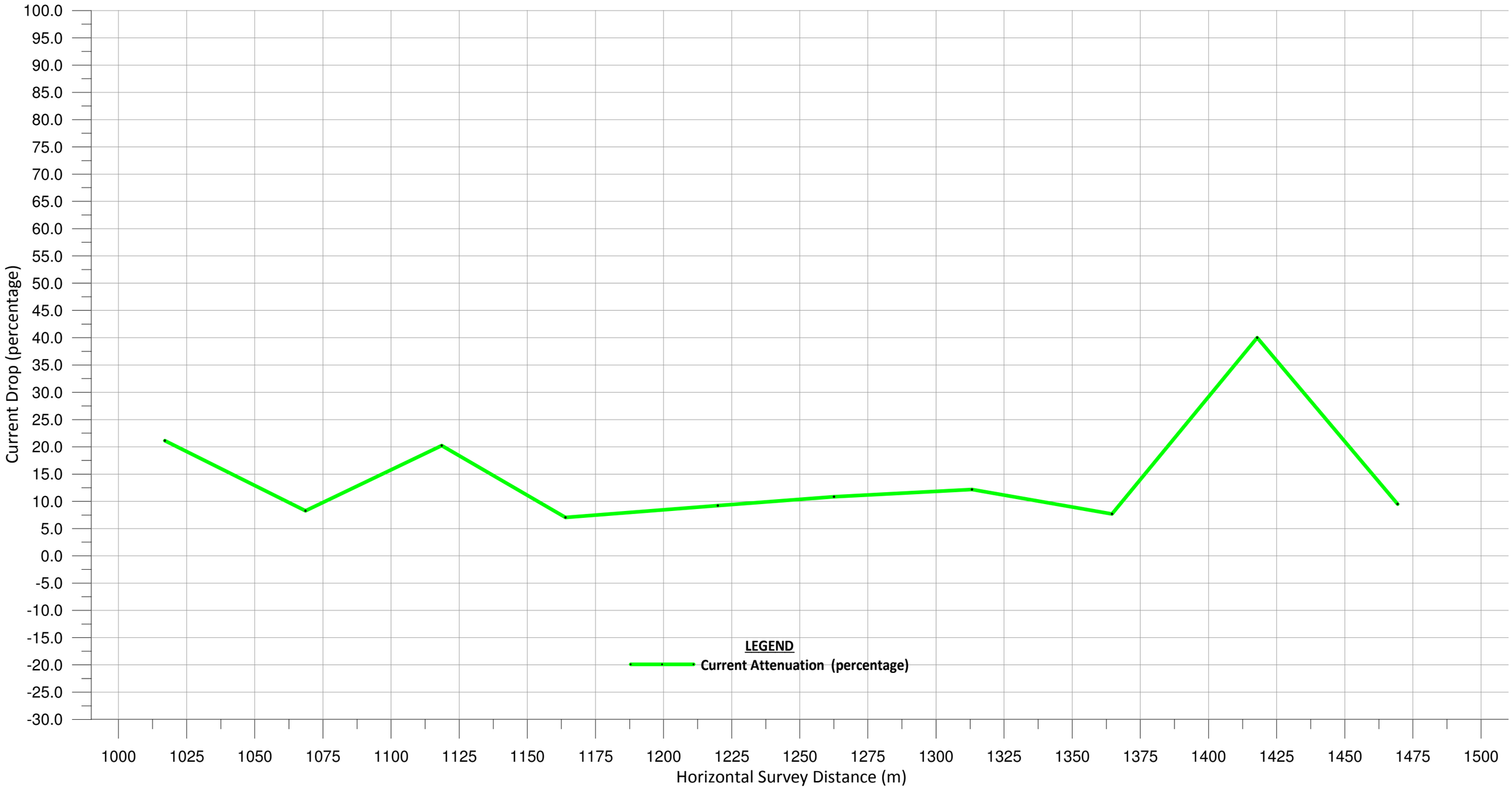
Notes:
The Coquitlam - Vancouver IP ACCA survey was completed in August 2012. The current was supplied utilizing a Spectrum XLI 100 watt 512 Hz Transmitter.

E-MAC CORROSION INC.
Ph. (780) 444-EMAC (3622) Fax. (780) 466-3658
Designed By: RAB
Drawn By: RAB

Project:
Fortis BC
508mm (NPS 20) Pipeline
Coquitlam - Vancouver IP, Coastal (BC)
AC Current Attenuation Profile
2012

FORTIS BC™

Dwg. #: 508-CVIP-ACCA-002		Sheet: 2 of 17
Date: December 6, 2012		
Scale:		
No.	Revision / Issue	Date



Notes:
The Coquitlam - Vancouver IP ACCA survey was completed in August 2012. The current was supplied utilizing a Spectrum XLI 100 watt 512 Hz Transmitter.

E-MAC CORROSION INC.
Ph. (780) 444-EMAC (3622) Fax. (780) 466-3658
Designed By: RAB
Drawn By: RAB

Project:
Fortis BC
508mm (NPS 20) Pipeline
Coquitlam - Vancouver IP, Coastal (BC)
AC Current Attenuation Profile
2012

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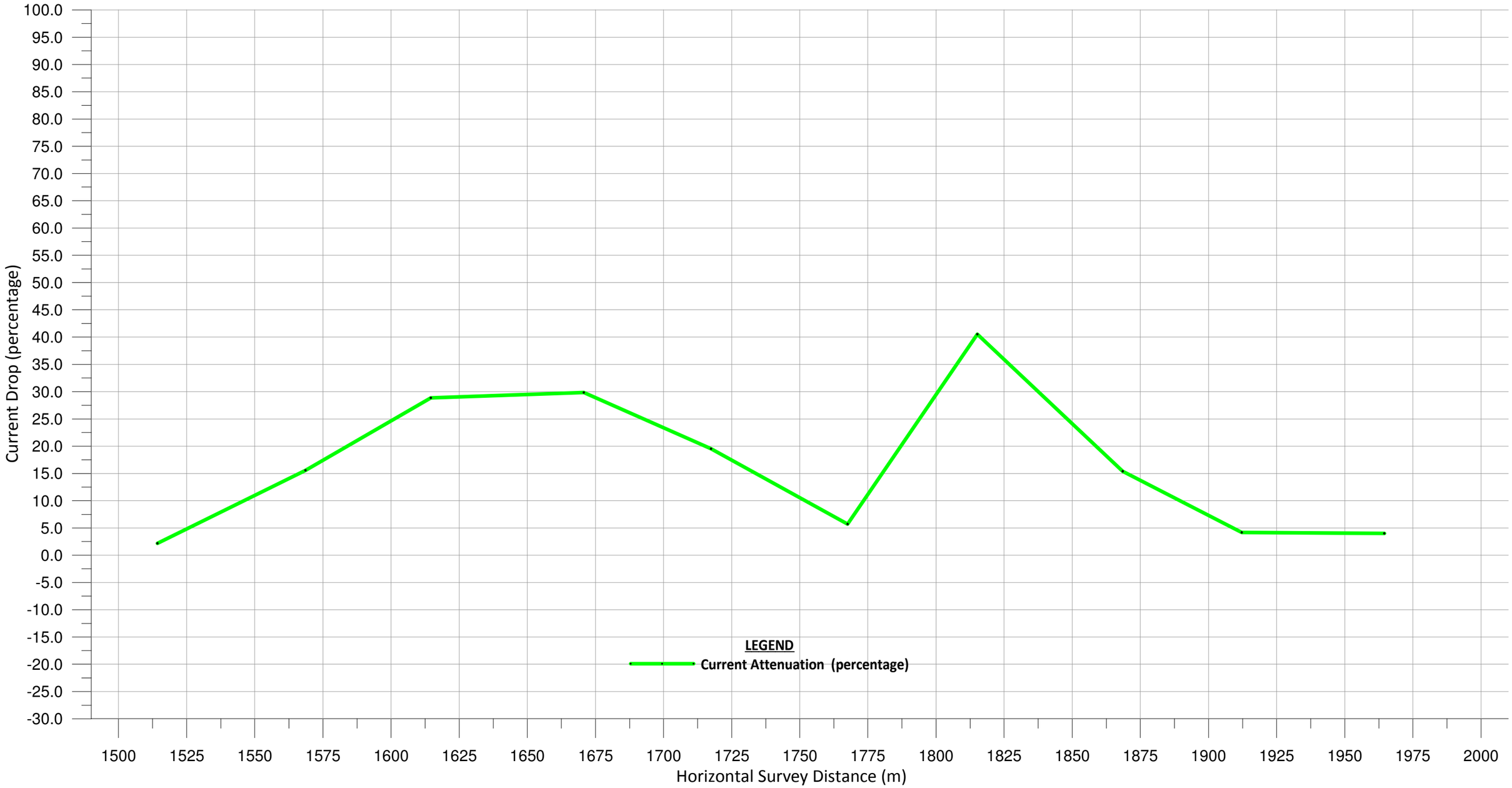
Dwg. #: 508-CVIP-ACCA-003		Sheet: 3 of 17
Date: December 6, 2012		
Scale:		
No.	Revision / Issue	Date



Notes:
The Coquitlam - Vancouver IP ACCA survey was completed in August 2012. The current was supplied utilizing a Spectrum XLI 100 watt 512 Hz Transmitter.

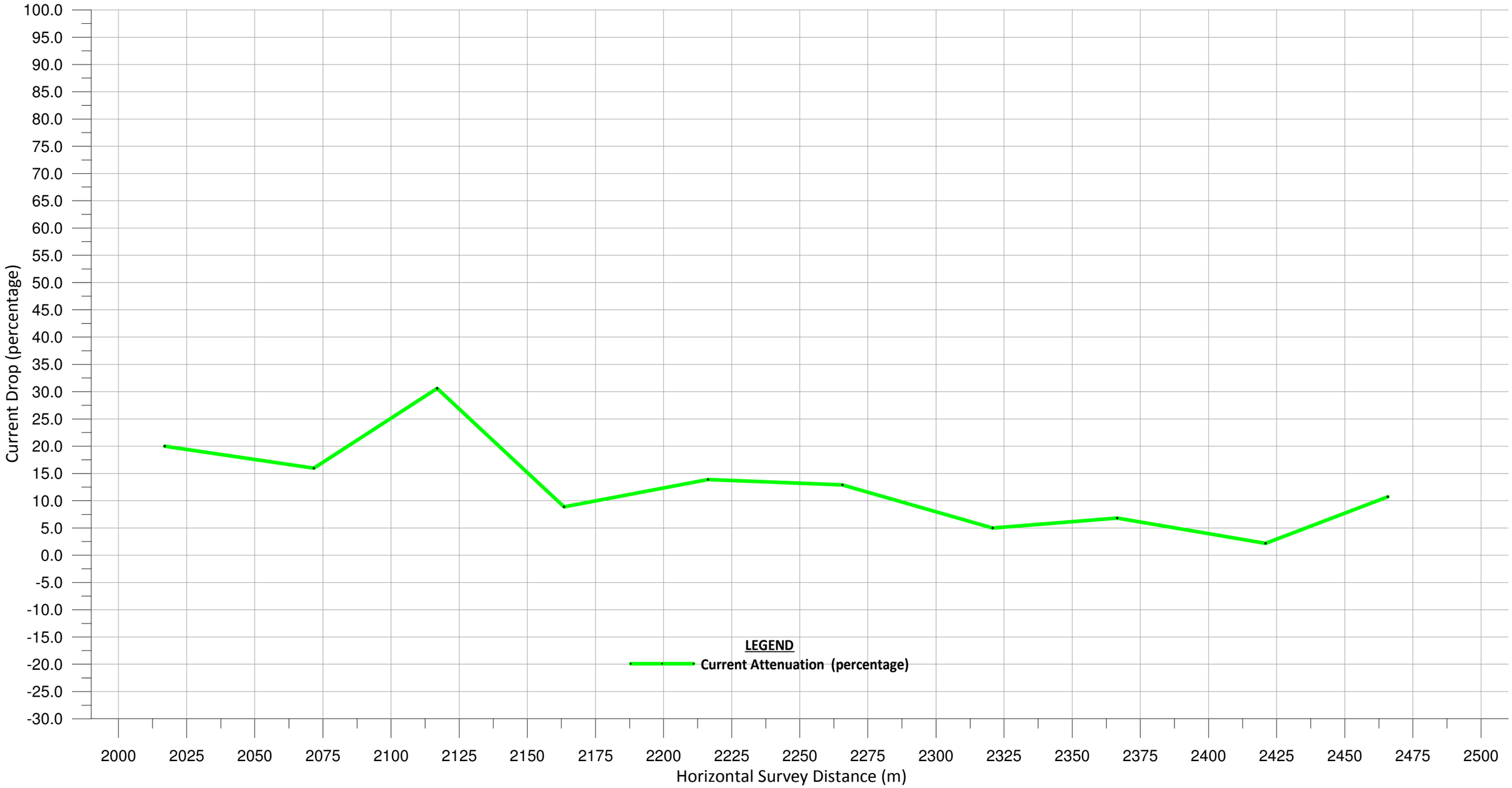
E-MAC CORROSION INC.
Ph. (780) 444-EMAC (3622) Fax. (780) 466-3658
Designed By: RAB
Drawn By: RAB

Project:
Fortis BC
508mm (NPS 20) Pipeline
Coquitlam - Vancouver IP, Coastal (BC)
AC Current Attenuation Profile
2012

FORTIS BC™

Dwg. #: 508-CVIP-ACCA-004	Sheet: 4 of 17
Date: December 6, 2012	
Scale:	

No.	Revision / Issue	Date



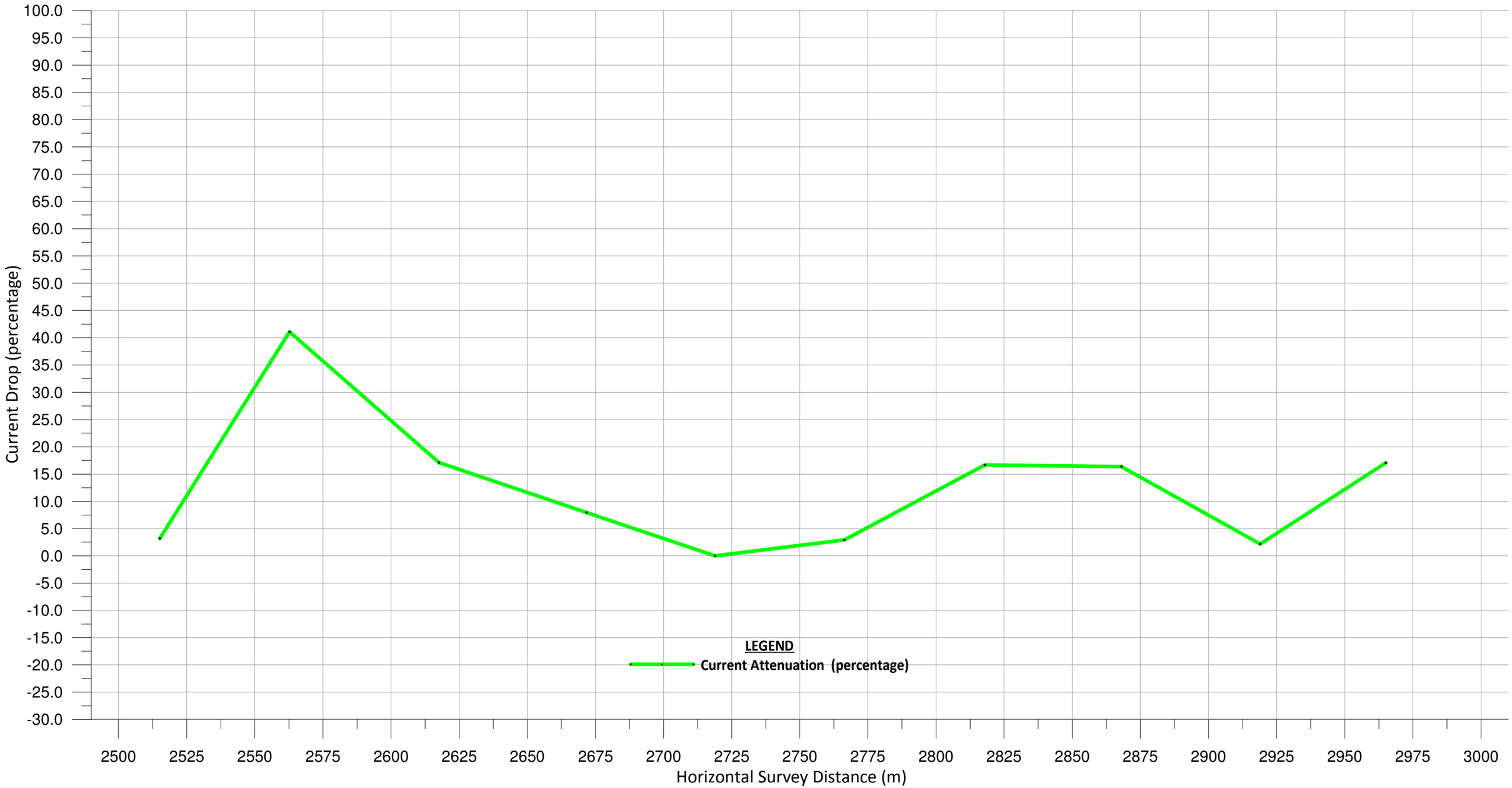
Notes:
The Coquitlam - Vancouver IP ACCA survey was completed in August 2012. The current was supplied utilizing a Spectrum XLI 100 watt 512 Hz Transmitter.

E-MAC CORROSION INC.
Ph. (780) 444-EMAC (3622) Fax. (780) 466-3658
Designed By: RAB
Drawn By: RAB

Project:
Fortis BC
508mm (NPS 20) Pipeline
Coquitlam - Vancouver IP, Coastal (BC)
AC Current Attenuation Profile
2012

FORTIS BC™

Dwg. #: 508-CVIP-ACCA-005		Sheet: 5 of 17
Date: December 6, 2012		
Scale:		
No.	Revision / Issue	Date



Notes:
The Coquitlam - Vancouver IP ACCA survey was completed in August 2012. The current was supplied utilizing a Spectrum XLI 100 watt 512 Hz Transmitter.

E-MAC CORROSION INC.
Ph. (780) 444-EMAC (3622) Fax. (780) 466-3658
Designed By: RAB
Drawn By: RAB

Project:
Fortis BC
508mm (NPS 20) Pipeline
Coquitlam - Vancouver IP, Coastal (BC)
AC Current Attenuation Profile
2012

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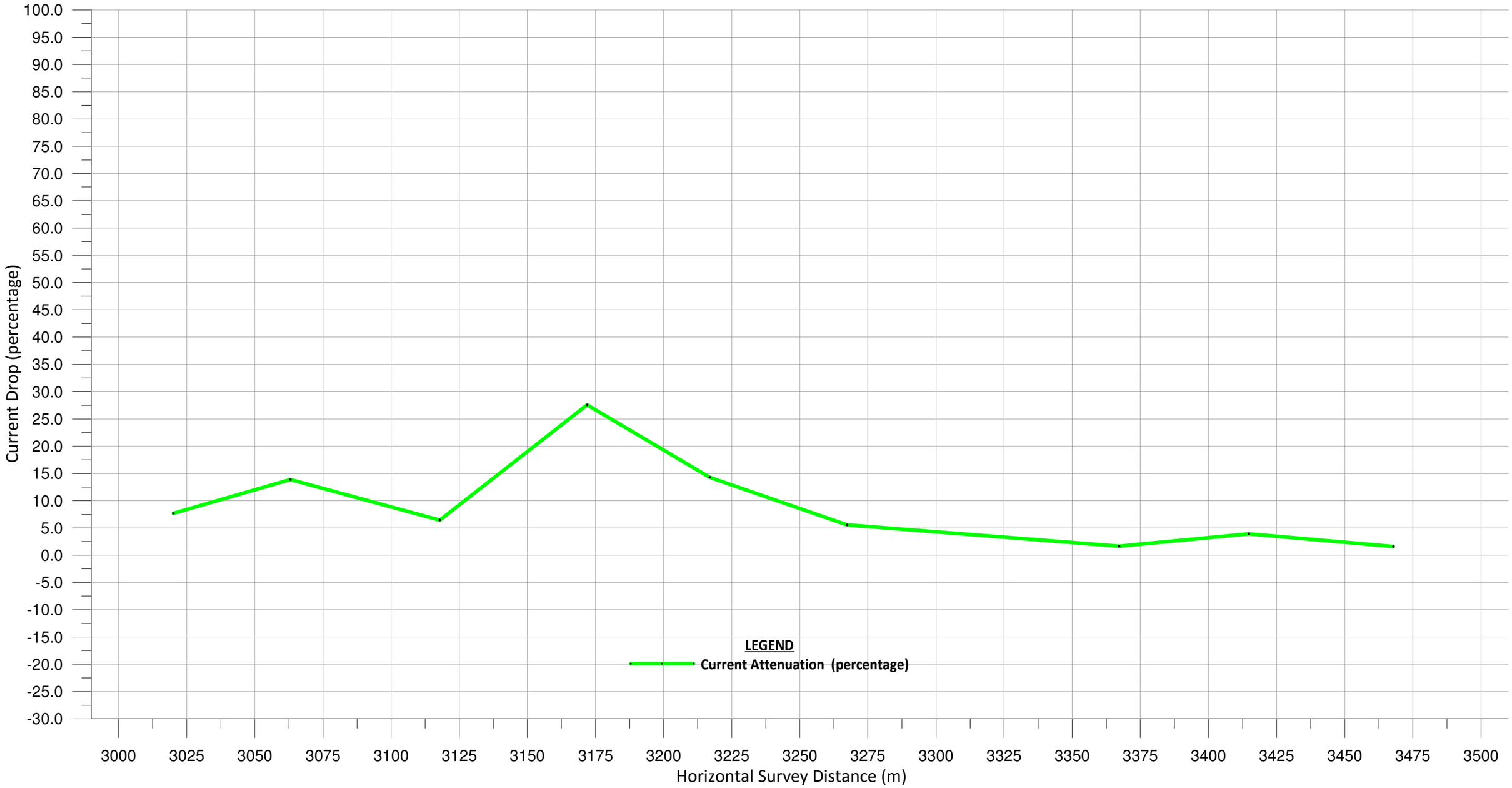
Dwg. #: 508-CVIP-ACCA-006		Sheet: 6 of 17
Date: December 6, 2012		
Scale:		
No.	Revision / Issue	Date



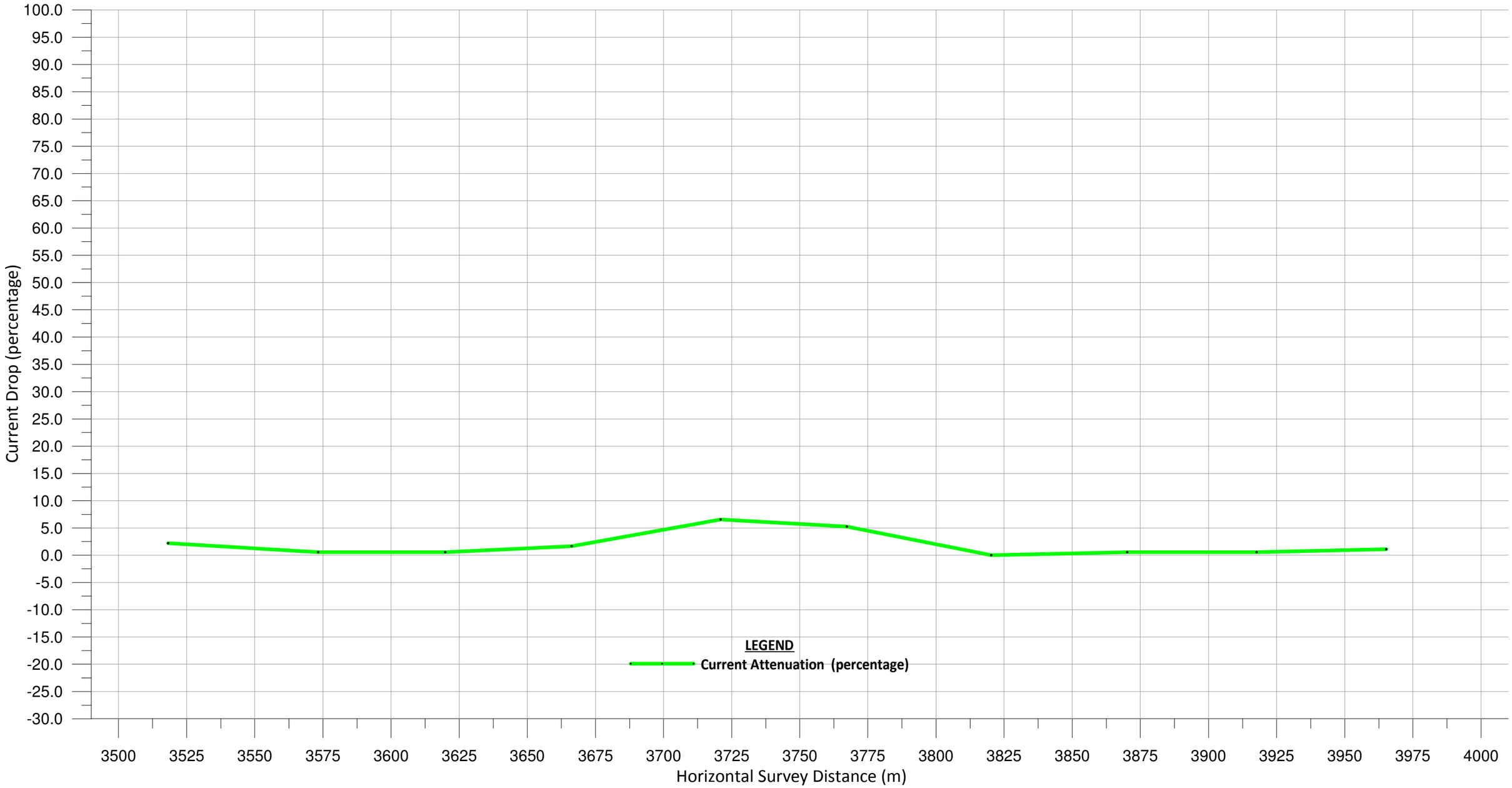
Notes:
The Coquitlam - Vancouver IP ACCA survey was completed in August 2012. The current was supplied utilizing a Spectrum XLI 100 watt 512 Hz Transmitter.

E-MAC CORROSION INC.
Ph. (780) 444-EMAC (3622) Fax. (780) 466-3658
Designed By: RAB
Drawn By: RAB

Project:
Fortis BC
508mm (NPS 20) Pipeline
Coquitlam - Vancouver IP, Coastal (BC)
AC Current Attenuation Profile
2012

FORTIS BC™

Dwg. #: 508-CVIP-ACCA-007		Sheet: 7 of 17
Date: December 6, 2012		
Scale:		
No.	Revision / Issue	Date



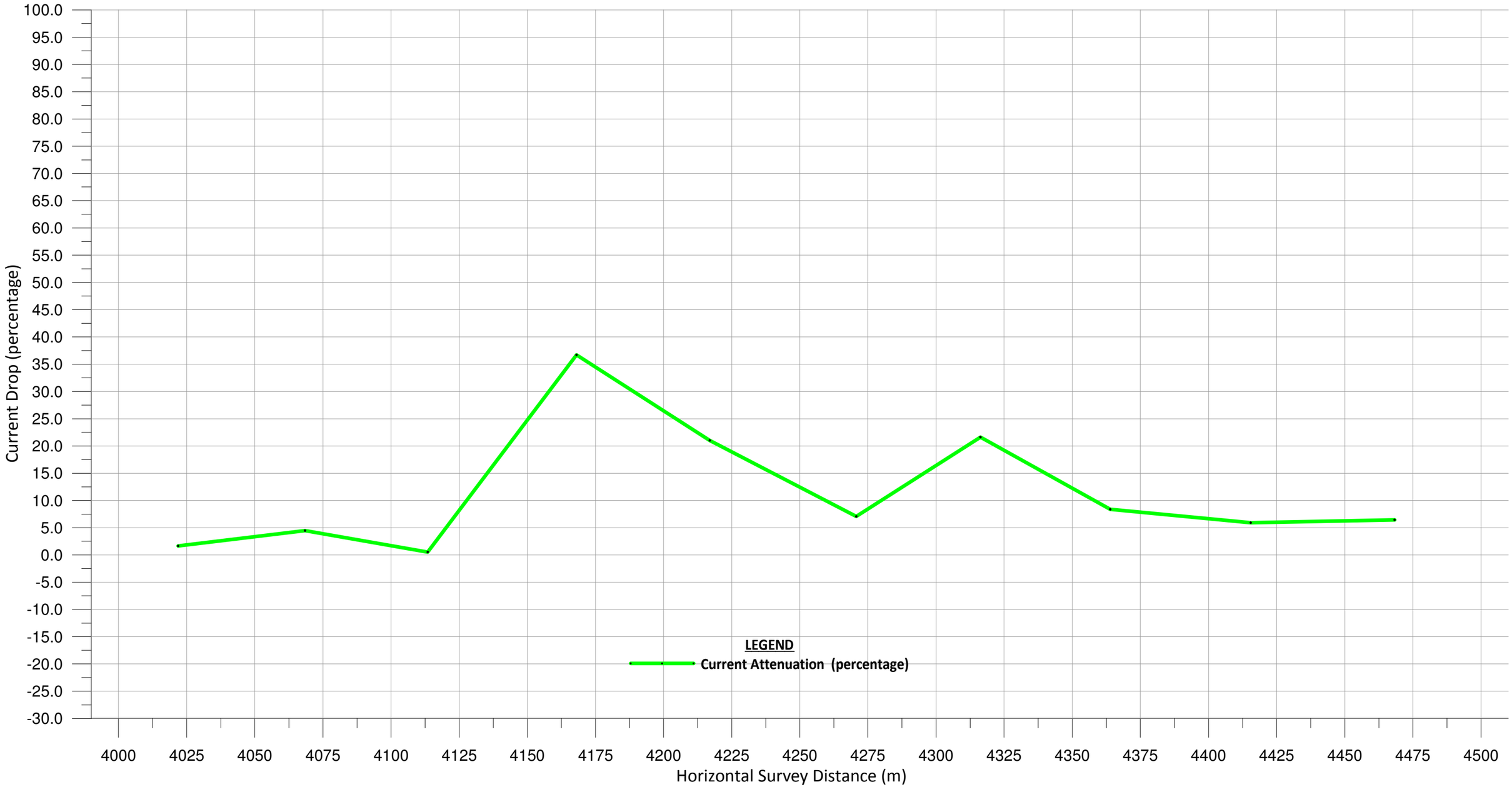
Notes:
The Coquitlam - Vancouver IP ACCA survey was completed in August 2012. The current was supplied utilizing a Spectrum XLI 100 watt 512 Hz Transmitter.

E-MAC CORROSION INC.
Ph. (780) 444-EMAC (3622) Fax. (780) 466-3658
Designed By: RAB
Drawn By: RAB

Project:
Fortis BC
508mm (NPS 20) Pipeline
Coquitlam - Vancouver IP, Coastal (BC)
AC Current Attenuation Profile
2012

FORTIS BC™

Dwg. #: 508-CVIP-ACCA-008		Sheet: 8 of 17
Date: December 6, 2012		
Scale:		
No.	Revision / Issue	Date



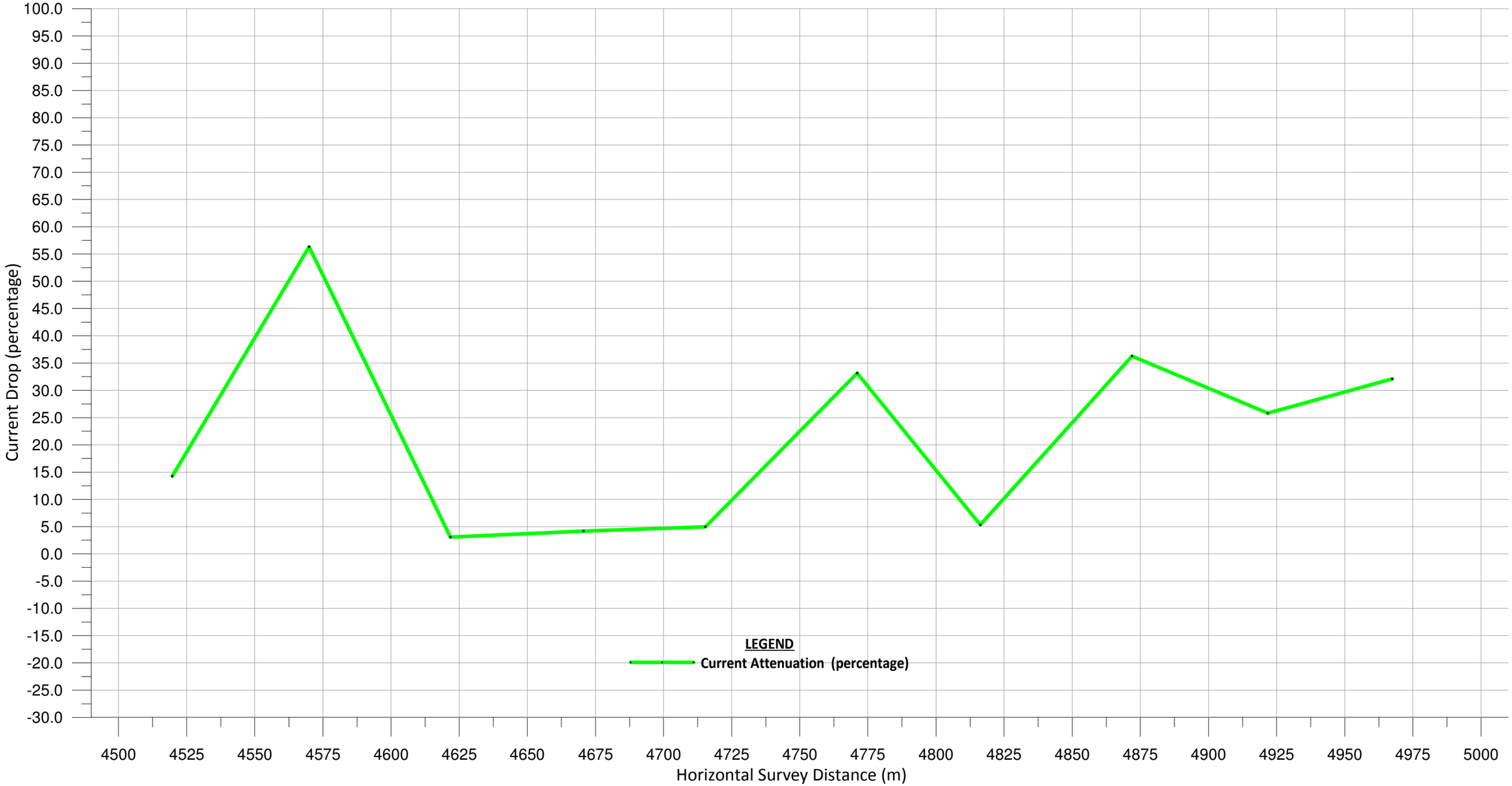
Notes:
The Coquitlam - Vancouver IP ACCA survey was completed in August 2012. The current was supplied utilizing a Spectrum XLI 100 watt 512 Hz Transmitter.

E-MAC CORROSION INC.
Ph. (780) 444-EMAC (3622) Fax. (780) 466-3658
Designed By: RAB
Drawn By: RAB

Project:
Fortis BC
508mm (NPS 20) Pipeline
Coquitlam - Vancouver IP, Coastal (BC)
AC Current Attenuation Profile
2012

FORTIS BC™

Dwg. #: 508-CVIP-ACCA-009		Sheet: 9 of 17
Date: December 6, 2012		
Scale:		
No.	Revision / Issue	Date



Notes:
The Coquitlam - Vancouver IP ACCA survey was completed in August 2012. The current was supplied utilizing a Spectrum XLI 100 watt 512 Hz Transmitter.

E-MAC CORROSION INC.
Ph. (780) 444-EMAC (3622) Fax. (780) 466-3658

Designed By: RAB
Drawn By: RAB

Project:
Fortis BC
508mm (NPS 20) Pipeline
Coquitlam - Vancouver IP, Coastal (BC)
AC Current Attenuation Profile
2012

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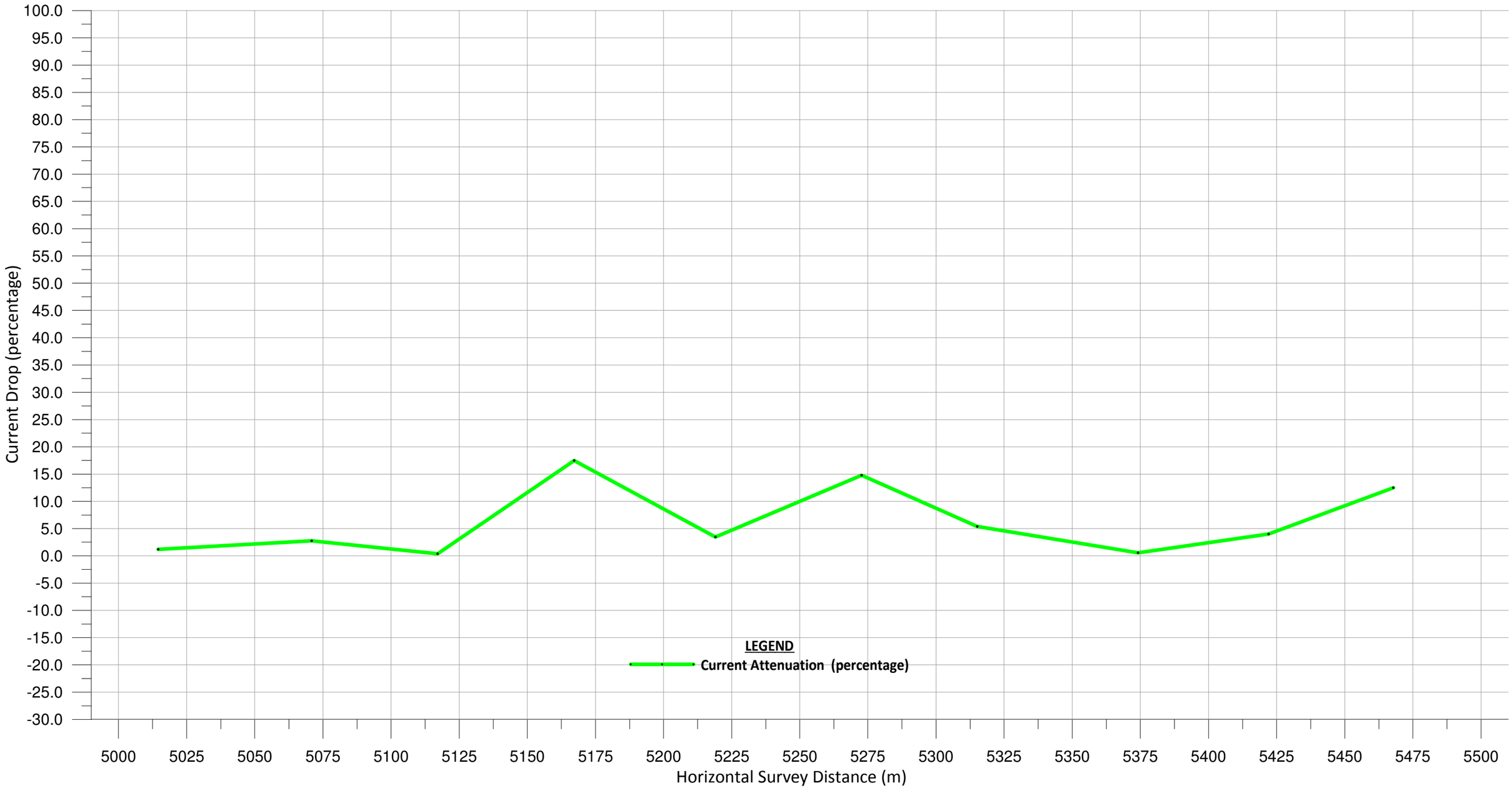
Dwg. #:	508-CVIP-ACCA-010
Date:	December 6, 2012
Scale:	
Sheet:	10 of 17

No.	Revision / Issue	Date



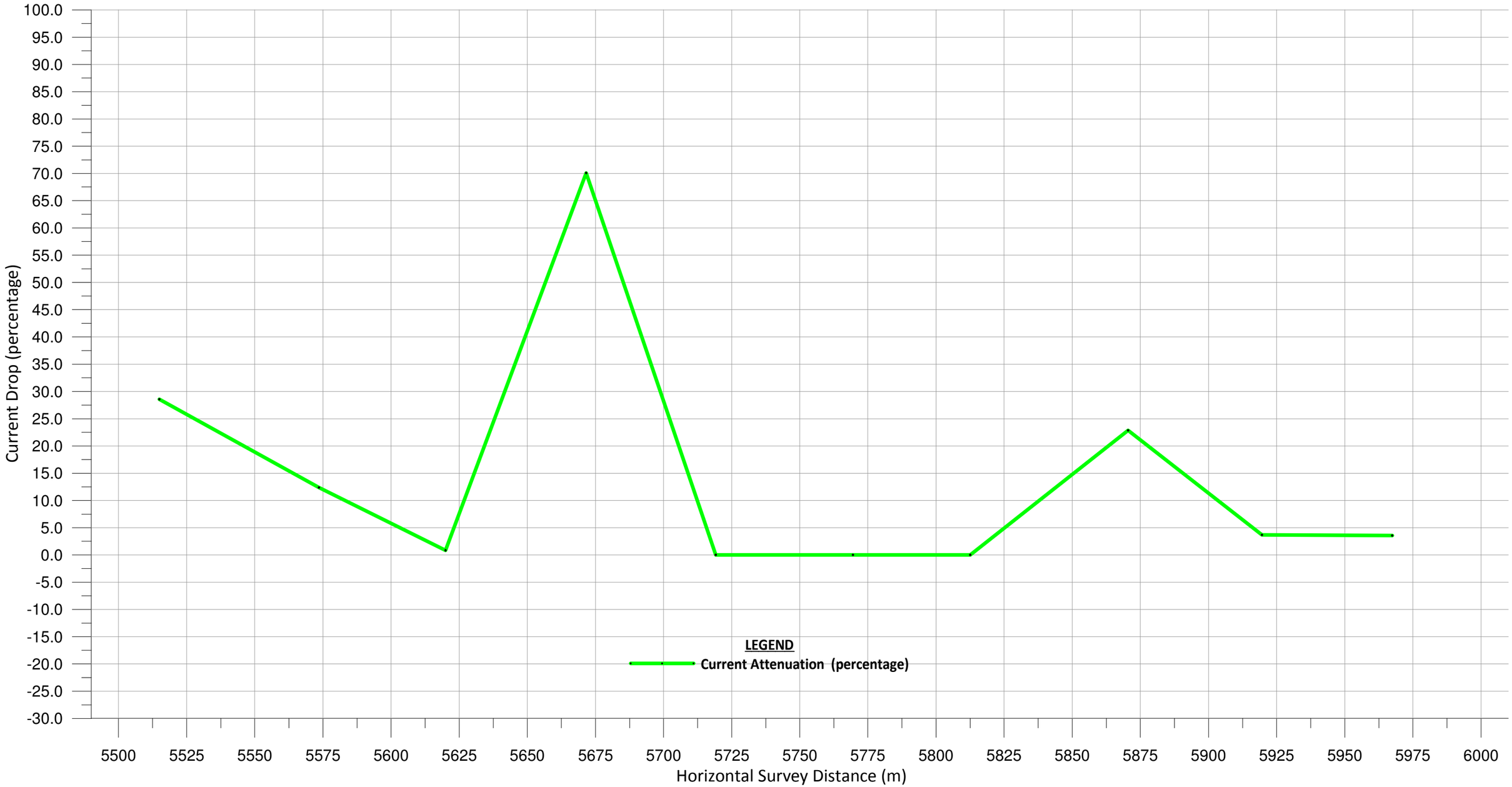
Notes:
The Coquitlam - Vancouver IP ACCA survey was completed in August 2012. The current was supplied utilizing a Spectrum XLI 100 watt 512 Hz Transmitter.

E-MAC CORROSION INC.
Ph. (780) 444-EMAC (3622) Fax. (780) 466-3658
Designed By: RAB
Drawn By: RAB

Project:
Fortis BC
508mm (NPS 20) Pipeline
Coquitlam - Vancouver IP, Coastal (BC)
AC Current Attenuation Profile
2012

FORTIS BC™

Dwg. #: 508-CVIP-ACCA-011		Sheet: 11 of 17
Date: December 6, 2012		
Scale:		
No.	Revision / Issue	Date



Notes:
The Coquitlam - Vancouver IP ACCA survey was completed in August 2012. The current was supplied utilizing a Spectrum XLI 100 watt 512 Hz Transmitter.

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Designed By: RAB
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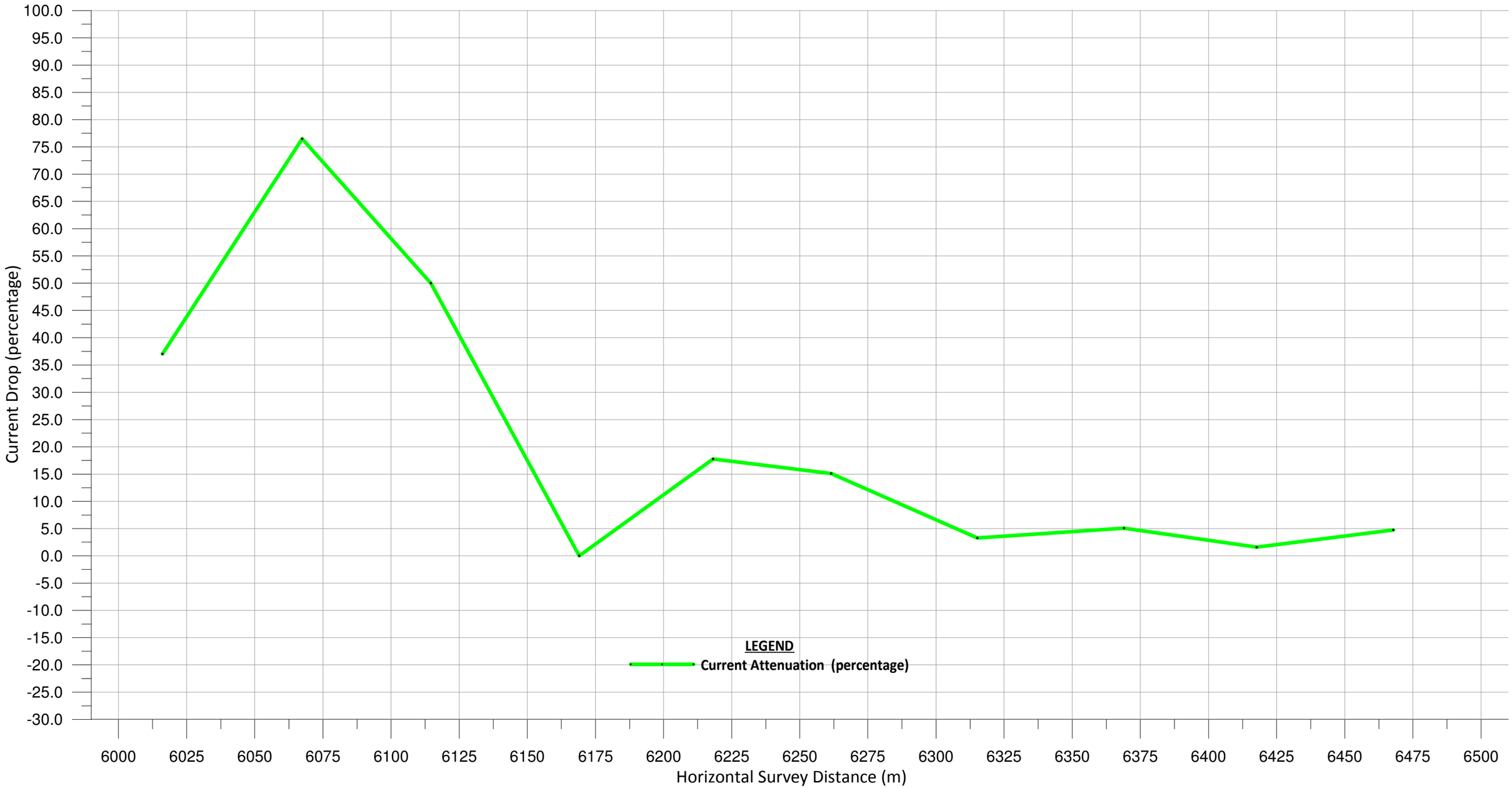
Project:
Fortis BC
508mm (NPS 20) Pipeline
Coquitlam - Vancouver IP, Coastal (BC)
AC Current Attenuation Profile
2012

FORTIS BC™

Dwg. #:	508-CVIP-ACCA-012
Date:	December 6, 2012
Scale:	
Sheet:	12 of 17

No.	Revision / Issue	Date



Notes:
The Coquitlam - Vancouver IP ACCA survey was completed in August 2012. The current was supplied utilizing a Spectrum XLI 100 watt 512 Hz Transmitter.

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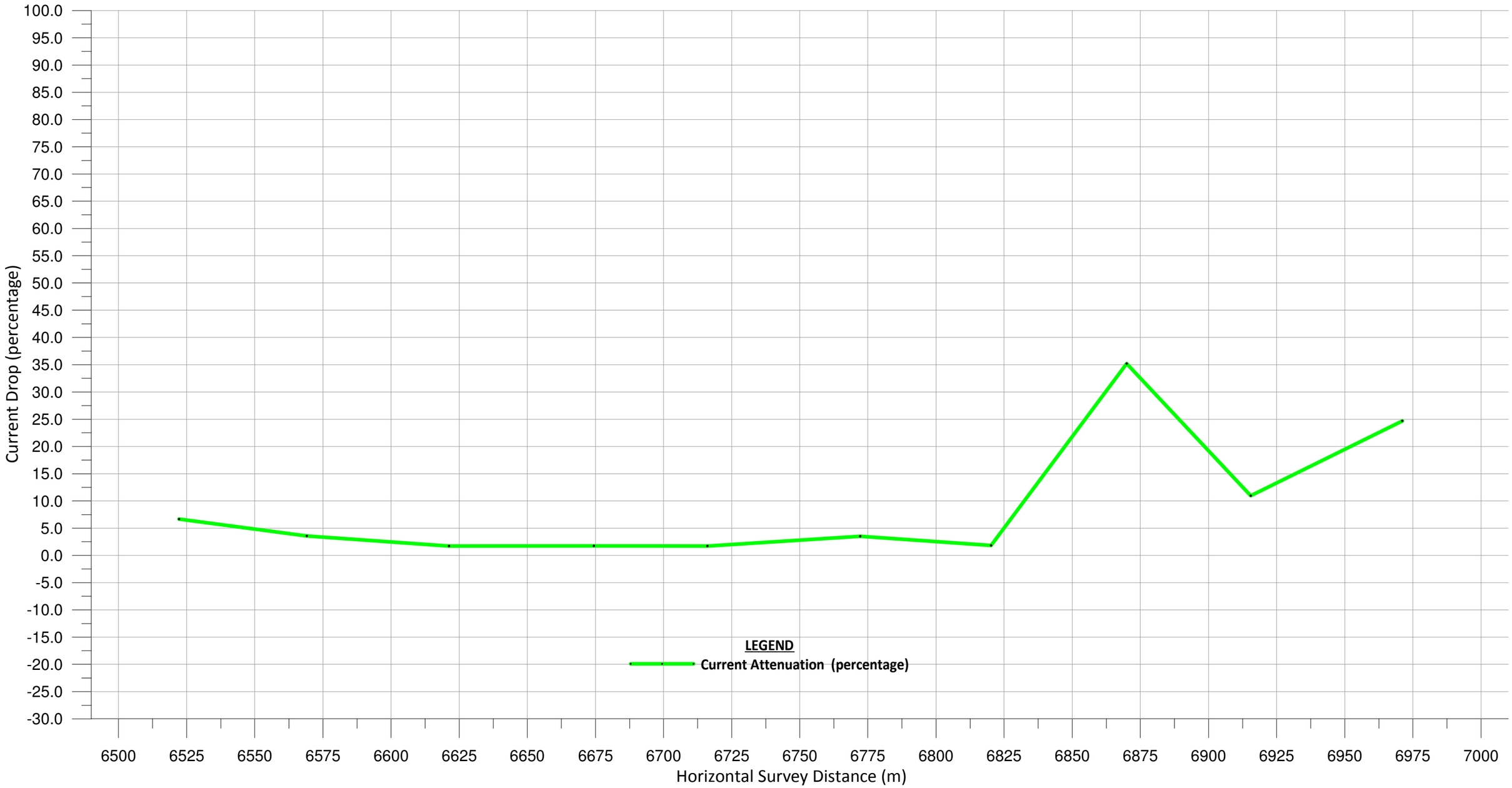
Ph. (780) 444-EMAC (3622) Fax. (780) 466-3658
Designed By: RAB
Drawn By: RAB

Project:
Fortis BC
508mm (NPS 20) Pipeline
Coquitlam - Vancouver IP, Coastal (BC)
AC Current Attenuation Profile
2012

FORTIS BC™

Dwg. #: 508-CVIP-ACCA-013		Sheet: 13 of 17
Date: December 6, 2012		
Scale:		
No.	Revision / Issue	Date



Notes:
The Coquitlam - Vancouver IP ACCA survey was completed in August 2012. The current was supplied utilizing a Spectrum XLI 100 watt 512 Hz Transmitter.

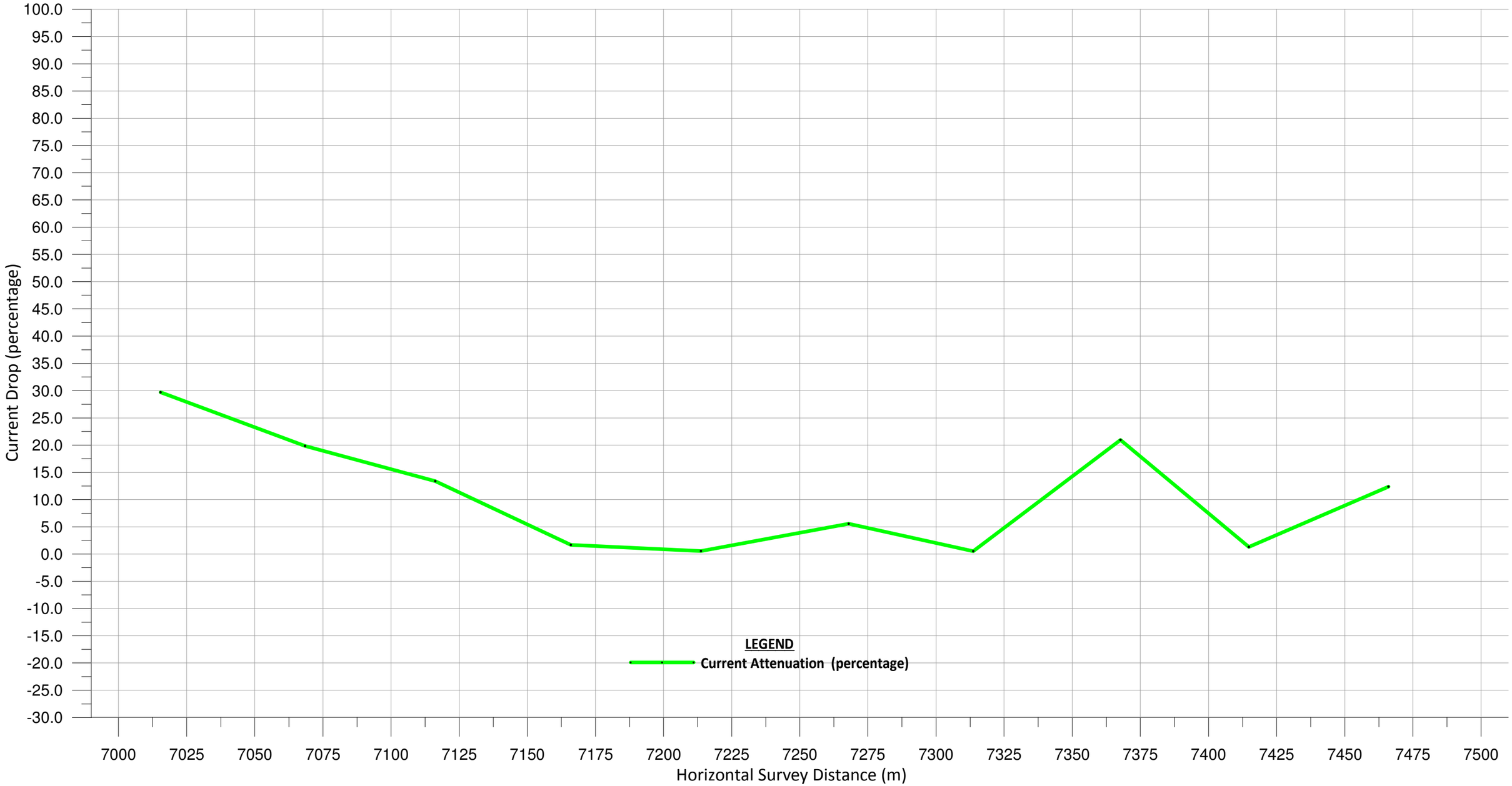
E-MAC CORROSION INC.
Ph. (780) 444-EMAC (3622) Fax. (780) 466-3658
Designed By: RAB
Drawn By: RAB

Project:
Fortis BC
508mm (NPS 20) Pipeline
Coquitlam - Vancouver IP, Coastal (BC)
AC Current Attenuation Profile
2012

FORTIS BC™

Dwg. #: 508-CVIP-ACCA-014	Sheet: 14 of 17
Date: December 6, 2012	
Scale:	

No.	Revision / Issue	Date



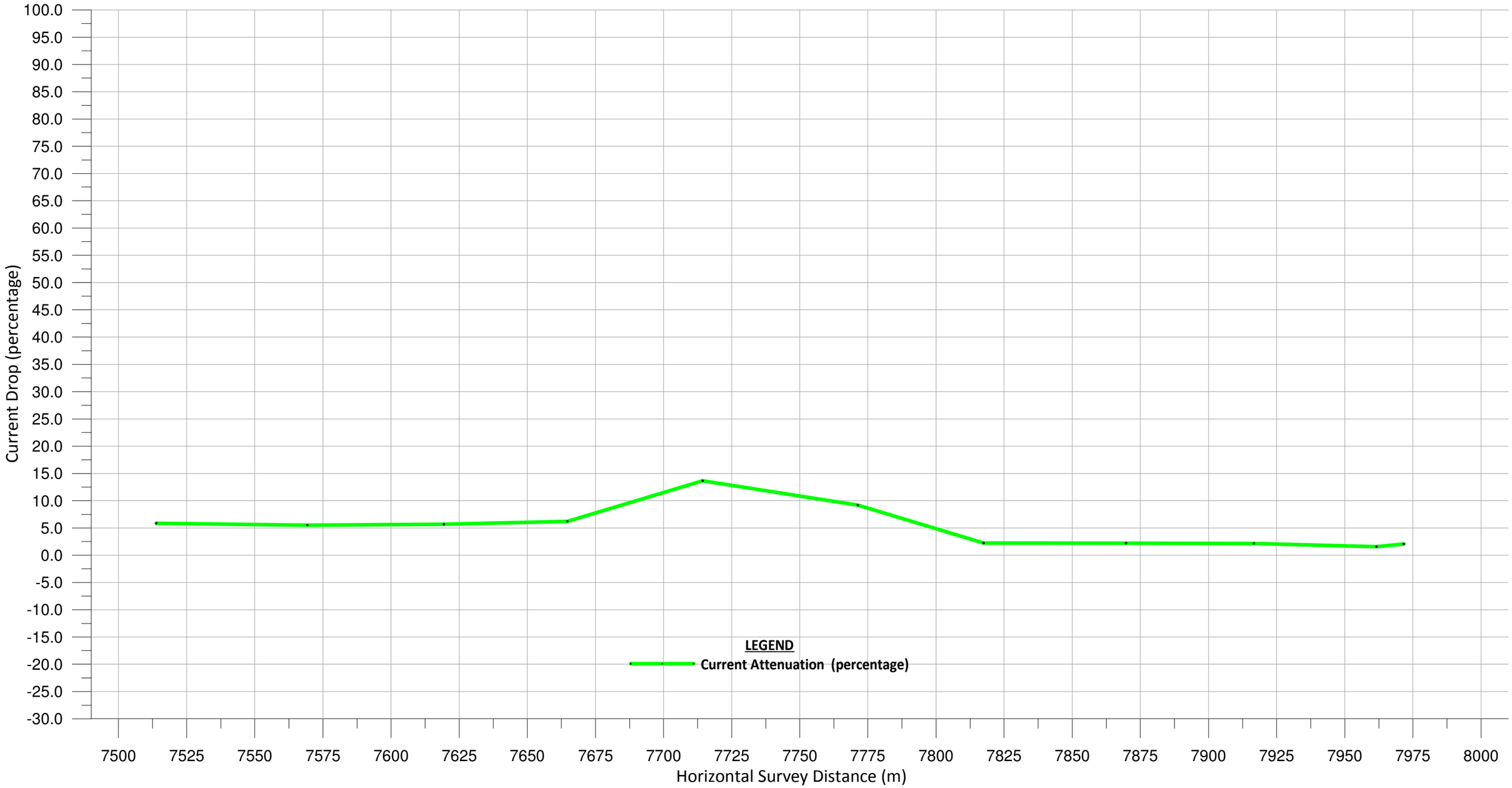
Notes:
The Coquitlam - Vancouver IP ACCA survey was completed in August 2012. The current was supplied utilizing a Spectrum XLI 100 watt 512 Hz Transmitter.

E-MAC CORROSION INC.
Ph. (780) 444-EMAC (3622) Fax. (780) 466-3658
Designed By: RAB
Drawn By: RAB

Project:
Fortis BC
508mm (NPS 20) Pipeline
Coquitlam - Vancouver IP, Coastal (BC)
AC Current Attenuation Profile
2012

FORTIS BC™

Dwg. #: 508-CVIP-ACCA-015		Sheet: 15 of 17
Date: December 6, 2012		
Scale:		
No.	Revision / Issue	Date



Notes:
The Coquitlam - Vancouver IP ACCA survey was completed in August 2012. The current was supplied utilizing a Spectrum XLI 100 watt 512 Hz Transmitter.

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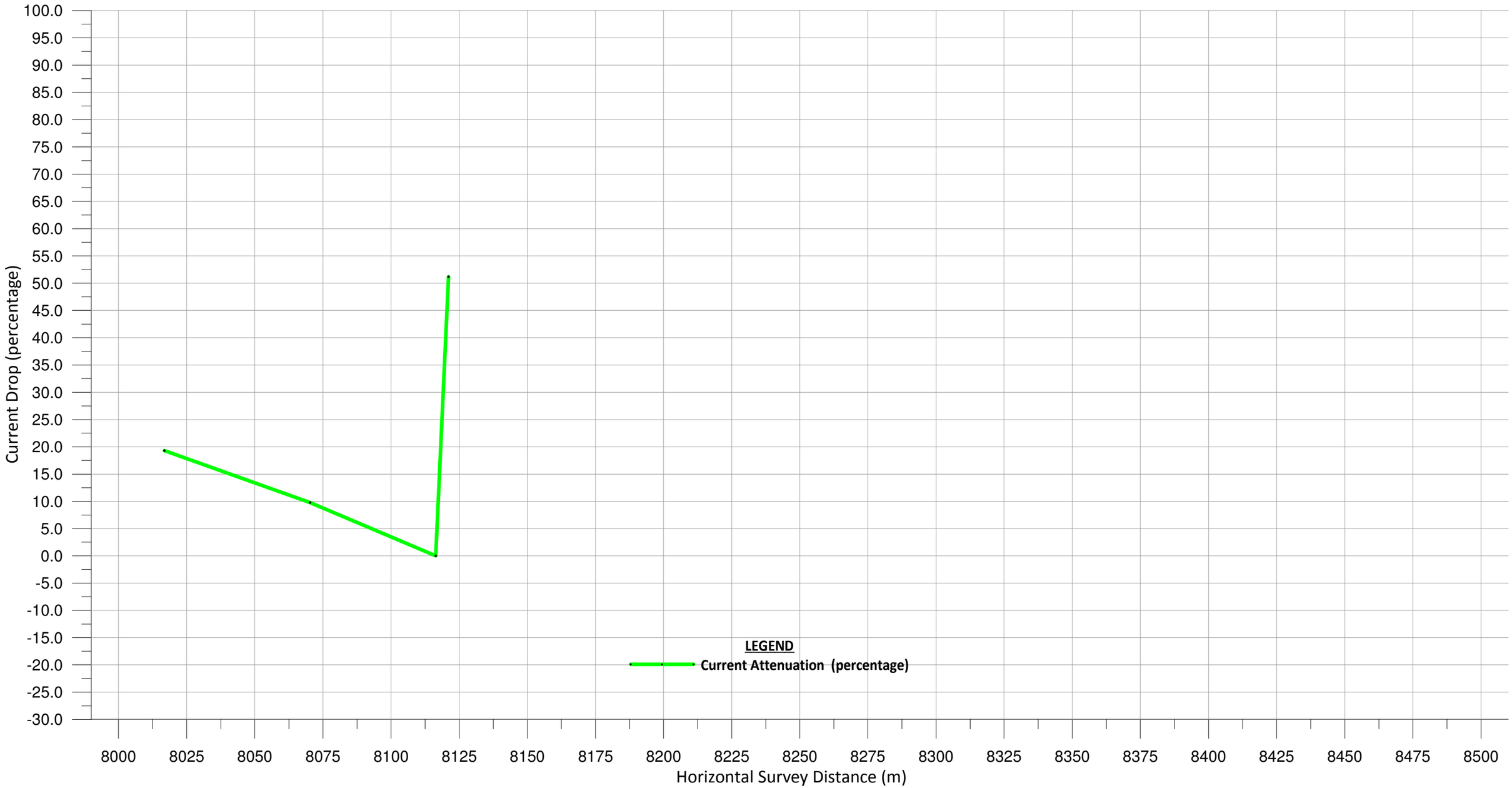
Ph. (780) 444-EMAC (3622) Fax. (780) 466-3658
Designed By: RAB
Drawn By: RAB

Project:
Fortis BC
508mm (NPS 20) Pipeline
Coquitlam - Vancouver IP, Coastal (BC)
AC Current Attenuation Profile
2012

FORTIS BC™

Dwg. #: 508-CVIP-ACCA-016		Sheet: 16 of 17
Date: December 6, 2012		
Scale:		
No.	Revision / Issue	Date



Notes:
The Coquitlam - Vancouver IP ACCA survey was completed in August 2012. The current was supplied utilizing a Spectrum XLI 100 watt 512 Hz Transmitter.

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Designed By: RAB
Drawn By: RAB

Project:
Fortis BC
508mm (NPS 20) Pipeline
Coquitlam - Vancouver IP, Coastal (BC)
AC Current Attenuation Profile
2012

FORTIS BC™

Dwg. #: 508-CVIP-ACCA-017		Sheet: 17 of 17
Date: December 6, 2012		
Scale:		
No.	Revision / Issue	Date

FORTIS BC™

MEMO

To	File	Date	March 18, 2013
		From	Ian Thornton, AScT - Integrity Analyst
Re	FortisBC 508mm (NPS 20) IP Pipeline Coquitlam to Burnaby, Coastal (BC) Depth of Cover/Close Interval Survey 2012. January 17, 2013 E-MAC Corrosion Inc.	CC	

FortisBC received the subject report on January 17, 2013. E-MAC Corrosion Inc. was retained under Purchase Order 4500037111 to complete the following scope of work on the 508mm IP Pipeline:

1. Cathodic Protection Interference Investigation at Coquitlam Gate Station

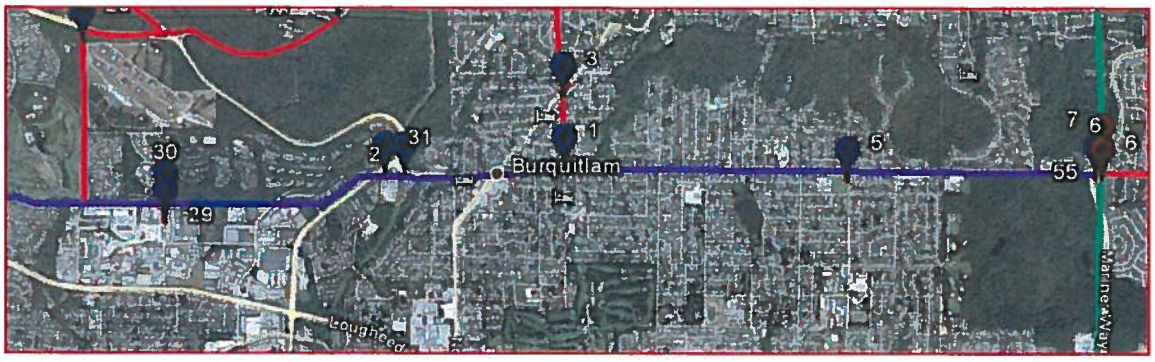
   Complete a comprehensive DC interference investigation at Coquitlam Gate Station. At this station, there are two transmission pressure pipeline inlets and one outlet, these pipelines are protected by impressed current off site. There is an intermediate pressure pipeline outlet which is electrically isolated at the riser and protected by impressed current off site. In addition, there is distribution pressure piping which is protected by impressed current off site, as well as a rectifier within the station. The rectifier inside the station was installed to provide protection to all station piping, however it is now used to supplement protection on the distribution piping system as well.

   The goals for this investigation are as follows:

   i. Confirm adequate cathodic protection is achieved on piping within the Station
   ii. Verify electrical isolations exist and are functioning properly
   iii. Identify and quantify any DC interference issues on the TP and IP pipelines entering and existing the Station

   It is expected that recommendations for mitigation of any DC interference will be conclude in a brief report. FortisBC will require that a member of the corrosion department be present and assist with the investigation.

2. Pre-assessment survey of the 20" IP pipeline extending from Coquitlam Gate Station to Lawrence Dr. in Burnaby as depicted in blue below:



The pre-assessment should include the following:

i. Reconnaissance of the pipeline alignment to allow for estimating costs to complete further survey work
ii. Locating test points to ensure an adequate number exist to efficiently complete a close-interval survey.
iii. Measurement of interrupted potentials at all test points
iv. Depth of cover survey
v. Current attenuation survey

Based on the pre-assessment, a brief summary report shall be provided along with a detailed cost estimate to complete Task 3.

3. Close Interval Potential Survey and ACVG

Complete a close interval potential survey on the 20" IP pipeline extending from the Coquitlam Gate Station to Lawrence Dr. (approx.. 9km). Consideration must be given to reference electrode contact to the soil, given that the majority of this pipeline lies beneath paved surfaces. Drill holes, water trucks etc. must be utilized as determined by the pre-assessment.

Complete an ACVG survey over areas identified in the pre-assessment to locate and quantify coating damage indications. Consideration must be given to reference electrode contact to the soil, given that the majority of this pipeline lies beneath paved surfaces. Drill holes, water trucks etc. must be utilized as determined by the pre-assessment.

Report Results:

The subject report concluded the following:

- Approximately 50% of the subject pipeline meets the -850mV (CSE) Criterion.
- 2 FortisBC DP rectifiers are interfering with CP potentials on the 508mm IP pipeline
- 1 foreign rectifier is interfering with CP potentials on the 508mm IP pipeline

Report Recommendations:

- Consider establishing electrical continuity between the FortisBC DP & IP pipeline systems.
- Once electrical continuity has been established between the DP & IP pipeline systems, consider a CIS of the entire pipeline to determine if the -850mV criterion can be achieved with the interference alleviated.
- Consider a depolarization CIS survey in order to determine if the 100mV polarization criterion is being achieved.

- Have an ACVG survey completed on all of the section identified in the previous table.
- Have a cathodic protection survey completed on the underground tank structures at the Race Track Gas station to determine if the CP system output can be reduced or if alternative mitigation measures should be implemented.

FortisBC Response to Report Results:

1. Have the Corrosion Control department bond in the DP rectifier located at Coquitlam gate Station immediately (Completed Jan. 21, 2013)
2. Have the Corrosion Control department evaluate the feasibility of bonding in the Stoney Creek DP rectifier to the 508mm IP Pipeline (Completed Jan. 21, 2013)
3. Complete a depolarization survey of 508mm IP pipeline from Coquitlam Gate Station to Shellmont
4. Have FortisBC CP consultant (E-MAC Corrosion Inc.) contact Race Track Gas and request cooperation in further investigating the potential CP interference between the two ICCP systems.
5. Complete ACVG survey's on all locations of the pipeline where it runs below unpaved surfaces. The ACVG technique is relatively ineffective where pin to soil contact is compromised (paved surfaces)
6. Complete a re-CIS survey from Coquitlam Gate Station to Robinson Street, once item #1 and #4 have been completed.

E-MAC Corrosion was retained under PO# 4500039728 (dated 03/14/2013) to complete the following scope of work in 2013:

> Following up from the work completed last year on the 20" Coquitlam-Vancouver IP Pipeline, the following work is to be completed in 2013 on this pipeline:
>
> 1. A depolarized potential survey extending from Coquitlam Gate Station to Shellmont
> 2. Complete and ACVG survey on all unpaved sections between Coquitlam Gate Station and Underhill Avenue
> 3. Re-CIS survey the section of pipeline from Coquitlam Gate Station to Poirier Avenue now that the DP rectifier at Coquitlam Gate is bonded into the IP pipeline.
> 4. Re-CIS the section of pipeline in front of Race Track Gas Station with the foreign ICCP system interrupting to further define the level of CP interference experienced of the FortisBC pipeline.

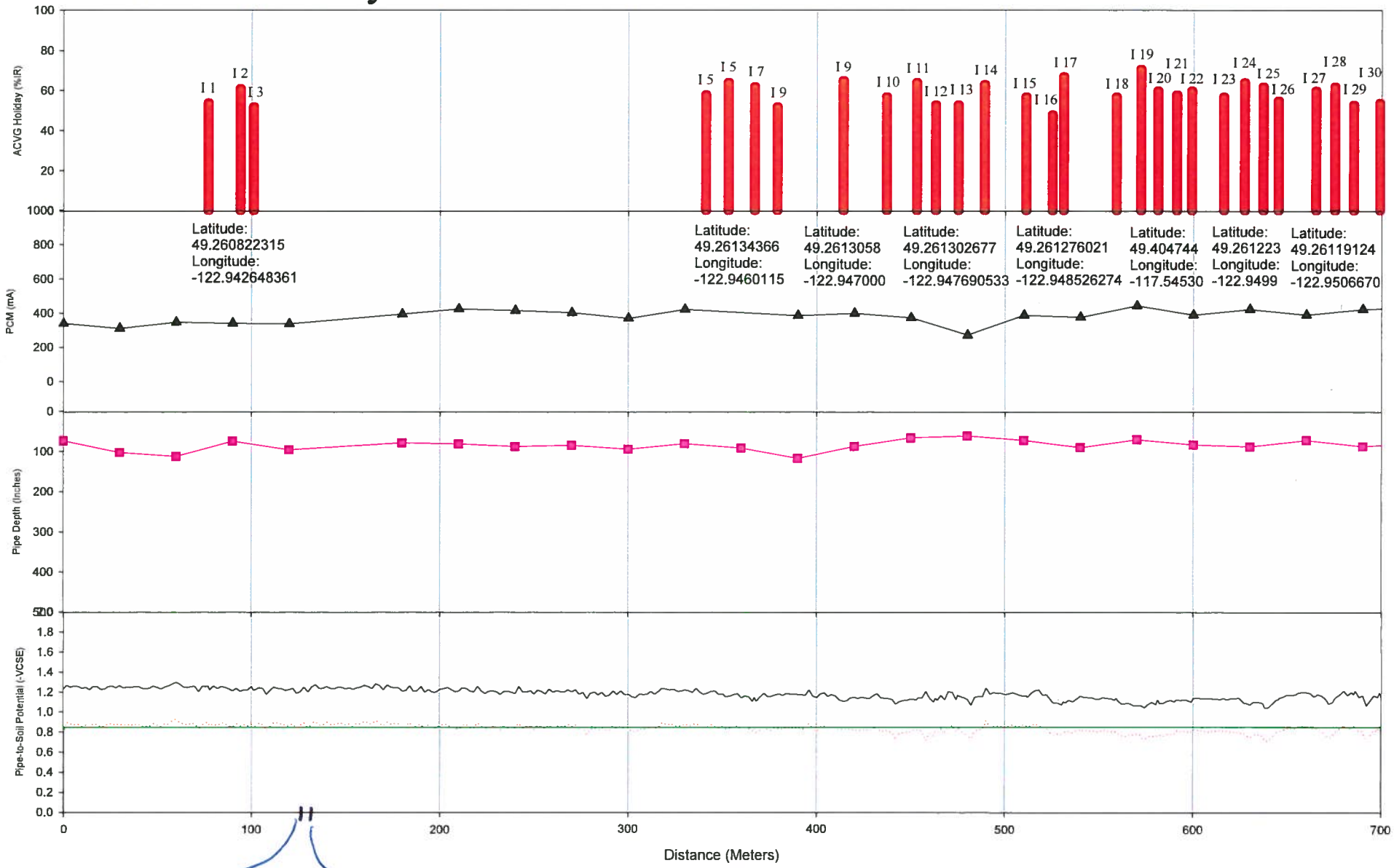
Ian Thornton, AScT
System Integrity Analyst
NACE CP Specialist #7388
NACE Certified Coating Inspector – Level 3 (#9217)

Applied Science Technologists and Technicians of British Columbia
17973
IAN C. THORNTON
03/18/2013
AScT

Lawrence

Broadway

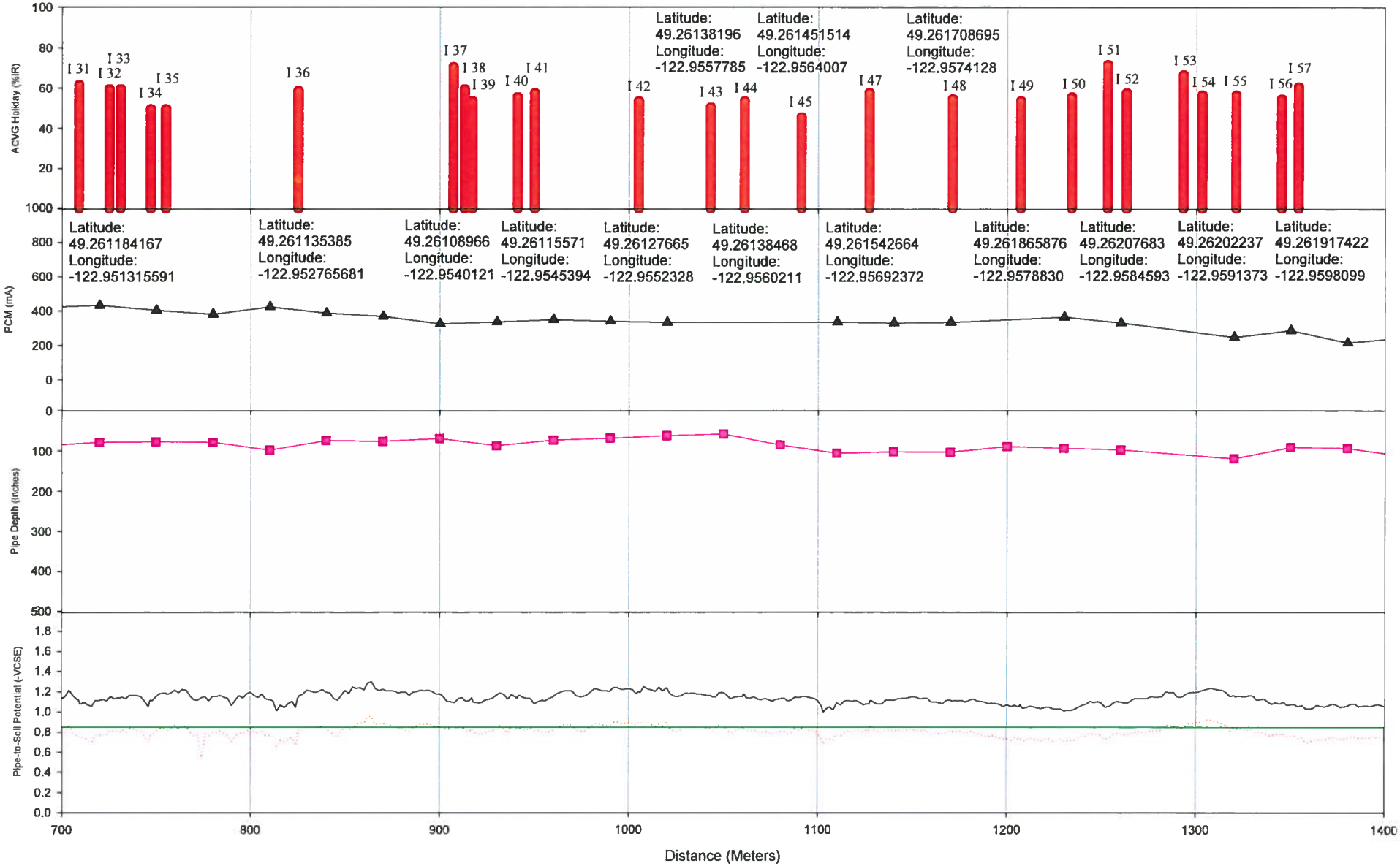
Lawrence To Hwy1



Leak(18/03/11) Leak(06/05/13)

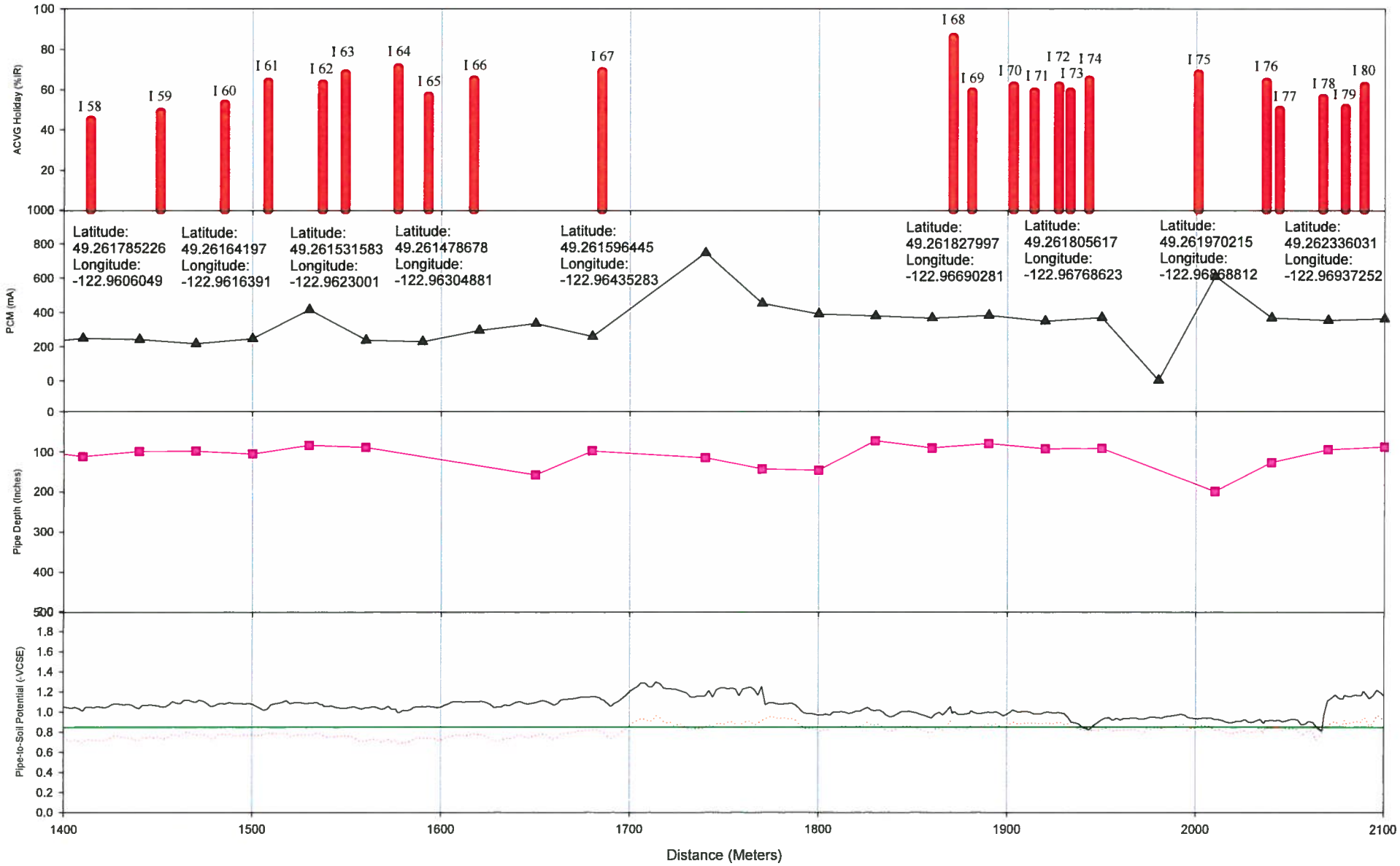
Broadway

Lawrence To Hwy1



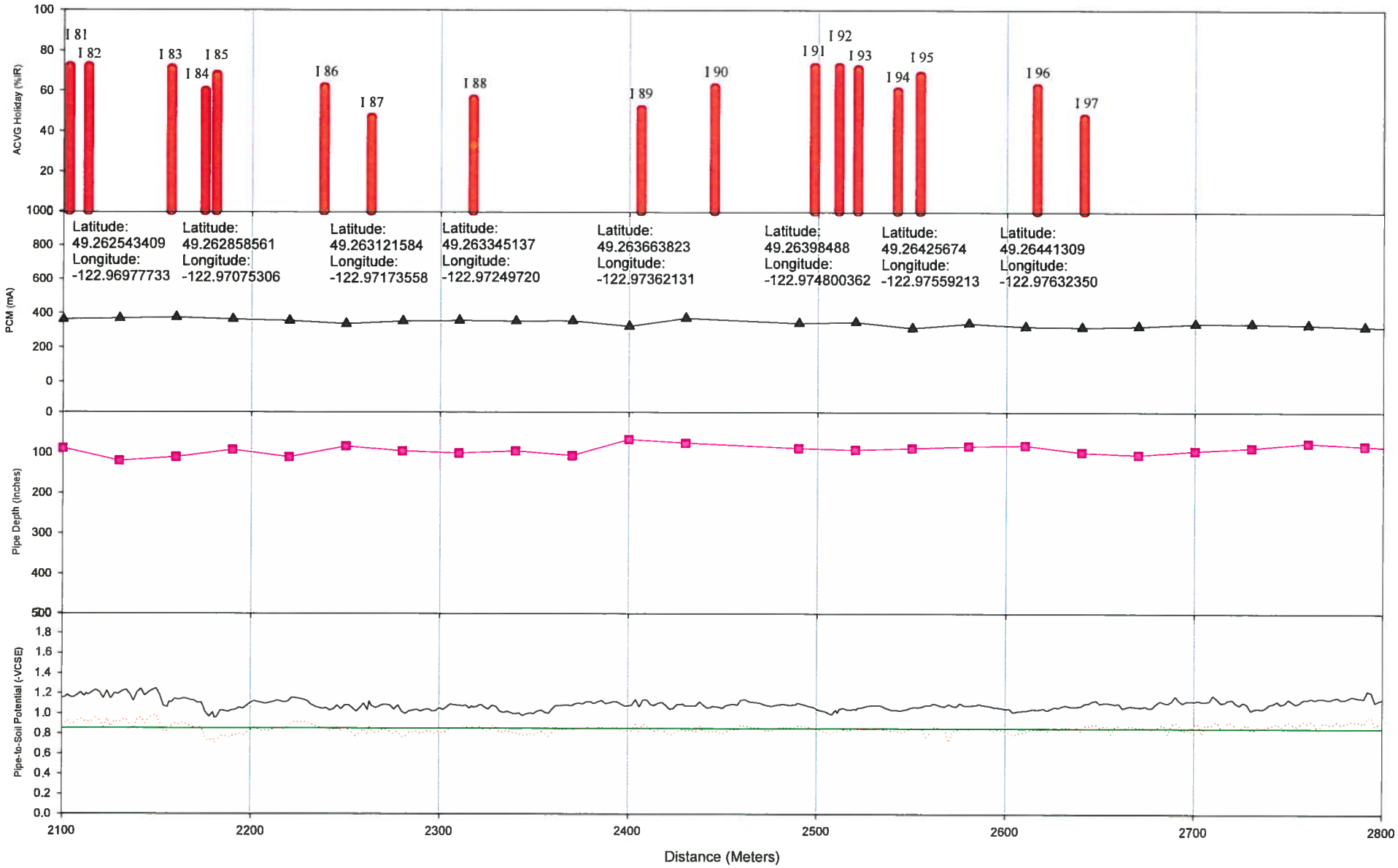
Broadway

Lawrence To Hwy1



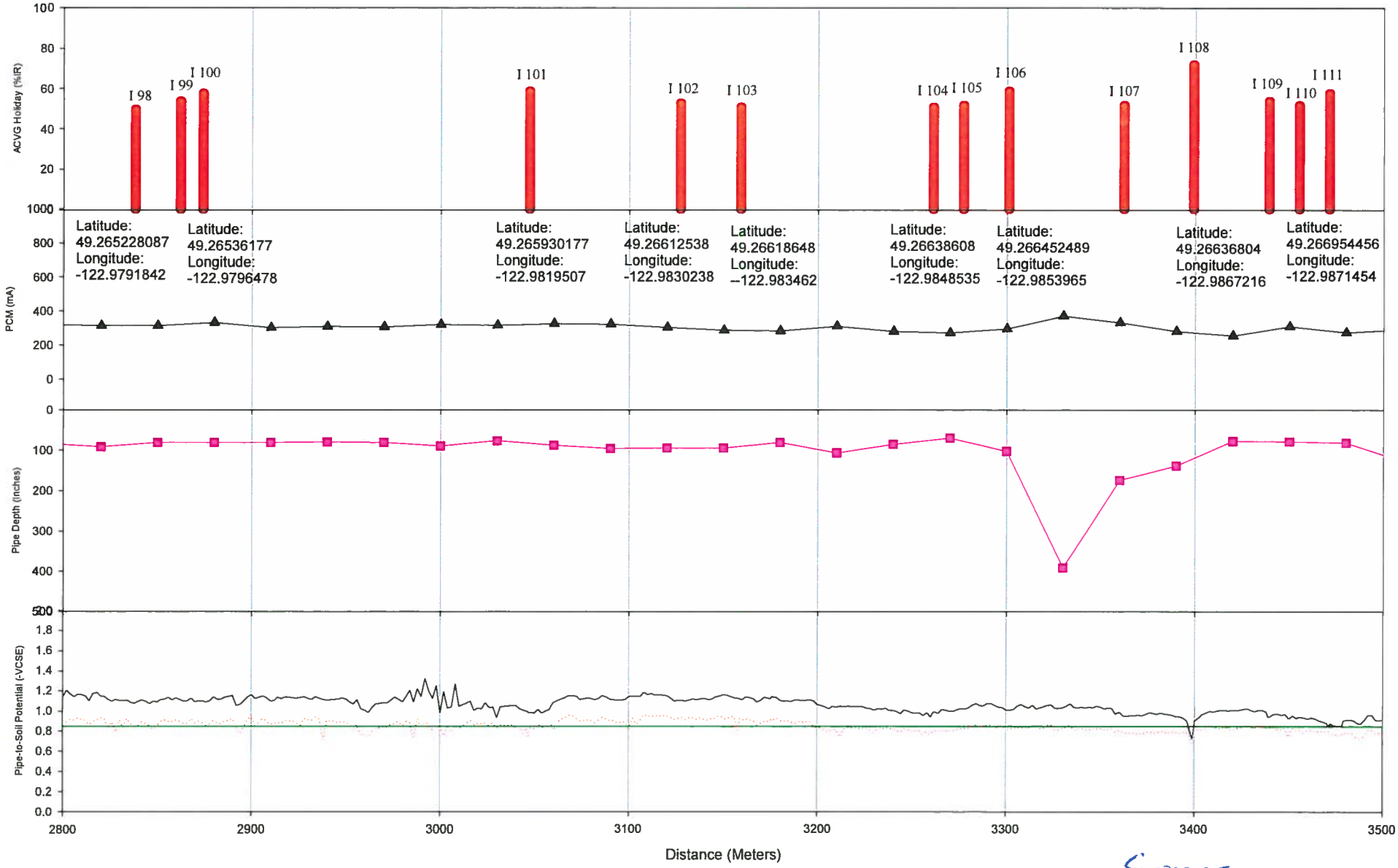
Broadway

Lawrence To Hwy1



Broadway → Springer

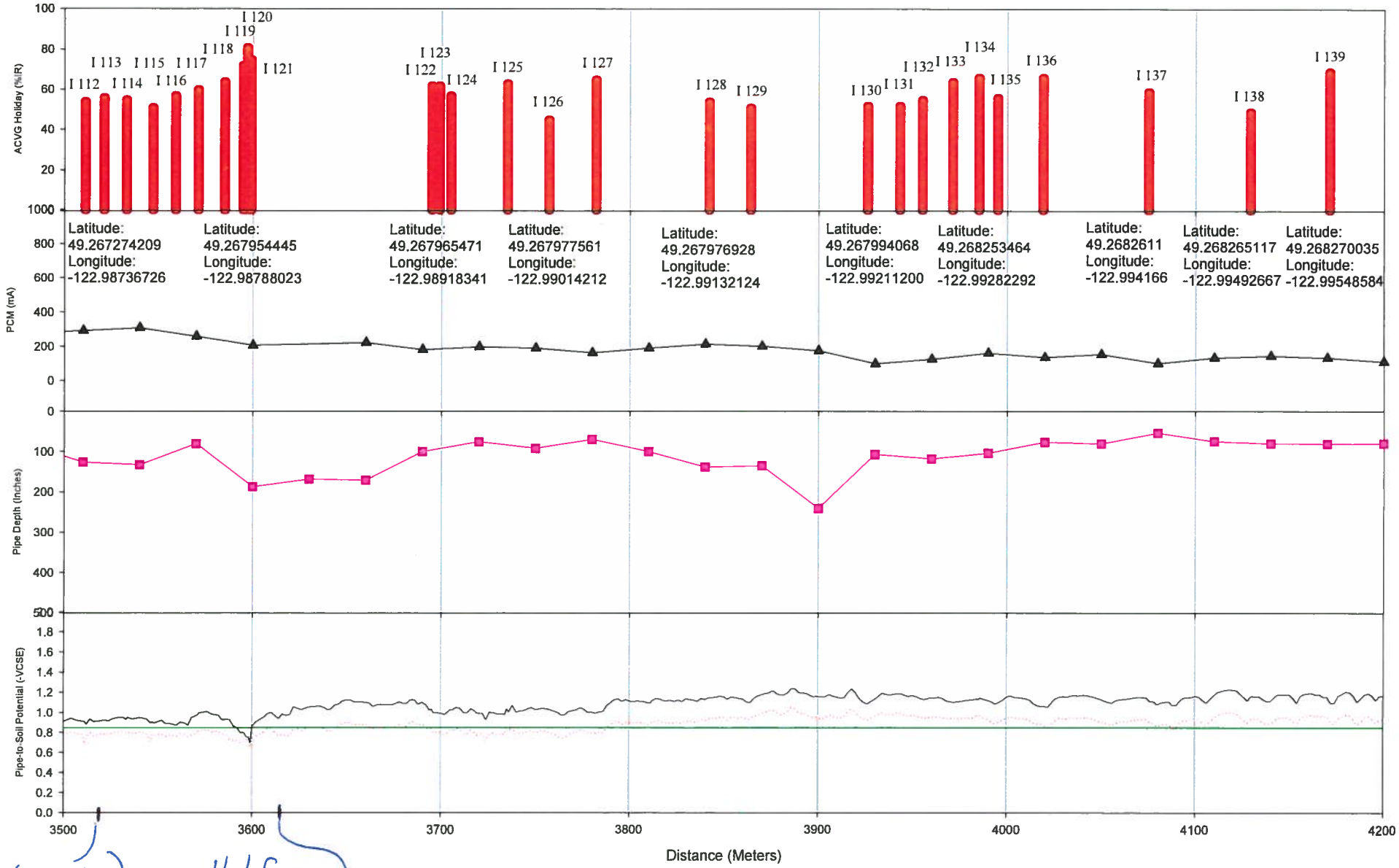
Lawrence To Hwy1



Springer

Springer Halifax Delta Brentlawn

Lawrence To Hwy1

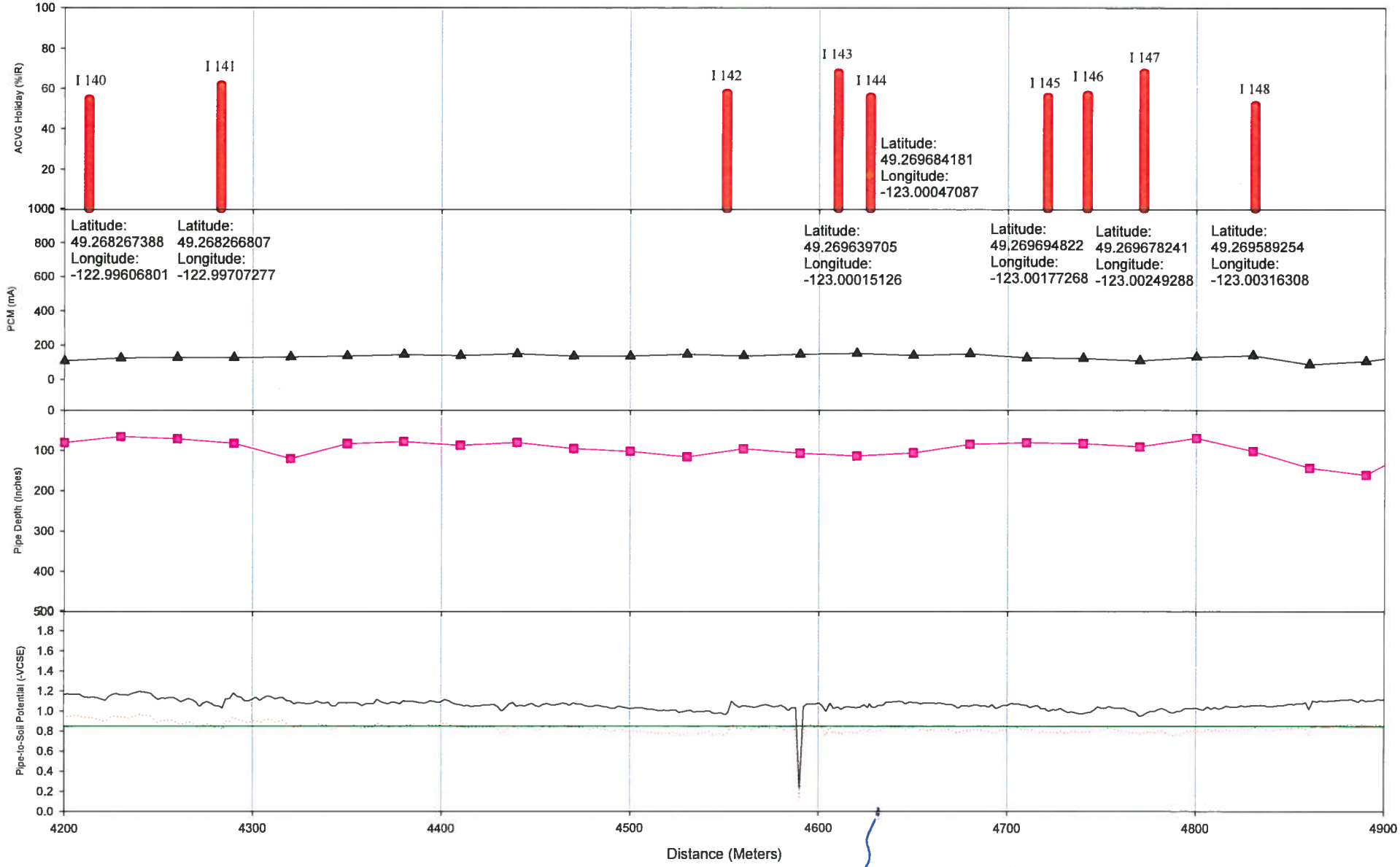


Leak (18/11/87) Halifax Leak (27/06/13)

Fairlawn

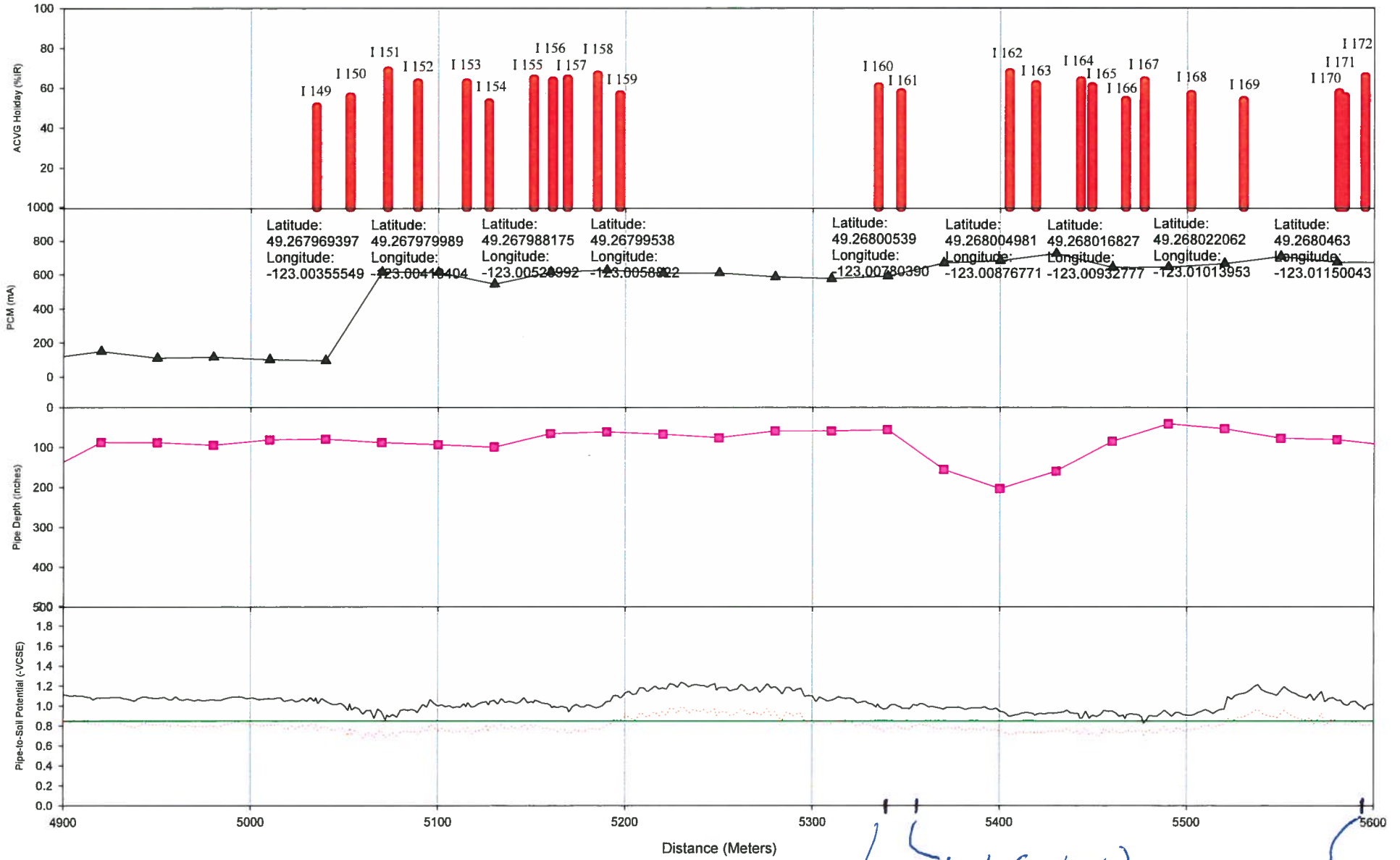
Brentlawn | Beta | Lane (Brentlawn) | Lane | Willingdon

Lawrence To Hwy1



Leak (21/07/01)

Lawrence To Hwy1



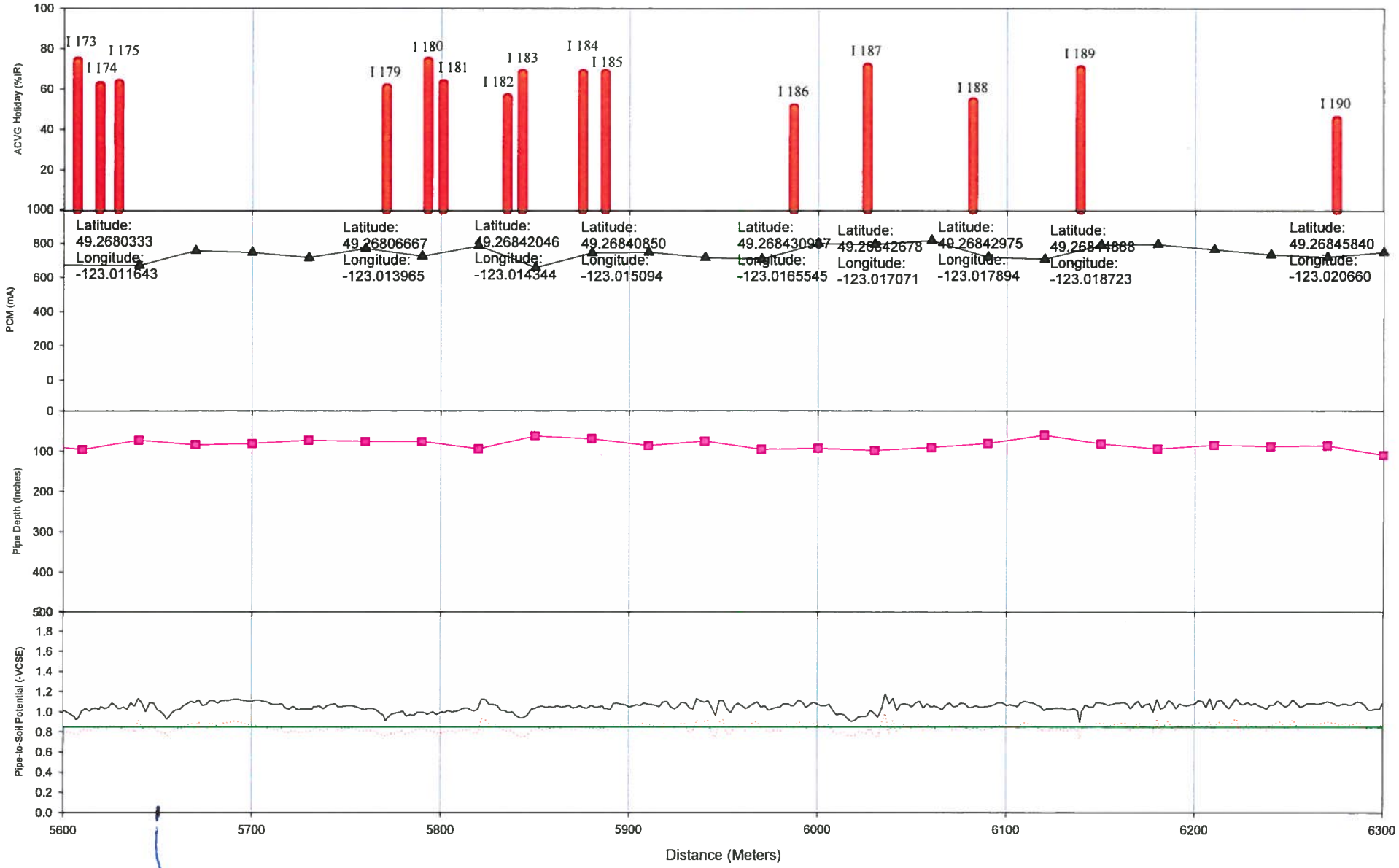
Leak (08/08/13)

Leak (20/08/13)

Leak (09/10/13)

Halifax | Gilmore | 2nd Ave

Lawrence To Hwy1



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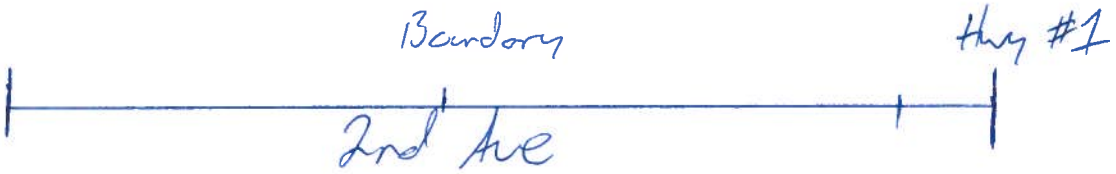

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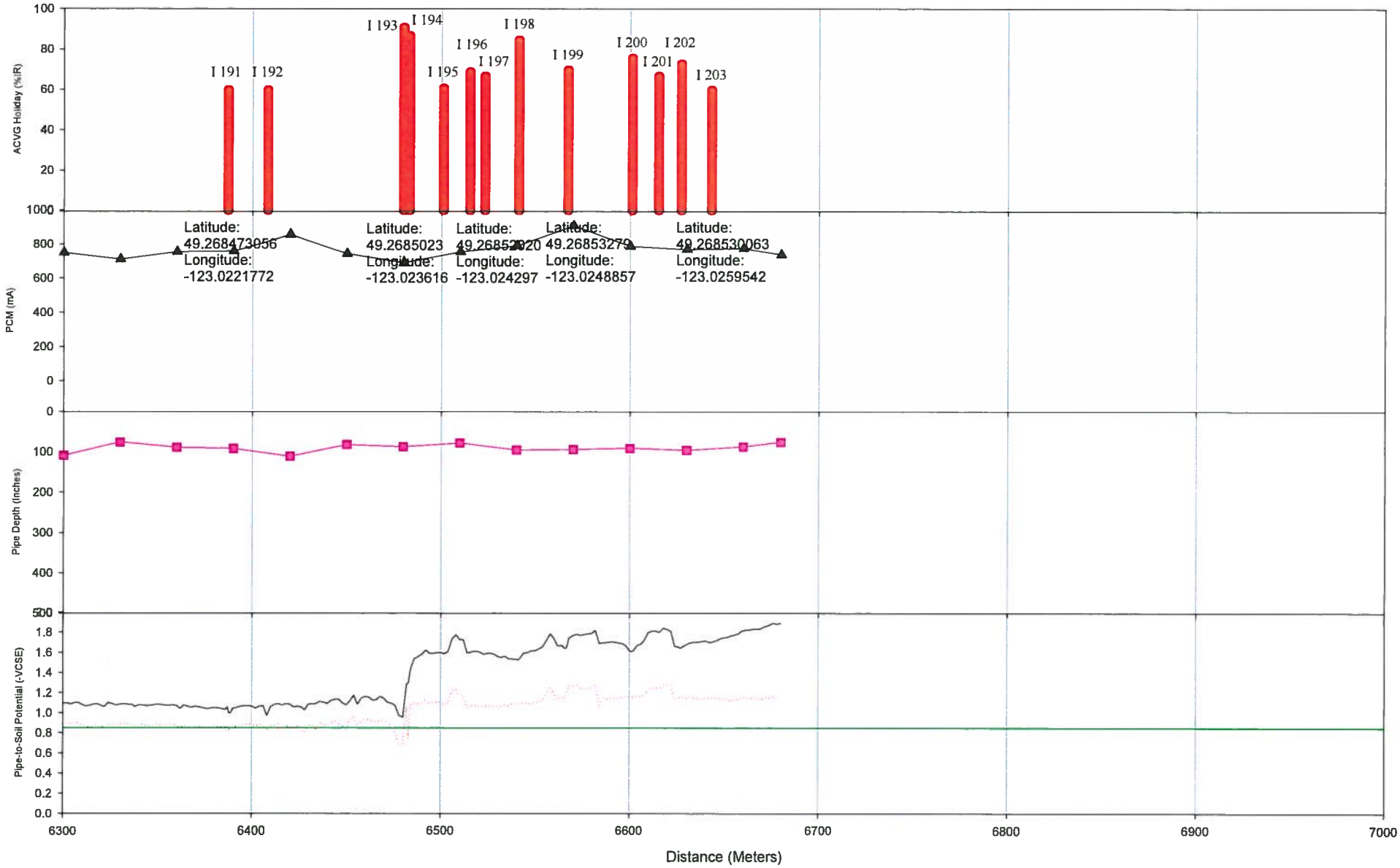

FortisBC

Test Point Inspections

Selected CA/Sgmnts: COASTAL; METRO; BURNABY; IP; COQUITLAM-BURNABY IP; 1

Filter Settings: Relative Location # is between 1 and 4

Options: Report based on "Selected CA/Sgmnts"

CP Region: COASTAL

SubRegion: METRO

Municipal: BURNABY

Pressure: IP

CA/Sgmnt Code: COQUITLAM-BURNABY IP **CA/Sgmnt Name:** FID 42057

CA/Sgmnt Code and Pipe	Location #	Location Description	RFID	Structure P/S	Structure IRF	Effective Native P/S	Inspection Date	Inspection Remarks	Inspection Date and Time	Latitude	Longitude
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				-1.540			4/20/1995		4/20/1995 12:00:00 AM		
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				-1.600			9/22/1997		9/22/1997 12:00:00 AM		
				-1.430			12/1/1998		12/1/1998 12:00:00 AM		
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				-1.500	-1.420		4/7/2003		4/7/2003 12:00:00 AM		
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				-2.080			11/1/2008		11/1/2008 12:00:00 AM		
				-2.000			11/10/2009		11/10/2009 12:00:00 AM		
				-2.250			11/15/2010		11/15/2010 12:00:00 AM		
				-2.100	-0.910	-0.510	12/21/2012	Interference of Coq. Gt.	12/21/2012 12:00:00 AM		
				-2.325	-1.160	-0.510	11/22/2013		11/22/2013 12:00:00 AM		
COQUITLA	2	Como Lk. @ Westwood		-1.500			1/3/1994		1/3/1994 12:00:00 AM	49.26317491	-122.79494960
				-1.260			4/26/1995		4/26/1995 12:00:00 AM		
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				-1.455	-1.040		4/7/2003		4/7/2003 12:00:00 AM		
				-1.650			11/4/2005		11/4/2005 12:00:00 AM		
				-1.660			2/28/2006		2/28/2006 12:00:00 AM		
				-1.670			2/28/2007		2/28/2007 12:00:00 AM		
				-1.470			11/1/2008		11/1/2008 12:00:00 AM		
				-1.670			11/10/2009		11/10/2009 12:00:00 AM		
				-1.600			11/15/2010		11/15/2010 12:00:00 AM		
				-1.745	-0.920	-0.525	12/21/2012		12/21/2012 12:00:00 AM		
				-1.650	-0.890	-0.525	11/22/2013		11/22/2013 12:00:00 AM		
COQUITLA	3	Poirier - S. of Como Lk.		-1.160			1/3/1994		1/3/1994 12:00:00 AM	49.26258978	-122.84656420
				-1.160			4/20/1995		4/20/1995 12:00:00 AM		
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CA/Sgmnt Code and Pipe	Location #	Location Description	RFID	Structure P/S	Structure IRF	Effective Native P/S	Inspection Date	Inspection Remarks	Inspection Date and Time	Latitude	Longitude
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				-1.170	-0.870	-0.518	12/21/2012		12/21/2012 12:00:00 AM		
				-1.475	-1.110	-0.518	11/22/2013		11/22/2013 12:00:00 AM		
COQUITLA	4	Robinson & Como Lk.		-1.210			1/3/1994		1/3/1994 12:00:00 AM	49.26355881	-122.87991790
				-1.290			4/20/1995		4/20/1995 12:00:00 AM		
				-1.080			4/19/1996		4/19/1996 12:00:00 AM		
				-1.120			9/22/1997		9/22/1997 12:00:00 AM		
				-1.080			12/1/1998		12/1/1998 12:00:00 AM		
				-0.965			11/18/2002		11/18/2002 12:00:00 AM		
				-1.085	-0.910		4/7/2003		4/7/2003 12:00:00 AM		
				-1.200			11/4/2005		11/4/2005 12:00:00 AM		
				-1.200			2/28/2006		2/28/2006 12:00:00 AM		
				-1.210			2/28/2007		2/28/2007 12:00:00 AM		
				-1.135			11/1/2008		11/1/2008 12:00:00 AM		
				-1.170			11/10/2009		11/10/2009 12:00:00 AM		
				-1.230			11/15/2010		11/15/2010 12:00:00 AM		
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CA/Sgmnt Code: COQUITLAM-BURNABY IP Records: 60

Pressure: IP Records: 60

Municipal: BURNABY Records: 60

SubRegion: METRO Records: 60

CP Region: COASTAL Records: 60

Total Records: 60

FortisBC

Test Point Inspections

Selected CA/Sgmnts: COASTAL; METRO; BURNABY; IP; COQUITLAM-BURNABY IP; 1

Filter Settings: Relative Location # is between 8 and 11

Options: Report based on "Selected CA/Sgmnts"

CP Region: COASTAL

SubRegion: METRO

Municipal: BURNABY

Pressure: IP

CA/Sgmnt Code: COQUITLAM-BURNABY IP **CA/Sgmnt Name:** FID 42057

CA/Sgmnt Code and Pipe	Location #	Location Description	RFID	Structure P/S	Structure IRF	Effective Native P/S	Inspection Date	Inspection Remarks	Inspection Date and Time	Latitude	Longitude
COQUITLA	8	Broadway & Gaglardi way		-1.090			1/3/1994		1/3/1994 12:00:00 AM	49.26294903	-122.89897060
				-1.110			4/20/1995		4/20/1995 12:00:00 AM		
				-1.200			4/19/1996		4/19/1996 12:00:00 AM		
				-1.340			9/22/1997		9/22/1997 12:00:00 AM		
				-1.170			12/1/1998		12/1/1998 12:00:00 AM		
				-1.115			11/18/2002		11/18/2002 12:00:00 AM		
				-1.155	-0.925		4/7/2003		4/7/2003 12:00:00 AM		
				-1.230			11/4/2005		11/4/2005 12:00:00 AM		
				-1.330			2/28/2006		2/28/2006 12:00:00 AM		
				-1.290			2/28/2007		2/28/2007 12:00:00 AM		
				-1.200			11/1/2008		11/1/2008 12:00:00 AM		
				-1.200			11/10/2009		11/10/2009 12:00:00 AM		
				-1.530			11/15/2010		11/15/2010 12:00:00 AM		
				-1.350	-1.110	-0.650	12/21/2012	In Hydro Sub Stn.	12/21/2012 12:00:00 AM		
				-1.075	-0.960	-0.650	11/22/2013		11/22/2013 12:00:00 AM		
COQUITLA	9	EPL Gaglardi Way @ Broadway		-1.240			11/29/1996		11/29/1996 12:00:00 AM	49.26304119	-122.90131240
				-1.400			11/28/1997		11/28/1997 12:00:00 AM		
				-1.400			10/19/1998		10/19/1998 12:00:00 AM		
				-1.175			11/2/2002		11/2/2002 12:00:00 AM		
				-0.900	-0.720	-0.800	7/15/2003		7/15/2003 12:00:00 AM		
				-1.350	-0.930	-0.610	12/11/2012		12/11/2012 12:00:00 AM		
				-1.340	-0.930	-0.610	11/22/2013		11/22/2013 12:00:00 AM		
COQUITLA	10	Underhill & BCHRW		-1.225			1/2/1994		1/2/1994 12:00:00 AM	49.26078012	-122.92737590
				-1.350			1/2/1995		1/2/1995 12:00:00 AM		
				-1.330			11/29/1996		11/29/1996 12:00:00 AM		
				-1.390			11/28/1997		11/28/1997 12:00:00 AM		
				-1.340			10/19/1998		10/19/1998 12:00:00 AM		
				-1.205			11/2/2002		11/2/2002 12:00:00 AM		
				-1.075	-0.850		7/15/2003		7/15/2003 12:00:00 AM		
				-1.295	-0.920		12/20/2004		12/20/2004 12:00:00 AM		
				-1.275			12/1/2006		12/1/2006 12:00:00 AM		
				-1.000			12/1/2007		12/1/2007 12:00:00 AM		
				-1.215			11/26/2008		11/26/2008 12:00:00 AM		
				-1.060		-0.660	9/30/2009		9/30/2009 12:00:00 AM		
				-1.240		-0.660	11/15/2010		11/15/2010 12:00:00 AM		
				-1.100	-0.730	-0.660	10/21/2011		10/21/2011 12:00:00 AM		
				-1.210	-0.860	-0.660	11/10/2012		11/10/2012 12:00:00 AM		
				-1.240	-0.880	-0.660	11/22/2013		11/22/2013 12:00:00 AM		
COQUITLA	11	Broadway & Underhill		-1.540			1/2/1994		1/2/1994 12:00:00 AM	49.25947649	-122.92743850

CA/Sgmnt Code and Pipe	Location #	Location Description	RFID	Structure P/S	Structure IRF	Effective Native P/S	Inspection Date	Inspection Remarks	Inspection Date and Time	Latitude	Longitude
				-1.570			1/2/1995		1/2/1995 12:00:00 AM		
				-1.500			11/29/1996		11/29/1996 12:00:00 AM		
				-1.715			11/28/1997		11/28/1997 12:00:00 AM		
				-1.600			10/19/1998		10/19/1998 12:00:00 AM		
				-1.460			11/2/2002		11/2/2002 12:00:00 AM		
				-1.340	-0.910		7/15/2003		7/15/2003 12:00:00 AM		
				-1.695	-1.090		12/20/2004		12/20/2004 12:00:00 AM		
				-1.680			12/1/2006		12/1/2006 12:00:00 AM		
				-1.620			12/1/2007		12/1/2007 12:00:00 AM		
				-1.595			11/26/2008		11/26/2008 12:00:00 AM		
				-1.500		-0.660	9/30/2009		9/30/2009 12:00:00 AM		
				-1.520		-0.660	11/15/2010		11/15/2010 12:00:00 AM		
				-1.460	-0.800	-0.660	10/21/2011		10/21/2011 12:00:00 AM		
				-1.530	-0.850	-0.660	11/15/2012		11/15/2012 12:00:00 AM		
				-1.560	-0.860	-0.660	11/22/2013		11/22/2013 12:00:00 AM		

CA/Sgmnt Code: COQUITLAM-BURNABY IP Records: 54

Pressure: IP Records: 54

Municipal: BURNABY Records: 54

SubRegion: METRO Records: 54

CP Region: COASTAL Records: 54

Total Records: 54

FortisBC

Test Point Inspections

Selected CA/Sgmnts: COASTAL; METRO; BURNABY; IP; COQUITLAM-BURNABY IP; 1

Filter Settings: Relative Location # is between 21 and 24

Options: Report based on "Selected CA/Sgmnts"

CP Region: COASTAL

SubRegion: METRO

Municipal: BURNABY

Pressure: IP

CA/Sgmnt Code: COQUITLAM-BURNABY IP **CA/Sgmnt Name:** FID 42057

CA/Sgmnt Code and Pipe	Location #	Location Description	RFID	Structure P/S	Structure IRF	Effective Native P/S	Inspection Date	Inspection Remarks	Inspection Date and Time	Latitude	Longitude
COQUITLA	21	6522 Broadway EPL		-1.020			1/2/1994		1/2/1994 12:00:00 AM	49.26231706	-122.96928560
				-1.210			1/2/1995		1/2/1995 12:00:00 AM		
				-1.210			11/29/1996		11/29/1996 12:00:00 AM		
				-1.225			11/28/1997		11/28/1997 12:00:00 AM		
				-1.140			10/19/1998		10/19/1998 12:00:00 AM		
				-1.085			11/2/2002		11/2/2002 12:00:00 AM		
				-0.925	-0.880		7/15/2003		7/15/2003 12:00:00 AM		
				-1.165	-0.960		12/20/2004		12/20/2004 12:00:00 AM		
				-1.160			12/1/2006		12/1/2006 12:00:00 AM		
				-1.100			12/1/2007		12/1/2007 12:00:00 AM		
				-1.050			11/26/2008		11/26/2008 12:00:00 AM		
				-0.975		-0.625	9/30/2009		9/30/2009 12:00:00 AM		
				-1.090		-0.625	10/19/2010		10/19/2010 12:00:00 AM		
				-1.110		-0.625	10/13/2011		10/13/2011 12:00:00 AM		
				-1.090	-0.890	-0.625	11/15/2012		11/15/2012 12:00:00 AM		
				-1.130	-0.920	-0.625	11/22/2013		11/22/2013 12:00:00 AM		
COQUITLA	22	Springer & Broadway		-0.810			1/2/1994		1/2/1994 12:00:00 AM	49.26633802	-122.98662680
				-0.920			1/2/1995		1/2/1995 12:00:00 AM		
				-0.820			11/29/1996		11/29/1996 12:00:00 AM		
				-0.860			11/28/1997		11/28/1997 12:00:00 AM		
				-0.850			10/19/1998		10/19/1998 12:00:00 AM		
				-0.810			11/2/2002		11/2/2002 12:00:00 AM		
				-0.845	-0.760	-0.660	7/15/2003		7/15/2003 12:00:00 AM		
				-0.980	-0.850	-0.660	12/20/2004		12/20/2004 12:00:00 AM		
				-1.000		-0.660	12/1/2006		12/1/2006 12:00:00 AM		
				-0.965		-0.660	12/1/2007		12/1/2007 12:00:00 AM		
				-0.960		-0.660	11/26/2008		11/26/2008 12:00:00 AM		
				-0.800		-0.660	9/30/2009		9/30/2009 12:00:00 AM		
				-0.945		-0.660	10/19/2010		10/19/2010 12:00:00 AM		
				-0.780	-0.680	-0.660	10/21/2011		10/21/2011 12:00:00 AM		
				-0.955	-0.790	-0.660	11/15/2012		11/15/2012 12:00:00 AM		
				-1.010	-0.860	-0.660	11/22/2013		11/22/2013 12:00:00 AM		
COQUITLA	24	Springer & Halifax		-1.110			1/2/1994		1/2/1994 12:00:00 AM	49.26798178	-122.98779990
				-1.400			1/2/1995		1/2/1995 12:00:00 AM		
				-0.850			11/29/1996		11/29/1996 12:00:00 AM		
				-0.900			11/28/1997		11/28/1997 12:00:00 AM		
				-0.840			10/19/1998		10/19/1998 12:00:00 AM		
				-0.820			11/2/2002		11/2/2002 12:00:00 AM		
				-0.840	-0.780	-0.620	7/15/2003		7/15/2003 12:00:00 AM		
				-1.010	-0.850	-0.620	12/20/2004		12/20/2004 12:00:00 AM		

CA/Sgmnt Code and Pipe	Location #	Location Description	RFID	Structure P/S	Structure IRF	Effective Native P/S	Inspection Date	Inspection Remarks	Inspection Date and Time	Latitude	Longitude
				-1.015		-0.620	12/1/2006		12/1/2006 12:00:00 AM		
				-0.985		-0.620	12/1/2007		12/1/2007 12:00:00 AM		
				-0.930		-0.620	11/26/2008		11/26/2008 12:00:00 AM		
				-0.880		-0.620	9/30/2009		9/30/2009 12:00:00 AM		
				-0.985		-0.620	10/19/2010		10/19/2010 12:00:00 AM		
				-0.890	-0.730	-0.620	10/21/2011		10/21/2011 12:00:00 AM		
				-0.965	-0.830	-0.620	11/15/2012		11/15/2012 12:00:00 AM		
				-1.005	-0.870	-0.620	11/22/2013		11/22/2013 12:00:00 AM		

CA/Sgmnt Code: COQUITLAM-BURNABY IP Records: 48

Pressure: IP Records: 48

Municipal: BURNABY Records: 48

SubRegion: METRO Records: 48

CP Region: COASTAL Records: 48

Total Records: 48

FortisBC

Test Point Inspections

Selected CA/Sgmnts: COASTAL; METRO; BURNABY; IP; COQUITLAM-BURNABY IP; 1

Filter Settings: Relative Location # is between 30 and 30

Options: Report based on "Selected CA/Sgmnts"

CP Region: COASTAL

SubRegion: METRO

Municipal: BURNABY

Pressure: IP

CA/Sgmnt Code: COQUITLAM-BURNABY IP **CA/Sgmnt Name:** FID 42057

CA/Sgmnt Code and Pipe	Location #	Location Description	RFID	Structure P/S	Structure IRF	Effective Native P/S	Inspection Date	Inspection Remarks	Inspection Date and Time	Latitude	Longitude
COQUITLA	30	Fairlawn & L/S Brentlawn		-1.090			1/2/1994		1/2/1994 12:00:00 AM	49.26969688	-123.00022740
				-0.920			4/19/1995		4/19/1995 12:00:00 AM		
				-1.115			11/29/1996		11/29/1996 12:00:00 AM		
				-1.325			11/28/1997		11/28/1997 12:00:00 AM		
				-1.200			10/19/1998		10/19/1998 12:00:00 AM		
				-1.090			11/2/2002		11/2/2002 12:00:00 AM		
				-1.010	-0.850		7/15/2003		7/15/2003 12:00:00 AM		
				-1.080	-0.880		12/20/2004		12/20/2004 12:00:00 AM		
				-1.120			12/1/2006		12/1/2006 12:00:00 AM		
				-1.075			12/1/2007	C.P.M. 10 and 101 are temporarily feeding C.P.M. 117.	12/1/2007 12:00:00 AM		
				-1.080			11/26/2008		11/26/2008 12:00:00 AM		
				-1.400		-0.590	9/30/2009		9/30/2009 12:00:00 AM		
				-1.560		-0.590	11/15/2010		11/15/2010 12:00:00 AM		
				-1.230	-0.940	-0.590	11/8/2011		11/8/2011 12:00:00 AM		
				-1.330	-0.990	-0.590	11/10/2012		11/10/2012 12:00:00 AM		
				-1.290	-0.960	-0.590	11/22/2013		11/22/2013 12:00:00 AM		

CA/Sgmnt Code: COQUITLAM-BURNABY IP Records: 16

Pressure: IP Records: 16

Municipal: BURNABY Records: 16

SubRegion: METRO Records: 16

CP Region: COASTAL Records: 16

Total Records: 16

FortisBC

Test Point Inspections

Selected CA/Sgmnts: COASTAL; METRO; BURNABY; IP; COQUITLAM-BURNABY IP; 1

Filter Settings: Relative Location # is between 132 and 132

Options: Report based on "Selected CA/Sgmnts"

CP Region: COASTAL

SubRegion: METRO

Municipal: BURNABY

Pressure: IP

CA/Sgmnt Code: COQUITLAM-BURNABY IP **CA/Sgmnt Name:** FID 42057

CA/Sgmnt Code and Pipe	Location #	Location Description	RFID	Structure P/S	Structure IRF	Effective Native P/S	Inspection Date	Inspection Remarks	Inspection Date and Time	Latitude	Longitude
COQUITLA	132	Halifix & Douglas		-0.930			1/2/1994		1/2/1994 12:00:00 AM		
				-0.960			4/19/1995		4/19/1995 12:00:00 AM		
				-1.195			11/29/1996		11/29/1996 12:00:00 AM		
				-1.235			11/28/1997		11/28/1997 12:00:00 AM		
				-1.200			10/19/1998		10/19/1998 12:00:00 AM		
				-1.040			11/2/2002		11/2/2002 12:00:00 AM		
				-0.960	-0.800	-0.720	7/15/2003		7/15/2003 12:00:00 AM		
				-1.170	-1.005	-0.720	12/20/2004		12/20/2004 12:00:00 AM		
				-1.190		-0.720	12/1/2006		12/1/2006 12:00:00 AM		
				-1.060		-0.720	12/1/2007	Coquitlam Gate is now isolated from C.P.M. 110	12/1/2007 12:00:00 AM		
				-1.055		-0.720	11/26/2008		11/26/2008 12:00:00 AM		
				-1.160		-0.720	9/30/2009		9/30/2009 12:00:00 AM		
				-1.105		-0.720	11/15/2010		11/15/2010 12:00:00 AM		
				-1.050		-0.720	11/18/2011		11/18/2011 12:00:00 AM		
				-1.090	-0.910	-0.720	11/10/2012		11/10/2012 12:00:00 AM		
				-1.105	-0.915	-0.720	11/22/2013		11/22/2013 12:00:00 AM		

CA/Sgmnt Code: COQUITLAM-BURNABY IP Records: 16

Pressure: IP Records: 16

Municipal: BURNABY Records: 16

SubRegion: METRO Records: 16

CP Region: COASTAL Records: 16

Total Records: 16

CA/Sgmnt Code and Pipe	Location #	Location Description	RFID	Structure P/S	Structure IRF	Effective Native P/S	Inspection Date	Inspection Remarks	Inspection Date and Time	Latitude	Longitude
VANCOUV	16	W 37th & Oak EI		-0.702			9/24/2012	MIDDLE OF LANE SEC EI	9/24/2012 11:03:06 A	49.23763657	-123.1277999
				-0.857	-0.767	-0.650	2/25/2013	MIDDLE OF OAK	2/25/2013 10:02:18 A		
VANCOUV	17	W. 37 Ave & L/E Granville		-0.897			9/24/2012		9/24/2012 10:40:52 A	49.23795314	-123.1387310
				-0.933	-0.806	-0.705	2/25/2013		2/25/2013 10:08:34 A		
VANCOUV	18	W. 37th & Pine		-0.857			9/24/2012		9/24/2012 10:24:21 A	49.23812866	-123.1469192
				-0.879	-0.736	-0.630	2/25/2013	GREEN T/L	2/25/2013 10:17:57 A		
VANCOUV	19	NEC E 29th & Nanaimo		-0.858			11/13/201		11/13/2012 12:11:03	49.24442876	-123.0549928
				-0.998	-0.852		3/19/2013		3/19/2013 12:08:47 P		
VANCOUV	20	Stainsbury & Lakewood		-1.186			11/13/201	open wires same read @ vent pipe	11/13/2012 12:26:09	49.25048106	-123.0621121
				-1.027	-0.789	-0.630	3/19/2013	taken on open exposed wires @ vent pipe	3/19/2013 12:24:49 P		
VANCOUV	21	NEC E 19th & Marshall		-1.029			11/13/201		11/13/2012 12:40:10	49.25304874	-123.0619835
				-1.121	-0.884		3/19/2013		3/19/2013 12:30:27 P		
VANCOUV	22	E 16th & Victoria		-1.083			11/13/201	nwc	11/13/2012 12:54:25	49.25615693	-123.0661005
				-1.207	-0.943		3/19/2013		3/19/2013 12:39:55 P		
VANCOUV	23	E 14th & Woodland					12/12/201	Cannot Locate	12/12/2012 12:00:00	49.25784565	-123.0737958
							3/19/2013	CANNOT LOCATE	3/19/2013 12:27:58 P		
VANCOUV	24	E 7th & Woodland		-0.856			11/13/201	valve stem	11/13/2012 1:30:44 P	49.26425854	-123.0737250
				-1.091	-0.733	-0.620	6/19/2013	NEC VALVE STEM	6/19/2013 10:20:15 A		
VANCOUV	25	E 6th & Quebec		-0.920			11/26/201	CPM 59	11/26/2012 12:00:00	49.26555252	-123.1030273
				-1.232	-0.875		3/19/2013	CPM59	3/19/2013 11:43:00 A		
VANCOUV	26	NWC E 6th & Quebec		-0.780			11/26/201	CPM 51 (Dead Anode Bed)	11/26/2012 12:00:00	49.26559706	-123.1030104
				-0.999	-0.865		5/22/2013	CPM 51	5/22/2013 11:23:47 A		
VANCOUV	28	E 5th & Fir		-0.900			12/12/201		12/12/2012 12:00:00	49.26700974	-123.1413116
				-0.898	-0.760	-0.530	5/22/2013		5/22/2013 11:43:05 A		
VANCOUV	29	E 5TH & Pine		-0.908			10/29/201		10/29/2012 11:59:44	49.26703262	-123.1429214
				-1.207	-1.082		5/22/2013		5/22/2013 11:40:20 A		
VANCOUV	30	Grandview & Semlin		-1.093			11/13/201		11/13/2012 11:24:27	49.26141139	-123.0640051
				-1.167	-0.940		2/27/2013	In sidewalk southside	2/27/2013 11:56:06 A		
VANCOUV	31	2nd & Woodland		-1.300			9/26/2012	TELEMETER	9/26/2012 1:28:54 PM	49.26833550	-123.0735834
				-1.214	-0.946		6/19/2013	TELEMETER	6/19/2013 11:55:11 A		
VANCOUV	32	E 2nd & Semlin		-1.268			10/29/201		10/29/2012 11:17:00	49.26868048	-123.0637522
				-1.244	-0.969		6/19/2013	T/L	6/19/2013 11:02:27 A		
VANCOUV	33	Slocan & E 29th (Reg Vault)		-1.242			11/13/201	on reg vault lid	11/13/2012 11:10:49	49.24452936	-123.0492035
				-1.105	-0.826	-0.690	6/19/2013	REG. VALVE	6/19/2013 9:48:38 AM		
VANCOUV	34	E 24th & Slocan		-1.280			11/13/201		11/13/2012 10:56:08	49.24887656	-123.0495168
				-1.012	-0.989		2/27/2013	take on #8 wire	2/27/2013 11:38:36 A		
VANCOUV	35	E 18th & Slocan		-0.825			11/13/201		11/13/2012 10:47:17	49.25397971	-123.0494561
				-1.180	-0.988		2/27/2013	taken on #8 grn (#8 yellow reads same)	2/27/2013 11:36:31 A		
VANCOUV	36	Grandview & Slocan (EI SEC)		-0.896			11/13/201		11/13/2012 10:16:33	49.25780214	-123.0494726

CA/Sgmnt Code and Pipe	Location #	Location Description	RFID	Structure P/S	Structure IRF	Effective Native P/S	Inspection Date	Inspection Remarks	Inspection Date and Time	Latitude	Longitude
				-1.423	-0.999		2/27/2013	taken @ rec on cathode	2/27/2013 11:10:07 A		
VANCOUV	37	E 3rd & Slocan		-1.195			12/12/201	SEC	12/12/2012 12:00:00	49.26765615	-123.0493520
				-1.065	-0.869		5/22/2013	SEC white wire	5/22/2013 1:46:05 PM		
VANCOUV	39	2nd & Cassiar		-0.905			12/12/201		12/12/2012 12:00:00	49.26849747	-123.0308990
				-1.013	-0.921		5/22/2013		5/22/2013 1:37:50 PM		
VANCOUV	40	2nd & Boundary		-0.980			12/12/201		12/12/2012 12:00:00	49.26843890	-123.0236410
				-1.140	-0.900		5/23/2013	NWC	5/23/2013 7:29:21 AM		
VANCOUV	41	Gravely & Boundary		-0.970			12/12/201		12/12/2012 12:00:00	49.27025025	-123.0237757
				-1.145	-0.896		5/22/2013	SWC Blk no tape	5/22/2013 2:14:15 PM		
VANCOUV	42	William & Skeena		-1.602			11/14/201		11/14/2012 1:02:23 P	49.27422154	-123.0284660
VANCOUV	43	Adanac & Kootenay		-1.200			12/12/201		12/12/2012 12:00:00	49.27737829	-123.0257068
VANCOUV	44	Pender & Kootenay		-1.058			11/14/201		11/14/2012 1:26:19 P	49.28013582	-123.0257084
VANCOUV	45	Dundas & Kootenay		-1.127			11/14/201		11/14/2012 1:39:43 P	49.28462939	-123.0257597
VANCOUV	46	Second Narrows Bridge		-0.920			12/12/201		12/12/2012 12:00:00	49.29170563	-123.0258952

CA/Sgmnt Code: VANCOUVER IP Records: 79

Pressure: IP Records: 79

Municipal: VANCOUVER - EAST Records: 79

SubRegion: METRO Records: 79

CP Region: COASTAL Records: 79

Total Records: 79

B C GAS CORROSION CONTROL IP SURVEY					
SYSTEM: VANCOUVER					
TECH: JUNG & WONG					
REF.	LOCATION	REMARK	DATE	P/S (mVCu)	AB
64	2ND & WOODLAND	RV #4141	3/9/1993	-880	
65	2ND & SEMLIN	TL	3/9/1993	-1450	
66	3RD & SLOCAN	EI(WHITE)	3/9/1993	-1200	
67	2ND & CASSIAR	NEC EI	3/9/1993	-930	
68	2ND & BOUNDARY	NWC EI(G)	3/9/1993	-1000	
69	2ND & BOUNDARY	NWC EI(WHITE)	3/9/1993	-1510	
70	2ND & CASSIAR	NEC EI(G)	3/9/1993	-930	

B C GAS
CORROSION CONTROL
IP SURVEY

SYSTEM: VANCOUVER

TECH: JUNG & WONG

REF.	LOCATION	REMARK	DATE	P/S (mVCu)	AB
63	2ND & WOODLAND	RV #4141	8/4/1994	-900	
64	2ND & SEMLIN	TL	8/4/1994	-1580	
65	3RD & SLOCAN	EI(WHITE)	8/4/1994	-1360	
66	2ND & CASSIAR	NEC EI	8/4/1994	-1210	
67	2ND & BOUNDARY	NWC EI(G)	8/4/1994	-1060	
68	2ND & BOUNDARY	NWC EI(WHITE)	8/4/1994	-1560	
69	2ND & CASSIAR	NEC EI(G)	8/4/1994	-930	

TERASEN GAS
CORROSION CONTROL
IP SURVEY

SYSTEM: VANCOUVER
TECH: J. JUNG

REF.	LOCATION	REMARK	DATE	P/S (mVCu)	AB
62	2ND & WOODLAND	NEC EI	22/2/95	-1150	
63	2ND & SEMLIN	TL	22/2/95	-1370	
64	3RD & SLOCAN	EI(WHITE)	22/2/95	-1150	
65	2ND & CASSIAR	NEC EI (WHITE)	22/2/95	-1040	
66	2ND & BOUNDARY	SWC EI(G)	22/2/95	-1290	
67	2ND & BOUNDARY	SWC EI(WHITE)	22/2/95	-960	
68	2ND & CASSIAR	NEC EI(G)	22/2/95	-980	

B C GAS
CORROSION CONTROL
IP SURVEY

SYSTEM: VANCOUVER

TECH: J. JUNG & S. WONG

REF.	LOCATION	REMARK	DATE	P/S (mVCu)	AB
64	2ND & WOODLAND	NEC EI	25/4/96	-1100	
65	2ND & SEMLIN	TL	25/4/96	-1350	
66	3RD & SLOCAN	EI(WHITE)	25/4/96	-1150	
67	2ND & CASSIAR	NEC EI (WHITE)	25/4/96	-1080	
68	2ND & BOUNDARY	SWC EI(G)	25/4/96	-1260	
69	2ND & BOUNDARY	SWC EI(WHITE)	25/4/96	-1260	
70	2ND & CASSIAR	NEC EI(G)	25/4/96	-1010	

B C GAS
CORROSION CONTROL
IP SURVEY

SYSTEM: VANCOUVER

TECH: J. JUNG & S. WONG

REF.	LOCATION	REMARK	DATE	P/S (mVCu)	AB
65	2ND & WOODLAND	NEC EI	3/27/1997	-1160	
66	2ND & SEMLIN	TL	3/27/1997	-1440	
67	3RD & SLOCAN	EI(WHITE)	3/27/1997	-1220	
68	2ND & CASSIAR	NEC EI (WHITE)	3/27/1997	-1120	
69	2ND & BOUNDARY	SWC EI	3/27/1997	-1310	
70	2ND & CASSIAR	NEC EI(G)	3/27/1997	-900	

B C GAS
CORROSION CONTROL
IP SURVEY

SYSTEM: VANCOUVER

TECH: J. JUNG & S. WONG

REF.	LOCATION	REMARK	DATE	P/S (mVCu)	AB
65	2ND & WOODLAND (White)	NEC EI	29/4/98	-1080	
	2ND & WOODLAND (Green)	NEC EI	29/4/98	-1160	
66	2ND & SEMLIN	TL	29/4/98	-1400	
67	3RD & SLOCAN	EI(WHITE)	29/4/98	-1220	
68	2ND & CASSIAR	NEC EI (WHITE)	29/4/98	-1120	
69	2ND & BOUNDARY	SWC EI	29/4/98	-1350	
70	2ND & CASSIAR	NEC EI(G)	29/4/98	-860	

B C GAS
CORROSION CONTROL
IP SURVEY

SYSTEM: VANCOUVER

TECH: J. JUNG & S. WONG

REF.	LOCATION	REMARK	DATE	P/S (mVCu)	AB
65	2ND & WOODLAND (White)	NEC EI	11-May-99	-940	
	2ND & WOODLAND (Green)	NEC EI	11-May-99	-1160	
66	2ND & SEMLIN	TL	11-May-99	-1340	
67	3RD & SLOCAN	EI(WHITE)	11-May-99	-1170	
68	2ND & CASSIAR	NEC EI (WHITE)	11-May-99	-1010	
69	2ND & BOUNDARY	SWC EI	11-May-99	-1350	
70	2ND & CASSIAR	NEC EI(G)	11-May-99	-870	

B C GAS
CORROSION CONTROL
IP SURVEY

SYSTEM: VANCOUVER

TECH: J. JUNG & S. WONG

REF.	LOCATION	REMARK	DATE	P/S (mVCu)	AB
65	2ND & WOODLAND (White)	NEC EI	31-Jul-00		
	2ND & WOODLAND (Green)	NEC EI	31-Jul-00		
66	2ND & SEMLIN	TL	31-Jul-00		
67	3RD & SLOCAN	EI(WHITE)	31-Jul-00		
68	2ND & CASSIAR	NEC EI (WHITE)	31-Jul-00		
69	2ND & BOUNDARY	SWC EI	31-Jul-00		
70	2ND & CASSIAR	NEC EI(G)	31-Jul-00		

B C GAS
CORROSION CONTROL
IP SURVEY

SYSTEM: VANCOUVER

TECH: J. JUNG & S. WONG

REF.	LOCATION	REMARK	DATE	P/S (mVCu)
65	2ND & WOODLAND (White)	NEC EI		
	2ND & WOODLAND (Green)	NEC EI		
66	2ND & SEMLIN	TL		
67	3RD & SLOCAN	EI(WHITE)		
68	2ND & CASSIAR	NEC EI (WHITE)		
69	2ND & BOUNDARY	SWC EI		
70	2ND & CASSIAR	NEC EI(G)		

B C GAS
CORROSION CONTROL
IP SURVEY

SYSTEM: VANCOUVER

TECH: J. JUNG & S. WONG

REF.	LOCATION	REMARK	DATE	P/S (mVCu)
65	2ND & WOODLAND (White)	NEC EI	16-Apr-02	-950
	2ND & WOODLAND (Green)	NEC EI	16-Apr-02	-1080
66	2ND & SEMLIN	TL	16-Apr-02	-1390
67	3RD & SLOCAN	EI(WHITE)	16-Apr-02	-1190
68	2ND & CASSIAR	NEC EI (WHITE)	16-Apr-02	-1090
69	2ND & BOUNDARY	SWC EI	16-Apr-02	-1330
70	2ND & CASSIAR	NEC EI	16-Apr-02	-980

B C GAS
CORROSION CONTROL
IP SURVEY

SYSTEM: VANCOUVER

TECH: J. JUNG & S. WONG

REF.	LOCATION	REMARK	DATE	P/S (mVCu) On	Off	Static	Polarization
45	2ND & WOODLAND (White)	NEC EI	18-Feb-03	-1080	-830		-830
46	2ND & WOODLAND (Green)	NEC EI	5-Feb-03	-1420	-1000	-790	-210
47	2ND & SEMLIN	TL	5-Feb-03	-1650	-1160	-970	-190
48	3RD & SLOCAN	EI(WHITE)	5-Feb-03	-1440	-980	-770	-210
49	2ND & CASSIAR	NEC EI (WHITE)	5-Feb-03	-1150	-863	-730	-133
50	2ND & BOUNDARY	SWC EI	5-Feb-03	-1450	-1100	-880	-220

TERASEN GAS
CORROSION CONTROL
IP SURVEY

SYSTEM: VANCOUVER
TECH: S. Wong

REF.	LOCATION	REMARK	DATE	P/S (mVCu)	AB
62	2ND & WOODLAND	NEC EI(Green)	28-Sep-04	-1220	
	2ND & WOODLAND	NEC EI(White)	28-Sep-04	-960	
63	2ND & SEMLIN	TL	18-Aug-04	-1489	
64	3RD & SLOCAN	EI(WHITE)	18-Aug-04	-1230	
65	2ND & CASSIAR	SWC EI	28-Sep-04	-1020	
66	2ND & BOUNDARY	SWC EI(G)	28-Sep-04	-1150	
67	2ND & BOUNDARY	SWC EI(WHITE)	28-Sep-04	-750	
68	2ND & CASSIAR	NEC EI(G)	18-Aug-04	-960	

TERASEN GAS
CORROSION CONTROL
IP SURVEY

SYSTEM: VANCOUVER
TECH: Swong 2005

REF.	LOCATION	REMARK	DATE	P/S (mVCu)	AB
62	2ND & WOODLAND	NEC EI (WHT # 12)	26-Apr-05	-948	
	2ND & WOODLAND	Telemeter	26-Apr-05	-1450	
	2ND & WOODLAND	EI (Open) Fence	26-Apr-05	-1410	
	2ND & WOODLAND	EI (Open) Fence	26-Apr-05	-1170	
63	2ND & SEMLIN	TL	26-Apr-05	-1472	
64	3RD & SLOCAN	EI(WHITE)	26-Apr-05	-1270	
65	2ND & CASSIAR	NEC EI	26-Apr-05	-990	
66	2ND & BOUNDARY	SWC EI(G)	07-Jun-05	-1090	
67	2ND & BOUNDARY	SWC EI(WHITE)	07-Jun-05	-1340	
68	2ND & CASSIAR	NEC EI	26-Apr-05	-990	

TERASEN GAS
CORROSION CONTROL
IP SURVEY

SYSTEM: VANCOUVER
TECH:

REF.	LOCATION	REMARK	DATE	P/S (mVCu)	AB	Tech
62	2ND & WOODLAND	NEC EI (WHT # 12)	12-Apr-06	-1080		Jung
	2ND & WOODLAND	Telemeter	12-Apr-06	-1320		Jung
	2ND & WOODLAND	EI (Open) Fence	12-Apr-06			Jung
	2ND & WOODLAND	EI (Open) Fence	12-Apr-06			Jung
63	2ND & SEMLIN	TL	12-Apr-06	-1480		Jung
66	2ND & BOUNDARY	SWC EI(G)	12-Apr-06	-1000		Jung
67	2ND & BOUNDARY	SWC EI(WHITE)	12-Apr-06	-1250		Jung
68	2ND & CASSIAR	NEC EI	12-Apr-06	-1030	.8A	Jung

TERASEN GAS
CORROSION CONTROL
IP SURVEY

SYSTEM: VANCOUVER
TECH: John Jung & Steve Wong

REF.	LOCATION	REMARK	DATE	P/S (mVCu)	AB
62	2ND & WOODLAND	NEC EI (WHT # 12)	03-May-07	-950	
	2ND & WOODLAND	Telemeter	03-May-07	-1710	
	2ND & WOODLAND	EI (Open) Fence, tape	03-May-07	-1280	
	2ND & WOODLAND	EI (Open) Fence	03-May-07	-1640	
63	2ND & SEMLIN	TL	03-May-07	-1350	
66	2ND & BOUNDARY	SWC EI(G)	03-May-07	-1020	
67	2ND & BOUNDARY	SWC EI(WHITE)	03-May-07	-1200	
68	2ND & CASSIAR	NEC EI	03-May-07	-950	.8A

TERASEN GAS
CORROSION CONTROL
IP SURVEY

SYSTEM: VANCOUVER
TECH: John Jung & Steve Wong

REF.	LOCATION	REMARK	DATE	P/S (mVCu)	AB	Tech
62	2ND & WOODLAND	NEC EI (WHT # 12)	10-Apr-08	-950		Jung
	2ND & WOODLAND	Telemeter	10-Apr-08	-1700		Jung
63	2ND & SEMLIN	TL	10-Apr-08	-1340		Jung
66	2ND & BOUNDARY	SWC EI(G)	10-Apr-08	-900		Jung
67	2ND & BOUNDARY	SWC EI(WHITE)	10-Apr-08	-1060		Jung
68	2ND & CASSIAR	NEC EI	10-Apr-08	-1060	.8A	Jung

TERASEN GAS
CORROSION CONTROL
IP SURVEY

SYSTEM: VANCOUVER
TECH: John Jung & Steve Wong

REF.	LOCATION	REMARK	DATE	P/S (mVCu)	AB
62	2ND & WOODLAND	NEC EI (WHT # 12)	12-Aug-09	-870	
	2ND & WOODLAND	Telemeter	12-Aug-09	-1250	
63	2ND & SEMLIN	TL	12-Aug-09	-1270	
66	2ND & BOUNDARY	SWC EI(G)	12-Aug-09	-850	
67	2ND & BOUNDARY	SWC EI(WHITE)	12-Aug-09	-1060	
68	2ND & CASSIAR	NEC EI	12-Aug-09	-850	.55A

TERASEN GAS
CORROSION CONTROL
IP SURVEY

SYSTEM: VANCOUVER
TECH: John Jung & Steve Wong

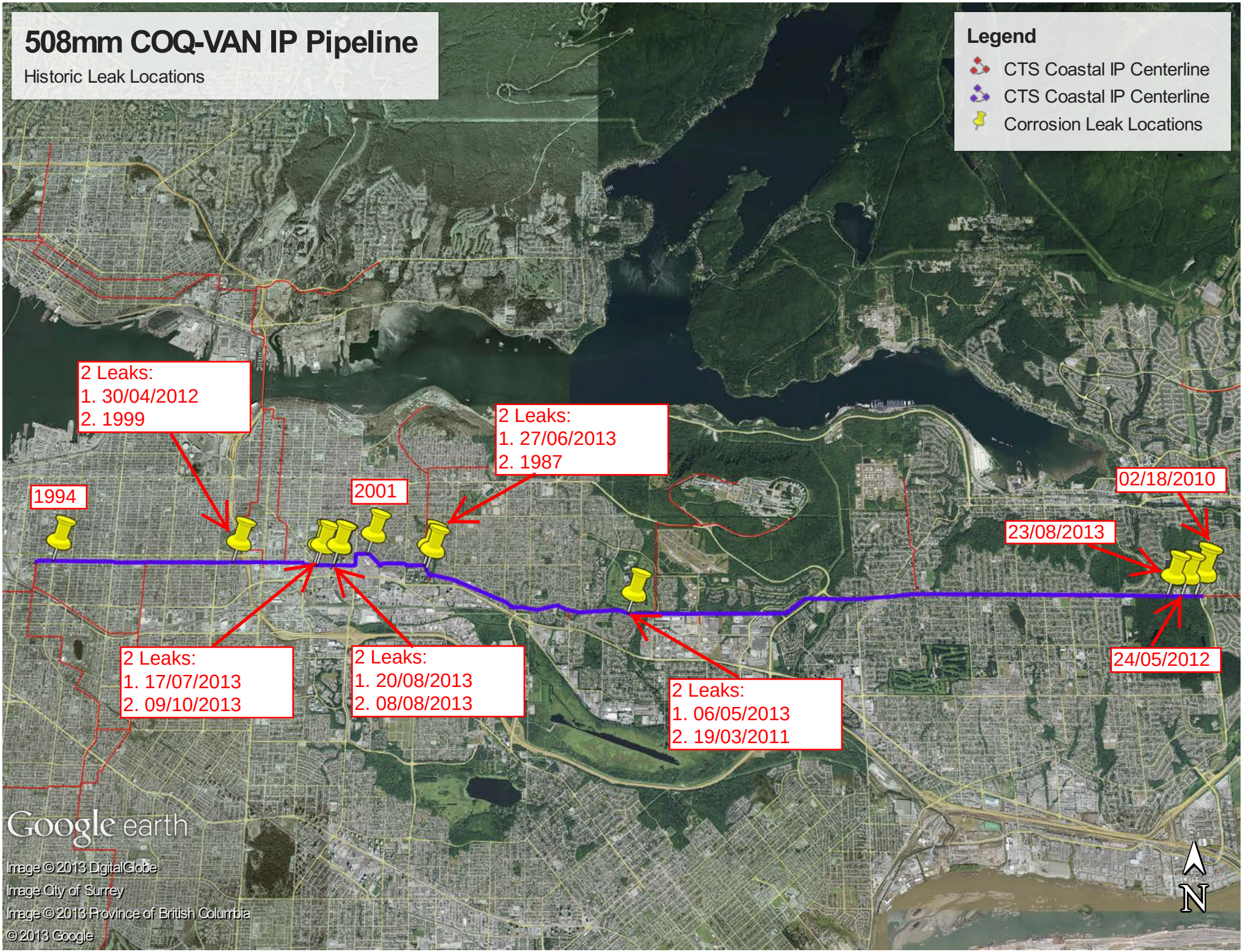
REF.	LOCATION	REMARK	DATE	P/S (mVCu)	AB
62	2ND & WOODLAND	NEC EI (WHT # 12)	26-Mar-10	-850	
	2ND & WOODLAND	Telemeter	26-Mar-10	-1450	
63	2ND & SEMLIN	TL	26-Mar-10	-1160	
66	2ND & BOUNDARY	SWC EI(G)	26-Mar-10	-850	
67	2ND & BOUNDARY	SWC EI(WHITE)	26-Mar-10	-1070	0.23A
68	2ND & CASSIAR	NEC EI	26-Mar-10	-900	.6A

Appendix 3

FortisBC Response to General Order 2013-25

508mm Coquitlam to Vancouver IP Pipeline

Historic Leak Map


508mm COQ-VAN IP Pipeline
Historic Leak Locations
Legend
CTS Coastal IP Centerline
CTS Coastal IP Centerline
Corrosion Leak Locations
2 Leaks:
1. 30/04/2012
2. 1999
2 Leaks:
1. 27/06/2013
2. 1987
1994
2001
02/18/2010
23/08/2013
2 Leaks:
1. 17/07/2013
2. 09/10/2013
2 Leaks:
1. 20/08/2013
2. 08/08/2013
2 Leaks:
1. 06/05/2013
2. 19/03/2011
24/05/2012
Google earth
Image © 2013 DigitalGlobe
Image City of Surrey
Image © 2013 Province of British Columbia
© 2013 Google
N

Appendix 4

FortisBC Response to General Order 2013-25

508mm Coquitlam to Vancouver IP Pipeline

BC Oil and Gas Commission General Order 2013-25

October 30, 2013 Enforcement File: 13-96

Fortis BC Energy Inc.
16705 Fraser Highway
Surrey, BC, V4N 0E8
Attention: Keith Recsky, Sr. Integrity Engineer

Re: General Order 2013-25

Dear Mr. Recsky

Please find attached a Commission order in regard to pipeline Project 1045 in the Burnaby area, and the recent leaks associated with it.

If you have any questions or concerns, please do not hesitate to contact Mr. Jason Wilson, Pipeline Engineer with the Commission at 250 980-6072.

Thanking you in advance.

Yours Truly,

Keith Rande
Manager Enforcement
Oil and Gas Commission

cc. Dean Zimmer, Director C&E, OGC
Jason Wilson, Pipeline Engineer, OGC

GENERAL ORDER 2013-25
Section 49 *Oil and Gas Activities Act*

Issued to:

Fortis BC Energy Inc.
16705 Fraser Highway
Surrey, BC, V4N 0E8

Attention: Keith Recsky

Order:

Pursuant to section 49(1)(b) of the *Oil and Gas Activities Act* (the Act), I, Dean Zimmer, order that Fortis BC Energy Inc. (Fortis BC) must:

1. On or before December 1, 2013 complete and submit to the Oil and Gas Commission (Commission):
    a. An engineering assessment of Pipeline Project 1045 (the subject pipeline) that includes but is not limited to:
        i. a timeline to repair, replace or discontinue the use of the subject pipeline;
        ii. interim measures to continue the safe operation of the subject pipeline and rationale for those measures;
        iii. a contingency plan in the event that the pipeline becomes inoperable prior to its repair or replacement;
        iv. the performance measures and defined acceptability criteria which would demonstrate fitness for service, as per CSA Z662-11, Clause 3.3;
        v. description of the leak detection program and its efficiency;
        vi. all information obtained from cut-outs of the subject pipeline performed within the last ten years that provides evidence of the subject pipeline condition;
        vii. the cause, size, and axial location of the through-wall failure, and the integrity of the surrounding material for each failure in 2013.

    b. An estimate of the volume of gas lost during the most recent leak;

    c. Records of the closed interval surveys of the cathodic protection system for the past five years, and;

    d. A map of the subject pipeline that shows all failure locations over the past five years.

2. Complete leak surveys on the subject pipeline at a minimum of once per week.

3. Submit the information required in Item 1 electronically to the Commission at C&E@bcogc.ca.

Conditions:

A. This order shall remain in effect until amended or terminated in whole or in part by the Commission.

Reasons:

I make this order for the following reasons:

i. Fortis BC is the operator responsible for the subject pipeline.

ii. The subject pipeline has experienced seven leaks to date in 2013, two leaks in 2012, and six leaks prior to that.

iii. Fortis BC has identified external corrosion as the cause.

iv. I am of the opinion that the subject pipeline may pose a risk to public safety and the environment.

Review and Appeal:

Fortis BC may request a review of this order under section 70 of the Act by submitting a request for review to: ogc.determinationreviews@bcogc.ca.

Fortis BC may appeal this order to the Oil and Gas Tribunals under section 72 of the Act. The process for appeals may be found at www.ogat.gov.bc.ca and a notice of appeal may be sent to the Oil and Gas Appeals Tribunal at:

Oil and Gas Appeals Tribunal
PO Box 4925 Stn Prov Govt
Victoria, BC, V8W 9V1

_____
Dean Zimmer
Director, Compliance and Enforcement
Oil and Gas Commission

DATED AT Fort St. John, in the Province of British Columbia, this 30th day of October, 2013.

Appendix A-4

D.G. HONEGGER CONSULTING
SITE-SPECIFIC SEISMIC VULNERABILITY ASSESSMENT

Summary of Site-Specific Seismic Vulnerability Assessment of FortisBC Energy Gas Pipeline Location LM-7

Revision 0

February 2013

D.G. Honegger Consulting
2690 Shetland Place
Arroyo Grande, California 93420
Telephone / Fax: 805-473-0856

REVISION RECORD

Revision	Description	Date
0	Original issue	Feb 20, 2012

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2.3 Recommended Action at Location LM-7 3
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APPENDIX 1: FORTISBC IP PIPELINE SEGMENTS NEAR FRASER GATE STATION, VANCOUVER, BC (LM-7)

1.0 BACKGROUND

Based upon the findings from a regional vulnerability assessment conducted in 2010 (DGHC, 2010), FortisBC Energy (Fortis) identified fifteen locations for site-specific assessment of the likely seismic ground displacement hazard and the pipeline response to that displacement. The assessments of seismic ground displacement hazard were performed by geotechnical consultants contracted directly by Fortis. Ground displacement estimates for ground shaking with mean return periods of 475-years and 2,475-years. The findings from these assessments were documented in a single report to Fortis (DGHC, 2012).

The dominant hazard identified was related to liquefaction and subsequent lateral spread displacement of river banks crossed by the pipelines. Three general approaches were used in assessing pipeline response to lateral spread ground displacements: rigorous finite element analysis of entire pipeline crossings (following recommendations in Honegger and Nyman, 2004 and PRCI, 2009), simplified finite element analysis of selected pipeline segments, simple hand calculations.

For the cases in which finite element analyses were used, ground displacements were applied in multiple increments with longitudinal strains extracted at each increment. The amount of displacement applied in the pipeline analyses was greater than estimated in the geotechnical hazard assessment in order to capture the margin against unacceptable response. The ratio of acceptable strain to computed strain at the estimated ground displacement does not provide a reliable estimate of the safety margin because strains can increase rapidly under certain circumstances with relatively small increases in ground displacement.

The results from finite element analyses were generally presented in three ways:

1. Plots of the deformed pipeline shape at the end of the analysis
2. The variation of longitudinal strain magnitude (largest numerical value of longitudinal tension or compression strain) along the pipeline model
3. Plots of maximum longitudinal tension and compression strain at any location along the pipeline model as a function of applied ground displacement.

The material in this report has been extracted from the site-specific assessment report (DGHC, 2012). As the purpose of this summary report is to capture the level of pipeline vulnerability and recommended follow-on study or mitigation measures, background information on the assessment methodology and acceptance criteria have been omitted from this summary report.

2.0 ASSESSMENT OF LOCATION LM-7

This section summarizes the assessment for location LM-7. Pipeline properties used in the pipeline assessment are provided in Table 1.

2.1 LM-7 Location and Geotechnical Hazard

Site LM-7 is located on the north bank of the North Arm of the Fraser River in Vancouver, BC. Fortis operates a NPS 30 intermediate pressure (IP) pipeline through the subject site with a wall thickness of 6.4 mm and fabricated from A-139 Grade B steel (specified minimum yield strength of 240 MPa). Fortis also operates NPS 20 and NPS 24 transmission pressure (TP) pipelines extending south from the Fraser River Gate Station across the Fraser River. However, these TP pipeline segments are outside the area depicted for LM-7 and are not addressed herein. The Golder report addressing the earthquake displacement hazards at site LM-7 is provided in Appendix 1.

Approximately 500 m of the IP pipeline is located within the site and the configuration of the pipeline segments is shown in Figure 1. At the western extent of the site, the IP pipeline is located perpendicular to the river bank, within the travelled lanes of Elliott Street. At the southern extent of Elliott Street, the pipeline changes alignment and continues to the east, parallel to the river bank. The pipeline is located within East Kent Avenue North for some 180 m before it crosses the CP Rail right-of-way to the south, and continues to the east along East Kent Avenue South. The IP pipeline reaches its terminus at the Fraser River Gate Station, some 500 m east of Elliott Street.

The pipeline along East Kent Avenue North is located outside the limits of potentially liquefiable soil deposits. Ground displacement hazards estimated by Golder for a return period of 2,475 years for the portion of the pipeline along East Kent Avenue South include lateral spread displacement of 1.6 m toward the river and settlement of 0.03 m. The corresponding lateral spread displacement for a return period of 475 years was estimated to be 0.3 m.

2.2 Assessment of LM-7 Vulnerability

A finite element analysis was performed to assess the pipeline response to a block-type displacement over the entire zone in Figure 1. The displacements applied in the analysis were defined as twice the displacements estimated by Golder to provide information on the margin between pipeline displacement capacity and the expected displacement.

The pipeline geometry for the finite element model was based upon drawing X-65265-R2. The pipeline plan and profile are illustrated in Figure 2 and the applied ground displacements are illustrated with the pipeline model plan in Figure 2. The eastern 225 m of pipeline was installed with continuous set-on weights and an additional 70 m of the pipe immediately west of this zone

was installed with set on weights with a length of 2.7 m to 3.0 m at a spacing of 7.6 m. The horizontal soil restraint for portions of the pipeline with continuous set-on weights was modified to be based upon the horizontal projected area of the set-on weight. The weight of the set-on weights was added to the uplift restraint for plain pipe to approximately account for increased vertical restraint for portions of the pipeline with continuous set-on weights. Where spaced set-on weights were installed, the soil restraint in the horizontal and vertical directions was modified to be the average of the restrain for straight pipe and the restraint for continuous set-on weights.

A plot of the strain magnitude at the end of the analysis and a plot of the variation in maximum longitudinal strain versus horizontal ground displacement are provided in Figures 3 and 4, respectively. Considering the pipeline vintage (constructed in 1959), the allowable tension strain limit for pressure integrity is judged to be 1% to 3%. The allowable compression strain for pressure integrity is 1.8% based upon the relationship between the ratio of wall thickness to pipe diameter in PRCI guidelines (Honegger and Nyman, 2004). Based upon these strain limits, the horizontal displacement capacity is approximately 0.5 m, which is greater than the 475-year displacement estimate but well below the 2,475-year displacement estimate of 1.6 m.

2.3 Recommended Action at Location LM-7

Two options exist for improving pipeline response. The existing pipeline could be replaced with a pipeline having a higher grade of steel and a thicker pipe wall. Replacing the pipeline in the existing right-of-way would require installation of a temporary by-pass pipeline. An alternate option is to avoid the hazard by relocating the pipeline on East Kent Avenue South to East Kent Avenue North.

3.0 REFERENCES

1. D.G. Honegger Consulting (DGHC), 2010. "Regional Seismic Risk Assessment of Terasen Natural Gas Pipelines", report prepared for Terasen Gas, August 13.
2. D.G. Honegger Consulting (DGHC), 2012. "Site-Specific Seismic Vulnerability Assessment of FortisBC Energy Gas Pipeline Locations," report prepared for FortisBC Energy, February 17.
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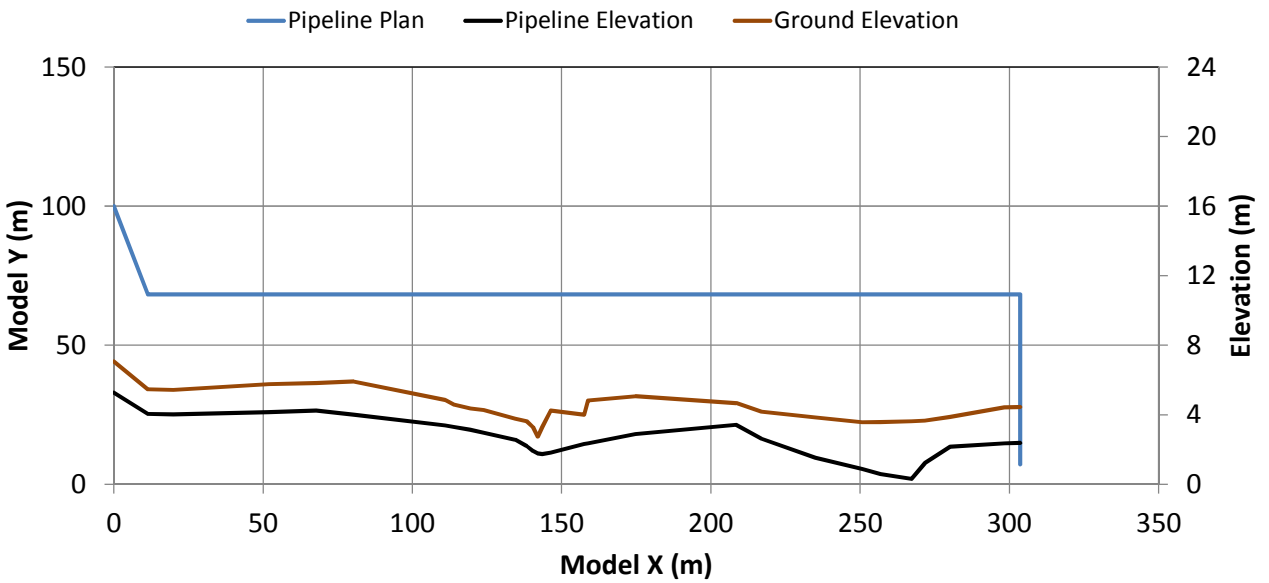
4. Nyman, D.J. (ed.), 1984. "Guidelines for the Seismic Design of Oil and Gas Pipeline Systems," Technical Council on Lifeline Earthquake Engineering, American Society of Civil Engineers.
5. PRCI, 2009. "Guidelines for Constructing Natural Gas and Liquid Hydrocarbon Pipelines in Areas Subject to Landslide and Subsidence Hazards," report prepared by D.G. Honegger Consulting, C-CORE, and SSD, Inc., Catalog No. L52292.

Table 1: LM-7 Pipeline Parameters Used in the Assessment

NPS	Outside Diameter (mm)	Wall Thickness (mm)	Pipe Steel Grade	Operating Pressure (MPa)	Acceptable Strains (%)			
					Cont. Operation		Press. Integrity	
					Tens	Comp	Tens	Comp
30	762	6.4	240	0.69	2.0	0.3	4.0	1.5

Figure 1: LM-7 Location



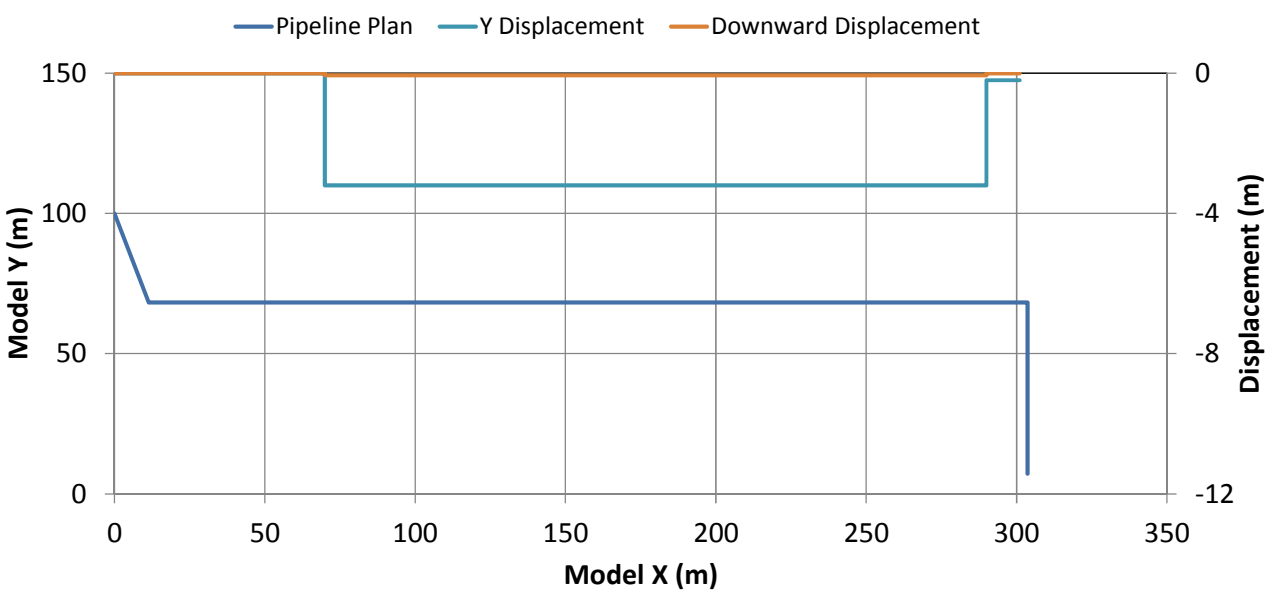


Figure 2: LM-7 Pipeline Model (top) and Applied Ground Displacements (bottom)

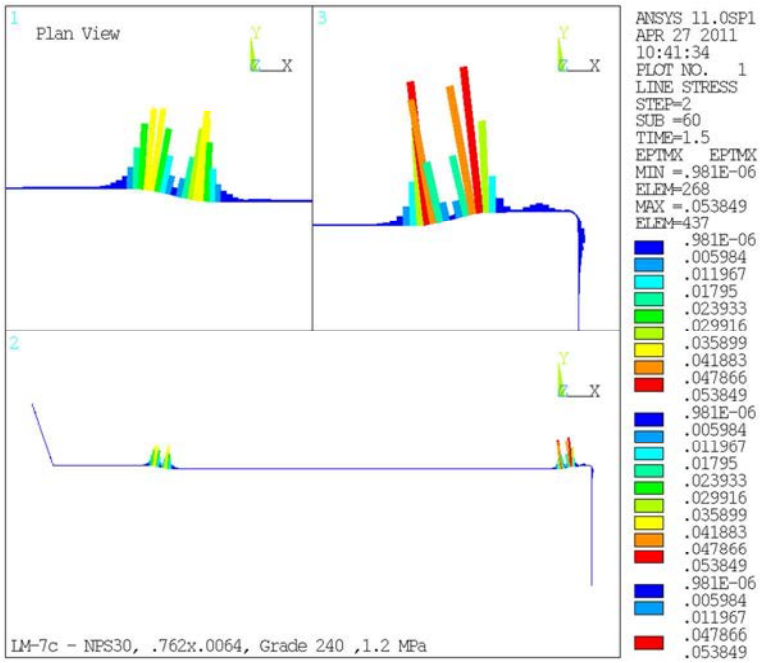


Figure 3: Strain Magnitude Distribution at the Estimated Lateral Spread Displacement

(size and color of contours correspond to strain in mm/mm)

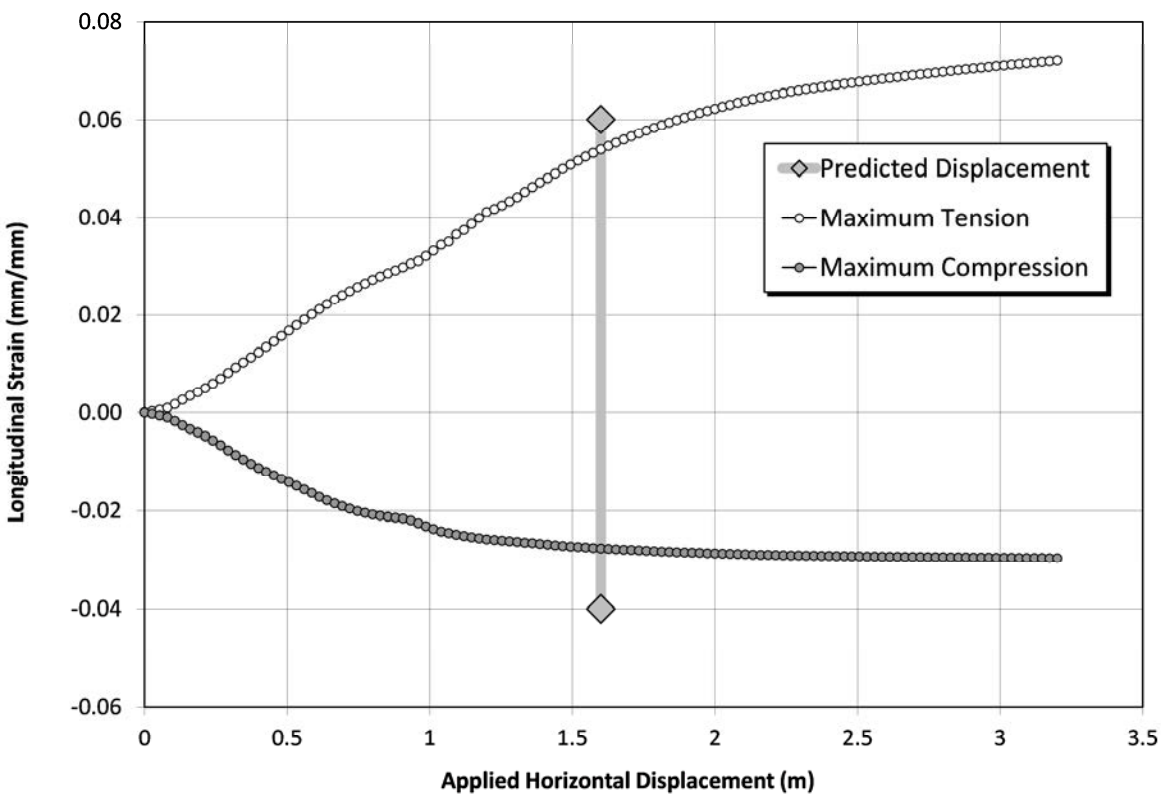


Figure 4: Longitudinal Strain vs. Lateral Spread Displacement

APPENDIX 1

FORTISBC IP PIPELINE SEGMENTS NEAR FRASER GATE STATION, VANCOUVER, BC (LM-7)

February 15, 2012

SITE-SPECIFIC SEISMIC VULNERABILITY ASSESSMENT

FortisBC IP Pipeline Segments near Fraser Gate Station, Vancouver, BC (LM-7)

Submitted to:
FortisBC Energy Inc.
16705 Fraser Highway
Surrey, BC
V4N 0E8

REPORT

Report Number: 10-1447-0255/6000

Distribution:

2 Copies - FortisBC Energy Inc.

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Golder Associates

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1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by FortisBC Energy Inc. (FortisBC), formerly Terasen Gas Inc., to carry out a site-specific seismic vulnerability assessment of FortisBC Pipeline Segments located between Elliott Street and FortisBC's Fraser Gate Station No.3 in Vancouver, BC. The intermediate pressure (I.P.) pipeline segments at the site are identified as LM-7 in FortisBC's RFP (Reference: P101891JGW) issued on September 3, 2010.

The potential seismic vulnerability of the Fraser Gate Station was first identified in the regional assessment completed by EQE International Inc. (EQE) and Golder in 1994. Following this regional study, Golder was retained to carry out a geotechnical investigation and provide a site-specific vulnerability assessment of the Gate Station and transmission pressure (T.P.) pipelines that extend south across the Fraser River. Ground improvement to reduce the potential for significant ground movements under strong seismic shaking was subsequently carried out at the Gate Station site.

A regional seismic risk assessment was carried out for FortisBC's coastal pipeline system by D.G. Honegger Consulting (DGHC) and Golder in 2009 (DGHC's report titled "*Regional Seismic Risk assessment of Terasen Natural Gas Pipelines*") based on the 4th generation seismic hazard mapping developed by the Geological Survey of Canada as input to the 2005 National Building Code of Canada, and the potential seismic vulnerability of the I.P. pipeline segments located between Elliott Street and Gate Station at LM-7 was identified in the regional seismic risk assessment. Following review of the recommendations of the regional study, a more detailed, site-specific seismic vulnerability assessment was requested by FortisBC to evaluate the likely performance of the pipelines when subject to seismic shaking corresponding to the seismic risk levels of 475 and 2,475 year return periods consistent with the GSC 4th generation seismic hazard mapping.

The scope of work for this study is described in detail in our proposal to FortisBC dated September 21, 2010 and includes the following tasks:

- Collect available data on subsurface conditions and pipeline configurations. The subsurface information and topographic details obtained during previous work at the Gate Station are to be utilized in the current study;
- Carry out a site reconnaissance to visually examine the site conditions;
- Carry out ground response analyses based on the 4th generation seismic hazard model developed by GSC for probabilistic ground motions established for 475-year (10% in 50 years) and 2,475-year (2% in 50 years) return periods;
- Carry out engineering analyses to estimate the magnitude and pattern of displacements along the pipeline segments as input to the structural evaluation of the pipeline segments;
- Assist with the structural vulnerability assessment of the pipeline segments to be carried out by FortisBC's Pipeline Specialist and incorporate the results in the final report; and
- Identify conceptual site remediation schemes.

This report includes a summary of the historical test holes put down at the site, a brief description of the engineering properties of the overburden soils inferred from all available subsurface data, the methodology followed in the engineering analyses to estimate the permanent ground deformations along the pipeline segments due to the design ground motions, the results of the engineering analyses, and the proposed conceptual remedial measures to improve the seismic performance requirements.

This report should be read in conjunction with **"Important Information and Limitations of This Report"** which is appended following the text of the report. The reader's attention is specifically drawn to this information, as it is essential that it is followed for the proper use and interpretation of this report.

2.0 BACKGROUND INFORMATION

2.1 Site Conditions

The site LM-7 is located on the north bank of the North Arm of the Fraser River in Vancouver, BC. The site is bounded to the west by Elliott Street, to the north by SE Marine Drive, to the east by the Gate Station, and to the south by parkland and the Fraser River (see Figure 2-1).

The site is situated within developed land primarily consisting of single-family residential dwellings, mid-rise apartment buildings and municipal parkland on the bank of the Fraser River. At the northern limit of the site, SE Marine Drive is at a relatively consistent elevation on the order of +22 to +24 metres. The natural topography of the site slopes down towards the Fraser River at average slope of about 8 percent to the horizontal to meet the shoreline at an elevation of approximately 0 m elevation. South of the site, the river bed elevation continues to decrease at a similar slope.

Surficial geology information published by the Geological Survey of Canada indicates that the site is generally underlain by Fraser River sediments consisting of overbank silty deposits, overlying dense Vashon Drift and Capilano Sediments.

2.2 Pipeline Configurations

FortisBC operates 762 mm nominal diameter I.P. pipelines through the subject site. Approximately 500 m of the IP pipeline is located within the site and the configuration of the pipeline segments is shown in Figure 2-2. FortisBC also operates 508 mm and 610 mm nominal diameter T.P. pipelines extending south from the Gate Station across the Fraser River. However, these T.P. pipeline segments are outside the area depicted for LM-7 and are not addressed herein.

At the eastern extent of the site, the I.P. pipeline is located perpendicular to the river bank, within the travelled lanes of Elliott Street. At the southern extent of Elliott Street, the pipeline changes alignment and continues to the east, parallel to the river bank. The pipeline is located within East Kent Avenue North for some 180 m before it crosses the CP Rail right-of-way to the south, and continues to the east along East Kent Avenue South. The I.P. pipeline reaches its terminus at the Gate Station, some 500 m east of Elliott Street.

Following discussions with FortisBC, we have considered that the pipelines are buried about 1.5 m to 2 m below ground surface. The actual depth of burial is not known at present.

2.3 Earthquake-Induced Hazards

The north bank of the North Arm of the Fraser River is aligned parallel to the alignment of the majority of the I.P. pipeline segments at the site. The pipeline segments are located about 40 m to 80 m from the river bank and instability of the river bank leading to lateral deformations towards the river during strong seismic shaking is considered as the primary earthquake-induced hazard to the pipeline.

An aerial photograph illustrating the potential earthquake-induced hazard at the site is shown on Figure 2-3.

3.0 SITE-SPECIFIC SEISMIC HAZARD PARAMETERS

Site-specific seismic hazard motion parameters established from the interactive website maintained by the Geological Survey of Canada (GSC) are summarized in Table 3-1. The ground motion parameters have been established for two different return periods that correspond to probabilities of 10% and 2% exceedance in 50 years. They correspond to Class C ground conditions or for soil profiles where the average shear wave velocity of the upper 30 m varies between 360 m/s and 760 m/s.

Table 3-1: Site-Specific Probabilistic Firm-Ground Motion Parameters (Site Class C)

Return Period	PHGA	Sa (0.2s)	Sa (0.5s)	Sa (1.0s)	Sa (2.0s)
475-Years (10% Probability of exceedance in 50 years)	0.26 g	0.52 g	0.35 g	0.18 g	0.09 g
2,475-Years (2% Probability of exceedance in 50 years)	0.50 g	1.00 g	0.67 g	0.34 g	0.17 g

Note: In Table 3-1, PHGA refers to peak horizontal ground acceleration; Sa refers to spectral acceleration for a given period.

4.0 AVAILABLE SUBSURFACE AND TOPOGRAPHIC INFORMATION

Golder previously carried out a geotechnical field investigation at the site in 1995 on behalf of FortisBC (then called BC Gas Utility Ltd.). The field investigation included both on-shore and off-shore drilling in several phases that were carried out between February and June 1995. A total of seven augerholes (denoted as AH95-1 through AH95-7), one mud-rotary borehole (denoted as BH95-1), and five electronic cone penetration tests (denoted as CPT95-1 through CPT95-5) were put down as part of the on-shore investigation. An additional three CPTs (denoted as CPT95-6 to CPT95-8) were subsequently put down within the river, south of the Gate Station. The approximate locations of the boreholes are shown in Figure 4-1.

The drilled augerholes and boreholes were put down depths ranging from about 2.3 m to 15.3 m below the ground surface at the time of the investigation. The on-shore CPTs were put down to depths between 6.9 m and 13.4 m below the ground surface at the time of the investigation and were terminated due to effective cone tip refusal in dense ground. Down-hole shear wave velocity measurements were carried out during advancement of CPT95-4 at one metre intervals. The off-shore CPTs were also put down to effective cone tip refusal at depths ranging from about 3.1 m to 9.2 m below the inferred river bottom.

Detailed descriptions of the soil conditions encountered at the test hole locations are included on the test hole logs from the 1995 investigation. Copies of the test hole logs and CPTs are included in Appendix A.

The topographic section data collected as part of the 1995 investigation together with the topographic information obtained from GIS map database maintained by the City of Vancouver were used in the current site-specific seismic vulnerability assessment.

5.0 SUBSURFACE CONDITIONS

The subsurface conditions at the subject site vary from east to west along the pipeline alignment. Towards the eastern extent of the site, within the Gate Station, the test holes encountered fill, overlying deposits of overbank silt and peat that ranged up to about 8 m thick that were underlain by the dense, till-like soils. The test holes put down towards the western extent of the site generally encountered fill thicknesses ranging from 0.3 m to 3.8 m overlying dense, till-like soils.

A critical section (Section A-A') was selected near the eastern extent of the site (see Figure 4-1), and a geological/geotechnical profile illustrating the inferred soil stratigraphy was developed as shown on Figure 5-1. The subsurface conditions at Section A-A' were inferred based on the data from test holes put down at the Gate Station site. The elevations shown on the figure are relative to the Geodetic Datum.

The geological/geotechnical profile at Section A-A' consists of the following soil strata at the pipeline location:

- Sand and gravel (Fill) with a thickness of about 2.2 m; overlying;
- A deposit fine-grained soils consisting of layers of silt and peat with a thickness of about 5.5 m; overlying;
- Compact to dense Fraser River sand with a thickness of about 0.8 m; overlying; and
- Dense, till-like Pleistocene deposits.

The dense, till-like Pleistocene deposits generally slope downwards towards the river. The thickness of the overbank silt and peat deposit overlying these till-like soils decreases with proximity to the river, and the geological/geotechnical profile at Section A-A' consists of the following soil strata near the shoreline:

- Sand and gravel (Fill) with a thickness of about 2.2 m; overlying;
- Loose to compact Fraser River sand with a thickness of about 12.5 m; overlying; and
- Dense, till-like Pleistocene deposits.

The test holes put down for assessment completed previously by Golder in 1997 towards the western extent of the site generally encountered fill thicknesses ranging from 0.3 m to 3.8 m overlying dense, till-like soils inferred to be Pleistocene deposits. The till-like soils are inferred to be at a depth of about 1.5 m in the vicinity of the pipeline. The earthquake-induced hazards are not considered to pose a significant threat to the pipeline where firm-ground is very near the surface. A geological/geotechnical profile, denoted as Section B-B', illustrating the inferred soil stratigraphy at the western extent of the site is shown on Figure 5-2.

Shear strength (S_u) values within the silt stratum were interpreted from CPT data using an empirical approach and the interpreted strength values are shown on Figure 5-3. The strength profiles indicate that the upper portion of the fine-grained deposit has an average S_u of about 25 kPa, and increases to about 42 kPa with depth.

Equivalent Standard Penetration Test (SPT) $(N_1)_{60}$ values were also obtained from the CPT data within the compact to dense layer underlying the silt deposit using an empirical approach and the computed SPT profiles are shown on Figure 5-4.

Index test carried out on selected samples of the peat and silt deposit indicated the natural water content ranging between about 32 and 196 percent. The plasticity indices established from testing of samples obtained within this deposit ranged from 10 to 12 percent, with an average of 11 percent.

6.0 GEOTECHNICAL ASSESSMENT UNDER SEISMIC LOADING

Geotechnical analyses were carried out to evaluate the performance of the subject site in the vicinity of Section A-A' under seismic loading, and they consisted of the following:

- Site-specific seismic ground response analyses to estimate the induced cyclic shear stress levels under the design seismic loading conditions considering 1D soil columns;
- Assessment of the liquefaction potential of the site soils;
- Assessment of post-seismic stability of the site; and
- Evaluation of the earthquake-induced permanent lateral ground displacements utilising the results of the above analyses.

The details of the geotechnical assessment are presented in the following sections. It should be noted that the groundwater level noted at the time of drilling (1995) was used in the geotechnical assessment. The water level in the vicinity of Section A-A' near shoreline (AH95-5) was noted to be at a depth of 3 m (Elevation 0 m Geodetic) below ground surface, while the water level was noted to be about 2 m below ground surface (Elevation +2.8 m Geodetic) at the pipeline location (AH95-4 and AH95-7). The groundwater level at the site is expected to vary with the tidal variations of the adjacent North Arm of the Fraser River and seasonal precipitation and drainage conditions.

Considering that the firm-ground is very near the surface in the vicinity of Section B-B' and the earthquake-induced hazards are not considered to pose a threat to the pipeline, no further site-specific geotechnical analyses were considered necessary and hence were not carried out.

6.1 Ground Response Analyses

The subsurface conditions towards the river bank and at the pipeline location are different as noted in Section 5.0 and ground response analyses were undertaken for the subsurface conditions encountered in the vicinity of Section A-A' at the pipeline location using the computer program ProShake to obtain the time-history at the pipeline location as input to evaluate the permanent lateral movements under the 475-year and 2,475-year ground motions.

Results of the ground response analyses carried out as part of the site-specific vulnerability assessment carried out previously (1997) were utilized to infer the liquefaction potential of the granular soils encountered near shoreline considering that the previous assessment was carried out for similar return periods (*i.e.,* 475-year and 2,000-year) with lower seismic hazard parameters.

Details of the selection of input parameters required for the response analyses along with the results are provided below.

6.1.1 Small-Strain Shear Modulus

The small-strain shear modulus (G_{max}) for the site soils with the exception of the fill layer was estimated using the measured cone tip resistance at CPT95-1 and CPT95-5. The values of G_{max} and cone tip-resistance (q_t) are related through the following expression:

$G_{max} = 50 \bullet Pa \{(q_t - \sigma'_v)/Pa\}^m$, where σ'_v, and Pa are effective vertical stress and atmospheric pressure, respectively. The exponent m equals 0.6 for sands, 0.8 for silts, and 1.0 for clays (Mayne, 2009).

The small-strain shear modulus (G_{max}) of the fill layer was estimated using the following empirical equation with an assumed SPT $(N_1)_{60}$ value of 9 to 10 blows/0.3 m.

The values of G_{max} and SPT $(N_1)_{60}$ are related through the following expression:

$G_{max} = 21.7 \bullet Pa \bullet 20 [(N_1)_{60}]^{1/3} [\sigma'_m / Pa]^{1/2}$, where σ'_m and Pa are mean effective stress and atmospheric pressure, respectively.

Figure 6-1 shows the measured velocities along with the velocity profiles used in the ground response analyses.

6.1.2 Depth and Shear Wave Velocity of Firm Ground

The CPTs put down at the site encountered practical refusal to further penetration at depths ranging from 6.9 m (CPT95-1) to 13.4 m (CPT95-2) within dense strata considered to be the Pleistocene deposits which could be considered as firm ground (average Vs of 360 m/s to 760 m/s).

In the ground response analyses, the depth to firm-ground at the pipeline location was assumed to be 8.5 m below ground surface and a conservative estimate of shear wave velocity of 760 m/s was assumed for the firm-ground.

6.1.3 Firm-Ground Acceleration Time Histories

For the site-specific ground response analyses, records from the 1992 Landers, 1989 Loma Prieta, and 1999 Chi Chi earthquake were selected as representative time-histories for the 2,475-year ground motions, while the 1971 San Fernando, 1992 Olympia and 1989 Loma Prieta were selected for the 475-year ground motions.

The above selected time-histories were spectrally-matched to GSC target spectra corresponding to 475-year and 2,475-year ground motions at a Lower Mainland site with similar PGA's as part of the in-house development of suite of time histories.

6.2 Liquefaction Susceptibility

The liquefaction susceptibility of granular soils was evaluated by comparing the penetration resistance required to trigger liquefaction with the available penetration resistance. Liquefaction is predicted to occur when the available penetration resistance is less than the resistance required.

The penetration resistance required to trigger liquefaction was computed using the cyclic resistance ratio (CRR) induced by the design earthquake and Idriss and Boulanger (2006) liquefaction resistance charts. The variations in cyclic stress ratio (CSR) induced by the design earthquake with depth were computed using the computer program ProShake. Design earthquakes of magnitude M7 that is representative of 10 cycles of effective loading, was used in the assessment of liquefaction susceptibility of soils under the 475-year and 2,475-year ground motions.

The liquefaction susceptibility of the fine-grained soils was evaluated using the criterion developed by Boulanger and Idriss (2006) based on the recent Task Force Report on "Geotechnical Guidelines For Buildings On Liquefiable Sites in Accordance with NBC 2005 for Greater Vancouver Region" dated May 8, 2007. Based on the criterion, soils with plasticity index (PI) less than seven (7) percent are generally susceptible to liquefaction.

6.2.1 Liquefaction Susceptibility of Granular Soils

The liquefaction potential of the granular soils for the 475-year and 2,475-year ground motions are as follows:

- The near-continuous profile of equivalent SPT $(N_1)_{60}$ values obtained from CPT95-1 was used to assess the liquefaction potential of the granular soils encountered in the vicinity of the pipeline, near Section A-A'. The results indicate that the granular fill materials encountered below water table have a high risk of liquefaction under both 475-year and 2,475-year ground motions, while the compact to dense Fraser River sand deposit underlying the silt and peat deposits have a low risk of liquefaction under the design ground motions; and
- Based on the liquefaction assessment carried out as part of the site-specific vulnerability assessment at the Gate Station (Golder, 1997), the loose to compact granular soils encountered closer to the river near Section A-A' have a high risk of liquefaction under both 475-year and 2,475-year ground motions.

6.2.2 Liquefaction Susceptibility of Fine-Grained Soils

The silt and peat deposits encountered at the site are not considered to be susceptible to liquefaction based on Boulanger and Idriss (2006) considering that the plasticity indices established for samples tested from these deposits are higher than seven (7) percent.

6.3 Post-Seismic Slope Stability

Analyses were carried out to evaluate the post-seismic stability of the overall river bank in the vicinity of the I.P. pipeline alignment. These analyses took into consideration the plan location and the approximate depth of embedment of the pipeline. The slip surfaces that could potentially impact the pipeline were prescribed based on judgement and the Factors of Safety (FOS's) against failure were computed. It should be recognised that the

slip surfaces that encompass the pipeline extending through the bank of the river and in to the river channel are considered to be representative of failure surfaces that are anticipated to have the highest impact on the pipeline segments.

The cross-section developed at Section A-A' was considered in the stability assessment considering the topographical features and subsurface conditions encountered at the site. The results of the analyses along with the input parameters used are presented below. The Factors of Safety under static loading conditions are also presented for completeness.

The soil parameters for static loading conditions and non-liquefiable strata were derived based on the results of the historical field investigation carried out at the subject site and published correlations. The soil parameters for the potentially liquefiable soils were selected based on the correlation developed by Idriss & Boulanger (2006) considering the standard penetration values and fines content of the liquefiable soils. The soil parameters used in the stability analyses are summarized in Table 6-1.

Table 6-1: Post-Seismic Soil Parameters – Section A-A'

Soil Type	Unit Weight	$(N1)_{60cs}$	Static		Post-Seismic	
	(kN/m^3)		ϕ (°)	S_u (kPa)	ϕ (°)	S_{ur} (kPa)
Fill	19	10	32	-		$0.08\sigma_v'$
Upper Silt/Peat	17	-	-	25	-	20
Lower Silt/Peat	17	-	-	42	-	34
Sand (near shoreline)	18	10	30	-	-	$0.08\sigma_v'$
Sand (below Silt/Peat)	18	20	35	-	35	-
Pleistocene Deposits	21	-	38	-	38	-

Figures 6-3 and 6-4 present the results of the slope stability analyses completed for judgement-based prescribed failure surfaces that encompass the pipeline at Section A-A'. The results of the assessment indicate the following:

- Slip surface analyzed has a Factor of Safety of 3.3 under static loading conditions (see Figure 6-3); and
- Slip surfaces analyzed have Factors of Safety varying from 1.6 to 1.9 under post-seismic loading conditions considering the extent of liquefaction corresponding to both 475-year and 2,475-year ground motions (see Figure 6-4).

6.4 Earthquake-Induced Lateral Displacements

The permanent lateral deformations at the subject site are expected to occur due to instability of the north bank of the North Arm Fraser River, and they were estimated using the Newmark sliding block method (1965) in which the potential failure mass is treated as a rigid body assumed to incrementally slide (*i.e.,* displace) when the shaking-induced inertial forces exceed the sliding resistance (*i.e.,* shear strength) of the underlying soils. The Newmark approach involves explicit calculation of cumulative seismic deformations. The acceleration time history of the approximate soil mass undergoing deformations was computed and used as input along with the

computed yield acceleration to evaluate the likely magnitude of ground deformations by double integrating the accelerations in excess of the yield acceleration. The accumulated deformations are reported herein, and they represent the approximate magnitude of seismic movements anticipated in the vicinity of the pipeline.

The results of the post-seismic slope stability analyses without the application of any inertia loads but with residual shear strength values assigned to the potentially liquefied soils, reported in Section 6.3 above, indicated that the Factors of Safety against possible prescribed failure surfaces encompassing the pipeline are greater than unity. Considering that the Factors of Safety are above unity, a flow slide failure of the soil mass leading to "unlimited" or large deformations is unlikely to occur. However, some "limited" deformations are expected. We have computed these deformations by extending the Newmark sliding block method for sites underlying potentially liquefiable soils by computing the applicable yield acceleration values for the slip surfaces with soil properties degraded to reflect the liquefied conditions.

The following steps were carried out to estimate the permanent lateral deformation using Newmark approach:

- Carry out a pseudo-static stability analyses under post-seismic soil conditions to compute the yield acceleration for selected prescribed failure surfaces as noted in the previous section; and
- Calculate the permanent lateral deformation using a time history analysis in which the excursions of the acceleration time history of the failure mass above the yield acceleration are double integrated. The time-histories computed from the ground response analyses at the pipeline location were considered as the representative time-histories for the Newmark deformation analyses.

The computed permanent deformations at the west bank along with the computed yield accelerations of the failure mass for the design ground motions (*i.e.,* 475 year and 2,475 year return periods) at Section A-A' are summarized in Table 6-2. The slip surfaces explored in the deformation analyses using the Newmark method are shown in Figure 6-4.

Table 6-2: Permanent Lateral Deformations

Section	Yield Acceleration (g)		PGSA (g)		Maximum Lateral Displacement (mm)	
	475 Year	2,475 Year	475 Year	2,475 Year	475 Year	2,475 Year
A-A'	0.06	0.06	0.30	0.39	300	1,600

The established methods of earthquake-induced lateral displacement analyses, such as the MLR Method, are applicable for larger river channels with potentially liquefiable soils extending significant distance from the river banks. Considering that the lateral extent of potentially liquefiable soils encountered at the site is limited to near shoreline and the soils underlying the pipeline segments are not considered to be liquefiable, we have not pursued deformation analyses using the MLR empirical method for this site.

6.5 Earthquake-Induced Vertical Displacements

Saturated liquefiable soils are expected to generate excess pore pressure under seismic loading and settle as the pore pressure dissipates. Idriss and Boulanger (2006) proposed a method estimating settlement of loose sands under earthquake loading.

The computed downward ground movements using the Idriss and Boulanger (2006) empirical charts at Section A-A' are summarized in Table 6-3 for the design ground motions.

Table 6-3: Permanent Vertical Settlements

Section	Vertical Settlements (mm)	
	475 Year	2,475 Year
A-A'	30	30

6.6 Upheaval Movement of Pipelines

Pipelines that are buried in liquefied soils are likely to undergo upheaval movements when the buoyant force is larger than the self weight of the pipe and resistance offered by the liquefied soil. For such upheaval to occur, the pipeline needs to be embedded in an extensive zone of soil liquefaction and in very loose soils. Considering that most of the medium diameter pipelines are designed with a marginal factor of safety against buoyancy and ignoring the resistance offered by the surrounding soil, we consider the risk of upheaval movement of the pipeline at the site to be low.

7.0 SOIL PARAMETERS FOR SOIL-PIPE INTERACTION ANALYSES

The interaction response of the pipe with the surrounding soil is important in determining the pipeline vulnerability to ground displacements. The soil-pipe interaction is commonly characterized by "soil-spring", which are determined from typical strength and deformation parameters of the soils around the pipe.

The actual soil conditions surrounding long pipeline systems such as the IP segments that are considered in the current study are difficult to establish via site-specific field investigations. The width of the trench, backfill soil types and level of compaction used are unknown/uncertain and cannot established with any degree of accuracy/certainty except near major underground structures such as chambers/pressure reducing stations. For pipelines with shallow depths of embedment of 1.5 to 2 m, the contrast in stiffness of soils inside the trench may not be too different from those of the surrounding native soils even if they are compacted to some level. The state of practice is to consider the properties of native soils with some variations in the parameters to account for uncertainty/variability.

Considering that the pipeline is located at the boundary of the liquefiable and non-liquefiable fills, the selected parameters for the soil-springs are provided for both liquefiable and non-liquefiable fills, and are summarized in Table 6-4.

Table 6-4: Soil Parameters

Section	Soil Parameters	
	Unit weight (kN/m^3)	Residual Strength
Fill (liquefied)	19 ± 1	S_u (kPa) – 0.08σ_v'± 5
Fill (prior to liquefaction)	19 ± 1	ϕ (°) – 32 ± 2

If the pipeline analysis results are sensitive to the spring stiffness values and their proposed variations, we recommend that further analyses be undertaken to confirm the validity of the spring stiffness values presented herein.

The earthquake-induced ground displacement hazard posing a threat to the pipeline segments within the western extent of the site is considered to be low. Hence, the seismic loading-induced lateral and vertical deformations were computed only for the stratigraphic profile developed at Section A-A', and the results of these analyses may be applied to the segment of the pipeline within the eastern extent of the site as shown on Figure 6-5. In addition, based on previous analyses completed by Golder, the lateral deformations at the Gate Station site are considered to be in the order of 100 mm considering that a ground improvement program using the vibro-replacement stone column installation method has already been implemented to improve the liquefaction resistance of the site soils.

The site soil stratigraphy varies from fill underlain by shallow till at Section B-B' to fill underlain by deeper till with Fraser River sand sandwiched near shore at the Gate Station. The seismic deformation hazard has been conservatively assessed at Section A-A' considering an overburden soil stratigraphy similar to that at the Gate Station consistent with the simplified methods of analyses used.

8.0 RESULTS OF THE PIPELINE EVALUATIONS AND GEOTECHNICAL SITE REMEDIATION MEASURES

The structural assessment of the pipeline has been carried out by DGHC, under contract to FortisBC, based on the estimated lateral spread ground movements and soil-pipe interaction input data provided in Sections 6.0 and 7.0 above. The results of the assessment indicate that the pipeline is highly vulnerable to the predicted 475-year and 2,475-year ground movements. It has been recommended that relocation of the pipeline north of the rail tracks to East Kent Avenue North, where the competent till-like soils are encountered at shallow depth, be considered. This will limit the earthquake-induced ground movements to a tolerable level at the pipeline.

Considering that the relocation of the pipeline is the most cost effective remedial option to improve the pipeline performance, no geotechnical remedial measures are required.

9.0 CLOSURE

We trust that the contents of this report meet your immediate requirements. If you have any questions or need further information, please do not hesitate to contact the undersigned.

GOLDER ASSOCIATES LTD.

ORIGINAL SIGNED

Viji Fernando, M.E.Sc, P.Eng.
Senior Geotechnical Engineer

ORIGINAL SIGNED

Matt Kennedy, M.Sc. (Eng.), P.Eng.
Geotechnical Engineer

ORIGINAL SIGNED

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Geotechnical Engineer

Reviewed by:

ORIGINAL SIGNED

Upul D. Atukorala, Ph.D., P.Eng.
Principal and Senior Geotechnical Engineer

VF/MJK/MM/UDA/nnv/js

\\bur1-s-filesrv2\final\2010\1447\10-1447-0255\phase 6000\rep 0215_12 lm-7 final\rep 0215_12 lm-7 pipeline segments final.doc

IMPORTANT INFORMATION AND LIMITATIONS OF THIS REPORT

Standard of Care: Golder Associates Ltd. (Golder) has prepared this report in a manner consistent with that level of care and skill ordinarily exercised by members of the engineering and science professions currently practising under similar conditions in the jurisdiction in which the services are provided, subject to the time limits and physical constraints applicable to this report. No other warranty, expressed or implied is made.

Basis and Use of the Report: This report has been prepared for the specific site, design objective, development and purpose described to Golder by the Client. The factual data, interpretations and recommendations pertain to a specific project as described in this report and are not applicable to any other project or site location. Any change of site conditions, purpose, development plans or if the project is not initiated within eighteen months of the date of the report may alter the validity of the report. Golder cannot be responsible for use of this report, or portions thereof, unless Golder is requested to review and, if necessary, revise the report.

The information, recommendations and opinions expressed in this report are for the sole benefit of the Client. No other party may use or rely on this report or any portion thereof without Golder's express written consent. If the report was prepared to be included for a specific permit application process, then upon the reasonable request of the client, Golder may authorize in writing the use of this report by the regulatory agency as an Approved User for the specific and identified purpose of the applicable permit review process. Any other use of this report by others is prohibited and is without responsibility to Golder. The report, all plans, data, drawings and other documents as well as all electronic media prepared by Golder are considered its professional work product and shall remain the copyright property of Golder, who authorizes only the Client and Approved Users to make copies of the report, but only in such quantities as are reasonably necessary for the use of the report by those parties. The Client and Approved Users may not give, lend, sell, or otherwise make available the report or any portion thereof to any other party without the express written permission of Golder. The Client acknowledges that electronic media is susceptible to unauthorized modification, deterioration and incompatibility and therefore the Client cannot rely upon the electronic media versions of Golder's report or other work products.

The report is of a summary nature and is not intended to stand alone without reference to the instructions given to Golder by the Client, communications between Golder and the Client, and to any other reports prepared by Golder for the Client relative to the specific site described in the report. In order to properly understand the suggestions, recommendations and opinions expressed in this report, reference must be made to the whole of the report. Golder cannot be responsible for use of portions of the report without reference to the entire report.

Unless otherwise stated, the suggestions, recommendations and opinions given in this report are intended only for the guidance of the Client in the design of the specific project. The extent and detail of investigations, including the number of test holes, necessary to determine all of the relevant conditions which may affect construction costs would normally be greater than has been carried out for design purposes. Contractors bidding on, or undertaking the work, should rely on their own investigations, as well as their own interpretations of the factual data presented in the report, as to how subsurface conditions may affect their work, including but not limited to proposed construction techniques, schedule, safety and equipment capabilities.

Soil, Rock and Groundwater Conditions: Classification and identification of soils, rocks, and geologic units have been based on commonly accepted methods employed in the practice of geotechnical engineering and related disciplines. Classification and identification of the type and condition of these materials or units involves judgment, and boundaries between different soil, rock or geologic types or units may be transitional rather than abrupt. Accordingly, Golder does not warrant or guarantee the exactness of the descriptions.

Special risks occur whenever engineering or related disciplines are applied to identify subsurface conditions and even a comprehensive investigation, sampling and testing program may fail to detect all or certain subsurface conditions. The environmental, geologic, geotechnical, geochemical and hydrogeologic conditions that Golder interprets to exist between and beyond sampling points may differ from those that actually exist. In addition to soil variability, fill of variable physical and chemical composition can be present over portions of the site or on adjacent properties. **The professional services retained for this project include only the geotechnical aspects of the subsurface conditions at the site, unless otherwise specifically stated and identified in the report.** The presence or implication(s) of possible surface and/or subsurface contamination resulting from previous activities or uses of the site and/or resulting from the introduction onto the site of materials from off-site sources are outside the terms of reference for this project and have not been investigated or addressed.

Soil and groundwater conditions shown in the factual data and described in the report are the observed conditions at the time of their determination or measurement. Unless otherwise noted, those conditions form the basis of the recommendations in the report. Groundwater conditions may vary between and beyond reported locations and can be affected by annual, seasonal and meteorological conditions. The condition of the soil, rock and groundwater may be significantly altered by construction activities (traffic, excavation, groundwater level lowering, pile driving, blasting, *etc.*) on the site or on adjacent sites. Excavation may expose the soils to changes due to wetting, drying or frost. Unless otherwise indicated the soil must be protected from these changes during construction.

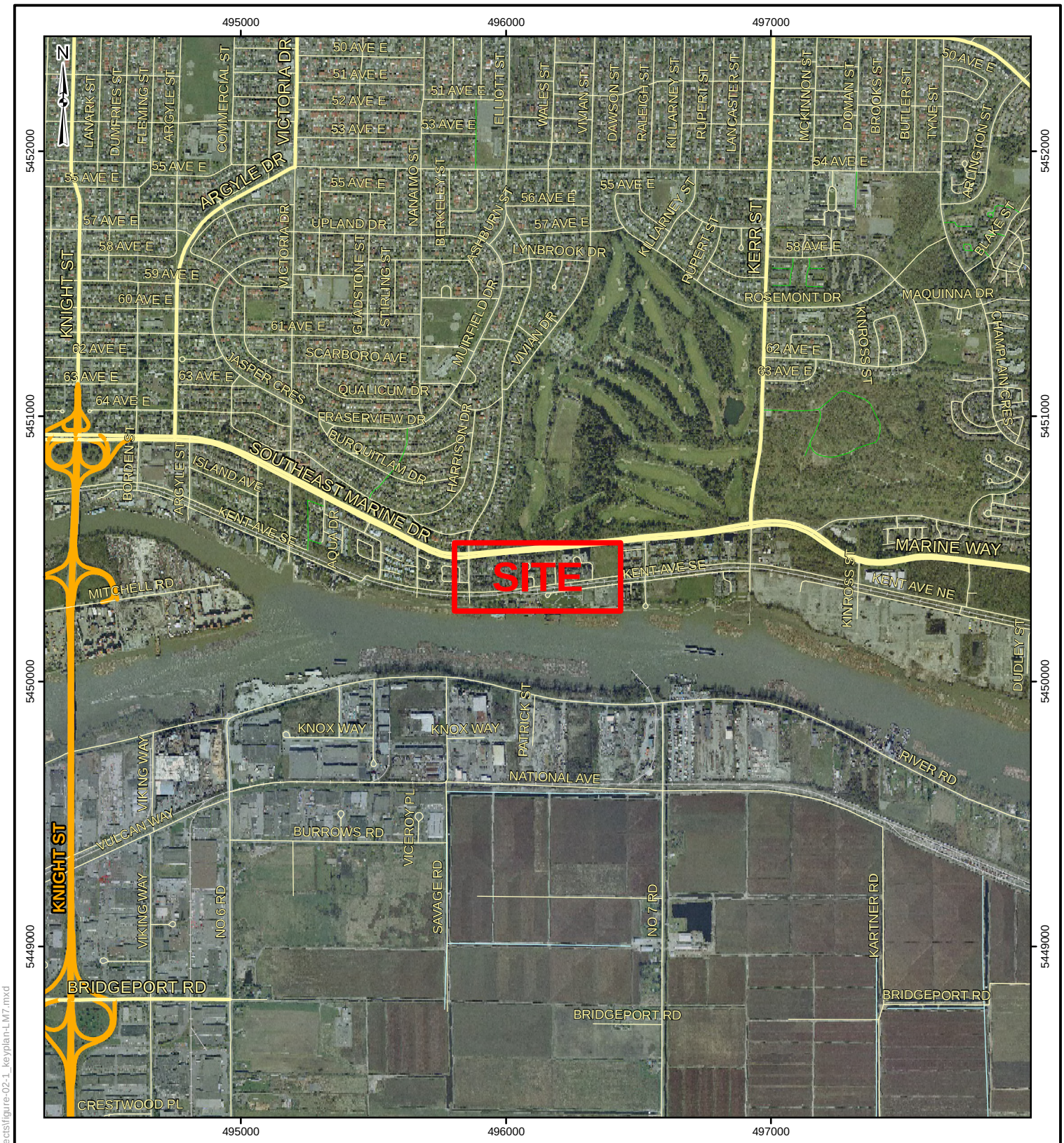
Sample Disposal: Golder will dispose of all uncontaminated soil and/or rock samples 90 days following issue of this report or, upon written request of the Client, will store uncontaminated samples and materials at the Client's expense. In the event that actual contaminated soils, fills or groundwater are encountered or are inferred to be present, all contaminated samples shall remain the property and responsibility of the Client for proper disposal.

Follow-Up and Construction Services: All details of the design were not known at the time of submission of Golder's report. Golder should be retained to review the final design, project plans and documents prior to construction, to confirm that they are consistent with the intent of Golder's report.

During construction, Golder should be retained to perform sufficient and timely observations of encountered conditions to confirm and document that the subsurface conditions do not materially differ from those interpreted conditions considered in the preparation of Golder's report and to confirm and document that construction activities do not adversely affect the suggestions, recommendations and opinions contained in Golder's report. Adequate field review, observation and testing during construction are necessary for Golder to be able to provide letters of assurance, in accordance with the requirements of many regulatory authorities. In cases where this recommendation is not followed, Golder's responsibility is limited to interpreting accurately the information encountered at the borehole locations, at the time of their initial determination or measurement during the preparation of the Report.

Changed Conditions and Drainage: Where conditions encountered at the site differ significantly from those anticipated in this report, either due to natural variability of subsurface conditions or construction activities, it is a condition of this report that Golder be notified of any changes and be provided with an opportunity to review or revise the recommendations within this report. Recognition of changed soil and rock conditions requires experience and it is recommended that Golder be employed to visit the site with sufficient frequency to detect if conditions have changed significantly.

Drainage of subsurface water is commonly required either for temporary or permanent installations for the project. Improper design or construction of drainage or dewatering can have serious consequences. Golder takes no responsibility for the effects of drainage unless specifically involved in the detailed design and construction monitoring of the system.



LEGEND

- Project Site
- Expressway
- Major Road
- Local Road
- Trail
- Ferry Route
- Railroad
- River

500 0 500

SCALE 1:20,000 METRES

REFERENCE

Transportation features obtained from DMTI Spatial Inc.
Orthophotos obtained from the Province of British Colulmbia.
Datum: NAD 83 Projection: UTM Zone 10

PROJECT FORTISBC ENERGY INC.
SITE-SPECIFIC SEISMIC VULNERABILITY ASSESSMENT
VANCOUVER, B.C.

TITLE

KEY PLAN

Golder Associates
Greater Vancouver Office, B.C.

PROJECT No. 10-1447-0255			PHASE No. 6000/6007	
DESIGN	MK	24JAN11	SCALE AS SHOWN	REV. 0
GIS	MH	24JAN11	FIGURE 2-1	
CHECK	VF	24JAN11		
REVIEW	UDA	24JAN11		

N:\Bur-Graphics\Projects\2010\1447\10-1447-0255\GIS\projects\figure-02-1_keyplan-LM7.mxd

LEGEND

- INTERMEDIATE PRESSURE PIPELINE
- TRANSMISSION PRESSURE PIPELINE
- SITE OUTLINE

0 20 40 60 80 100

SCALE IN METRES

REFERENCES

1. IMAGERY OBTAINED FROM DATA.VANCOUVER.CA ON DATE: FEBRUARY 5, 2011

PROJECT

FORTISBC ENERGY INC.
SITE SPECIFIC SEISMIC VULNERABILITY ASSESSMENT
VANCOUVER, B.C.

TITLE

PIPELINE CONFIGURATION

Golder Associates
Greater Vancouver Office, BC

PROJECT No. 10-1447-0255			PHASE No. 6000/6007	
DESIGN	MJK	05NOV10	SCALE AS SHOWN	REV. –
CADD	MJK	04FEB11	**FIGURE 2-2**	
CHECK	VF	14FEB11		
REVIEW	UDA	14FEB11		

Drawing File: \\bur1-s-cadsrv1\Active_2010\1447\10-1447-0255 Terasen Site Specific Seismic Assessments\6000 - Reporting\Drawings (Golder)\Final\LM-7 Site Plans.dwg Friday, January 20, 2012 11:20:26 AM By: MKennedy

LEGEND

- FORTISBC I.P. PIPELINE (APPROXIMATE)
- FORTISBC T.P. PIPELINE (APPROXIMATE)
- POTENTIAL GROUND MOVEMENT

REFERENCES

1. BASE PLAN IMAGERY OBTAINED FROM BING MAPS
   HTTP://WWW.MAPS.BING.COM
   ON DATE: JANUARY 11, 2011

PROJECT

FORTISBC ENERGY INC.
SITE SPECIFIC SEISMIC VULNERABILITY ASSESSMENT
VANCOUVER, B.C.

TITLE

POTENTIAL SEISMIC HAZARD

Golder Associates

PROJECT No.	10-1447-0255		PHASE No. 6000/6007	
DESIGN	MJK	02JAN11	SCALE NTS	REV.
CADD	MJK	04FEB11	**FIGURE 2-3**	
CHECK	VF	14FEB11		
REVIEW	UDA	14FEB11		

LEGEND

- AH/CPT95-01 — HISTORICAL TEST HOLE LOCATION
- INTERMEDIATE PRESSURE PIPELINE
- TRANSMISSION PRESSURE PIPELINE
- ANALYSIS SECTION

0 20 40 60 80 100
SCALE IN METRES

REFERENCES

1. IMAGERY OBTAINED FROM DATA.VANCOUVER.CA ON DATE: FEBRUARY 5, 2011

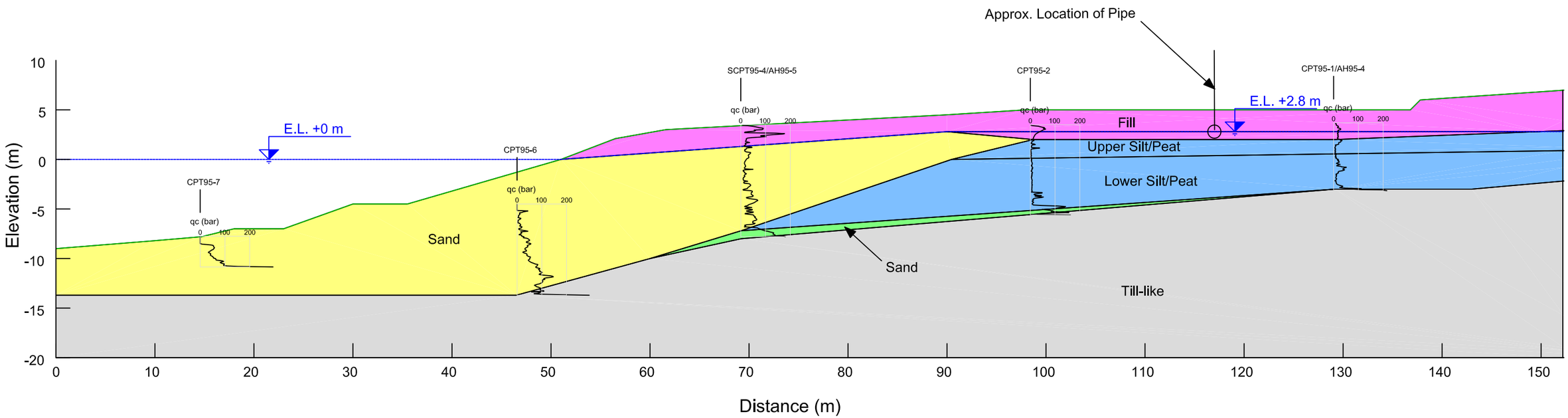
PROJECT
FORTISBC ENERGY INC.
SITE SPECIFIC SEISMIC VULNERABILITY ASSESSMENT
VANCOUVER, B.C.

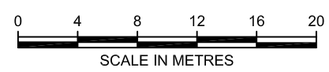
TITLE
TEST HOLES AND ANALYSIS SECTIONS

Golder Associates
Greater Vancouver Office, BC

PROJECT No. 10-1447-0255			PHASE No.	6000/6007
DESIGN	MJK	05NOV10	SCALE AS SHOWN	REV. –
CADD	MJK	04FEB11	**FIGURE 4-1**	
CHECK	VF	14FEB11		
REVIEW	UDA	14FEB11		

Drawing File: \\burl-s-cadsrv1\Active_2010\1447\10-1447-0255 Terasen Site Specific Seismic Assessments\6000 - Reporting\Drawings (Golder)\Final\LM-7 Site Plans.dwg Friday, January 20, 2012 11:20:26 AM By: MKennedy





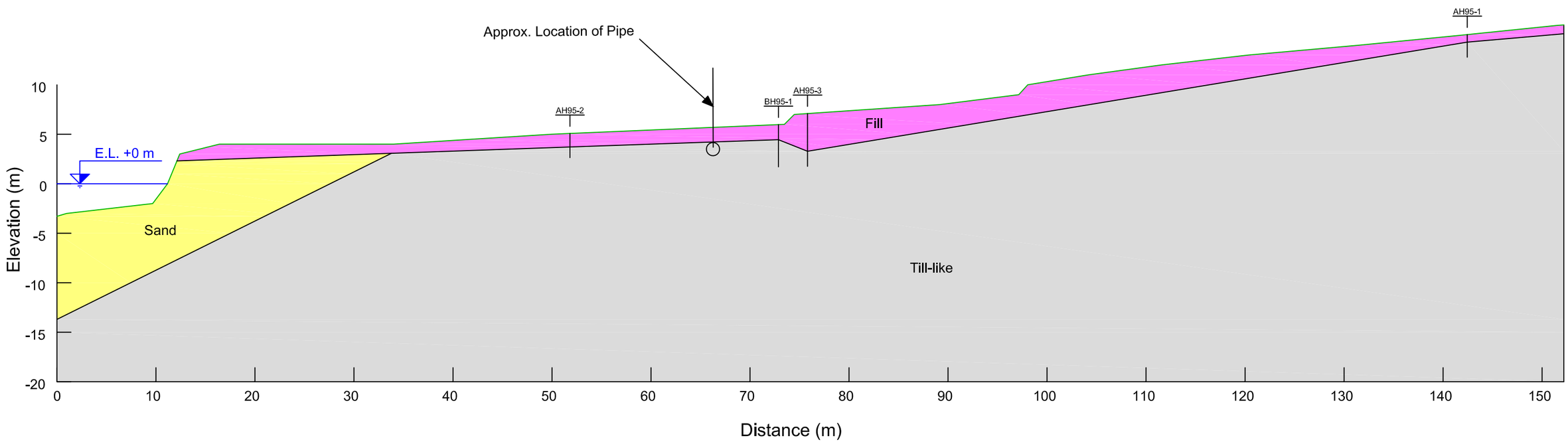
PROJECT
FORTISBC ENERGY INC.
SITE-SPECIFIC SEISMIC VULNERABILITY ASSESSMENT
SURREY, B.C.

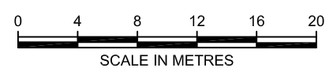
TITLE
STRATIGRAPHIC PROFILE
SECTION A-A'

Golder Associates
Greater Vancouver Office, BC

PROJECT No. 10-1447-0255			PHASE No.	6000/6007
DESIGN	MM	01FEB11	SCALE AS SHOWN	REV. –
CADD	MJK	03FEB11		
CHECK	VF	14FEB11	**FIGURE 5-1**	
REVIEW	UDA	14FEB11		

Drawing File: \\burl-s-cadsrv1\Active_2010\1447\10-1447-0255 Terasen Site Specific Seismic Assessments\6000 - Reporting\Drawings (Golder)\Final\LM-7 Section Figures.dwg Friday, January 20, 2012 1:22:13 PM By: MMloo





PROJECT

FORTISBC ENERGY INC.
SITE-SPECIFIC SEISMIC VULNERABILITY ASSESSMENT
SURREY, B.C.

TITLE

STRATIGRAPHIC PROFILE
SECTION B-B'

Golder Associates
Greater Vancouver Office, BC

PROJECT No. 10-1447-0255			PHASE No.	6000/6007
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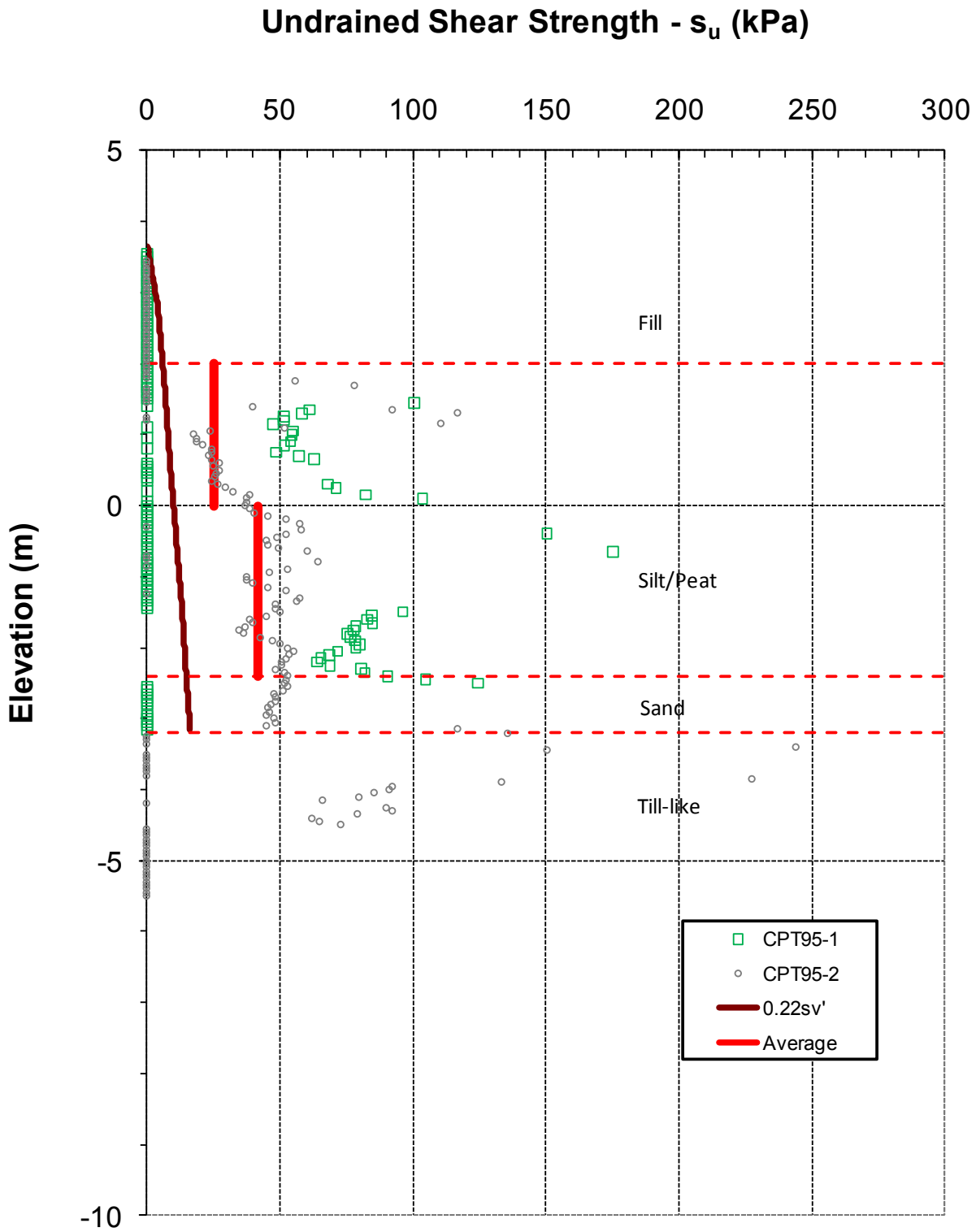
CHECK	VF	14FEB11	**FIGURE 5-2**	
REVIEW	UDA	14FEB11		

Drawing File: \\burl-s-cadsrv1\Active_2010\1447\10-1447-0255 Terasen Site Specific Seismic Assessments\6000 - Reporting\Drawings (Golder)\Final\LM-7 Section Figures.dwg Friday, January 20, 2012 1:22:13 PM By: MMloo



PROJECT

FORTISBC ENERGY INC.
SITE-SPECIFIC SEISMIC VULNERABILITY ASSESSMENT
VANCOUVER, B.C.

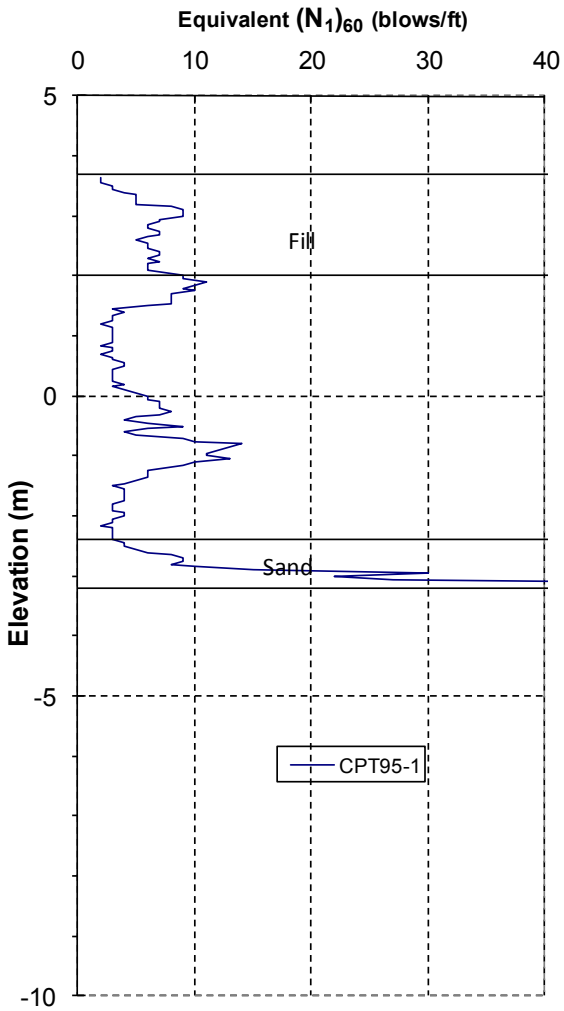
TITLE

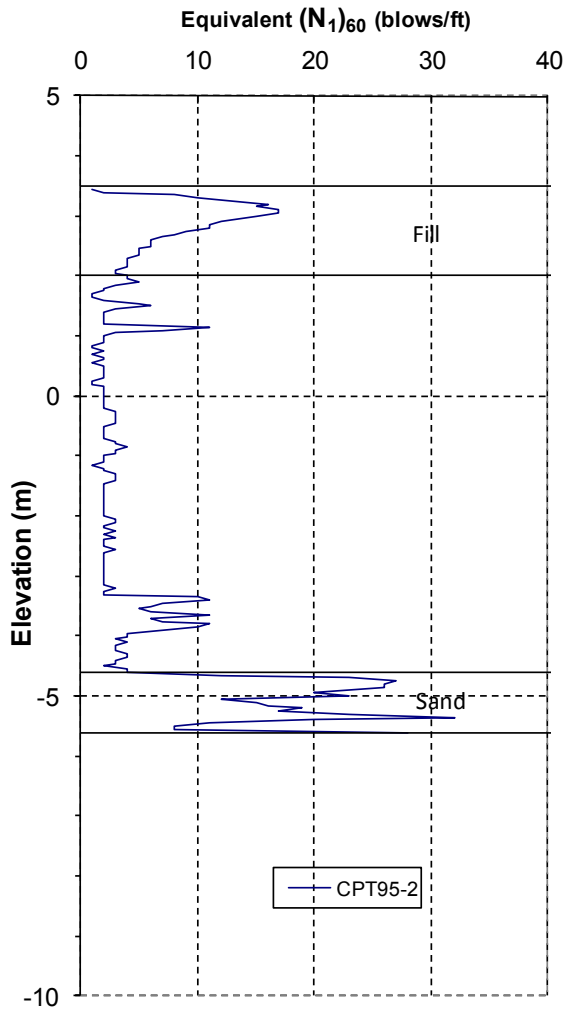
SHEAR STRENGTH PROFILES

Golder Associates

PROJECT No. 10-1447-0255			PHASE No. 6000/6007	
DESIGN	MM	06FEB11	SCALE AS SHOWN	REV.
CADD	--	--	**FIGURE 5-3**	
CHECK	VF	06FEB11		
REVIEW	UDA	14FEB11		

\\BUR1-S-FILESRV2\FINAL\2010\1447\10-1447-0255\PHASE 6000\REP 0215_12 LM-7 FINAL\FIGURES\FIGURE 5-3.PPT





PROJECT

FORTISBC ENERGY INC.
SITE SPECIFIC SEISMIC VULNERABILITY ASSESSMENT
VANCOUVER, B.C.

TITLE

SPT$(N_1)_{60}$ PROFILES

Golder Associates

PROJECT No.	10-1447-0255		PHASE / TASK No.	6000/6007
DESIGN	MM	06FEB11	SCALE NTS	REV.
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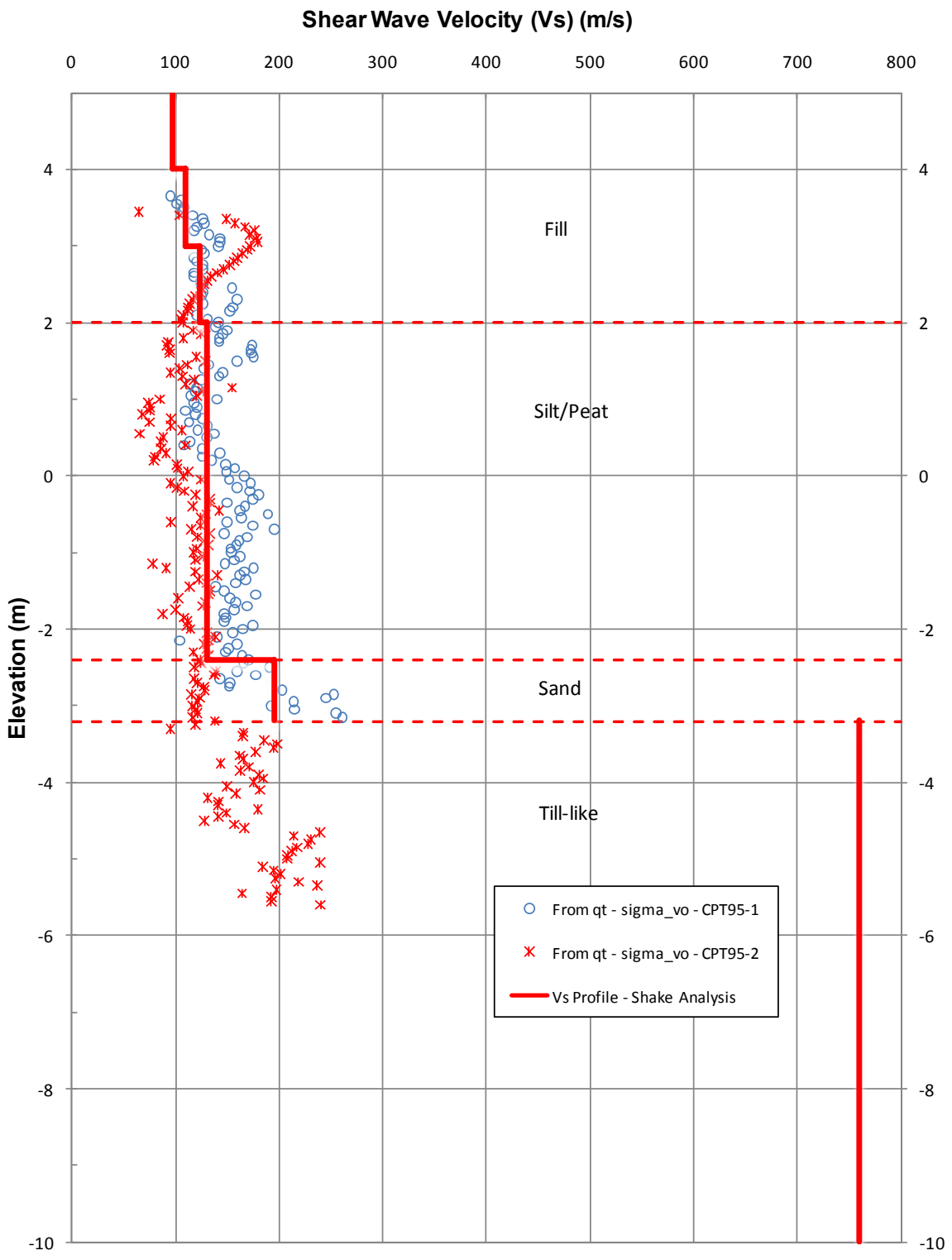
CHECK	VF	06FEB11	**FIGURE 5-4**	
REVIEW	UDA	14FEB11		



PROJECT

FORTISBC ENERGY INC.
SITE-SPECIFIC SEISMIC VULNERABILITY ASSESSMENT
VANCOUVER, B.C.

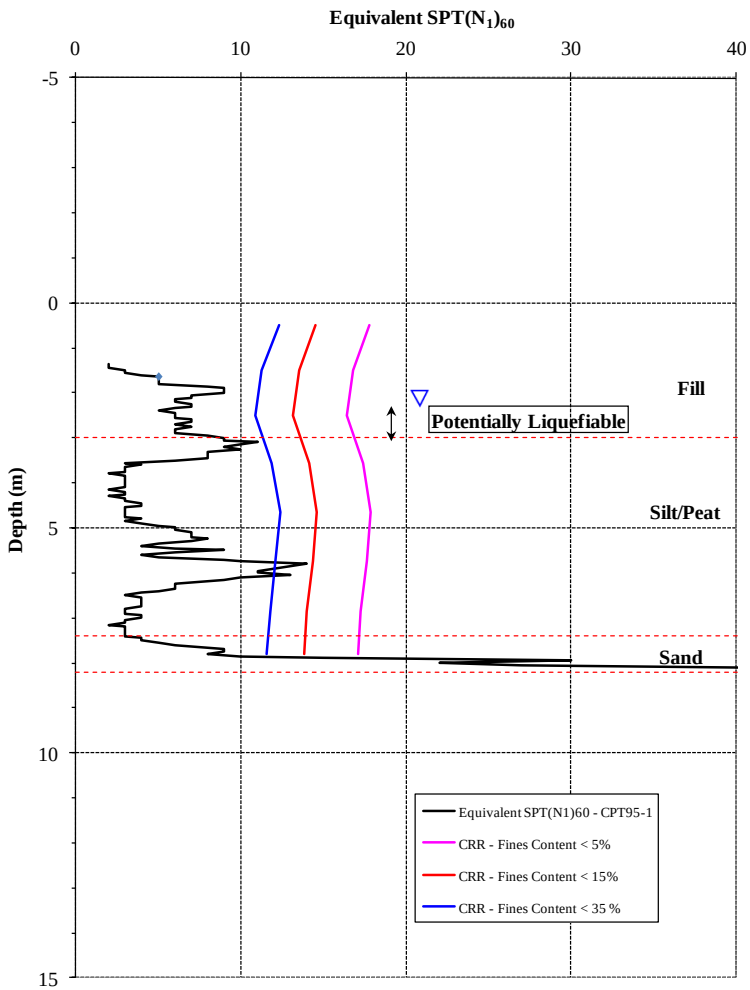
TITLE

SHEAR WAVE VELOCITY PROFILES

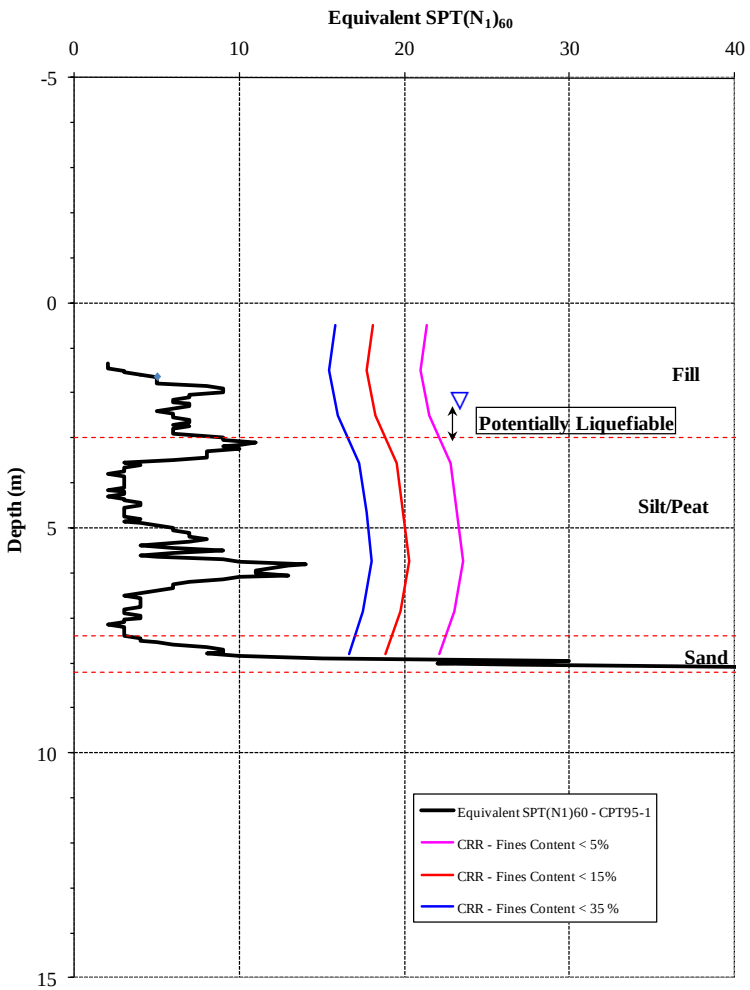
Golder Associates

PROJECT No. 10-1447-0255			PHASE No. 6000/6007	
DESIGN	MM	06FEB11	SCALE AS SHOWN	REV.
CADD	--	--	**FIGURE 6-1**	
CHECK	VF	06FEB11		
REVIEW	UDA	14FEB11		

\\BUR1-S-FILESRV2\FINAL\2010\1447\10-1447-0255\PHASE 6000\REP 0215_12 LM-7 FINAL\FIGURES\FIGURE 6-1.PPT



(a) 475 Year Ground Motions



(b) 2,475 Year Ground Motions

PROJECT

FORTISBC ENERGY INC.
SITE SPECIFIC SEISMIC VULNERABILITY ASSESSMENT
VANCOUVER, B.C.

TITLE

LIQUEFACTION SUSCEPTIBILITY OF SOILS

Golder Associates

PROJECT No.	10-1447-0255		PHASE No.	6000/6007
DESIGN	MM	06FEB11	SCALE NTS	REV.
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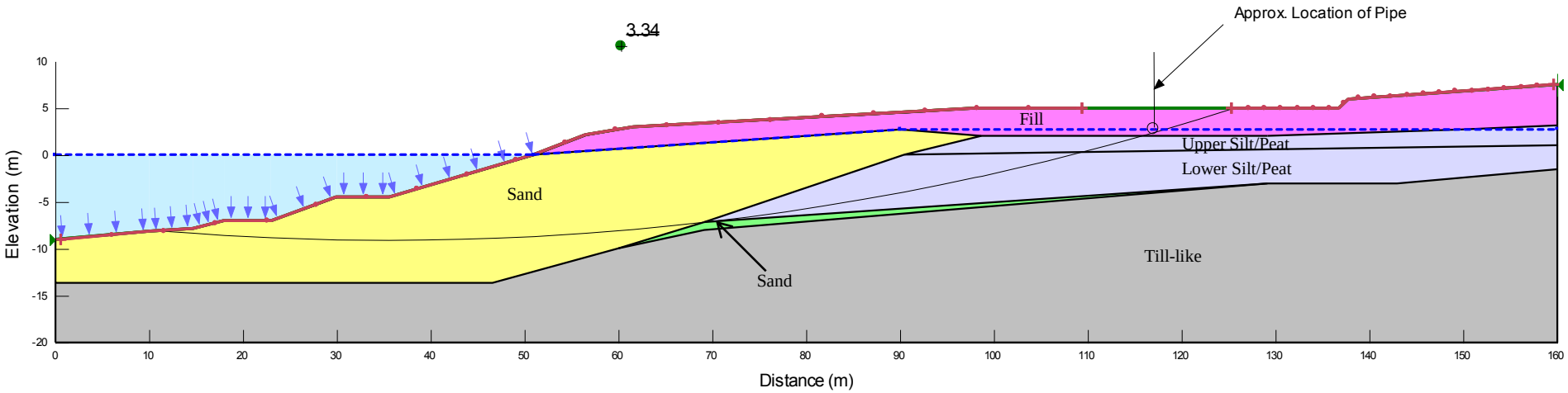
CHECK	VF	06FEB11	**FIGURE 6-2**	
REVIEW	UDA	14FEB11		



PROJECT

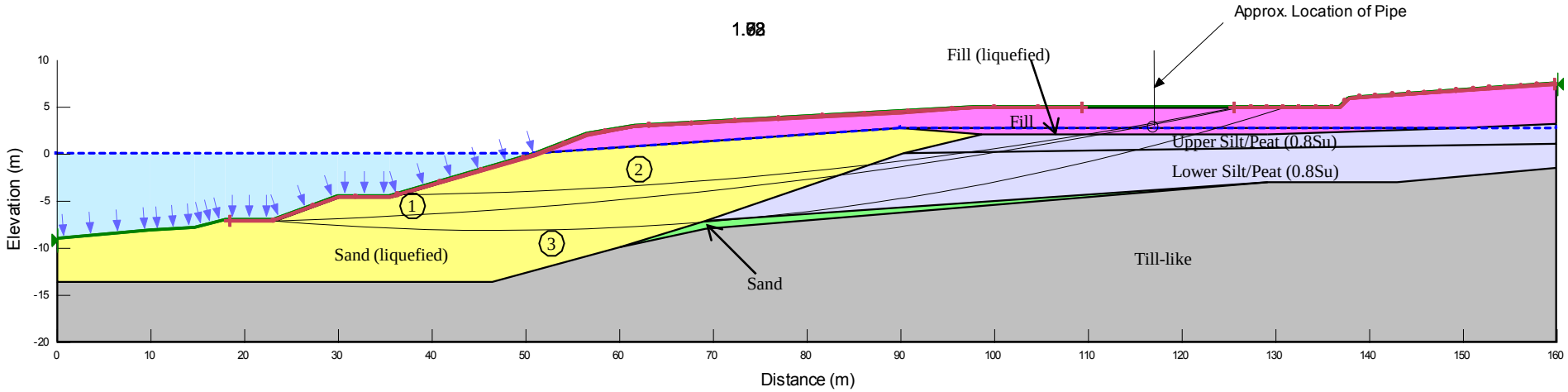
FORTISBC ENERGY INC.
SITE SPECIFIC SEISMIC VULNERABILITY ASSESSMENT
VANCOUVER, B.C.

TITLE

STABILITY ASSESSMENT – SECTION A-A'
STATIC LOADING CONDITIONS

Golder Associates

PROJECT No.	10-1447-0255		PHASE No.	6000/6007
DESIGN	MM	06FEB11	SCALE NTS	REV.
CADD	--	--		
CHECK	VF	06FEB11	**FIGURE 6-3**	
REVIEW	UDA	11FEB11		



Slip Surface No.	Factor of Safety
1	1.6
2	1.8
3	1.9

PROJECT

FORTISBC ENERGY INC.
SITE SPECIFIC SEISMIC VULNERABILITY ASSESSMENT
VANCOUVER, B.C.

TITLE

POST-SEISMIC STABILITY – SECTION A-A'
475 YEAR AND 2,475 YEAR GROUND MOTIONS
POSSIBLE FAILURE SURFACES

Golder Associates

PROJECT No.	10-1447-0255		PHASE No.	6000/6007
DESIGN	MM	06FEB11	SCALE NTS	REV.
CADD	--	--		
CHECK	VF	06FEB11	**FIGURE 6-4**	
REVIEW	UDA	11FEB11		

LEGEND

INTERMEDIATE PRESSURE PIPELINE

TRANSMISSION PRESSURE PIPELINE

0 20 40 60 80 100

SCALE IN METRES

REFERENCES

1. IMAGERY OBTAINED FROM DATA.VANCOUVER.CA ON DATE: FEBRUARY 5, 2011

PROJECT

FORTISBC ENERGY INC.
SITE SPECIFIC SEISMIC VULNERABILITY ASSESSMENT
VANCOUVER, B.C.

TITLE

REPRESENTATIVE PIPELINE SEGMENT

Golder Associates
Greater Vancouver Office, BC

PROJECT No. 10-1447-0255			PHASE No.	6000/6007
DESIGN	MJK	05NOV10	SCALE AS SHOWN	REV. –
CADD	MJK	04FEB11	**FIGURE 6-5**	
CHECK	VF	14FEB11		
REVIEW	UDA	14FEB11		

Drawing File: \\burl-s-cadsrv1\Active_2010\1447\10-1447-0255 Terasen Site Specific Seismic Assessments\6000 - Reporting\Drawings (Golder)\Final\LM-7 Site Plans.dwg Friday, January 20, 2012 11:20:26 AM By: MKennedy

APPENDIX A

Record of Test Hole Logs and Electronic Cone Penetration Tests

PROJECT: 942-1211A

RECORD OF BOREHOLE BH 95-1

SHEET 1 OF 1

LOCATION: Fraser Gate Station, Vancouver, B.C.

BORING DATE: June 14, 1995

DATUM: G.S.

SAMPLER HAMMER,63.5kg; DROP,760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat.V - + Q - ● rem.V - ⊕ U - O)	HYDRAULIC CONDUCTIVITY, k, cm/s / WATER CONTENT, PERCENT (Wp ⊢—O W—⊣ Wl; 20 40 60 80)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		Ground Surface									
0	Mud Rotary - SPT, Foundex	Concrete Slab		0.00							
		Compact, moist, grey-brown, silty SAND and GRAVEL, (crush) (Fill).		0.15							
1					1	DO	19				
		Very dense, cemented, grey, moist, silty SAND, some gravel (Till-like).		1.52							
2					2	DO	133				
3											
4					3	DO	102				
		End of Borehole.		4.27							
5											
6											
7											
8											
9											
10											

DATA INPUT: BAD-June'95

DEPTH SCALE

1 to 50

Golder Associates

LOGGED: L.P.

CHECKED: D.W.

PROJECT: 942-1211A

LOCATION: BC Gas/Fraser Gate/Vancouver

RECORD OF BOREHOLE AH95-1

BORING DATE: Feb. 23, 1995

SHEET 1 OF 1

DATUM: G.S.

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat.V - + Q - ● rem.V - ⊕ U - O)	HYDRAULIC CONDUCTIVITY, k, cm/s / WATER CONTENT, PERCENT (Wp W Wl; 20 40 60 80)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		Ground Surface									
0	Solid Stem Auger / Mud Bay Drilling	Compact, dry, brown, sandy GRAVEL, some silt. (FILL)		0.00	1	AS					
		Compact to dense, grey, mottled, fine SAND, some gravel.		0.30	2	AS					
1		Dense, moist, grey, fine to medium SAND, trace gravel. (Till-Like)		0.76	3	AS					
2					4	AS					
		End of Borehole		2.29							
3											
4											
5											
6											
7											
8											
9											
10											

DATA INPUT: BAD-MAR.'95

DEPTH SCALE

1 to 50

Golder Associates

LOGGED: L.P.

CHECKED: D.W.

PROJECT: 942-1211A

RECORD OF BOREHOLE AH95-2

SHEET 1 OF 1

LOCATION: South of Railway Crossing of Pipeline

BORING DATE: Feb. 23, 1995

DATUM: G.S.

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat.V - + Q - ● rem.V - ⊕ U - O)	HYDRAULIC CONDUCTIVITY, k, cm/s / WATER CONTENT, PERCENT (Wp W Wl 20 40 60 80)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		Ground Surface									
0	Solid Stem Auger / Mud Bay Drilling	Compact, moist to wet, grey-brown, gravelly SAND to sandy GRAVEL. (FILL)		0.00	1	AS					Water Level in Open Hole.
1		Dense, moist, grey black, silty SAND, some gravel, trace organics. (FILL)		0.46	2	AS					
2		Dense to very dense, moist, silty, fine SAND, some gravel. (Till-Like)		1.37	3	AS					
		End of Borehole		2.44							
3											
4											
5											
6											
7											
8											
9											
10											

DATA INPUT: BAD-MAR.'95

DEPTH SCALE

1 to 50

Golder Associates

LOGGED: L.P.

CHECKED: D.W.

PROJECT: 942-1211A

RECORD OF BOREHOLE AH95-3

SHEET 1 OF 1

LOCATION: Elliot St. & Kent Ave. North Intersection.

BORING DATE: Feb. 23, 1995

DATUM: G.S.

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80)	SHEAR STRENGTH Cu, kPa (nat.V - + Q - ● rem.V - ⊕ U - O)	HYDRAULIC CONDUCTIVITY, k, cm/s	WATER CONTENT, PERCENT (Wp — W — Wl; 20 40 60 80)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		Ground Surface											
0	Solid Stem Auger / Mud Bay Drilling	0.08m Asphalt at surface.		0.00									
		Compact to dense, dry, gravelly SAND to sandy GRAVEL. (ROAD MULCH FILL)			1	AS							
1				0.76	2	AS							
2		Loose to compact, dry to moist, brown, fine to coarse SAND, trace gravel, trace organics, occasional pockets of silty SAND. (FILL)			3	AS							
3					4	AS							
					5	AS							
4		Dense to very dense, grey, silty SAND, some gravel. (Till-Like)		3.81	6	AS							
5					7	AS							
		End of Borehole		5.33									
6													
7													
8													
9													
10													

DATA INPUT: BAD-MAR.'95

DEPTH SCALE

1 to 50

Golder Associates

LOGGED: L.P.

CHECKED: D.W.

PROJECT: 942-1211A

RECORD OF BOREHOLE AH95-4/CPT95-1

SHEET 1 OF 1

LOCATION: Fraser Gate Station Compound.

BORING DATE: Feb. 23, 1995

DATUM: G.S.

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		Ground Surface							
0	Solid Stem Auger; Mud Bay Drilling	Loose, moist, grey black, organic SAND. (FILL)		0.00	1	AS			Bentonite Seal; Feb. 23/95; March 24/95
1									
2		Very soft to soft, wet, brown, silty PEAT, occasional pieces of decaying wood.		1.67	2	AS	0 & 2	>132	Native Backfill
		Very soft to soft, moist, grey brown, organic SILT, trace sand.		2.29	3	AS			
3		Soft, moist, grey, SILT, trace to some sand, trace to some clay, trace organics (wood), interbedded lenses of fine sand.		2.74	4	AS			Pea Gravel
4					5	AS			
5		Soft, moist, brown, fibrous to semi-fibrous PEAT, pieces of decaying wood.		5.03	6	AS	6 & 5	>195.6	Slotted PVC Pipe
		Soft to very soft, moist, grey, organic SILT.		5.49	7	AS			
6		Compact to dense, grey, fine to medium SAND, some organics (wood debris), trace gravel.		6.10	8	AS			
		End of Borehole		6.55					
7									
8									
9									
10									

DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m: 20 40 60 80

SHEAR STRENGTH Cu, kPa: nat.V - + Q - ●; rem.V - ⊕ U - ○

HYDRAULIC CONDUCTIVITY, k, cm/s

WATER CONTENT, PERCENT: Wp ⊢—○W—⊣ Wl; 20 40 60 80

DATA INPUT: BAD-MAR.'95

DEPTH SCALE

1 to 50

Golder Associates

LOGGED: L.P.

CHECKED: D.W.

PROJECT: 942-1211A

RECORD OF BOREHOLE AH95-5/SCPT95-4

LOCATION: Fraser Gate Station Compound.

BORING DATE: Feb. 23, 1995

DATUM: G.S.

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat.V - + Q - ●, rem.V - ⊕ U - O)	HYDRAULIC CONDUCTIVITY, k, cm/s / WATER CONTENT, PERCENT (Wp — W — Wl, 20 40 60 80)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		Ground Surface									
0	Solid Stem Auger / Mud Bay Drilling	Loose to compact, moist, brown black SAND, some organic, trace to some gravel, trace silt. (FILL)		0.00	1	AS					
1					2	AS					
2		Loose, wet, grey to brown, fine to coarse SAND, trace organics.		1.98	3	AS					Water Level in Open Hole.
3					4	AS					
4		Loose, wet, grey, silty, fine SAND to sandy SILT, trace to some organics.		3.50	5	AS					
5					6	AS					
					7	AS					
6					8	AS					
7		Loose to compact, wet, grey, fine SAND, trace to some silt, interbedded lenses of sandy silt.		6.10	9	AS					
					10	AS					
8					11	AS					
9					12	AS					
10					13	AS					

CONTINUED ON NEXT PAGE

DATA INPUT: BAD-MAR.'95

DEPTH SCALE
1 to 50

Golder Associates

LOGGED: L.P.
CHECKED: D.W.

PROJECT: 942-1211A

RECORD OF BOREHOLE AH95-5/SCPT95-4

SHEET 2 OF 2

LOCATION: Fraser Gate Station Compound.

BORING DATE: Feb. 23, 1995

DATUM: G.S.

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80)	SHEAR STRENGTH Cu, kPa (nat.V - + Q - ● rem.V - ⊕ U - ○)	HYDRAULIC CONDUCTIVITY, k, cm/s	WATER CONTENT, PERCENT (Wp — w — Wl; 20 40 60 80)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
10	Solid Stem Auger / Mud Bay Drilling	CONTINUED FROM PREVIOUS PAGE											
		As above.			13	AS							
				10.30									
11		Compact to dense, grey, silty, fine to coarse SAND, some gravel.			14	AS							
					15	AS							
12		End of Borehole		12.20									
13													
14													
15													
16													
17													
18													
19													
20													

DATA INPUT: BAD-MAR.'95

DEPTH SCALE

1 to 50

Golder Associates

LOGGED: L.P.

CHECKED: D.W.

PROJECT: 942-1211A

RECORD OF BOREHOLE AH95-6/CPT95-3

SHEET 1 OF 2

LOCATION: Fraser Gate Station Compound.

BORING DATE: Feb. 23, 1995

DATUM: G.S.

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat.V - + Q - ● rem.V - ⊕ U - O)	HYDRAULIC CONDUCTIVITY, k, cm/s / WATER CONTENT, PERCENT (Wp W Wl, 20 40 60 80)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
0	Solid Stem Auger / Mud Bay Drilling	Ground Surface									
		Loose to compact, grey, moist, silty SAND, some organics. (FILL)		0.00							Bentonite Seal
		Loose, moist, grey, silty SAND to sandy SILT, some organics (wood fragments). (FILL)		0.46	1	AS					Native Backfill
1											
2					2	AS					Feb. 23/95
											March 24/95
		Loose to compact, wet, grey, fine SAND, some silt to silty fine SAND with occasional lenses of silt.		2.74	3	AS					Sand Sloughed
3											
4											
		Loose to compact, wet, grey, fine SAND, trace silt.		4.27	4	AS					Slotted PVC Pipe
5											
6					5	AS					
7											
		Loose to compact, grey, wet, fine to coarse SAND, trace silt.		7.77	6	AS					
8											
9					7	AS					
10		CONTINUED ON NEXT PAGE									

DATA INPUT: BAD-MAR.'95

DEPTH SCALE

1 to 50

Golder Associates

LOGGED: L.P.

CHECKED: D.W.

PROJECT: 942-1211A

RECORD OF BOREHOLE AH95-6/CPT95-3

SHEET 2 OF 2

LOCATION: Fraser Gate Station Compound.

BORING DATE: Feb. 23, 1995

DATUM: G.S.

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat.V - + Q - ● rem.V - ⊕ U - ○)	HYDRAULIC CONDUCTIVITY, k, cm/s / WATER CONTENT, PERCENT (Wp W Wl 20 40 60 80)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
10	Solid Stem Auger / Mud Bay Drilling	CONTINUED FROM PREVIOUS PAGE									
		As above.									
11				11.00	8	AS					
12		Compact to dense, wet, grey, fine to coarse SAND, trace gravel.			9	AS					
13											
14				14.02							
		Dense, moist, grey, silty SAND, some gravel. (Till-Like)			10	AS					
15											
		End of Borehole		15.24							
16											
17											
18											
19											
20											

DATA INPUT: BAD-MAR.'95

DEPTH SCALE

1 to 50

Golder Associates

LOGGED: L.P.

CHECKED: D.W.

PROJECT: 942-1211A

RECORD OF BOREHOLE AH95-7/CPT 95-5 SHEET 1 OF 1

LOCATION: Fraser Gate Station Compound.

BORING DATE: March 24,1995

DATUM: G.S.

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20, 40, 60, 80)	SHEAR STRENGTH Cu, kPa (nat.V - +, rem.V - ⊕, Q - ●, U - ○)	HYDRAULIC CONDUCTIVITY, k, cm/s	WATER CONTENT, PERCENT (Wp, W, Wl; 20, 40, 60, 80)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		Ground Surface											
0	Solid Stem Auger; Mud Bay Drilling	Loose, grey SAND and SILT, some wood pieces. (FILL).		0.00									
		Loose, moist, grey, organic, sandy SILT, some decaying wood pieces.		0.30	1	AS							
1													
		Very soft to soft, moist to wet, grey SILT, trace fine sand, trace clay, trace organics, some fine sand to silt and fine to medium sand below 7.0m		1.67									Water Level in Open Hole, March 24/95.
2					2	AS							
3													
4					3	AS					71		
5											10		
					4	AS							
6											23		
7					5	AS							
8		Dense, fine to medium SAND, some cobbles, trace silt.		7.77	6	AS							
9		Very dense SAND and GRAVEL, some cobbles.		8.83	7	AS							
		End of Borehole.		9.29									
10													

DATA INPUT: BAD-MAR.'95

DEPTH SCALE

1 to 50

Golder Associates

LOGGED: T.S.

CHECKED: D.W.

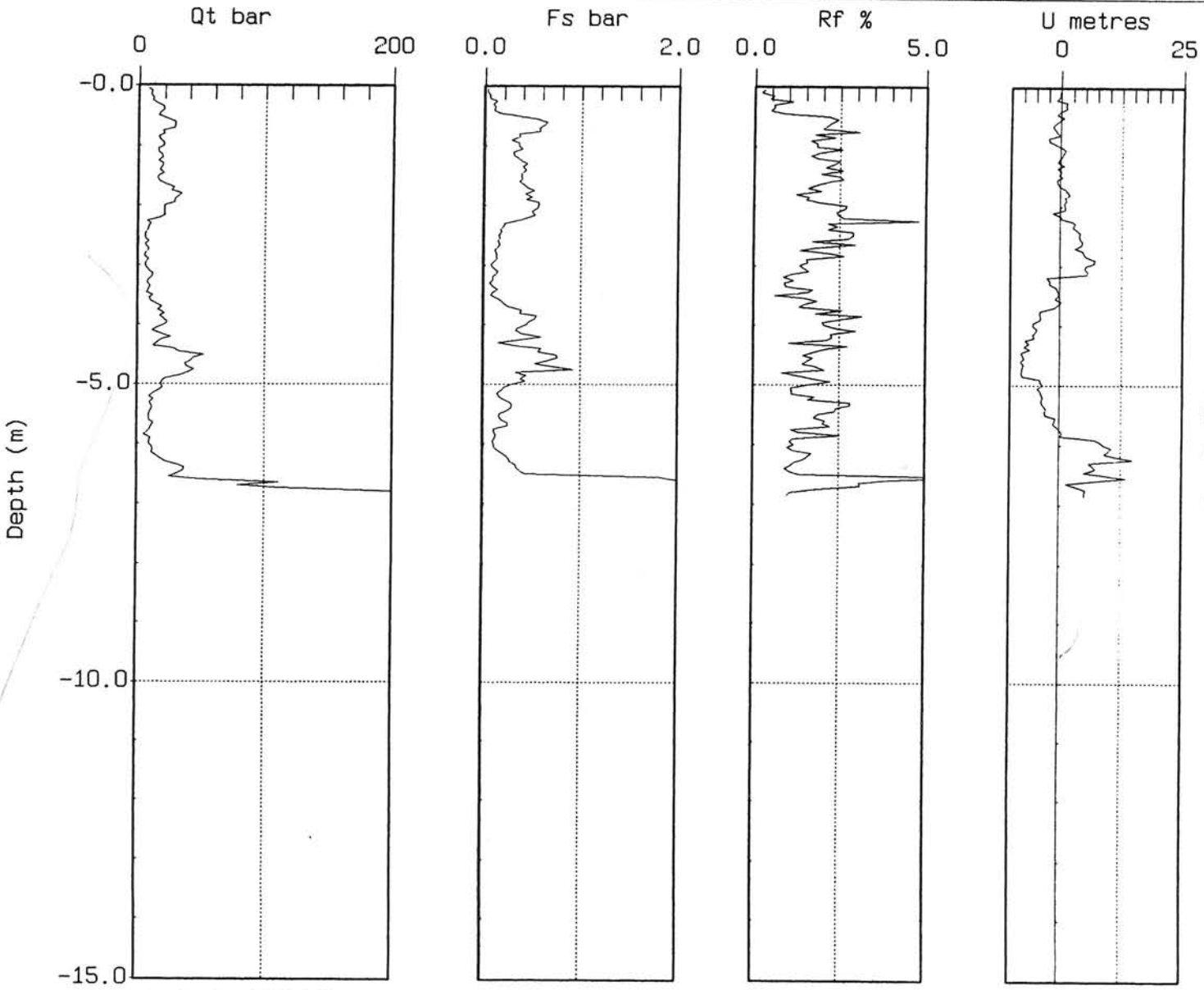
CONETEC

GOLDER ASSOCIATES

CPT 95-1/AH 95-4

Fraser Gate Station

Cone: 10 TON AD 028
Date: 02:23:95 12:27



Max. Depth: 6.85 (m)

Depth Inc.: 0.05 (m)

INFERRED SOIL STRATIGRAPHY

	Loose organic SAND, (fill).
1.7	*Soft PEAT*
2.3	*Very soft to soft organic SILT.*
2.7	*Soft SILT, trace to some sand, trace to some clay.*
5.0	*Soft PEAT.*
5.5	*Soft organic SILT.*
6.1	*Compact to dense SAND.*
6.9	*End of Hole (refusal)*

NOTE:
Soil stratigraphy based on augerhole AH 95-4 data at same location.

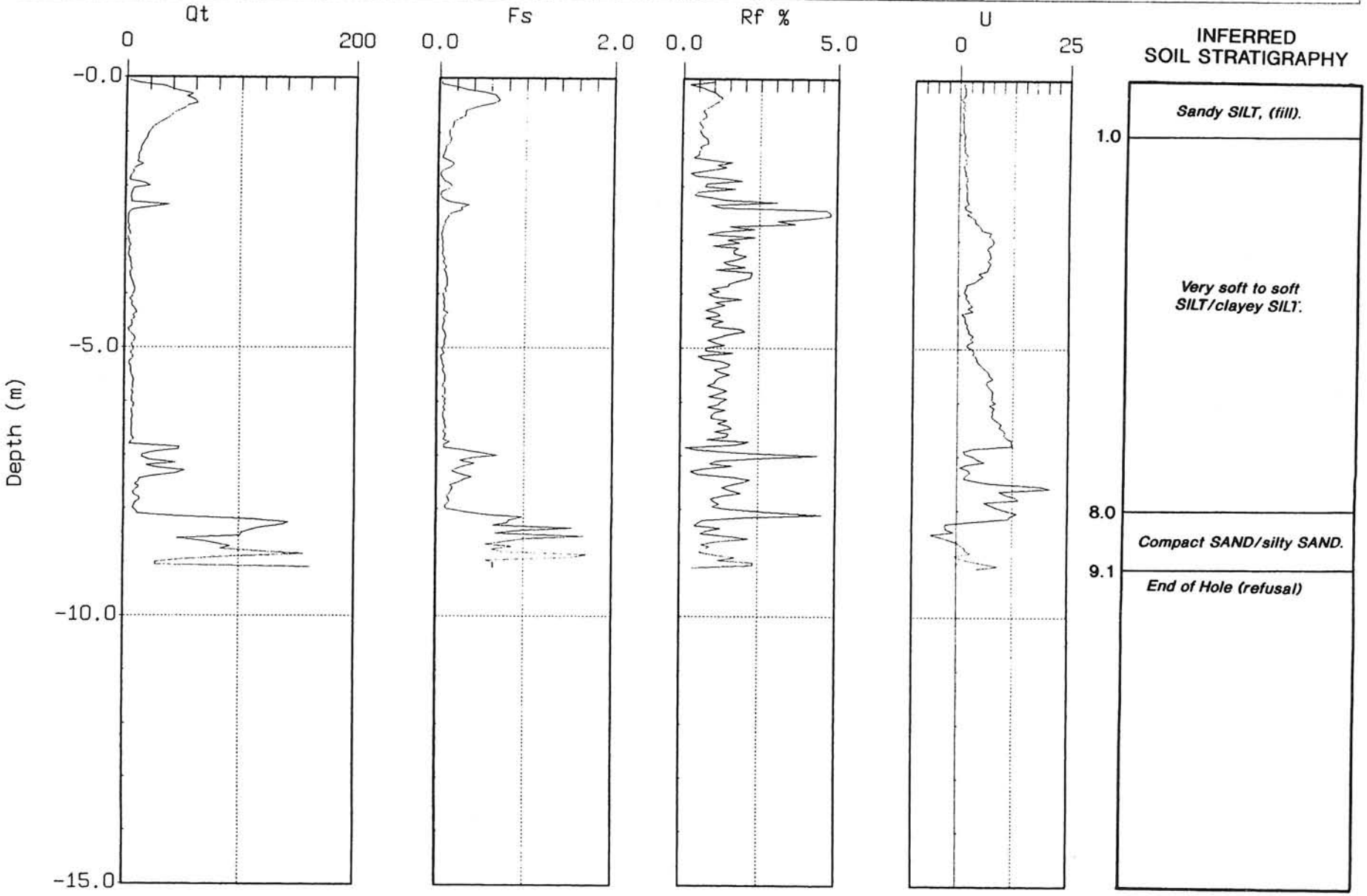
CONETEC

GOLDER ASSOCIATES

CPT 95-2

Fraser Gate Station

Cone: 10 TON AD 028
Date: 02:23:95 13:35



Max. Depth: 9.10 (m)

Depth Inc.: 0.05 (m)

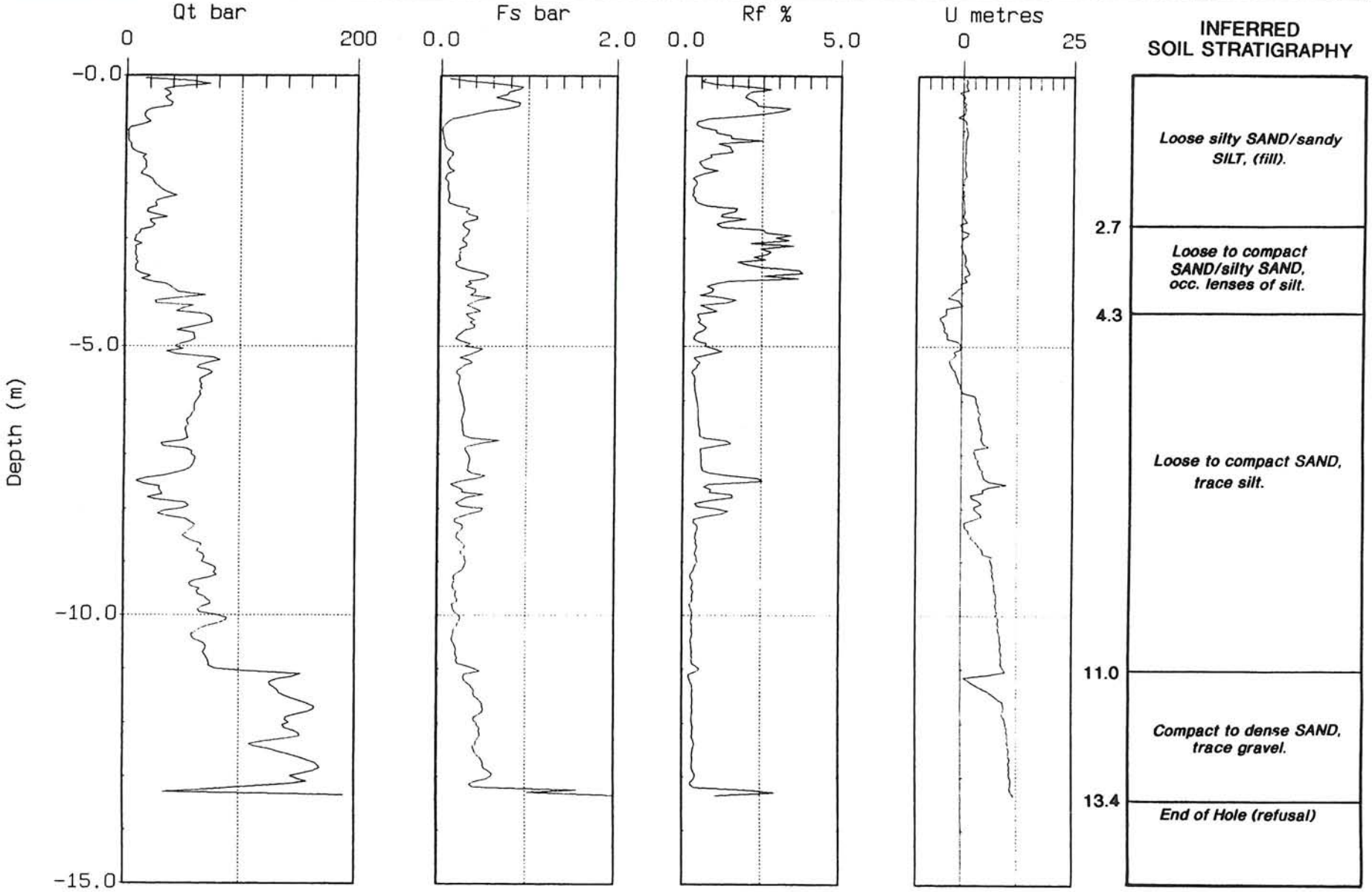
CONETEC

GOLDER ASSOCIATES

CPT 95-3/AH 95-6

Fraser Gate Station

Cone: 10 TON AD 028
Date: 02:23:95 14:08



Max. Depth: 13.35 (m)

Depth Inc.: 0.05 (m)

NOTE:
Soil stratigraphy based on augerhole AH 95-6 data at same location.

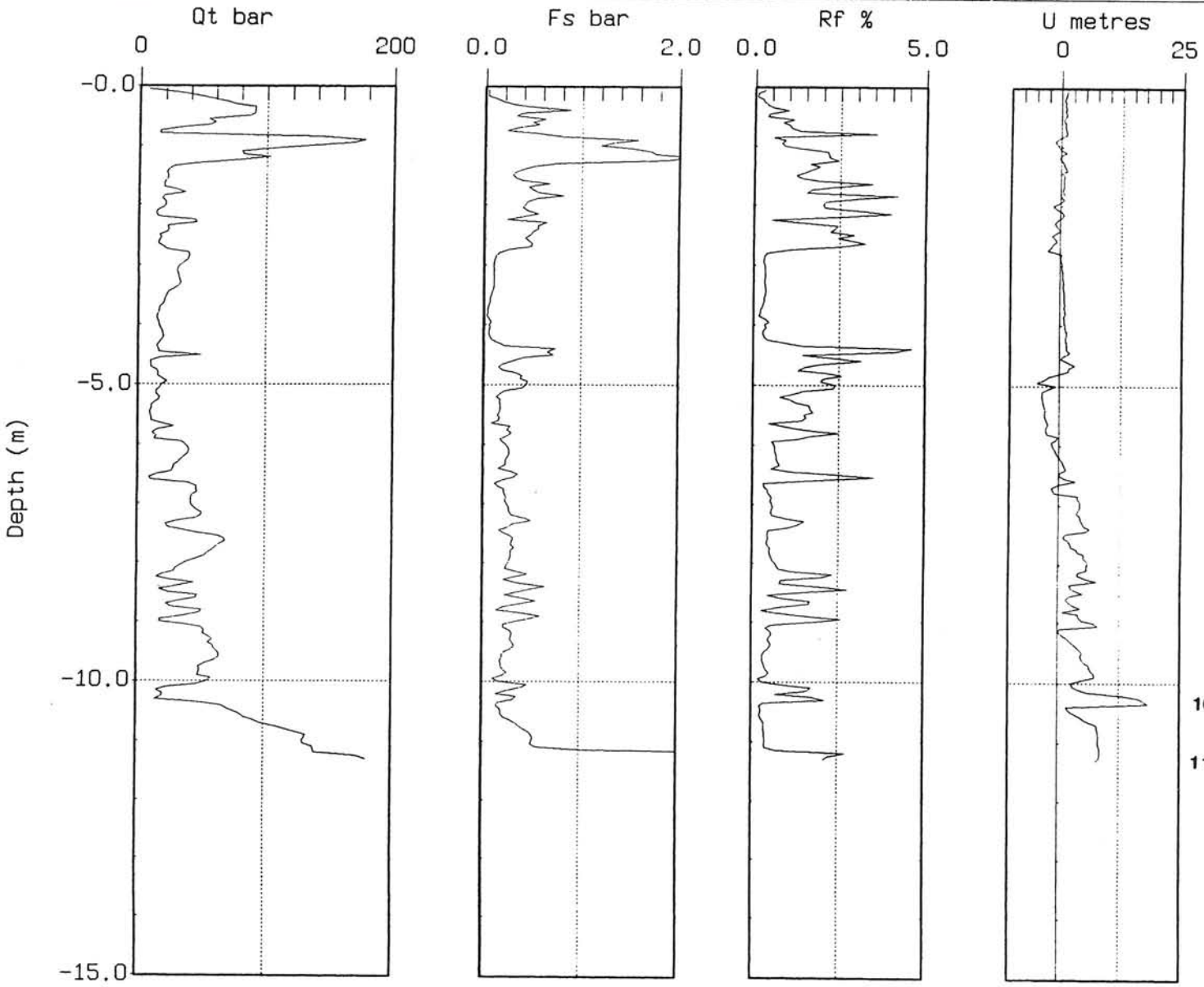
CONETEC

GOLDER ASSOCIATES

SCPT 95-4/AH 95-5

Fraser Gate Station

Cone: 10 TON AD 028
Date: 02:23:95 15:21



Max. Depth: 11.30 (m)

Depth Inc.: 0.05 (m)

INFERRED SOIL STRATIGRAPHY

	Loose to compact SAND, organics, trace silt (fill).
2.0	*Loose SAND, trace organics.*
3.5	*Loose SAND/sandy SILT.*
6.1	*Loose to compact SAND, trace to some silt, interbedded lenses of sandy silt.*
10.3	*Compact to dense SAND, some gravel.*
11.3	*End of Hole (refusal)*

NOTE:
Soil stratigraphy based on augerhole AH 95-5 data at same location.

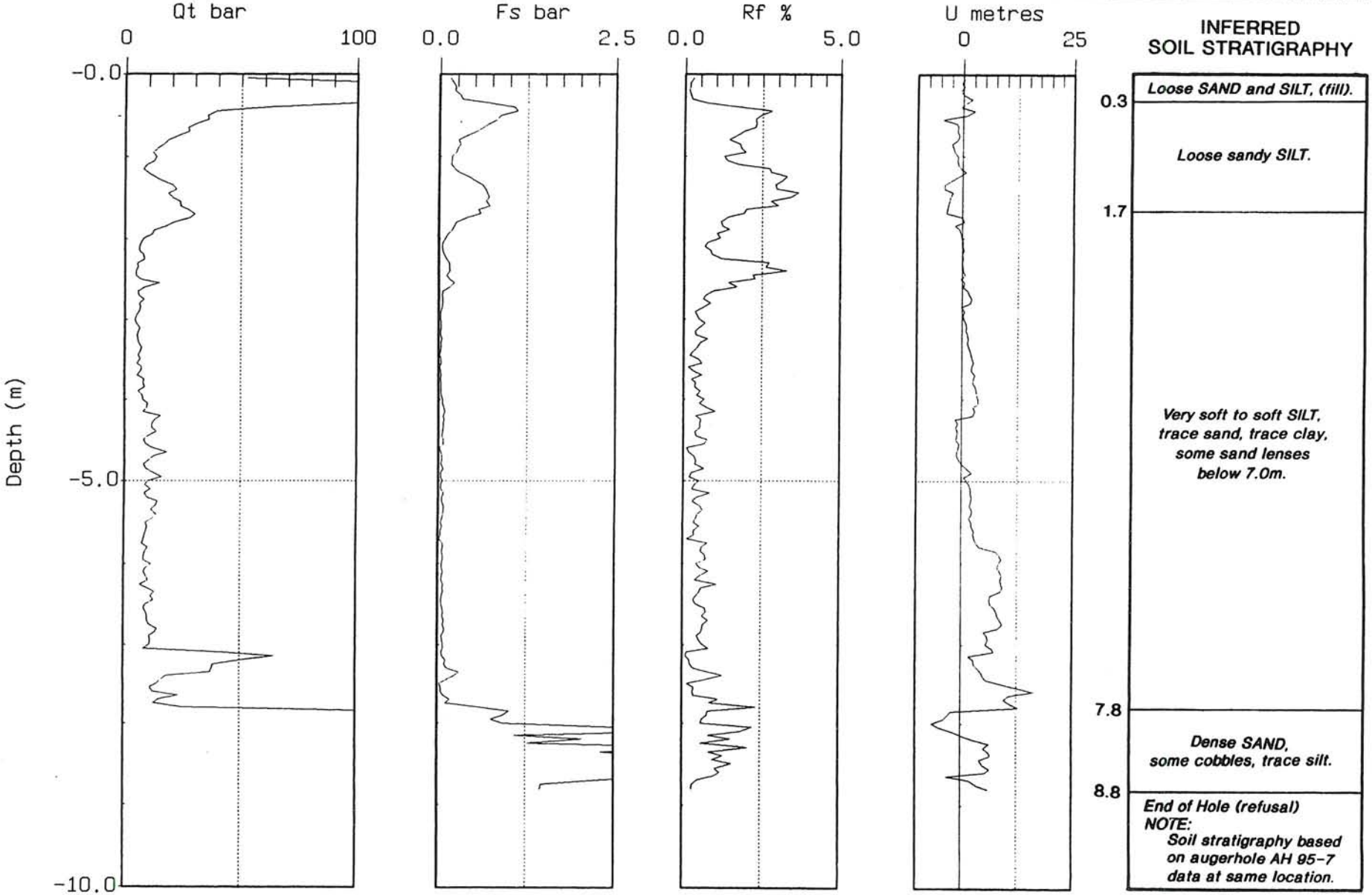
CONETEC

Golder

CPT 95-5/AH 95-7

Fraser Gate Station

Cone: 10 TON A 027
Date: 03:24:95 09:20



Max. Depth: 8.80 (m)

Depth Inc.: 0.05 (m)

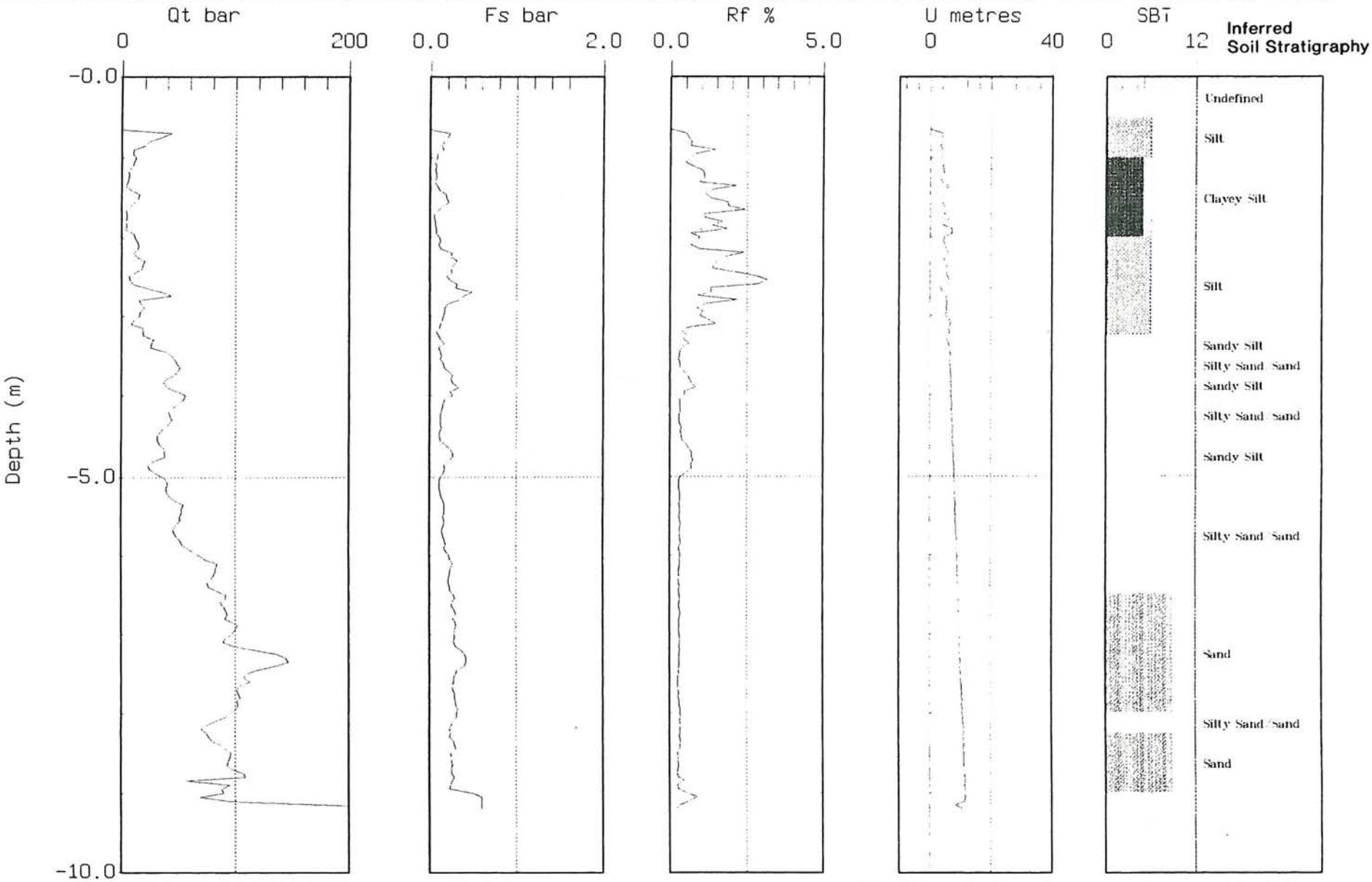
CONETEC

Golder Associates

CPT 95-6

Offshore – South of Fraser Gate Station

Cone: 10 TCN A 009
Date: 04/08/95 08:17



Max. Depth: 9.20 (m)

Depth Inc.: 0.05 (m)

SBT: Soil Behavior Type (Robertson and Campanella 1988)

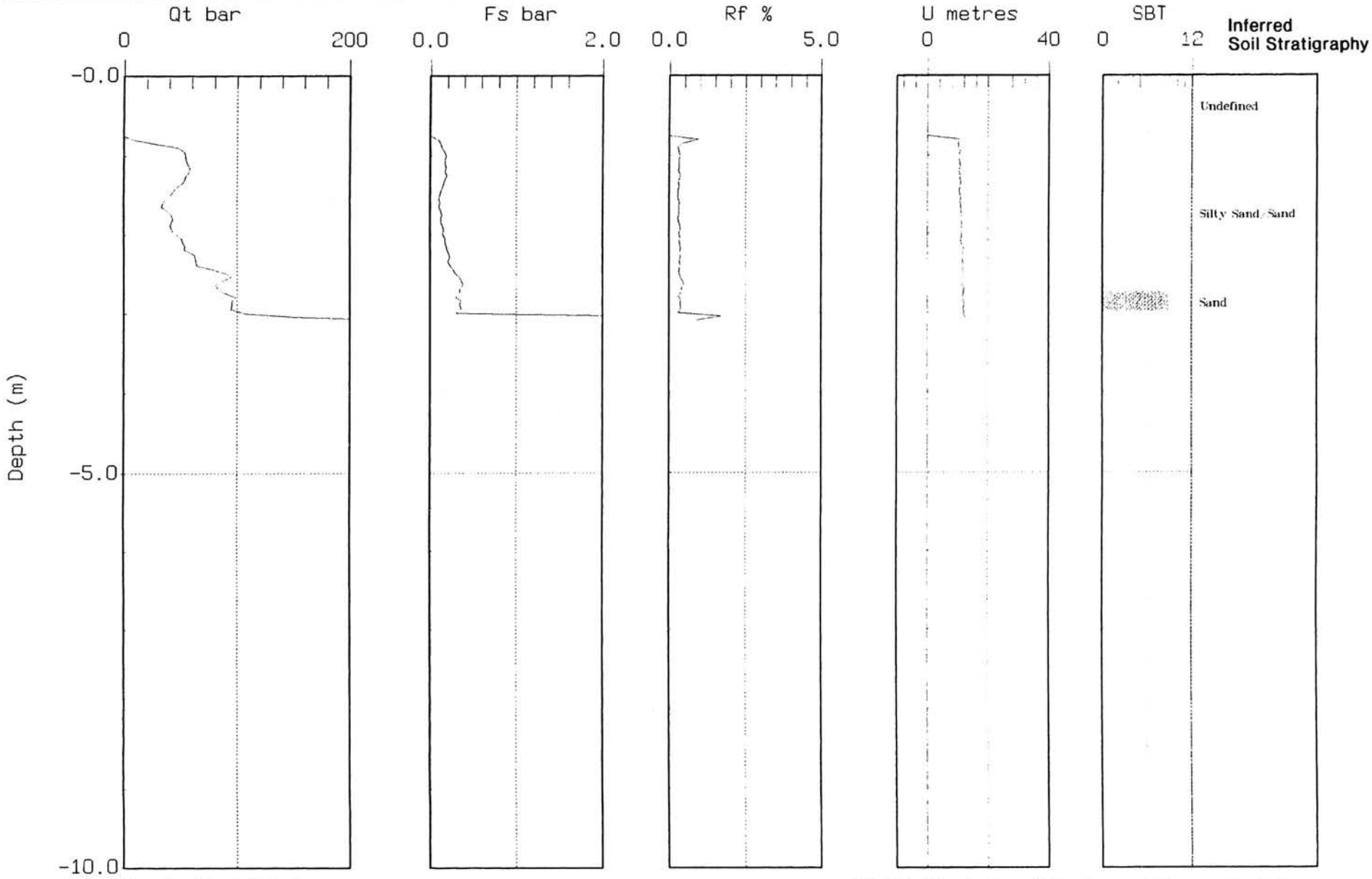
CONETEC

Golder Associates

CPT 95-7

Offshore – South of Fraser Gate Station

Cone: 10 TON A DE
Date: 04/08/95 10:14



Max. Depth: 3.10 (m)

Depth Inc.: 0.05 (m)

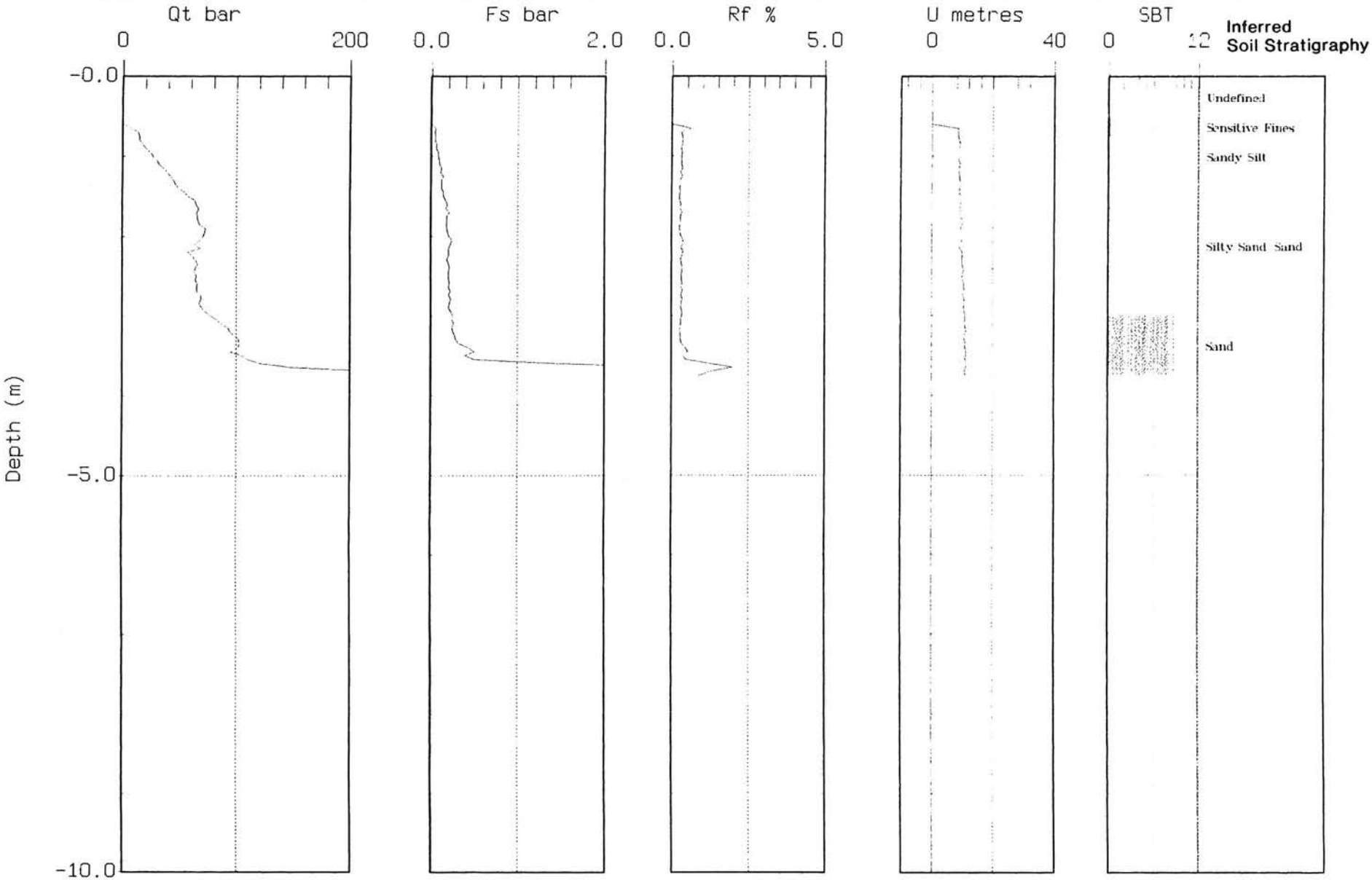
SBT: Soil Behavior Type (Robertson and Campanella 1988)

CONETEC

Golder Associates

CPT 95-8

Offshore – South of Fraser Gate Station



Max. Depth: 3.75 (m)

Depth Inc.: 0.05 (m)

SBT: Soil Behavior Type (Robertson and Campanella 1988)

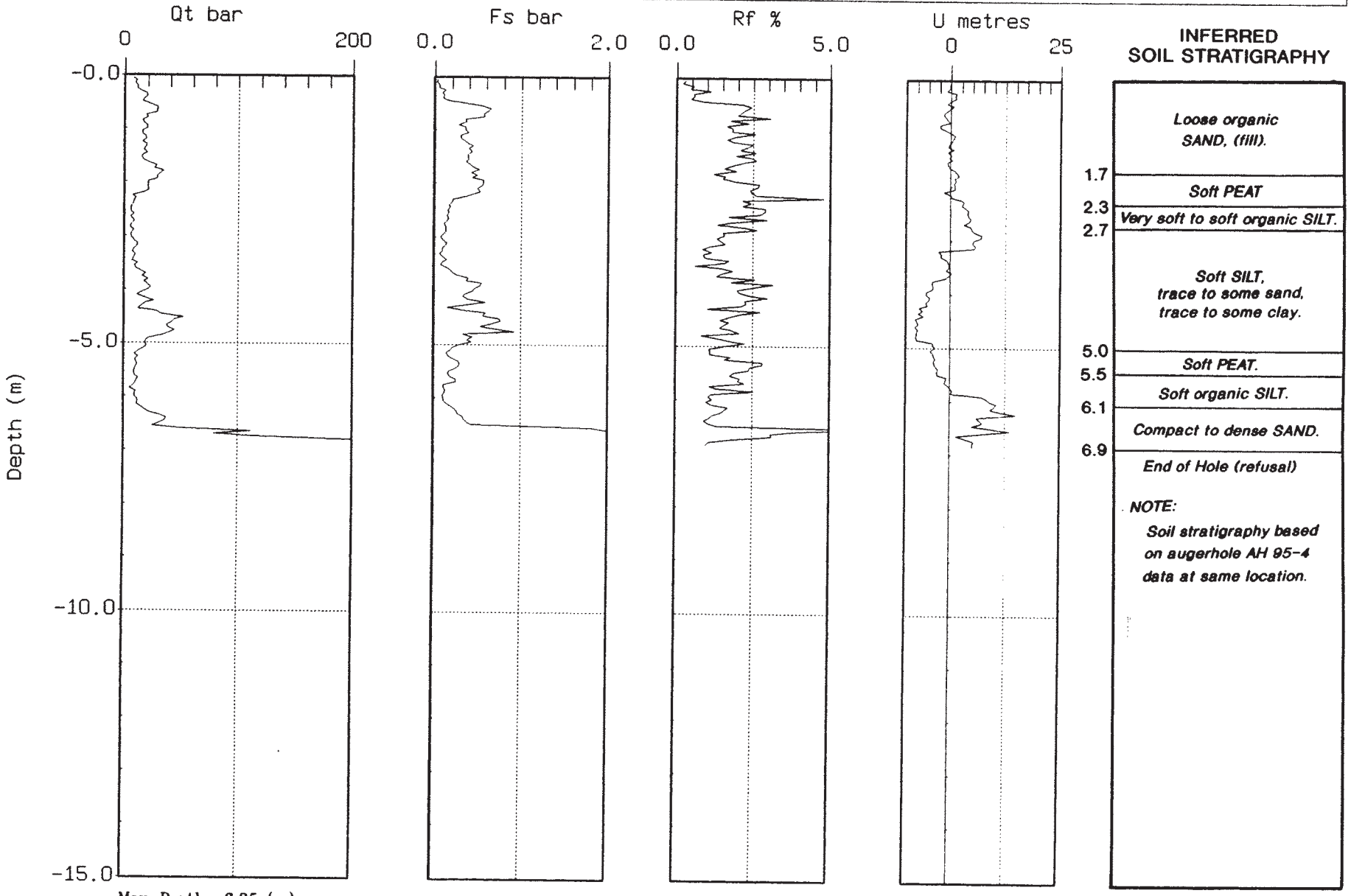
CONETEC

GOLDER ASSOCIATES

CPT 95-1/AH 95-4

Fraser Gate Station

Cone: 10 TON AD 028
Date: 02:23:95 12:27



Max. Depth: 6.85 (m)

Depth Inc.: 0.05 (m)

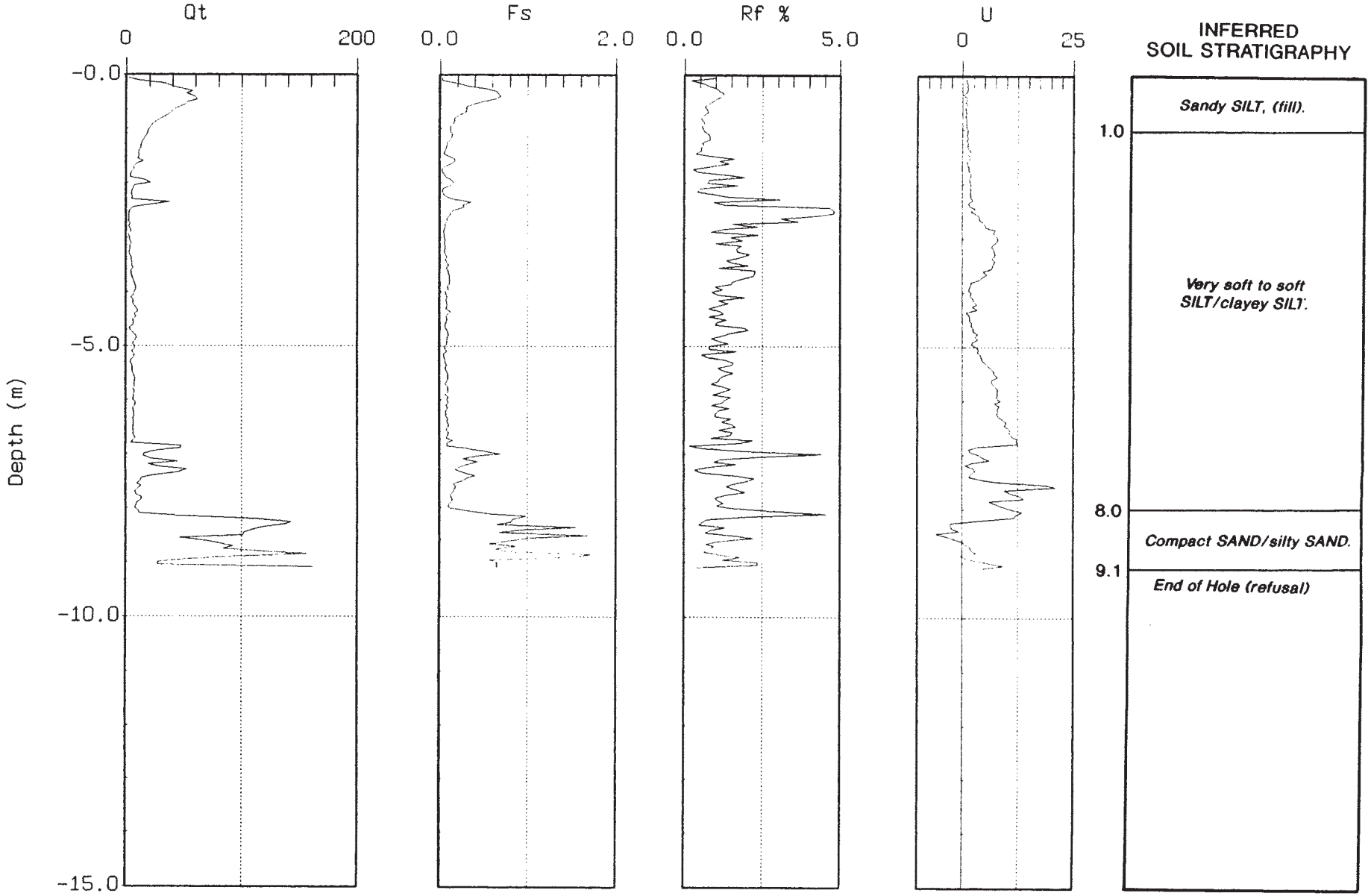
CONETEC

GOLDER ASSOCIATES

CPT 95-2

Fraser Gate Station

Cone: 10 TON AD 028
Date: 02:23:95 13:35



Max. Depth: 9.10 (m)

Depth Inc.: 0.05 (m)

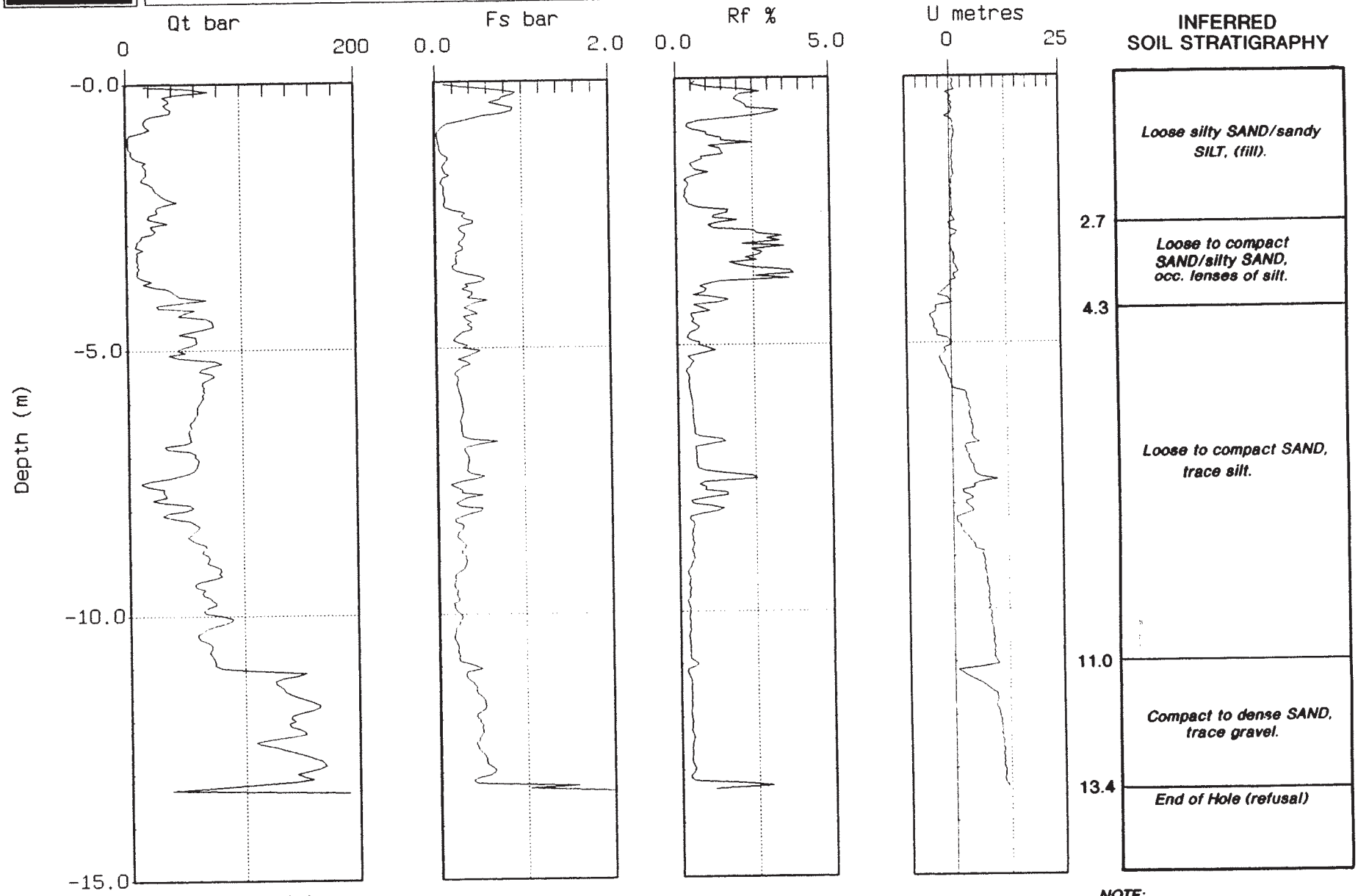
CONETEC

GOLDER ASSOCIATES

CPT 95-3/AH 95-6

Fraser Gate Station

Cone: 10 TON AD 028
Date: 02:23:95 14:08



Max. Depth: 13.35 (m)

Depth Inc.: 0.05 (m)

NOTE:
Soil stratigraphy based on augerhole AH 95-6 data at same location.

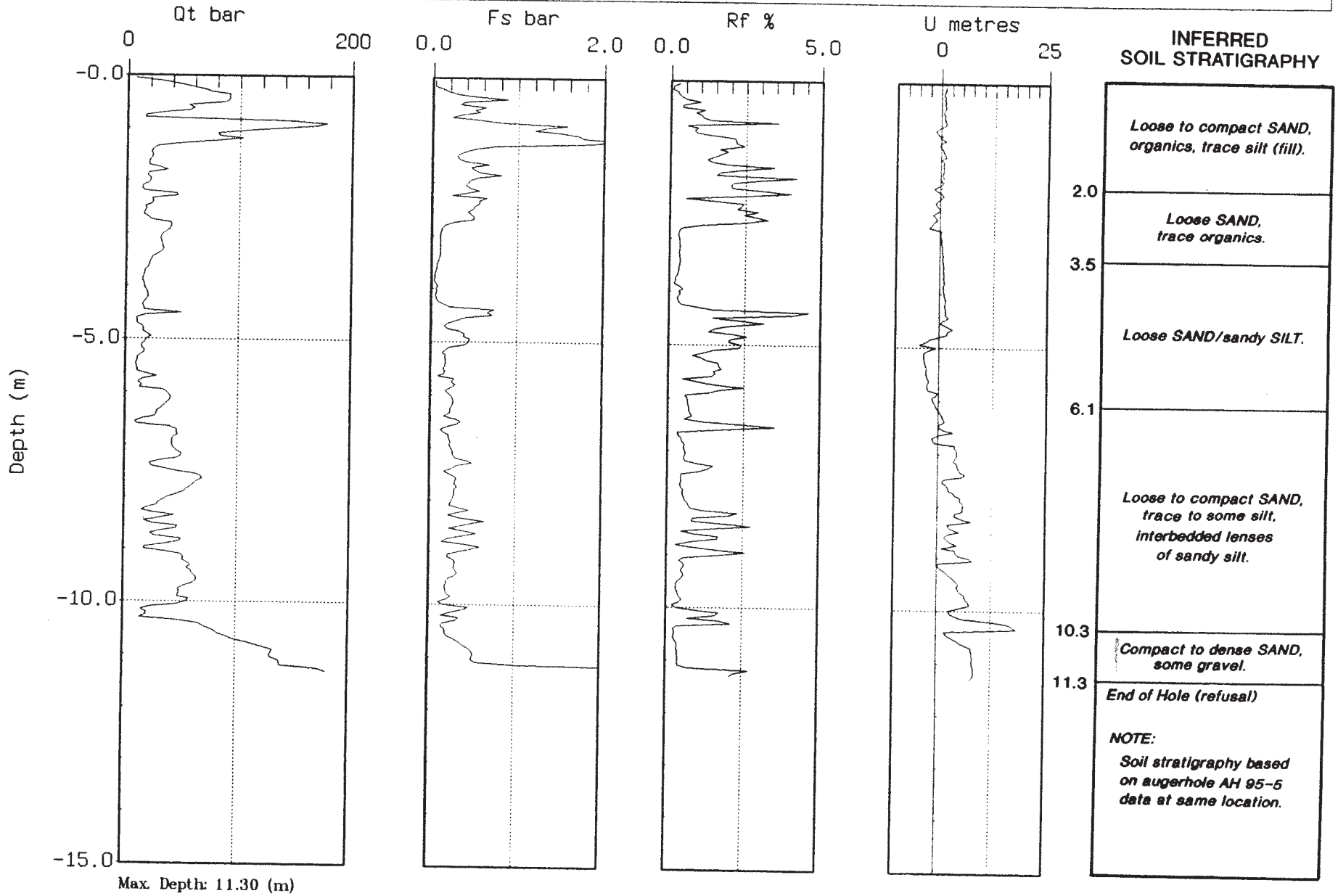
CONETEC

GOLDER ASSOCIATES

SCPT 95-4/AH 95-5

Fraser Gate Station

Cone: 10 TON AD 028
Date: 02:23:95 15:21



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Depth Inc.: 0.05 (m)

CONETEC

Golder

CPT 95-5/AH 95-7

Fraser Gate Station

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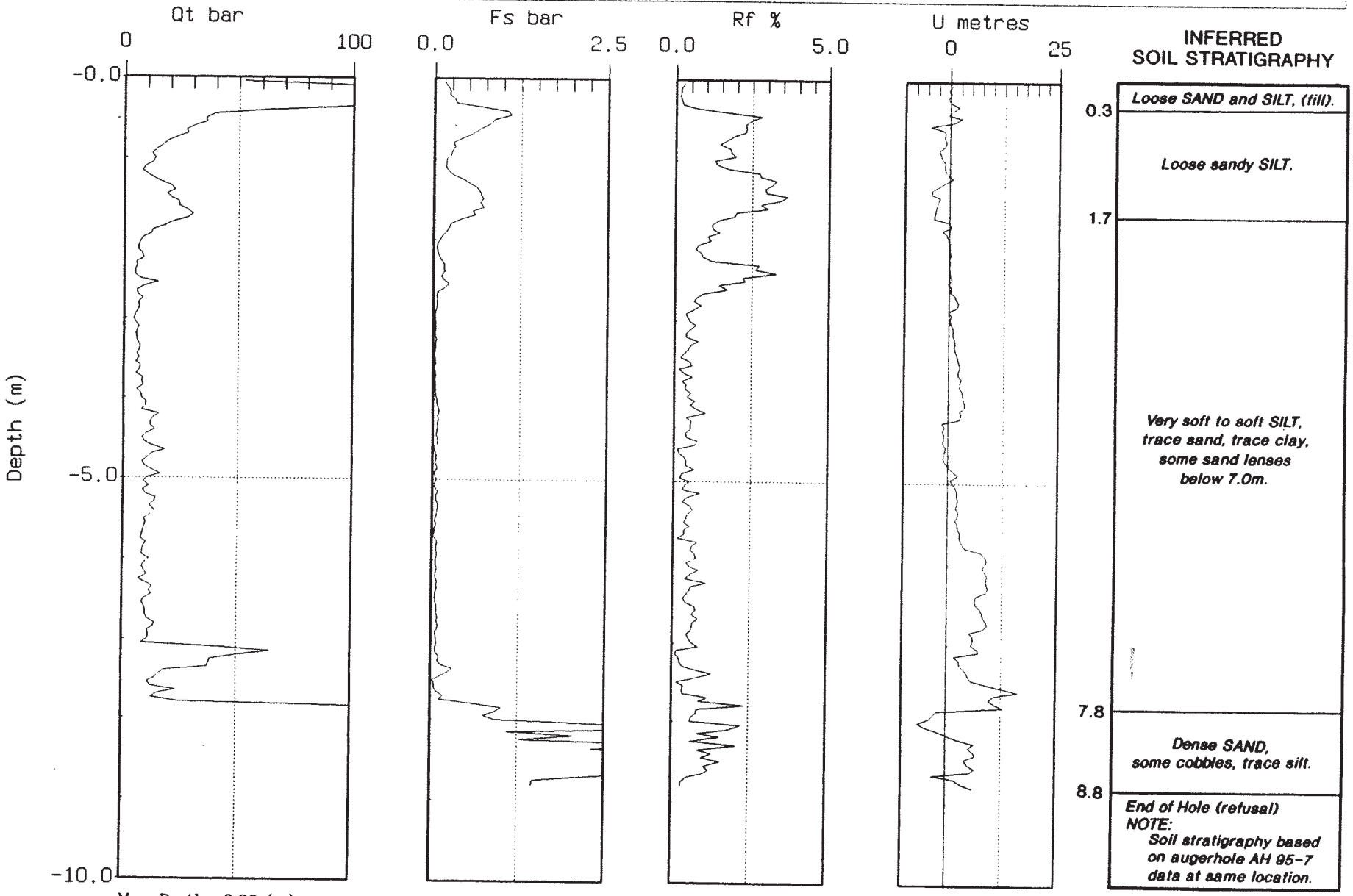

Max. Depth: 8.80 (m)

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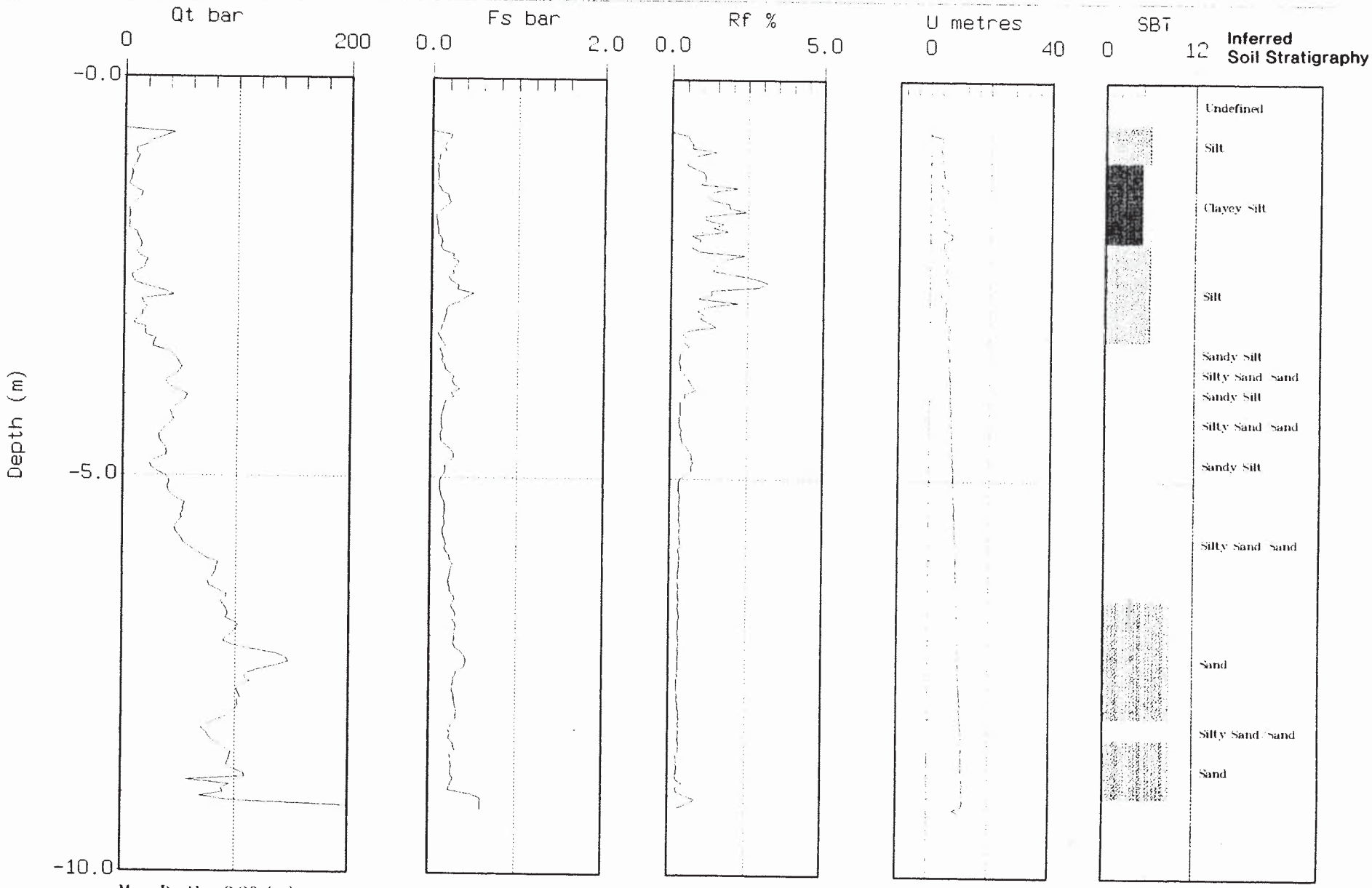
CONETEC

Golder Associates

CPT 95-6

Offshore – South of Fraser Gate Station

Done: [illegible]
Date: [illegible]



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Depth Inc.: 0.05 (m)

SBT: Soil Behavior Type (Robertson and Campanella 1988)

CONETEC

Golder Associates

CPT 95-7

Offshore – South of Fraser Gate Station

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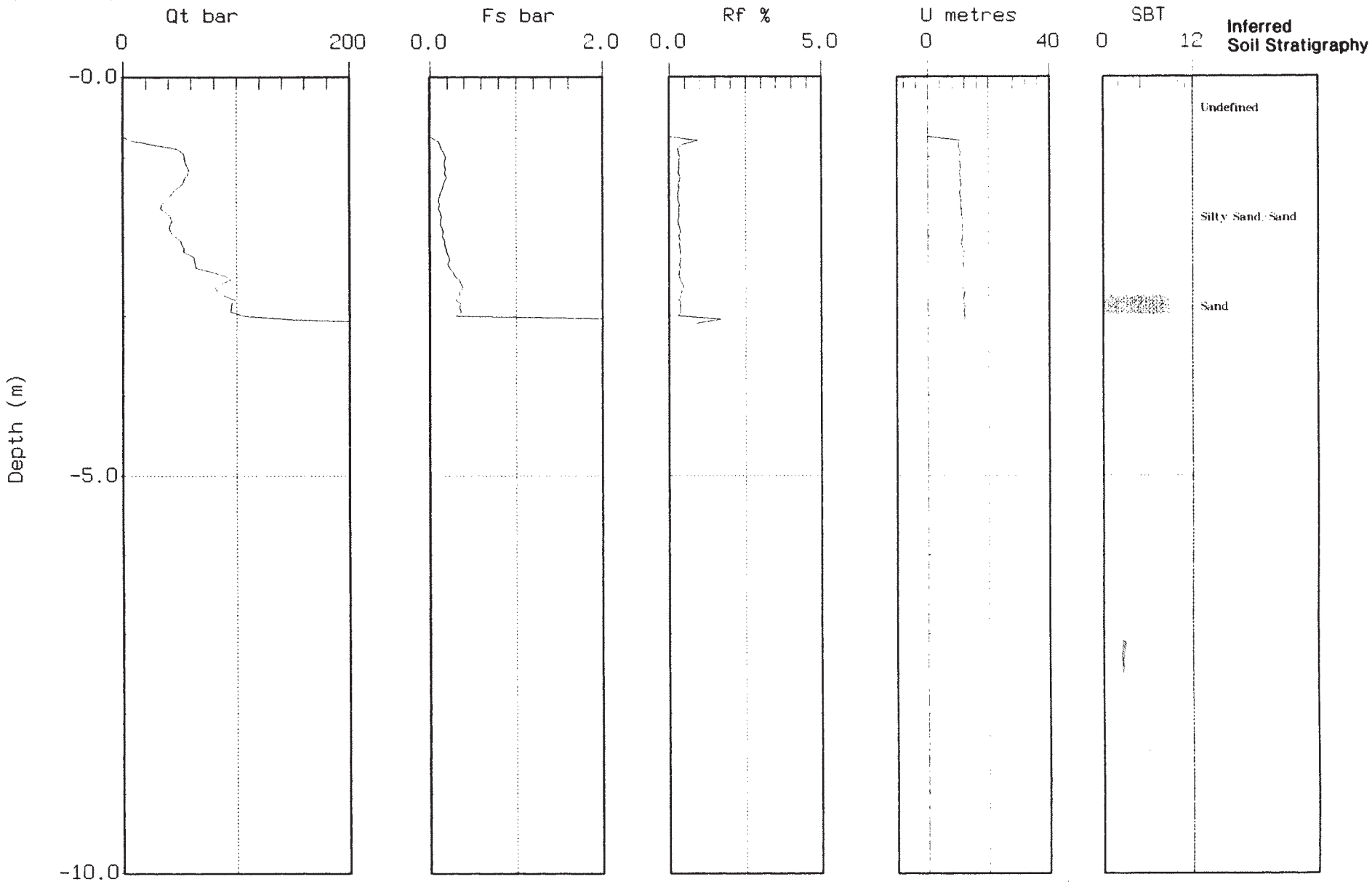


Max. Depth: 3.10 (m)

Depth Inc.: 0.05 (m)

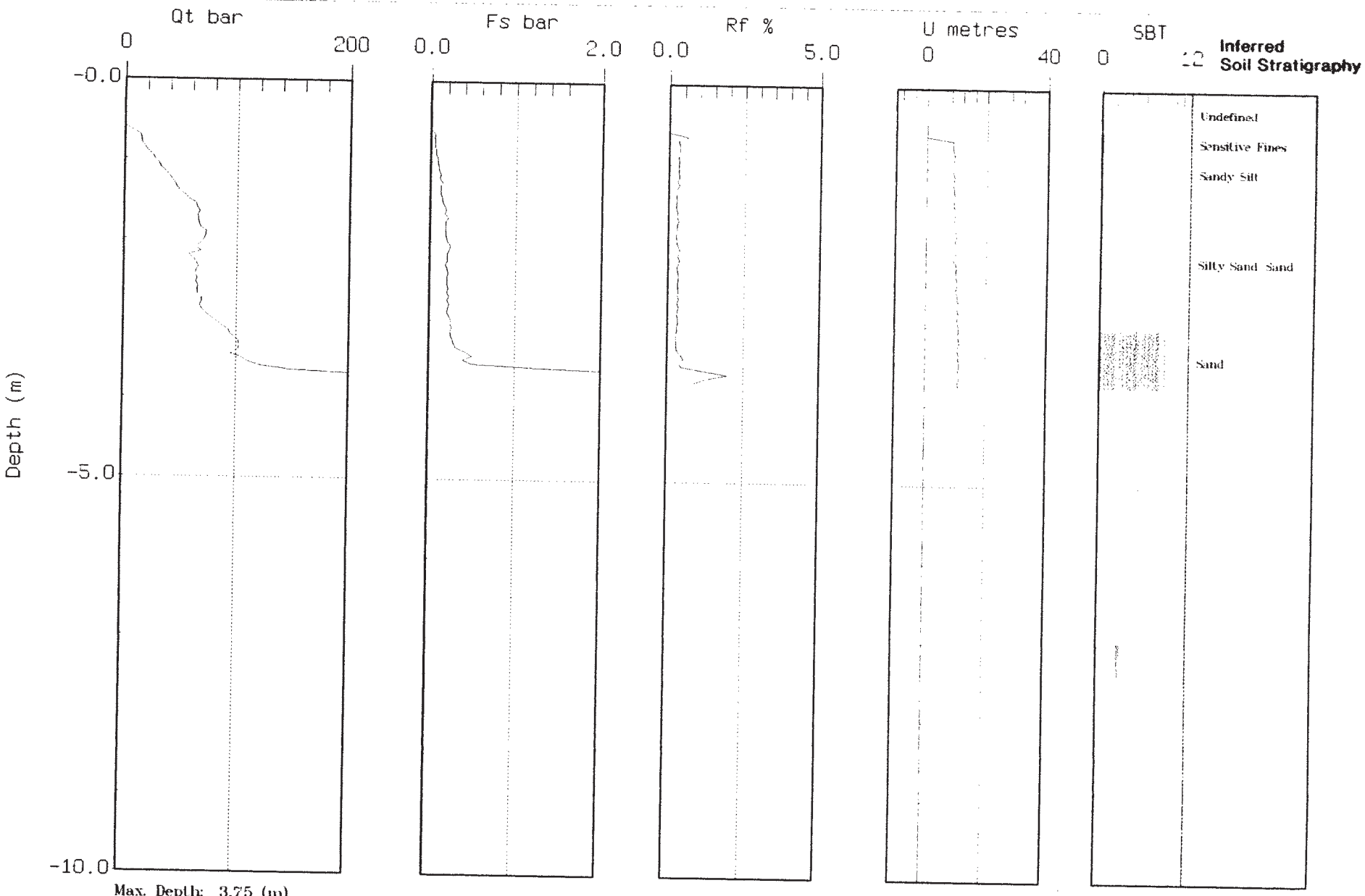
SBT: Soil Behavior Type (Robertson and Campanella 1988)

CONETEC

Golder Associates

CPT 95-8

Offshore – South of Fraser Gate Station



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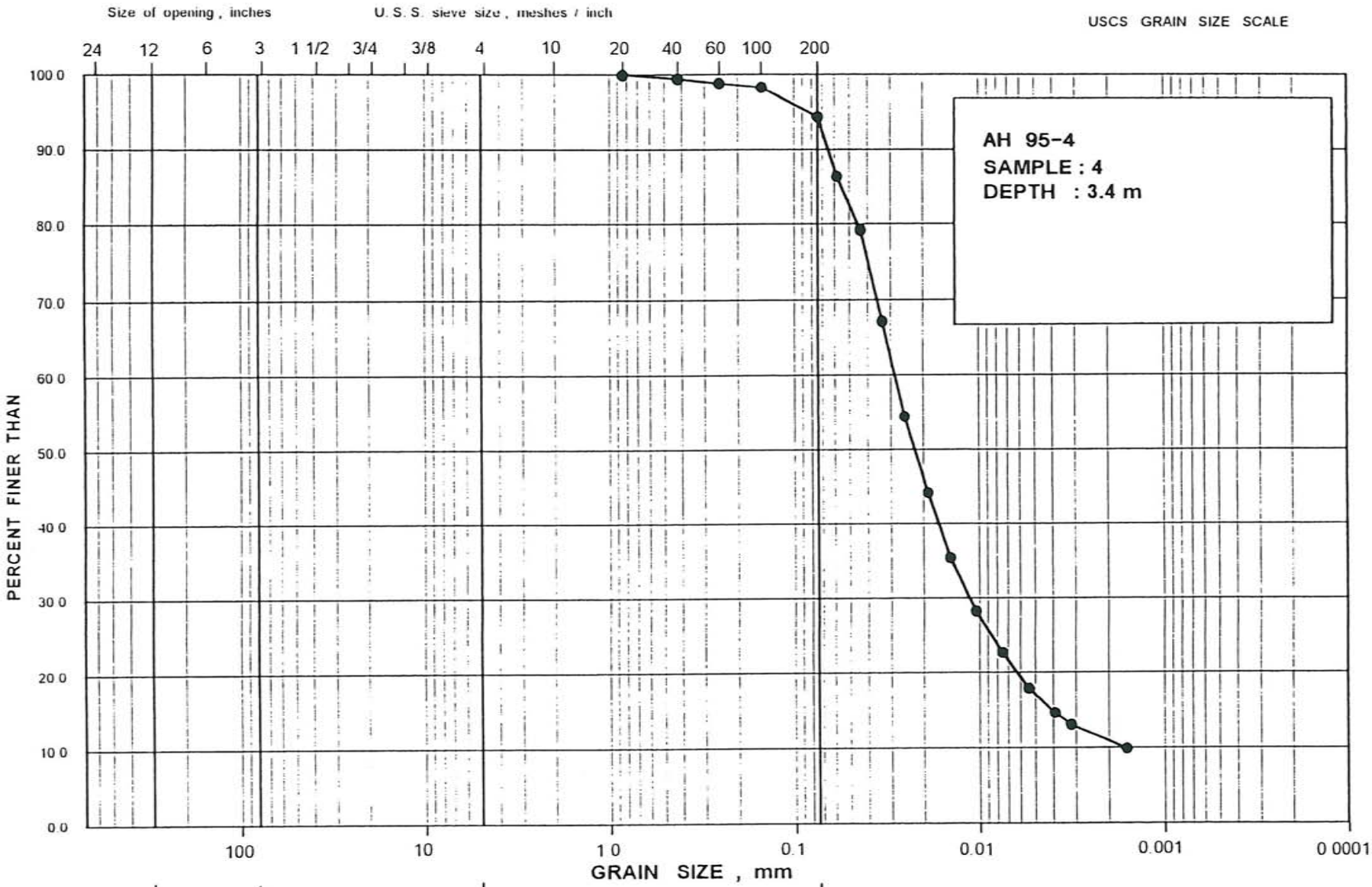
Depth Inc.: 0.05 (m)

SBT: Soil Behavior Type (Robertson and Campanella 1988)

APPENDIX B

Geotechnical Laboratory Test Results



Project No. 9421211A
Drawn M.O.
Reviewed
Date 03/14/95

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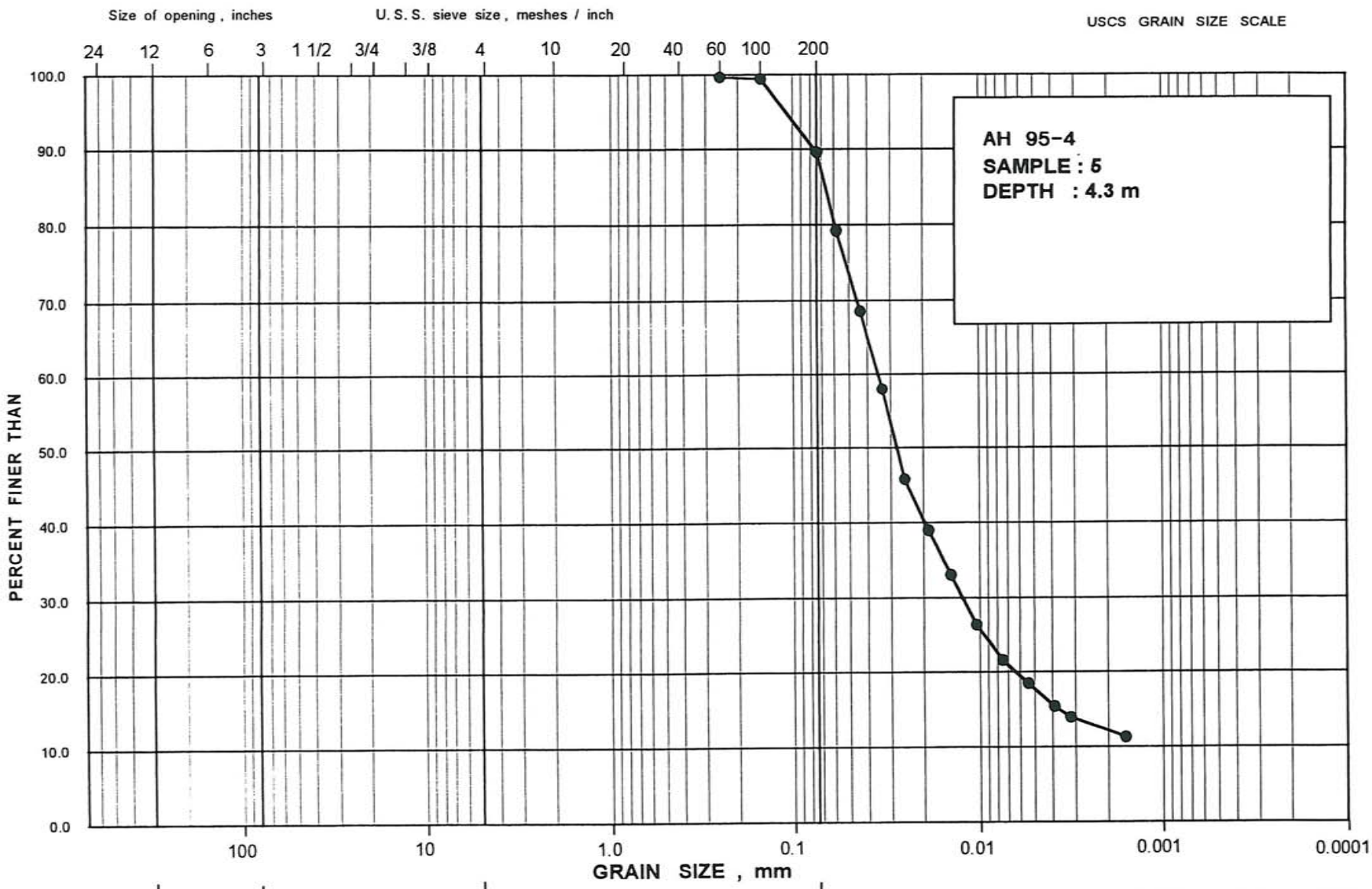
GRAIN SIZE DISTRIBUTION



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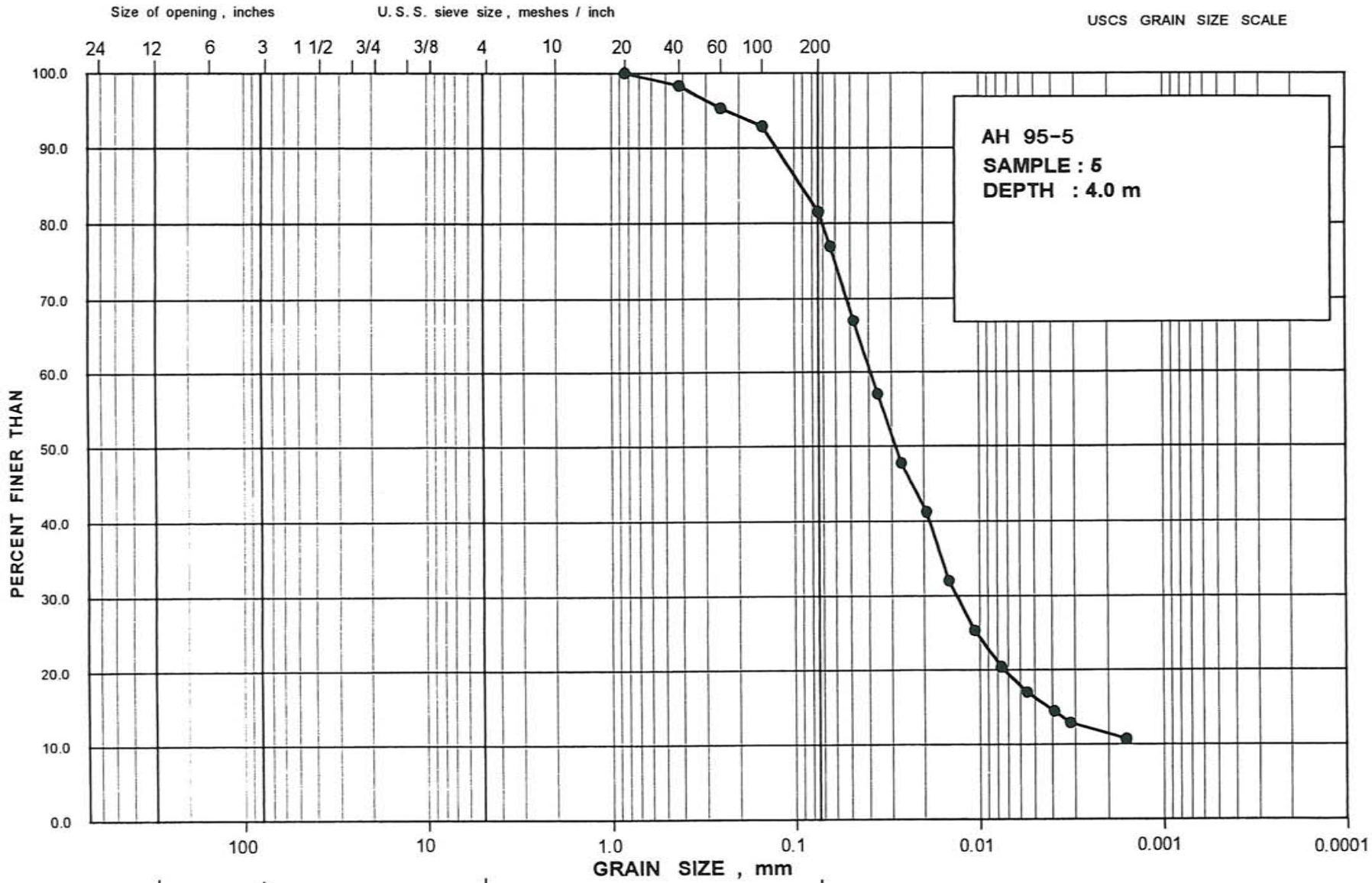

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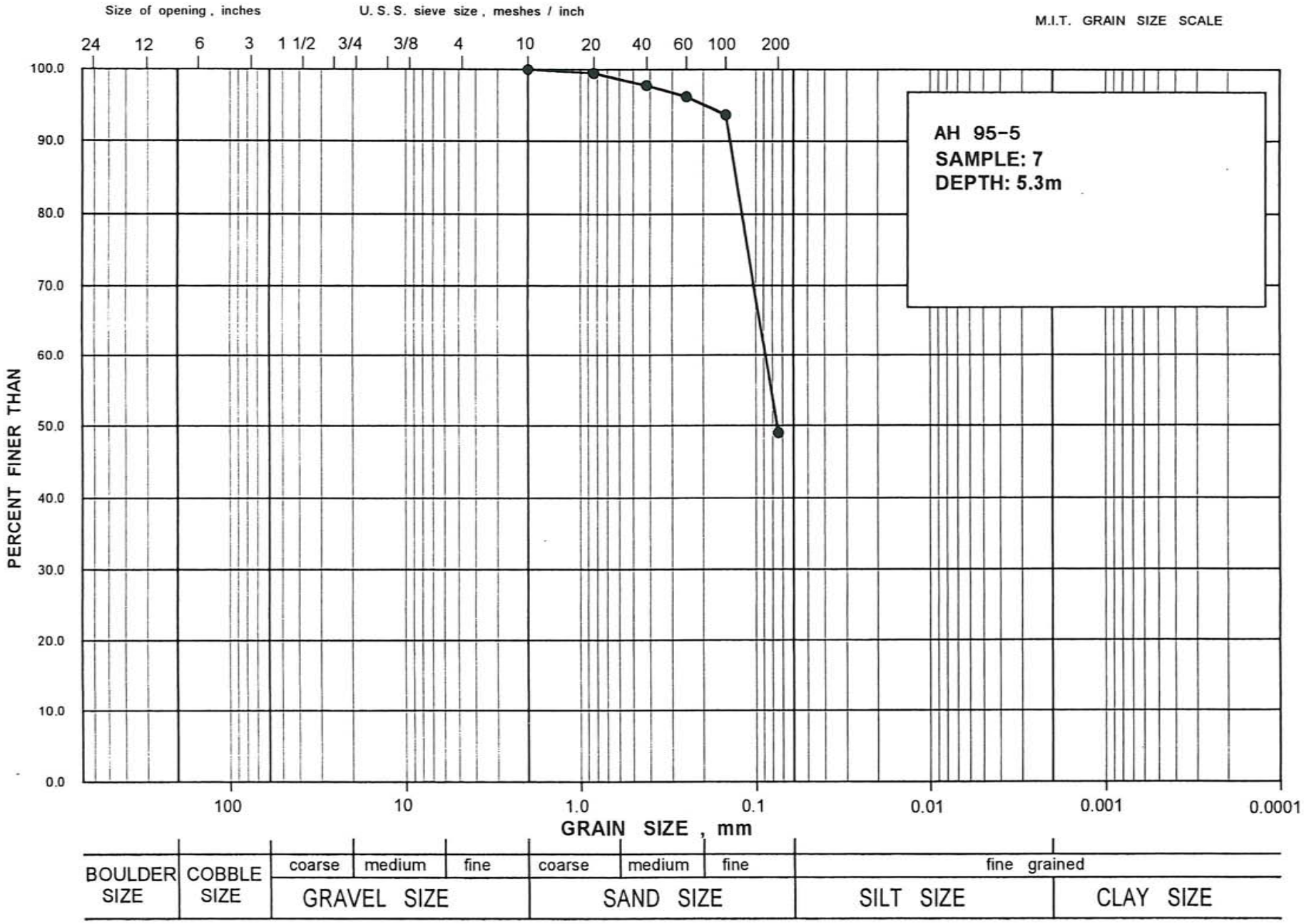

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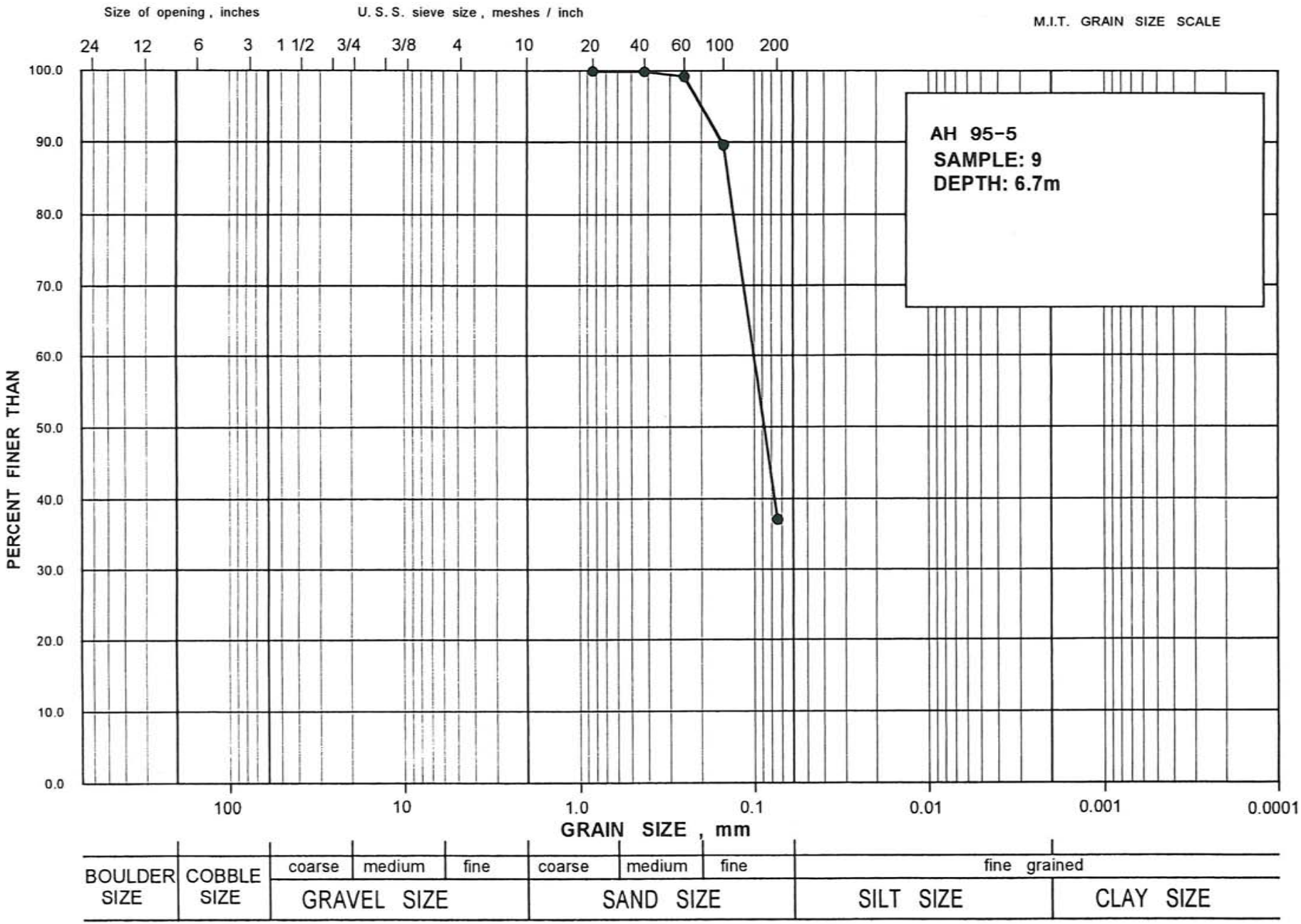

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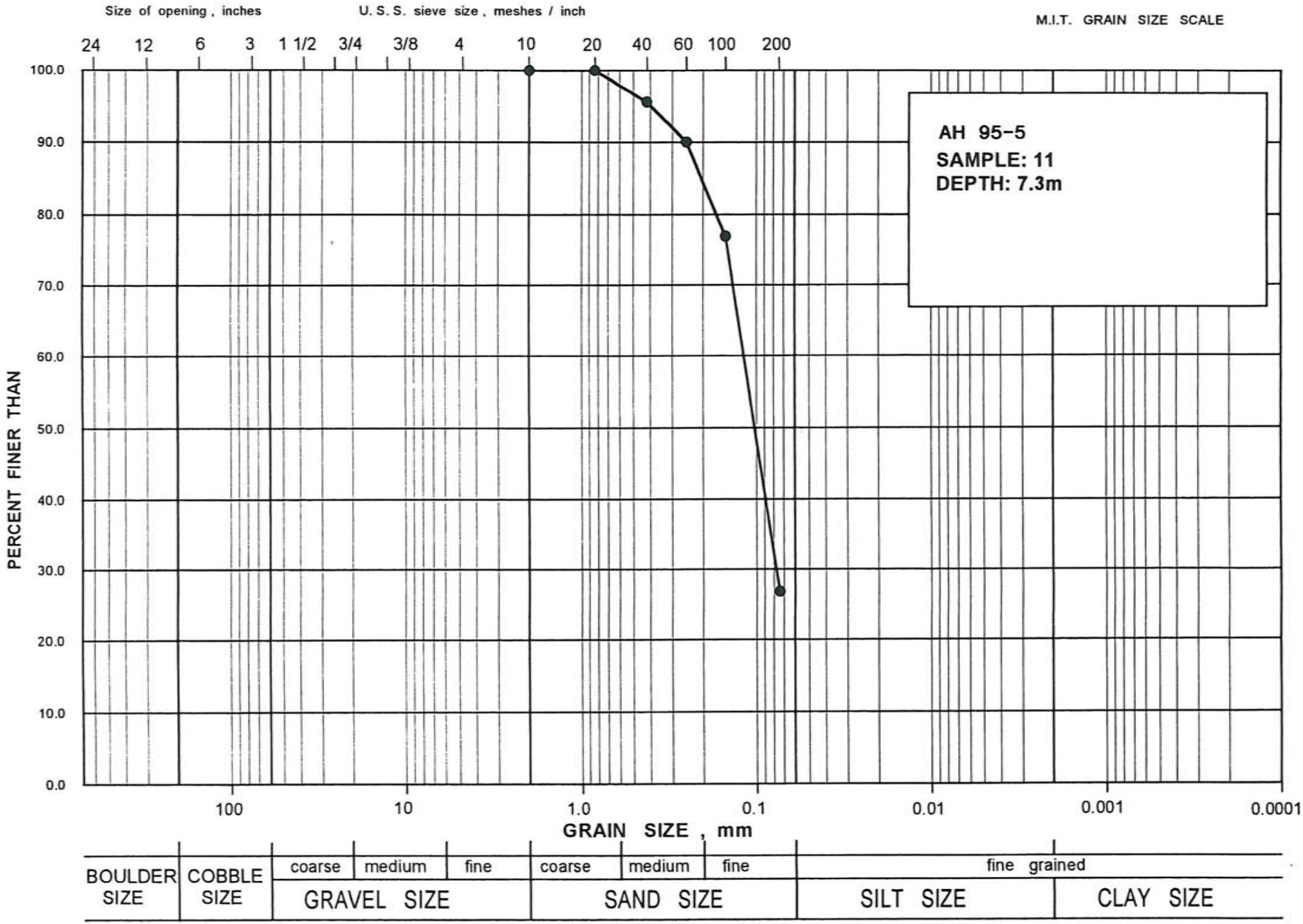

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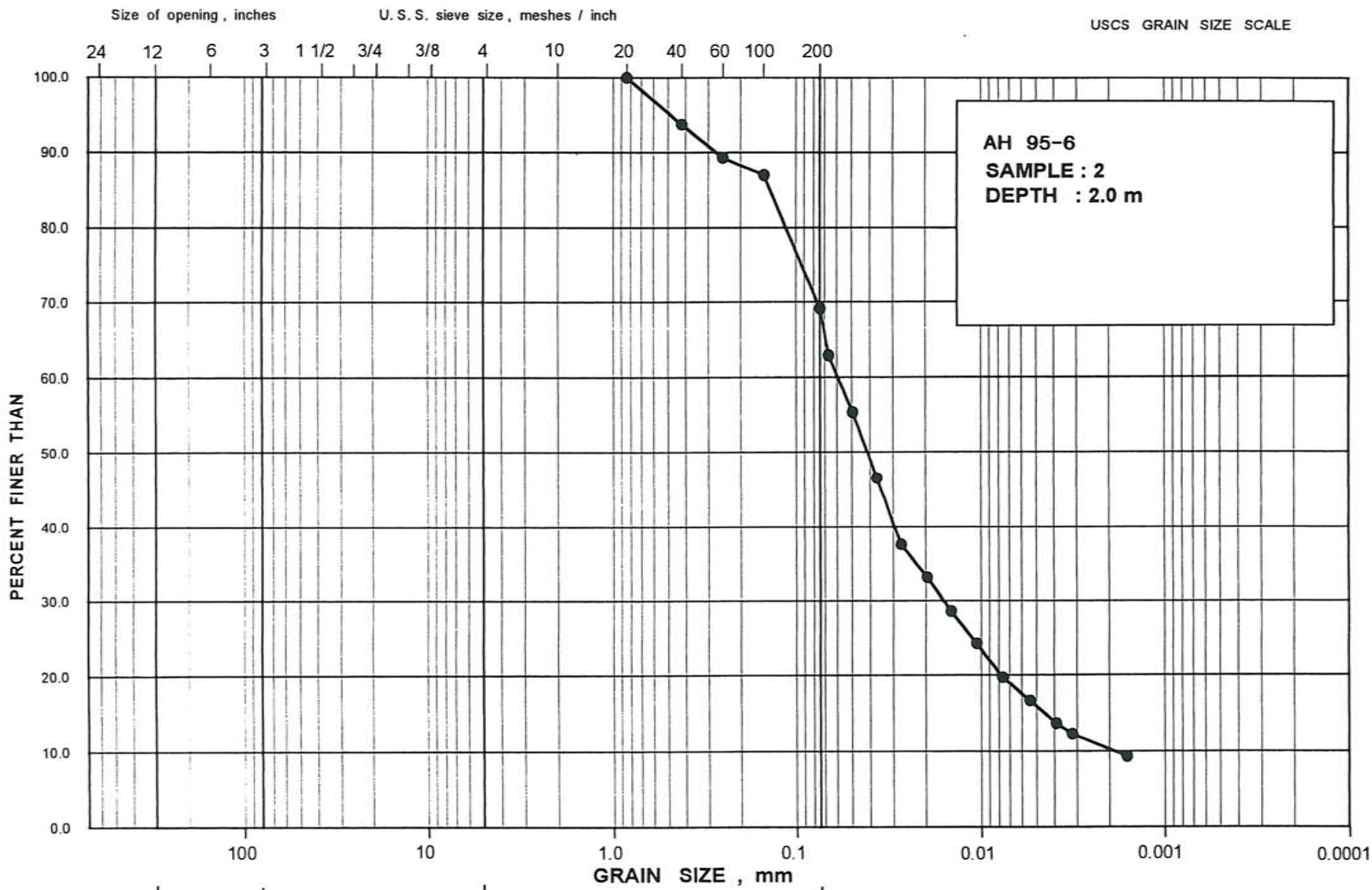

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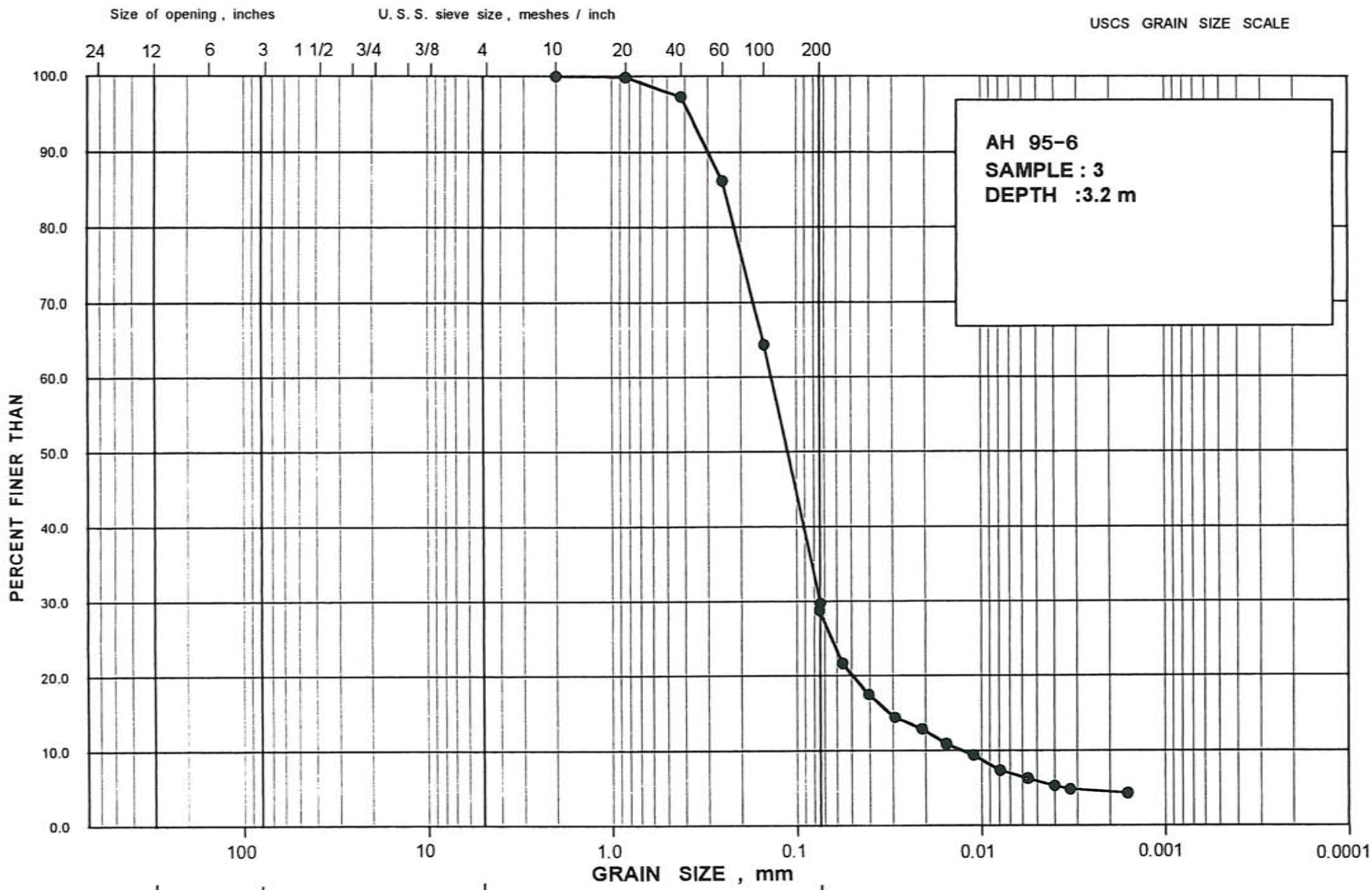

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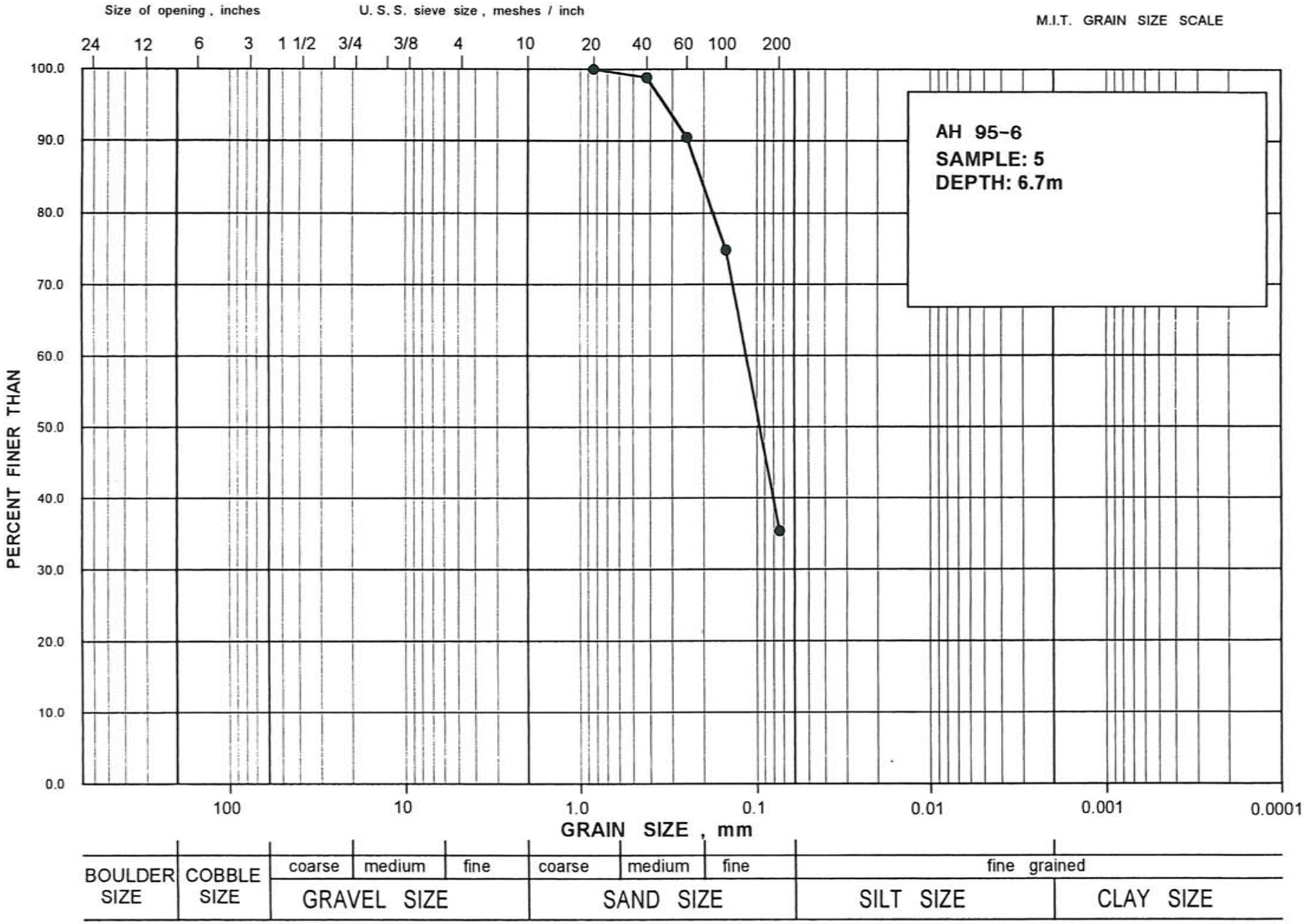

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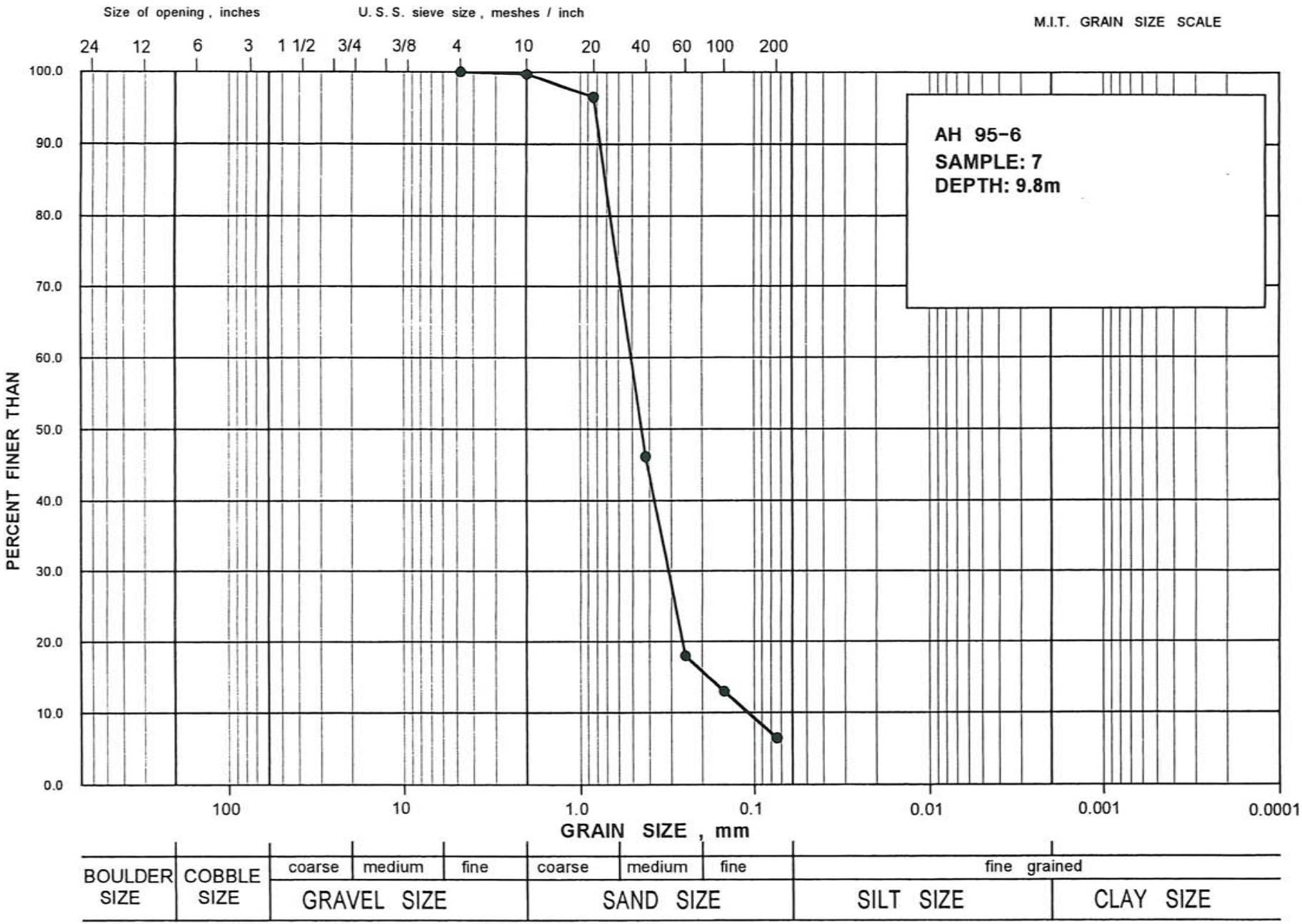

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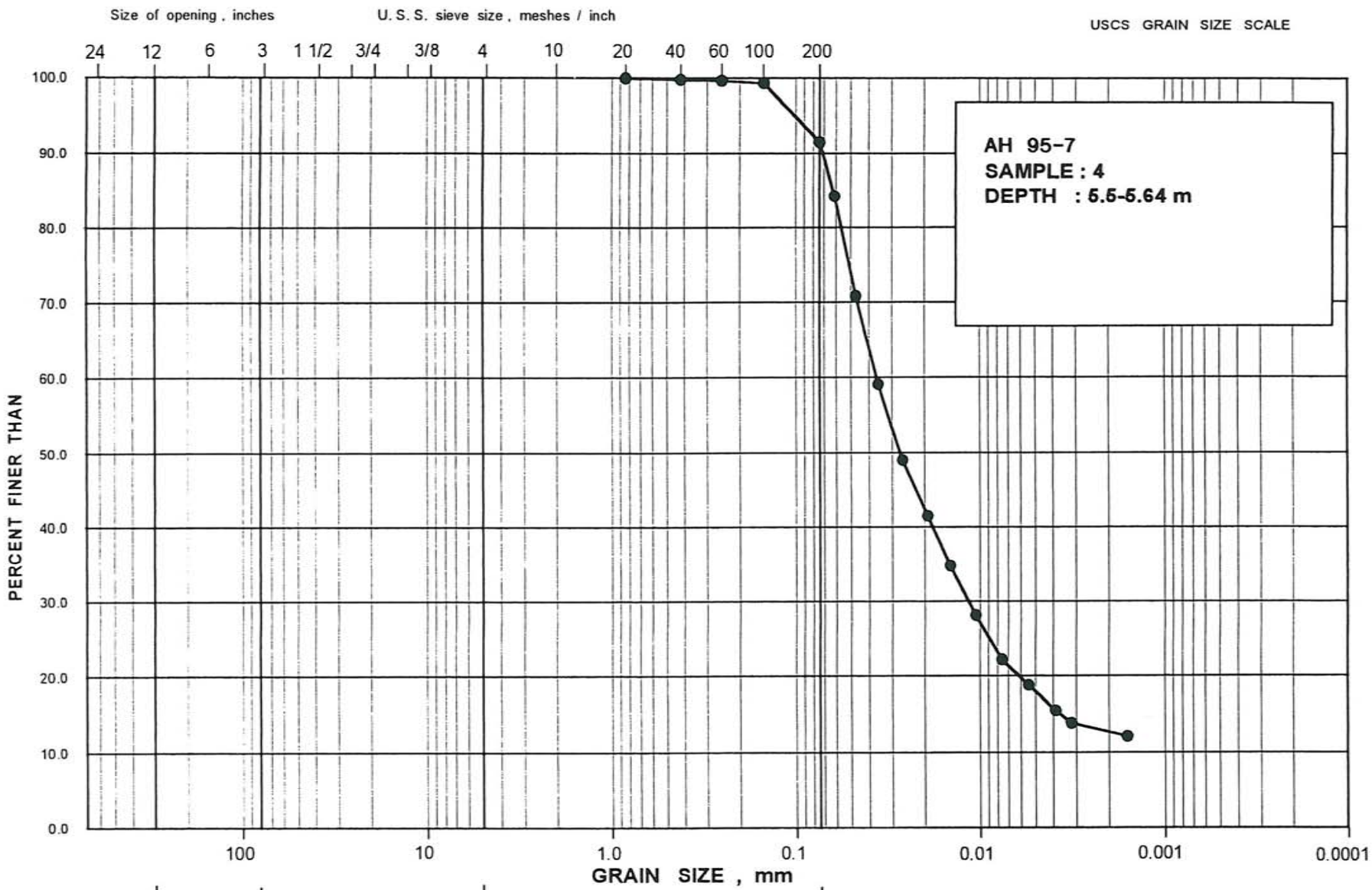

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Date .....03/30/95.....

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Golder Associates

Appendix A-5

RUITENBEEK
ECONOMIC CONSEQUENCE ANALYSIS

ECONOMIC CONSEQUENCE ANALYSIS OF HYPOTHETICAL NATURAL GAS SERVICE INTERRUPTIONS IN THE BRITISH COLUMBIA LOWER MAINLAND

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November 2014

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Acronyms

BC	British Columbia
CAPP	Canadian Association of Petroleum Producers
CBA	Cost Benefit Analysis
CEMP	Comprehensive Emergency Management Plan
CNG	Compressed Natural Gas
COS	Cost of Service
CPCN	Certificate of Public Convenience and Necessity
CTS	Coastal Transmission System
DFAA	Disaster Financial Assistance Arrangement
FEI	FortisBC Energy Inc.
FEU	FortisBC Energy Utilities
FEVI	FortisBC Energy Vancouver Island
FEW	FortisBC Energy Whistler
GDP	Gross Domestic Product
GJ	gigajoule
IP	Intermediate Pressure
kPa	kilopascal
LMSU	Lower Mainland System Upgrade
LNG	Liquefied Natural Gas
LTRP	Long Term Resource Plan
OECD	Organisation of Economic Cooperation and Development
PEP	Provincial Emergency Program
TEAMS	Temporary Emergency Assignment Management System
TP	Transmission Pressure
TSBC	Transportation Safety Board of Canada
WTAC	Willingness to Accept Compensation
WTP	Willingness to Pay

Executive Summary

This Report provides an economic assessment of potential economic costs associated with a variety of hypothetical unplanned outages which may impact the operation of the FortisBC Energy Inc. (FEI) natural gas delivery system in the British Columbia (BC) Lower Mainland region. The economic analyses and results are used in the context of an associated quantitative risk analysis[1] relating to FEI's potential system reinforcements in the Lower Mainland currently referred to as the Lower Mainland System Upgrade (LMSU) Project. The reader is cautioned that the analyses may not be suited for other purposes, especially those purposes relying on damage estimates for insurance or litigation purposes.

The scope of this work is to provide a quantitative estimate of the economic consequences of a credible worst case disruption in gas supply in the area of interest within the BC Lower Mainland. The quantitative analysis is complemented by qualitative discussions to inform the assumptions and to describe potential mitigating measures.

Project Background

FEI is planning to undertake a reinforcement of its Lower Mainland System to address capacity, integrity, and operational flexibility issues, and existing security of service vulnerabilities. The LMSU project consists of 5 major system upgrades involving Intermediate Pressure (IP) pipeline replacement, looping of existing Transmission Pressure (TP) pipelines, and facility upgrades at related stations. The redundancy provided by these upgrades will reduce vulnerabilities in the existing system that could potentially disrupt up to 250,000 customers for 5-25 days with aggregate peak day demands of the order of 400,000 GJ/d. This Report provides estimates of the potential economic consequences of such outages, as well as other smaller outages that may occur as a function of the location and circumstances of a failure in the current system. An important benefit of the LMSU Projects is that the costs of such outages are avoided.

The resultant Projects give rise to a number of potential "before" and "after" scenarios that may be considered in any project analyses. The starting point for most analyses can be considered to be the "As Is" system, and consequences represent the impacts of failures in up to 20 segments within this system. Investments in some or all of the 5 system upgrades will generally reduce some of these consequences to nil; there may also, however, still be residual risks after the investments if failures result in impacts on some (albeit fewer) customers, or if the failure frequency is reduced. For this reason, the report also calculates "Residual" impacts after selected upgrades are put in place. The same methods are used to estimate the Residual consequences (after the investments) as are used for the As Is consequences (before the investments). The actual expected economic risk reduction is a probability weighted difference of the before and after impacts.

Specifically, the analyses here seek to inform three specific risk reduction scenarios associated with subsets of the LMSU Projects evaluated in the quantitative risk analysis:

I. potential operating risk reduction as a result of the entire LMSU project, excluding the Fraser Gate NPS 30 IP pipeline Seismic Upgrade

II. potential operational risk reduction associated with replacing the existing Coquitlam NPS 20 IP pipeline operating at 1200 kPa with an NPS 30 IP pipeline operating at 2070 kPa and the addition of capacity at Coquitlam Gate Station achieved by looping the NPS 20 TP pipeline between the Cape Horn Valve Station and Coquitlam Gate Station with a NPS 36 TP pipeline

III. potential operational risk reduction associated with looping the existing NPS 24 TP pipeline between Nichol and the Port Mann Valve Station with a NPS 36 TP pipeline and looping the existing NPS 24 TP pipeline between Nichol Valve Station and Roebuck Valve Station

Methodology

Broadly, four types of mutually exclusive costs are considered and aggregated as below. It should be noted that any costs that would be incurred both with and without the Projects are

[1] Dynamic Risk Assessment Systems. "Quantitative Risk Assessment of LMSU Projects". November 2014.

not considered (for example, repair costs as a result of third party damage are not included as these costs are expected to be incurred both with and without the Projects). However, there are also repair costs associated with the ongoing response and repair of leaks that will be mitigated with the replacement of the Coquitlam Intermediate Pressure pipeline. These avoided costs are not included in this assessment.

Outages are described for scenarios associated with 14 potentially vulnerable segments of the current system. Some small IP segments were considered but do not contribute to changes in risk when comparing the "before" and "after" situations because: (i) the segments are currently vulnerable but would remain vulnerable after the upgrade; or, (ii) failures in these segments would have no consequences as there is some redundancy in the current system that can handle smaller scale outages. For each vulnerable segment, the following costs are considered.

A. Direct Fixed Expenditures as a Consequence of an Outage. These represent costs incurred in the event of any outage event that impacts a significant number of customers. These costs include expenditures associated with regulatory response, public opinion, government relations and customer loyalty programs. Based on FEI estimates, these are in aggregate expected to fall in a range of $480,000 to $4.75 million per outage.

B. Relight Costs. Relight costs, which are defined in this study to include shutdown, purging and relight cost, depend on the scale and location of the outage, resource availability, and unit costs of manpower and related resources. FEI has estimated the number in each customer class affected for each scenario, an appropriate relight schedule based on best efforts resource deployment, and the resultant costs of relighting customers. Resources for relight are deployed immediately after an outage but it is assumed that customers will have no service for at least a five day period during which the location and cause of the outage is identified and repaired – or is circumvented – to bring service back to impacted customers. The maximum impact identified is a failure in the Nichol to Roebuck segment; some 252,300 customers would be without gas for up to 25 days and the 18 day relight period would involve direct expenditures of approximately $29 million.

C. Revenue Loss. FEI will experience direct revenue losses through two mechanisms: (i) the outage event will reduce sales revenues depending on the duration of the outage, the estimated demand during the outage by a customer, and the applicable tariff (including cost of service [COS]) but excluding commodity cost; and, (ii) a potential long term revenue loss associated with the loss of some proportion of customers that were interrupted. Demand was estimated based on average customer demand profiles as presented in the FEU Long Term Resource Plan (LTRP, 2014) for the year 2016. A credible worst case scenario placed the disruption at the peak demand days associated with a December outage. A credible worst case benchmark scenario for long term revenue loss was developed based on the loss of annual sales from 10% of the customers interrupted for more than 10 days as a consequence of the outage.

D. Service Disruption. Service disruption was calculated using methods relying on estimated economic welfare losses to each different customer class. The welfare loss calculation is based on literature values associated with the willingness to accept compensation (WTAC) relating to the unplanned loss of a marketable commodity. A literature survey showed that such values are typically of the order of 3-10 times the price paid for the commodity (regarded as a revealed willingness to pay [WTP]). A criticality scale was developed that corresponded to higher WTAC/WTP ratios for safety and health issues. Service disruption costs are also sensitive to fuel switching opportunities that individual customer classes may typically have to address interruptions. Residential customers exhibited the highest ratios or multipliers; large interruptible customers potentially exhibit the lowest ratios because they potentially switch more readily. These disruption impacts are regarded as an appropriate proxy for incremental economic impacts.

The impacts exclude those that might be associated with disruptions of supply to potential expansion of LNG capacity in the BC Lower Mainland (either for export or domestic use).

Reference Case Results

Impacts for the Reference Case "As Is" consequences are shown in Table ES-1a, Table ES-2a and Figure ES-1; the locations correspond to the segment of pipeline or facility failure, not to the location of customers impacted. For example, a failure in one of the IP segments would impact customers in Metro Vancouver (Vancouver, West Vancouver, North Vancouver, Burnaby, and Coquitlam). A failure in the segments between Nichol and Fraser Gate Station would also impact customers in Metro

Vancouver, but additionally could impact customers in Surrey, Delta or Richmond. A failure in segments upstream of Coquitlam Gate Station (i.e., from Nichol to Coquitlam) would potentially impact some customers in Metro Vancouver but also some customers in Surrey, Squamish, Whistler, Vancouver Island and the Sunshine Coast.

The Reference Case corresponds to a range of base case assumptions as defined in this report; sensitivity cases describe scenarios that vary these base case assumptions.

The greatest impact is associated with a failure in the Nichol to Roebuck section, resulting in total economic consequences of approximately $565 million. Most of these losses are associated with the economic consequences of the service disruption ($256 million); long term revenue loss is also potentially of the same order of magnitude ($247 million).

Residual impacts are provided in Table ES-1b and Table ES-2b and are interpreted as the consequences that persist to some degree even after some of the upgrades have been completed. It is important to note that the "Residual" consequences cannot necessarily be subtracted from the "As Is" consequence to arrive at a net impact; adjustments must also be made for potential differences in failure likelihoods. These consequence estimates provide input to the quantitative risk analysis.

Sensitivity Analyses

The Reference Case consequence estimates are regarded as appropriate for decision making to the degree that they show relative scales of consequences among categories and locations. Sensitivity analyses can further inform decision-making as they demonstrate that costs can readily be significantly higher in the event that some assumptions are relaxed within credible limits.

For the Nichol to Roebuck failure scenario (252,300 customers impacted and economic consequences of $565 million) sensitivity analyses result in the following outcomes.

I. Long Term Revenue Loss Assumptions. The Reference Case was based on assumptions reflecting a 20 year loss discounted at 7%. A permanent loss discounted at 5% translates to a Total Consequence (with all other elements unchanged) of $784 million.

II. Response Delays. A delay of two weeks (additional 1 week shutdown plus 1 week additional relight time) might occur due to delays in re-establishing service coupled with longer relight requirements if resources are constrained. The additional costs translate into a Total Consequence or $777 million, representing about $15 million a day during the additional two week service disruption.

III. Colder Weather. A 20% increase in demand from residential, commercial, and firm industrial customers increases Total Consequences to $621 million.

IV. Colder Weather & Response Delays. Sensitivity Cases II and III above would together result in Total Consequences of $866 million.

V. Criticality. A 10% decrease in the most vulnerable residential, commercial, and small industrial uses reduces potential economic consequences by about 6% to $533 million.

Mitigating & Complicating Factors

The report discusses mitigating factors that could potentially reduce the actual costs of the impacts. For example, improved customer awareness and preparedness for outages would mitigate some impacts. Emergency preparedness protocols in the Province of BC generally advocate that individuals plan on being self-reliant for a few days for basic needs; BC public emergency services can potentially meet some needs for more extended periods.

General preparedness within the context of local emergency planning is also an appropriate mitigating response; currently, for example, Coquitlam formally identifies a natural gas outage as one of the risks for which their residents should have emergency plans.

Also, the Reference Case assumes that the relight of customers occurs on a best efforts basis without necessarily giving priority to any given customer class. Where possible, identification of more vulnerable customers would reduce the total impacts.

Response delays that result in extended shutdowns or prolonged relights are factors that will have among the greatest impacts on consequences. These are most likely to occur in more complex situations of multiple hazards. An earthquake, fire, extensive flooding, or extreme cold event could engender further delays due to the additional complications in mobilizing or accessing resources.

Table ES-1a. Estimated potential customer outages without LMSU Projects ("As Is")*

	Customers	Residential	Commercial	Industrial	Other
Nichol to Roebuck	252,300	223,641	27,546	1,053	60
Roebuck to Delta	252,300	223,641	27,546	1,053	60
Delta to Tilbury	229,690	203,471	25,181	991	47
Tilbury to Fraser	215,200	190,373	23,823	970	34
IP Segment 1	171,000	151,945	18,234	801	20
IP Segment 2	98,200	83,947	13,635	602	16
IP Segment 3	14,100	13,479	571	48	2
IP Segment 6	12,500	11,972	490	38	0
IP Segment 7	12,500	11,972	490	38	0
IP Segment 10	2,840	2,625	210	5	0
IP Segment 13	29,620	26,694	2,831	90	5
Cape Horn to Coquitlam	163,280	149,954	13,134	161	31
Port Mann to Cape Horn	163,280	149,954	13,134	161	31
Nichol to Port Mann	172,572	158,280	14,058	200	34

Table ES-1b. Estimated potential customer outages with selected upgrades ("Residual")*

	Customers	Residential	Commercial	Industrial	Other
Nichol to Roebuck	81,300	71,696	9,312	252	40
Roebuck to Delta	81,300	71,696	9,312	252	40
Delta to Tilbury	58,690	51,526	6,947	190	27
Tilbury to Fraser	44,200	38,428	5,589	169	14
IP Segment 1	0	0	0	0	0
IP Segment 2	0	0	0	0	0
IP Segment 3	0	0	0	0	0
IP Segment 6	0	0	0	0	0
IP Segment 7	0	0	0	0	0
IP Segment 10	2,840	2,625	210	5	0
IP Segment 13	0	0	0	0	0
Cape Horn to Coquitlam	121,880	112,744	9,086	27	23
Port Mann to Cape Horn	121,880	112,744	9,086	27	23
Nichol to Port Mann	131,172	121,070	10,010	66	26

* Notes:

IP Segments 4, 5, 8, 9, 11 and 12 can be isolated and would not be subjected to any disruptions in service either before ("As Is") or after ("Residual") any of the upgrade Projects are undertaken. The residual outages shown here correspond to the impacts after the IP System upgrades are undertaken; inspection shows that up to 171,000 customers are protected from a failure in the Nichol to Fraser segments and 41,400 customers are protected from a failure in the Nichol to Coquitlam segments.

Customer counts exclude potential new LNG customers.

Table ES-2a. Reference Case “As Is” economic consequences (millions $; 2014$).

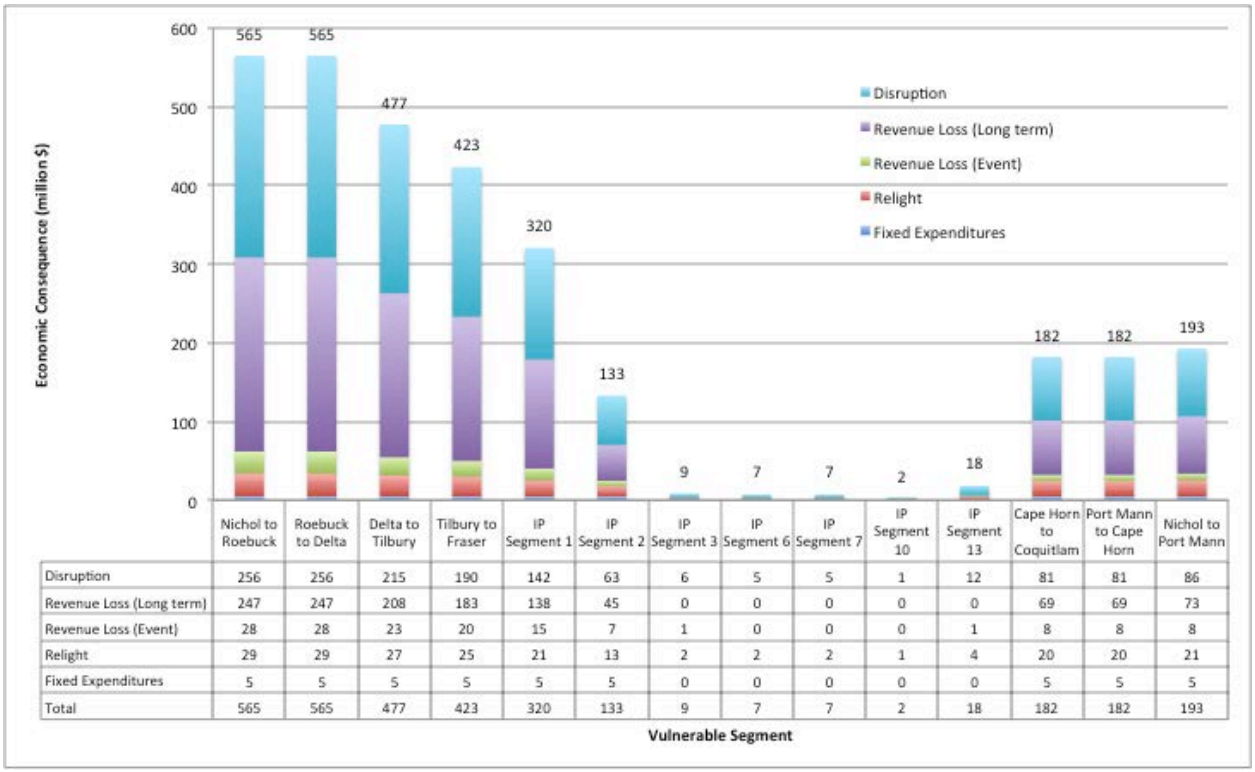
Vulnerable Segment	Direct Fixed Expenditures				Relight	Revenue Loss		Disruption	Total	Customers
	Regulatory Response	Public Opinion	Government Relations	Loyalty		Event	Long term			
Nichol to Roebuck	$ 0.25	$ 2.00	$ 0.50	$ 2.00	$ 29.14	$ 27.95	$ 246.64	$ 256.35	$ 564.83	252,300
Roebuck to Delta	$ 0.25	$ 2.00	$ 0.50	$ 2.00	$ 29.14	$ 27.95	$ 246.64	$ 256.35	$ 564.83	252,300
Delta to Tilbury	$ 0.25	$ 2.00	$ 0.50	$ 2.00	$ 26.74	$ 22.99	$ 208.31	$ 214.65	$ 477.44	229,690
Tilbury to Fraser	$ 0.25	$ 2.00	$ 0.50	$ 2.00	$ 25.21	$ 19.98	$ 183.21	$ 190.11	$ 423.25	215,200
IP Segment 1	$ 0.25	$ 2.00	$ 0.50	$ 2.00	$ 20.56	$ 14.88	$ 138.45	$ 141.78	$ 320.42	171,000
IP Segment 2	$ 0.25	$ 2.00	$ 0.50	$ 2.00	$ 12.72	$ 6.96	$ 45.47	$ 62.88	$ 132.77	98,200
IP Segment 3	$ 0.03	$ 0.20	$ 0.05	$ 0.20	$ 1.70	$ 0.58	$ -	$ 5.74	$ 8.50	14,100
IP Segment 6	$ 0.03	$ 0.20	$ 0.05	$ 0.20	$ 1.54	$ 0.45	$ -	$ 4.79	$ 7.26	12,500
IP Segment 7	$ 0.03	$ 0.20	$ 0.05	$ 0.20	$ 1.54	$ 0.45	$ -	$ 4.79	$ 7.26	12,500
IP Segment 10	$ 0.03	$ 0.20	$ 0.05	$ 0.20	$ 0.59	$ 0.09	$ -	$ 0.90	$ 2.06	2,840
IP Segment 13	$ 0.03	$ 0.20	$ 0.05	$ 0.20	$ 3.86	$ 1.24	$ -	$ 12.47	$ 18.05	29,620
Cape Horn to Coquitlam	$ 0.25	$ 2.00	$ 0.50	$ 2.00	$ 19.57	$ 7.88	$ 69.03	$ 80.71	$ 181.95	163,280
Port Mann to Cape Horn	$ 0.25	$ 2.00	$ 0.50	$ 2.00	$ 19.57	$ 7.88	$ 69.03	$ 80.71	$ 181.95	163,280
Nichol to Port Mann	$ 0.25	$ 2.00	$ 0.50	$ 2.00	$ 20.55	$ 8.41	$ 73.09	$ 85.84	$ 192.63	172,572

Table ES-2b. Reference Case “Residual” economic consequences (millions $; 2014$).

Vulnerable Segment	Direct Fixed Expenditures				Relight	Revenue Loss		Disruption	Total	Customers
	Regulatory Response	Public Opinion	Government Relations	Loyalty		Event	Long term			
Nichol to Roebuck	$ 0.25	$ 2.00	$ 0.50	$ 2.00	$ 10.23	$ 5.79	$ 42.06	$ 49.15	$ 111.98	81,300
Roebuck to Delta	$ 0.25	$ 2.00	$ 0.50	$ 2.00	$ 10.23	$ 5.79	$ 42.06	$ 49.15	$ 111.98	81,300
Delta to Tilbury	$ 0.25	$ 2.00	$ 0.50	$ 2.00	$ 7.90	$ 3.52	$ 13.39	$ 31.02	$ 60.59	58,690
Tilbury to Fraser	$ 0.25	$ 2.00	$ 0.50	$ 2.00	$ 6.41	$ 2.27	$ -	$ 21.44	$ 34.87	44,200
IP Segment 1	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	-
IP Segment 2	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	-
IP Segment 3	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	-
IP Segment 6	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	-
IP Segment 7	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	-
IP Segment 10	$ 0.03	$ 0.20	$ 0.05	$ 0.20	$ 0.59	$ 0.09	$ -	$ 0.90	$ 2.06	2,840
IP Segment 13	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	-
Cape Horn to Coquitlam	$ 0.25	$ 2.00	$ 0.50	$ 2.00	$ 15.20	$ 4.72	$ 32.34	$ 49.27	$ 106.27	121,880
Port Mann to Cape Horn	$ 0.25	$ 2.00	$ 0.50	$ 2.00	$ 15.20	$ 4.72	$ 32.34	$ 49.27	$ 106.27	121,880
Nichol to Port Mann	$ 0.25	$ 2.00	$ 0.50	$ 2.00	$ 18.04	$ 5.57	$ 42.70	$ 57.84	$ 128.91	131,172

The residual outages shown here correspond to the impacts after the IP System upgrades are undertaken; inspection shows that up to 171,000 customers are protected from a failure in the Nichol to Fraser segments and 41,400 customers are protected from a failure in the Nichol to Coquitlam segments. In the event of a failure in the Nichol to Port Mann segment, this corresponds to a net reduction in total consequences of approximately $64 million associated with these 41,400 customers.

Figure ES-1. Aggregate “As Is” economic consequences of outage without LMSU Projects.*



	Nichol to Roebuck	Roebuck to Delta	Delta to Tilbury	Tilbury to Fraser	IP Segment 1	IP Segment 2	IP Segment 3	IP Segment 6	IP Segment 7	IP Segment 10	IP Segment 13	Cape Horn to Coquitlam	Port Mann to Cape Horn	Nichol to Port Mann
Disruption	256	256	215	190	142	63	6	5	5	1	12	81	81	86
Revenue Loss (Long term)	247	247	208	183	138	45	0	0	0	0	0	69	69	73
Revenue Loss (Event)	28	28	23	20	15	7	1	0	0	0	1	8	8	8
Relight	29	29	27	25	21	13	2	2	2	1	4	20	20	21
Fixed Expenditures	5	5	5	5	5	5	0	0	0	0	0	5	5	5
Total	565	565	477	423	320	133	9	7	7	2	18	182	182	193

* IP Segments 4, 5, 8, 9, 11 and 12 can be isolated and would not be subjected to any disruptions in service either before (“As Is”) or after (“Residual”) any of the upgrade Projects are undertaken. Consequences are thus nil.

Section 1 – Background

Purpose and Scope of Report

The purpose of this report is to provide an economic assessment of potential economic costs associated with a variety of hypothetical unplanned outages arising from the operation of the FEI natural gas delivery system in the British Columbia (BC) Lower Mainland region. By way of context, in July 2014 FEI's Coastal Transmission System (CTS) serves approximately 600,000 natural gas customers in the BC Lower Mainland and approximately 700,000 including FortisBC Energy Vancouver Island (FEVI) and FortisBC Energy Whistler (FEW). The outages and interruptions described in the hypothetical scenarios contained in this report represent potential impacts on up to approximately 250,000 of these customers. The scenarios in the report represent impacts on individual customers that range from 5 to 25 days of supply disruption before service is restored.

The economic analyses and results are used in the context of a quantitative risk analysis relating to FEI's proposed Lower Mainland System Upgrade (LMSU) Project. The geographic area of relevance is shown on the maps in Annex A of this report. The analysis relies on the FEI approach to economic consequence analysis, which builds on estimates of outages and methodologies for determining the maximum time required to re-establish service (Annex B).

The reader is cautioned that the economic consequence analyses may not be suited for purposes other than the quantitative risk analyses noted above. Consequence estimates should not, for example, be regarded as equivalent to or a proxy for monetary estimates that may be used in the determination of insurance limits or damages litigation. The economic analyses reflect the following economic and estimating principles, which make the estimates suitable for risk analysis but not for these other purposes:

- Consequence analyses inform an eventual determination of the <u>incremental costs</u> associated with outage scenarios that are before and after a given proposed project is undertaken. Analyses use the same methodology, but are of two varieties: (a) "As Is" consequences reflect those associated with disruptions if they happened today; (b) "Residual" consequences reflect the outages and associated economic consequences after the project upgrades are completed at some future date. A probability-weighted difference in these consequence values informs the incremental cost (or benefit) analysis of the applicable project upgrades. The hypothetical nature of the outage scenarios is considered to be a "credible worst case scenario". For example, the scenarios assume that the outages occur over the coldest days of the year. The outage scenario thus would overestimate the damages in other circumstances, and damages in any real event would depend on specific circumstances surrounding the event. The selection of the credible worst case outage scenarios is intended to represent a conservative or precautionary approach to the analyses for the purpose of risk analyses.

- The incremental costs of disruptions <u>exclude damages to company property</u> as a direct consequence of a malfunction, external hazard, or third party impact. The likelihood of these impacts is not evaluated herein and they are assumed to exist both before and after any system upgrade.

- Outages and interruptions of the sort described in this report are rare events. There is therefore limited experience with such events in any given locale; empirical information on which to conduct such analyses is limited to selected characteristics of the customer base and not to any historical information relating to actual customer response to an outage. Economic principles, models, and parameters are thus introduced to provide insights into the potential level of impacts. The selection of these principles and parameters is again conducted to provide realistic estimates in a credible worst case scenario, but their selection may not represent impacts in event of an outage or interruption that differs from such a scenario.

- The analyses are conducted based on defined "typical customer" characteristics in different customer classes: (i) residential; (ii) commercial; (iii) industrial; and, (iv) a series of other customers typically associated with large-scale interruptible or curtailable services. An individual customer may differ from these typical characteristics, and may thus experience higher or lower impacts than the typical customer in event of a real outage event.

- The analyses of values of service disruptions include measures of lost consumer surplus, which is an economic concept representing the value that a typical customer may attribute to the loss of a service to which she is accustomed. Such values are best regarded as statistical averages over a customer class: their value can differ considerably among individual customers and consumer surplus is not normally regarded as a direct insurable loss. They are used in this analysis as a proxy for potential coping costs (which may involve real expenditures) plus any other personal economic impacts that are not readily expressed as direct expenditures.

- Qualitative mitigation and complicating factors can influence the consequences. The quantitative estimates herein must be understood within a more subjective, qualitative context, wherein other factors could mitigate or exacerbate the consequences. These qualitative aspects include mitigating factors such as general emergency preparedness by individuals and communities, potential prioritization of relight response, and general availability of alternative stocks of natural gas from liquefied natural gas (LNG) or compressed natural gas (CNG). By contrast, however, complicating factors from other hazards in any specific event (e.g., earthquake, severe weather, interface wildfire, extensive flooding) could increase shutdown times or protract relight efforts because of resource constraints relating to personnel availability or access to some customers. If such events also compromise other critical transportation or power infrastructure then response times and consequences would also be expected to be higher.

The project scope focuses on those costs directly associated with outages. As Is consequences are before any upgrades associated with the LMSU Project. Without the LMSU Project there will remain system reliability concerns, which could result in outages for some customers. Costs that are common in both scenarios (such as system repair costs in event of a line shutdown) are excluded from this analysis. It is important to note that this analysis does *not* imply that the possibility of a line shutdown has been eliminated. With the LMSU Project unplanned line

shutdowns are still possible (e.g., from a leak or a rupture), but there would be sufficient redundancy in the system to serve the customer base without a service disruption.[2] It should also be noted that the costs addressed within the scope of this analysis are those that will be subjected to probabilistic weighting within the risk analysis. There are other costs and benefits that would normally inform any eventual overall project cost-benefit analysis: the LMSU Projects will, for example, result in definite (100% probability) avoided O&M costs but these costs are not captured by this analysis.

This assessment does not seek to determine what is acceptable risk from either an individual or a social perspective. It does, however, seek to elaborate the potential economic consequences to permit improved risk communication, informed discussion, and – ultimately – better decision-making. The assessment also relies on conservative estimates of a credible worst case. While we all may be aware of a worst possible outcome, or a best possible outcome, most decisions from a societal perspective are not made solely on the extremes. It is acknowledged that individual perspectives can, however, differ from the broader societal perspectives. This analysis, however, is ultimately part of a statistical assessment of risks and – for that reason – its basic assumptions reflect an "average" situation from the perspective of an end-use customer. For example, in a 25 day disruption there is no question that a person waiting for a relight on the 25th day will be far more inconvenienced than someone who is relit after only 5 days of outage; the analysis of immediate service disruption impacts, however, treats each of these customers equivalently adjusting only for the duration of the outage experienced by each.

Lower Mainland System Upgrade Project Background

FEI is planning to undertake reinforcements of its Lower Mainland System to address capacity, integrity, and operational flexibility issues, and existing security of service vulnerabilities. Currently both the Fraser Gate Station (Fraser GS) and the Coquitlam Gate Station (Coquitlam GS) are required to meet Metro Intermediate Pressure (IP) demand throughout the year. Failure upstream, at, or downstream of either gate station will result in a loss of gas supply to a large number of Metro IP customers. The degree of supply overlap varies throughout the year depending on load. The Lower Mainland Gas System Upgrade reinforcements, if undertaken, will provide the capacity and operational flexibility to fully supply the Metro IP system from either the Fraser GS or the Coquitlam GS and therefore reduce the potential consequences of a failure upstream, at, or downstream of either gate station.

The Lower Mainland System Upgrade (LMSU) Project has been developed to address among other issues, these vulnerabilities. The LMSU Project consists of 5 major system upgrades, described as follows:

[2] This type of redundancy is common in most systems worldwide and is largely responsible for the perceived and real reliability of natural gas in markets. System resiliency concerns can extend far beyond the robustness of just the gas system to selected hazards such as corrosion, accidents or third party damage. For example, system resiliency of gas supply is a key concern in North American power system planning (NERC, October 2013), as natural gas is expected to contribute to a greater degree to electricity generation. Recent planning around the robustness of European gas supply has focused on its resilience to addressing hazards and circumstances related to human conflicts, geopolitical crises, deliberate attacks, and natural disasters (Carvalho *et al.*, March 2014).

1. Upsizing and operating pressure increase of a planned replacement of 20 km of NPS 20 IP pipeline (1200 kPa) with NPS 30 IP pipeline (2070 kPa) from Coquitlam Gate Station to 2nd & Woodland;
2. Replacement of 0.5 km NPS 30 IP pipeline (1200 kPa) from Fraser GS to East Kent & Elliott;
3. Looping of the existing NPS 20 TP pipeline (4020 kPa) between Cape Horn and Coquitlam GS with a NPS 36 TP (4020 kPa) pipeline;
4. Looping of the existing NPS 24 TP (4020 kPa) pipeline between Nichol Valve Station and Port Mann crossing with a NPS 36 TP (4020 kPa) pipeline;
5. Looping of the existing NPS 24 TP pipeline (4020 kPa) between Nichol Valve Station and Roebuck Valve Station with a NPS 42 TP (4020 kPa) pipeline.

The above facilities are shown in Annex Figure A1. Annex Figure A2 shows the analytical segments in the IP System between Fraser GS and Coquitlam GS.

The analyses conducted here seek to inform three specific risk reduction scenarios associated with subsets of the LMSU Projects to be evaluated in the quantitative risk analysis:

I. potential operating risk reduction as a result of the entire LMSU project, excluding the Fraser Gate NPS 30 IP pipeline Seismic Upgrade [upgrades 1, 3, 4 & 5]
II. potential operational risk reduction associated with replacing the existing Coquitlam NPS 20 IP pipeline operating at 1200 kPa with an NPS 30 IP pipeline operating at 2070 kPa and the addition of capacity at Coquitlam Gate Station achieved by looping the NPS 20 TP pipeline between the Cape Horn Valve Station and Coquitlam Gate Station with a NPS 36 TP pipeline [upgrades 1 & 3]
III. potential operational risk reduction associated with looping the existing NPS24 TP pipeline between Nichol and the Port Mann Valve Station with a NPS36 TP pipeline and looping the existing NPS24 TP pipeline between Nichol Valve Station and Roebuck Valve Station [upgrades 4 & 5]

Outline of Report

This report is organized as follows. This Section 1 provides general background information on the Project and on the scope and purpose of this report. Section 2 introduces and discusses a number of economic evaluation concepts relevant to estimating the economic impacts of an outage. Section 3 provides general background to the methodologies and assumptions used for this assessment; Section 3 also presents the Reference Case results. Section 4 provides the quantitative results of the sensitivity analyses relating both to economic and technical assumptions. Section 4 also summarizes a number of qualitative factors that may mitigate or exacerbate the economic consequences; these qualitative considerations cannot generally be put in monetary terms but the direction and potential magnitude of their impacts is discussed.

A series of annexes provides supplementary tabular and related information. Annex A shows maps of the areas of interest in the BC Lower Mainland. Annex B provides background to FEI's approach to consequence analysis, providing also the tabular information relating to outages, shutdown and relight times, and relight costs as estimated by FEI. Annex C provides a brief summary of selected Canadian incidents involving natural gas and electricity disruptions.

Section 2 – Some Concepts

This Section introduces and discusses a number of economic evaluation concepts relevant to estimating the economic impacts of an outage.

Choice of Analytical Approach in Measuring Hypothetical Losses & Impacts

Economic analyses of projects and their impacts can generally be categorized in a number of ways within the Canadian regulatory setting and traditions. *Financial* analyses are commonly found in a regulatory rate-setting context and focus on commercial economics within the regulated entity. *Economic* analyses more broadly consider effects outside of the regulated entity and extend the analytical net to a wider range of societal concerns, which can include aspects of economic efficiency, taxation, socio-economic effects, income distribution, intergenerational equity, employment, and impacts on gross domestic product (GDP). More recently, the economic valuation of environmental impacts has at times been included within this broader context. Regulatory requirements for such economic analyses differ among jurisdictions, but within the economic discipline itself formalized and accepted modeling techniques have generally been built around two quite different pillars: (i) social cost benefit analysis (CBA), which focuses on economic efficiency criteria normalized to monetary terms; and, (ii) economic impact analysis, which typically focuses on direct, indirect and induced multiplier effects on income, employment, GDP, and taxation. The theoretical economic bases for each of these types of analyses are sound and have well-established applications and limitations. It is not unusual to conduct some form of each of these within regulatory settings.

Economic impact analysis is most commonly conducted to describe the potential positive outcomes associated with a long-term project development. Multipliers describe linkages within a local or regional economy and generally show how effects in one sector can contribute to income, employment, or output in other sectors. The structural models on which these are designed are generally by definition stable long-term models that capture long-term historical relationships among industries. They are not generally intended to capture impacts of short-term disruptions or accidents. At best, if used in such a context, they may be able to generate order of magnitude impacts but will not be capable of discerning distribution of impacts at a local level. In addition, it is not uncommon for some types of accidents to generate some considerable amount of economic activity through rebuilding, cleanup, or repair if there was significant damage to private property or public infrastructure. But such damages should not be construed as "positive", even if they may increase GDP or employment at a local level.[3] In all circumstances, industries and society as a whole attempt to avoid accidents and do not generally regard such events positively. For these reasons, this report does not rely on such techniques to determine a consequence cost. It is, however, acknowledged that insights from some of the impact work can provide a useful comparison yardstick.[4]

[3] This report also excludes potential offsetting benefits that accrue in other energy sectors (e.g., power) if users move away from natural gas as a result of experiencing an outage.

[4] Annex C provides a review of some of the damages associated with various incidents in Canada that resulted in service disruptions in the energy sector.

The analyses in this report are more consistent with the styles of analyses conducted in support of a CBA. The losses are expressed in a manner that can eventually be treated as an "expected incremental cost". The incremental cost is associated with analyzing "Before LMSU" costs in the event of a disruption, addressing only those types of costs that would not be experienced "After LMSU". The "expected" part of the equation in normal CBA would reflect mean values for economic parameters. In this analysis, however, a departure from this is that – because the impacts are rare and decision-making is precautionary – the costs are generally guided by the idea that they respond to a credible worst case. These credible worst case costs are thus *conditional* on there being an outage; the probability of an outage is the subject of the analyses conducted by Dynamic Risk Assessment Systems (2014). The annual expected cost (or monetary *risk*) is the product of the annual event probability and the conditional cost. The resultant annual expected costs can be compared to other costs normally considered in cash flow analyses, and can be treated similarly in CBA.[5,6]

Consequences as a Change in Economic Wellbeing in Event of Loss

Consequences in the context of an unplanned loss or disruption can be generally expressed (in the language of economics) as a loss of well-being or utility to an end-user. The literature typically distinguishes between the willingness to pay (WTP) for a good or service, and the willingness to accept compensation (WTAC) for the loss of the good or withdrawal of a service. A relatively robust literature has been developed across both traded and untraded commodities to determine the expected relationship between these two values; traded commodities are those for which a price exists in the market place.[7] WTAC is characteristically higher than WTP, and

[5] An example of this approach is the CBA included within the WMR (2012) Reply Evidence at the Northern Gateway Hearings which relied on disruption costs prepared by Ruitenbeek and probability assessments prepared by Worley Parsons and Dynamic Risk Assessment Systems to describe expected costs associated with pipeline leaks and ruptures.

[6] In treating costs similarly, some caution is warranted in the use of discount rates. The economic literature and guidance from some authorities (e.g., Treasury Board of Canada 2007, pp 37-38) would generally recommend using lower discount rates for cash flows associated with conditional or uncertain damages experienced by individuals because such discount rates would be more driven by consumers' social rate of time preference, currently estimated at 3%/year for Canada. In this report, FEI has selected 7%/year as an appropriate discount rate but sensitivity analyses at a lower rate are considered in Section 4. We stress that this is a social discount rate that applies only to the vector of future income losses discount to the time of the event; other losses are confined to the duration of the event and are not discounted. This discount rate will normally differ from financial rates of discount that may be used in regulatory settings such as the setting of tariffs.

[7] Some studies also attempt to measure WTP for an avoided disruption or accident. These studies are less common and methodologically more problematic as they do not always communicate the risks (probabilities) associated with the avoided accident or malfunction. Examples include: (i) Carson *et al*. (2004) relating to oil spill prevention in California, and (ii) Chou *et al*. (2011) relating to preventing natural gas service disruption in France, Italy and the United Kingdom. These studies can provide important insights into preferences but they do not yield results that can be reliably used in risk analyses because the survey techniques did not attribute likelihoods of the avoided disruption; results are thus not readily transferable to other jurisdictions. For example, the highest value in the Chou *et al*. study was that in Italy respondents were willing to pay an incremental €75.43 annually to avoid one unplanned 3 day cut in service during a 5 year period, and €10.29 annually to avoid an unplanned 1 day cut in that same period (values are in 2008 terms). This demonstrates the non-linearity in potential extended disruptions, but does not necessarily reflect the economic damages in event of a disruption (which would be expected to be more).

for critical services relating to health and safety it can be an order of magnitude higher. Based on Horowitz and McConnell (2002), for most normal private goods WTAC/WTP is approximately 2.9:1 whereas for goods associated with health or safety it is 10.1:1; all goods taken together the WTAC/WTP is 7.2:1.

For current consumers of a product, the current market price is an appropriate measure of a revealed WTP. A loss of economic wellbeing can be approximated by the difference between the WTAC and the price of the commodity.[8]

Role of Risk Tolerance & Risk Perceptions

The economic literature on behavioural economics generally acknowledges the non-linearities that are often revealed in individual preferences. The WTP and WTAC dichotomy is one such example: each is a monetary measure of an incremental unit but WTP represents a gain of one unit whereas WTAC represents a loss of one unit and their values can differ by as much as an order of magnitude. Behavioural research has similarly shown that risk perceptions and approaches to acceptable risks in decision-making also can be non-linear in nature.[9] For example, individuals are often seen to be more risk averse if risks are imposed on them by others or if they are subject to hazards far beyond their control; yet they are risk neutral or even risk seeking if they perceive that they are in control of the risks or hazards. Consequently, in treating "credible worst cases", individuals are more likely to behave in a way that considers the extreme event to be their worst personal outcome. As an example in a concrete case, this report suggests that a worst credible case involves a 5-25 day disruption for about 250,000 customers in winter; the range corresponds to a relight period wherein some customers may be relit after 5 days but others may need to wait 25 days. The actual expected disruption for any individual customer is thus the mean: 15 days. But individual decisions are more likely to assume that the 25 day relight outcome will be their worst possible personal case in the absence of other information. Because the outcome is largely out of their control, an individual may add more days to this in making any explicit or implicit decisions regarding reliability of gas supply and potential costs associated with a disruption.

It should be noted that, although there is frequent acknowledgement that risk attitudes can influence demand and consumer choices, there is very little formal analysis in the energy demand literature that addresses this. In preparing a literature review conducted in the UK, Kayode and Nyamapfene (2011) remarked that: "as yet, little is known about the conditions under which personal commitment, normative beliefs, convenience or other attitudes make an

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Other studies (Sullivan et al 2009, President's Council of Economic Advisors 2013) conducted time series analyses using WTP approaches for electricity interruptions.

[8] Some adjustments are required to this approximation. More precisely, the loss of economic wellbeing corresponds to a loss of consumer surplus under some portion of the demand curve. Because the demand for critical goods and services such as natural gas is typically very inelastic in the near-term (which would be the case in event of a disruption), a small adjustment needs to be made to reflect the short-term supply elasticity of this commodity (see Section 3).

[9] Nobel laureate Daniel Kahneman's speech at the acceptance ceremonies in Sweden and his seminal 2003 article on the topic underlined the idea that decisions with equivalent – in probability terms – expected economic outcomes did not have equivalent personal preferences: his studies showed that personal financial losses were generally weighted 2:1 against personal gains in experiments. See Kahneman (2003).

important difference in energy demand. Formal models based on the assumption of rational choice may not capture the appropriate variables for energy user responses to changing conditions and as a result, may be quite wrong about the level of short run response to changes in the energy environment" [p 152]. This largely remains a challenge to estimating especially the long-term impacts on demand in the event of a significant disruption: (i) such events are rare and thus provide very little historical experience on which to conduct formal analyses; and, (ii) consumer decisions can be modeled but not readily tested in real life circumstances that permit tracking over a period that represents the life cycles of typical decisions. Section 3 describes scenarios and assumptions in which this report estimates long-term responses to natural gas demand in event of an outage; these assumptions are tested against a simple behavioural model that relies on risk-averse choices.

Coping Strategies & Mitigation Mechanisms

Estimating short-term costs of an outage – as is done in this report – is complicated by a number of qualitative factors that are difficult to incorporate explicitly into any quantitative analysis. If an outage is caused by a planned or known event, such as a routine maintenance operation that may affect only a handful of customers, disruption costs are essentially negligible as the scale is small and customers can implement pre-planned coping strategies to accommodate the disruption. In the event of an unplanned disruption, however, the set of available coping strategies is generally constrained – at least for the near-term – as implementation of the coping strategy itself requires some advanced preparation. The BC Emergency Services recommendation to "be prepared to be self-sufficient for 72 hours" in event of *any* emergency is appropriate because it reflects two key coping strategies: (i) provision of items and resources to meet basic needs; and, (ii) provision of a window of time during which one can organize oneself for a longer interruption. That period of time may involve lifestyle adjustments, or involve financial outlays to replace the lost services. Each individual and customer will generally have different opportunities and will make different choices. The existence of additional mitigation mechanisms will generally tend to lower direct costs of service disruptions, and a full analysis of such costs can lead to decisions to make greater efforts to implement such mechanisms. For example, FEI created a credible scenario that includes mobilization of available additional resources to limit service disruption and lengthy outage periods; this approach is reflected in the outage durations and relight costs shown in Annex B.

Summary

The analyses in this report provide a quantitative basis for estimating the economic consequences associated with a short-term unplanned outage of natural gas supplies to different classes of consumers. The estimated costs provide an estimate of losses consistent with valuations normally conducted in support of cost benefit analyses. Broadly speaking, the costs represent efficiency losses by the utility that include real financial losses through increased expenditures and loss of sales revenue. The costs also include efficiency losses by consumers through lost consumer surplus experienced by end-users. The analytical scenarios are based on credible worst case situations, but generally assume risk neutrality in analyzing the monetary impacts of such situations. The assumption of risk neutrality may understate the actual impacts of any outage, but incorporation of risk aversion within the estimates would be highly speculative.

Section 3 – Methodology, Assumptions & Results

This Section provides general background to the specific methodologies and assumptions used in this analysis, providing also the results for the benchmark Reference Case. For the convenience of presentation, figures are routinely rounded. Reference Case results are presented in Figure ES-1 and Table 3.1 for the "As Is" consequences before investment in any of the LMSU Projects. The figures and tables reflect that IP Segments 4, 5, 8, 9, 11 and 12 can be isolated and would not be subjected to any disruptions in service either before ("As Is") or after ("Residual") any of the upgrade Projects are undertaken; consequences are therefore nil.

Table 3.1 Reference Case Results – "As Is" Consequences ($ million)

Vulnerable Segment	Direct Fixed Expenditures				Relight	Revenue Loss		Disruption	Total	Customers
	Regulatory Response	Public Opinion	Government Relations	Loyalty		Event	Long term			
Nichol to Roebuck	$ 0.25	$ 2.00	$ 0.50	$ 2.00	$ 29.14	$ 27.95	$ 246.64	$ 256.35	$ 564.83	252,300
Roebuck to Delta	$ 0.25	$ 2.00	$ 0.50	$ 2.00	$ 29.14	$ 27.95	$ 246.64	$ 256.35	$ 564.83	252,300
Delta to Tilbury	$ 0.25	$ 2.00	$ 0.50	$ 2.00	$ 26.74	$ 22.99	$ 208.31	$ 214.65	$ 477.44	229,690
Tilbury to Fraser	$ 0.25	$ 2.00	$ 0.50	$ 2.00	$ 25.21	$ 19.98	$ 183.21	$ 190.11	$ 423.25	215,200
IP Segment 1	$ 0.25	$ 2.00	$ 0.50	$ 2.00	$ 20.56	$ 14.88	$ 138.45	$ 141.78	$ 320.42	171,000
IP Segment 2	$ 0.25	$ 2.00	$ 0.50	$ 2.00	$ 12.72	$ 6.96	$ 45.47	$ 62.88	$ 132.77	98,200
IP Segment 3	$ 0.03	$ 0.20	$ 0.05	$ 0.20	$ 1.70	$ 0.58	$ -	$ 5.74	$ 8.50	14,100
IP Segment 6	$ 0.03	$ 0.20	$ 0.05	$ 0.20	$ 1.54	$ 0.45	$ -	$ 4.79	$ 7.26	12,500
IP Segment 7	$ 0.03	$ 0.20	$ 0.05	$ 0.20	$ 1.54	$ 0.45	$ -	$ 4.79	$ 7.26	12,500
IP Segment 10	$ 0.03	$ 0.20	$ 0.05	$ 0.20	$ 0.59	$ 0.09	$ -	$ 0.90	$ 2.06	2,840
IP Segment 13	$ 0.03	$ 0.20	$ 0.05	$ 0.20	$ 3.86	$ 1.24	$ -	$ 12.47	$ 18.05	29,620
Cape Horn to Coquitlam	$ 0.25	$ 2.00	$ 0.50	$ 2.00	$ 19.57	$ 7.88	$ 69.03	$ 80.71	$ 181.95	163,280
Port Mann to Cape Horn	$ 0.25	$ 2.00	$ 0.50	$ 2.00	$ 19.57	$ 7.88	$ 69.03	$ 80.71	$ 181.95	163,280
Nichol to Port Mann	$ 0.25	$ 2.00	$ 0.50	$ 2.00	$ 20.55	$ 8.41	$ 73.09	$ 85.84	$ 192.63	172,572

Table 3.2 Reference Case Results – "Residual" Consequences ($ million)

Vulnerable Segment	Direct Fixed Expenditures				Relight	Revenue Loss		Disruption	Total	Customers
	Regulatory Response	Public Opinion	Government Relations	Loyalty		Event	Long term			
Nichol to Roebuck	$ 0.25	$ 2.00	$ 0.50	$ 2.00	$ 10.23	$ 5.79	$ 42.06	$ 49.15	$ 111.98	81,300
Roebuck to Delta	$ 0.25	$ 2.00	$ 0.50	$ 2.00	$ 10.23	$ 5.79	$ 42.06	$ 49.15	$ 111.98	81,300
Delta to Tilbury	$ 0.25	$ 2.00	$ 0.50	$ 2.00	$ 7.90	$ 3.52	$ 13.39	$ 31.02	$ 60.59	58,690
Tilbury to Fraser	$ 0.25	$ 2.00	$ 0.50	$ 2.00	$ 6.41	$ 2.27	$ -	$ 21.44	$ 34.87	44,200
IP Segment 1	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	-
IP Segment 2	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	-
IP Segment 3	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	-
IP Segment 6	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	-
IP Segment 7	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	-
IP Segment 10	$ 0.03	$ 0.20	$ 0.05	$ 0.20	$ 0.59	$ 0.09	$ -	$ 0.90	$ 2.06	2,840
IP Segment 13	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	-
Cape Horn to Coquitlam	$ 0.25	$ 2.00	$ 0.50	$ 2.00	$ 15.20	$ 4.72	$ 32.34	$ 49.27	$ 106.27	121,880
Port Mann to Cape Horn	$ 0.25	$ 2.00	$ 0.50	$ 2.00	$ 15.20	$ 4.72	$ 32.34	$ 49.27	$ 106.27	121,880
Nichol to Port Mann	$ 0.25	$ 2.00	$ 0.50	$ 2.00	$ 18.04	$ 5.57	$ 42.70	$ 57.84	$ 128.91	131,172

General Assumptions

Outages are described for scenarios associated with 14 potentially vulnerable segments of the current system. Customer outages relied on information provided by FEI, and are summarized in Table ES-1 with further detail provided in Annex Table B1. Customers were categorized by rate class and a Reference Case was developed that used information from demand forecasts in the LTRP (2014) with 2016 taken as a base year for demand estimates. The impacts exclude any that might be associated with disruptions of supply to potential expansion of LNG capacity in the BC Lower Mainland (either for export or domestic use). All cost figures are expressed in real 2014 terms. Impacts on revenues and related values were based on currently published tariffs with terms in effect in July 2014.

All costs are incurred within a short period associated with the disruption event. An exception to this involves an estimate of long-term revenue losses. To place these losses in present value terms, a 7%/yr real discount rate was selected to discount them to the time of the hypothetical disruption event. This Reference Case discount rate is consistent with current practice in cost benefit analysis, and is regarded as appropriate given the opportunity cost of capital and other factors such as consumer time preference. It may different from rates used for other purposes in the regulatory setting; commonly rates used in tariff determination, for example, will be financial discount rates expressed in nominal (as opposed to real) terms and consider primarily different weightings to various sources of capital.

Categories of Impacts

Four types of mutually exclusive costs are considered for each vulnerable segment: (i) Direct Expenditures; (ii) Relight Costs; (iii) Revenue Losses; and, (iv) Service Disruption. Costs that would be incurred both with and without the project are not considered. Examples of such costs include repairs to the failed portion of the pipeline, which are assumed to be the same with and without the LMSU Project. Also, some small IP segments are excluded because: (i) they are currently vulnerable but would either remain vulnerable after the upgrade; or, (ii) they would not be adversely impacted as there is some redundancy in the current system that can handle smaller scale outages.

It should be noted that the 14 potentially vulnerable segments were selected after it was determined that a number of IP Segments (4, 5, 8, 9, 11, and 12 in Annex A maps) fell into the excluded category and are not reported herein. IP Segment 10 is reported in the tables here but its location is effectively a pivot point to the extent that both before and after the LMSU it would be vulnerable to a very localized malfunction in the pipeline; the incremental costs with a failure in that section are thus zero. This leaves 13 segments for which costs are non-zero. Of these, ten are vulnerable because they consist of single pipelines with no redundancy available; a failure in any of these sections will cause potential impacts at a magnitude described in this report.

The other three segments (Roebuck to Delta; Delta to Tilbury; Tilbury to Fraser) are currently looped pipelines; a failure in one pipeline would normally have no incremental effects because the adjacent pipeline provides redundancy. However, some types of failure in these three segments could cause damage in the adjacent line; such a “concomitant failure” is described in Dynamic Risk Assessment Systems (2014) and is generally associated only with those sections where the distance between the pipelines is such that a failure in one pipeline constitutes a potential hazard to the adjacent pipeline. The reader will note that the difference between the “As Is” and the “Residual” customers impacted by incidents in these three segments is identical to the number of customers downstream of Fraser Gate (171,000).

Direct Fixed Expenditures as a Consequence of an Outage

These represent costs incurred in the event of any outage event that impacts a significant number of customers. Table 3.1 shows these costs to include expenditures associated with regulatory response, public opinion, government relations and customer loyalty programs. Based on FEI estimates, these are in aggregate expected to fall in a range of $480,000 to $4.75 million per outage.

These costs are consistent with those prepared during the Huntingdon CPCN, although some were revisited and further improved. First, all costs are now described in two levels where fixed costs are less if fewer customers are impacted. The Huntingdon estimates previously considered only one single large outage, whereas this report treats 14 scenarios of varying scales. Second, expenditures on customer loyalty programs were revisited and increased to place these on a comparable level to expenditures on public awareness programs. These customer loyalty expenditure levels are regarded as necessary to retain customers and provide some moderate assistance for any inconvenience. It is acknowledged that some customers may still inevitably choose to reduce their future reliance on natural gas usage as a consequence of the interruption; these longer term impacts on customer numbers or customer usage are treated explicitly below as potential long term revenue losses to the utility.

Relight Costs

Relight costs depend on the scale and location of the outage, resource availability, and unit costs of manpower and related resources. FEI has estimated the number in each customer class affected for each scenario, an appropriate relight schedule based on best efforts resource deployment, and the resultant costs of relighting customers. Table 3.3 provides a summary of the "As Is" relight assumptions and expenditures; Annex Table B2 provides full details of different cost components for both the "As Is" and "Residual" consequences.

Table 3.3 Relight Assumptions and Expenditures – "As Is" Consequences

Location	Outages	Maximum Repair or Shutdown Time (days)	Total Time Required (days)	Total Cost (MM$)
Nichol to Roebuck (Metro & Valley)	252,300	7.2	24.8	$ 29.14
Roebuck to Delta	252,300	7.2	24.8	$ 29.14
Delta to Tilbury	229,690	6.6	22.7	$ 26.74
Tilbury to Fraser	215,200	6.3	21.4	$ 25.21
Fraser Gate Station to Coquitlam Gate Station IP System				
IP Segment 1	171,000	6.2	19.8	$ 20.56
IP Segment 2	98,200	5.0	12.8	$ 12.72
IP Segment 3	14,100	5.0	8.2	$ 1.70
IP Segment 6	12,500	5.0	7.9	$ 1.54
IP Segment 7	12,500	5.0	7.9	$ 1.54
IP Segment 10	2,840	5.0	5.6	$ 0.59
IP Segment 13	29,620	5.0	8.9	$ 3.85
Cape Horn to Coquitlam (Metro, Squamish, Whistler, VI)	163,280	5.1	16.0	$ 19.57
Port Mann to Cape Horn	163,280	5.1	16.0	$ 19.57
Nichol to Port Mann (Metro, Valley, Squamish, Whistler, VI)	172,572	5.0	15.8	$ 20.55

Source: FEI estimates. Total Cost includes 30% contingency. See also Annex B.

Resources for relight are deployed immediately after an outage but it is assumed that customers will have no service for at least a five day period during which the location and cause of the outage is identified and repaired – or is circumvented – to bring service back to impacted customers. The maximum impact identified is a failure in either the Nichol to Roebuck TP segment or the Roebuck to Delta TP segment; some 252,300 customers would be without gas for up to 25 days and the relight period would involve direct expenditures of approximately $29 million.

Relight costs for other scenarios are lower, normally having a clear correspondence to the scale of the relight. The relight schedule assumes 14 productive hours per day, and would accommodate two trips to every customer. The relight costs include mobilization and training for shutdown and relight, travel and subsistence costs, support costs, purge costs, and a 30% allowance for corporate overheads. The costs do not reflect recovery of any potential insurance benefit from a claim for relight expenses.[10]

Revenue Loss

FEI will experience direct revenue losses through two mechanisms: (i) the outage event will reduce sales revenues depending on the duration of the outage, the estimated demand during the outage by a customer, and the applicable tariff (including cost of service) but excluding commodity cost; and, (ii) a potential long term revenue loss associated with the loss of some proportion of customers that were interrupted.

Event Losses. Demand was estimated based on average customer demand profiles as presented in the FEU Long Term Resource Plan (LTRP, 2014) for the year 2016. A credible worst case scenario placed the disruption at the peak demand days associated with a December outage; on average this implied that normal gas use during the outage period was about 2.3 times the average daily gas use. Lost revenue during the event was based on applicable tariffs for each customer class in mid-2014. For each customer class an average representative tariff was used to represent the sales price to the customer of the gas. The sales price included the commodity cost ($4.64/GJ) and a cost of service (COS) element using loads for a typical customer in that class. Table 3.4 summarizes these parameters. The revenue loss for any customer class was calculated based on the foregone gas deliveries multiplied by the COS for any given customer class. The foregone gas deliveries were a function of the days at total shutdown and the mean relight period. For example, a 25 day interruption comprising a 5 day total shutdown and a 20 day period that progressively relights all customers is equivalent to a 15 day total interruption in gas deliveries at the peak demand level.

Table 3.4 Assumptions relating to sales revenue impacts

Customer Class	Typical Scale* (GJ/mo)	Rate Category Used	Commodity ($/GJ)	Cost of Service ($/GJ)	Total ($/GJ)
Residential	6-8	Rate 1	$4.64	$6.43	$11.07
Commercial	43-68	Rate 2	$4.64	$4.67	$9.31
Industrial/Large Commercial	750 - >2,000	Rate 3 (proxy)	$4.64	$3.73	$8.37
Interruptible & Curtailable	>13,000	Rate 27	$4.64	$1.36	$6.00
Other Industrial	800	Rate 27 (proxy)	$4.64	$1.36	$6.00

* Scale varies among vulnerable segment depending upon composition of customers.

The resultant revenue loss is summarized for each scenario in Table 3.1 (for "As Is" consequences) and in Table 3.2 (for "Residual" consequences). The maximum revenue loss

[10] FEI does carry insurance coverage but these are not taken as an offset in this analyses because they represent simply a redistribution of costs and in any event may in due course result in a change in premiums or availability of cover (which are also not reflected in this analysis). FEI currently holds relight coverage subject to a 10 day waiting period to a limit of $30 million.

corresponds to a failure in the Nichol to Roebuck segment or the Roebuck to Delta segment in which FEI loses $27.95 million in direct sales revenue. Note that it is assumed that (i) all operational costs are fixed and there are no net savings from delivering the lower quantities of natural gas during the interruption period; and, (ii) no net losses of commodity sales are experienced by the owner of natural gas as adequate spot markets would exist to clear this gas in other markets.[11]

Long-term Revenue Losses. Long term losses can be of different types. They are assumed to occur in response to prolonged outages that impact customers' perceived reliability of natural gas services. The responses can in principle take many potential forms: (i) reduction in reliance on natural gas by existing customers, but with little change in customer count; (ii) reduction in customer count; (iii) eventual reduction in usage once existing equipment and capital stock is renewed. In addition, it should be noted that the losses may also occur because customers that otherwise might have considered natural gas are – after the incident – no longer persuaded to sign on. Finally, a pure economic response effect might occur if reduced demand eventually translates into higher tariffs as the fixed costs of unused capacity are spread over the existing customer base.

Simulations were conducted that reflect a credible worst case benchmark scenario for long term revenue loss. The benchmark scenario was tested against a simple risk averse behavioural model that reflected potential consumer response to outages. The benchmark scenario is based on the loss of annual sales from 10% of the customers who are interrupted for more than 10 days as a consequence of the outage. The loss is assumed to occur over a 20 year period, which is the mean expected economic life for natural gas space heating equipment (Lekov *et al.*, 2012). This loss stream is discounted at a real rate of 7%/yr. The methodology predicts non-zero impacts for 9 of the scenarios; these range from approximately $45 million to $220 million. The other scenarios have outages of less than nine days that do not trigger the ten day hurdle. The methodology predicted a reduction in gas sales equivalent to a 3.6%-7.5% reduction in average use within these 9 scenarios (or equivalently no change in average use but a 3.6%-7.5% decline in customer numbers).

To validate the assumptions, these results can be compared to a behavioural model in which a customer considers the life cycle costs of natural gas by including the cost of a temporary disruption within the average price of gas over a fixed period. A risk averse customer would reasonably allocate the temporary service disruption costs (described below) for an assumed "personal credible worst case" disruption over a decision period. We take a decision period to be 15 years, representing conservative estimates of the typical life of a mix of natural gas assets including water heating and furnace equipment (based on Lekov *et al*. 2010), and assume that our risk averse customer predicts one such event will disrupt her for one month over this period. This scenario is equivalent to an 11.3% long-term price premium on the purchase of natural gas by our customer. In OECD countries generally, surveys suggest that long-term own-price elasticities for natural gas approach -0.5%,[12] implying that this scenario would generate a 6-7%

[11] This loss of sales revenue is technically a business interruption for FEI. The losses would not generally be eligible for interruption insurance in its current policies, which provide for coverage only after 30 days of ongoing interruption. The incidents considered in these Reference Case scenarios are all under one month.

[12] See Bernstein R, Madlener R. 2011; Shoostari 2014.

decline in long term volumes in perpetuity; the decline could be greater if the resultant revenue loss were partially made up through increased tariffs on other customers, which would in turn induce a second order effect on volume declines. These results suggest that the loss scenario generating a 3.6%-7.5% decline in gas sales is credible. We note further that the behavioural model presumes losses in perpetuity while the numbers presented in the Reference Case correspond to a 20 year loss; the permanent loss (in perpetuity) results are addressed in Section 4 as a sensitivity analysis.

Service Disruption

Service disruption was calculated using methods relying on estimated economic welfare losses to each different customer class. The welfare loss calculation is based on literature values associated with the willingness to accept compensation (WTAC) relating to the unplanned loss of a marketable commodity. A literature survey showed that such values are typically of the order of 3-10 times the price paid for the commodity (regarded as a revealed willingness to pay [WTP]). A criticality scale was developed that corresponded to higher WTAC/WTP ratios for safety and health issues. The Reference Case is also sensitive to switching opportunities that individual customer classes may typically have to address interruptions. Residential customers exhibited the highest ratios or multipliers; large interruptible customers potentially exhibit the lowest. These disruption impacts are regarded as an appropriate proxy for incremental economic impacts. Table 3.5 shows the parameters derived as multipliers, which result in an equivalent loss in welfare (consumer surplus) for a given class of customer.

Table 3.5 Assumptions relating to service disruption impacts

Customer Class	Criticality*	Multiplier**	Reference Price ($/GJ)	Δ Welfare ($/GJ)
Residential	80%	7.220	$11.07	$79.94
Commercial	30%	3.895	$9.31	$36.26
Industrial/Large Commercial	10%	2.565	$8.37	$21.47
Interruptible, Curtailable, Other***	0%	0.285	$6.00	$1.71

* Criticality is an estimate of the proportion of use dedicated to critical functions associated with health and safety; these include space and water heating. ** The multiplier represents a factor to be applied to the sales price (WTP or Reference Price) to derive a change in welfare estimate. All multipliers include a negative adjustment of 5% to reflect that the short-run demand elasticity for natural gas is not perfectly inelastic. The adjustment reflects an elasticity of (minus) 0.1. *** For interruptible and other customers, 0% criticality is assumed but a fuel opportunity cost of 30% (0.3) is applied.

The maximum service disruption consequence anticipated is approximately $256 million and is again associated with a malfunction involving locations between the Nichol Valve Station and the Delta Valve Station. The impacts of this service disruption are primarily borne by the residential sector: approximately $170 million across some 224,000 residential customers. The reader is reminded that this assumes a relight schedule that does not give priority to any given customer. Critical customers are not identified as such and would be connected at any time during the period.

Section 4 – Sensitivity Analyses

The reference case consequence estimates are regarded as appropriate for decision making to the degree that they show relative scales of consequences among categories and locations. Sensitivity analyses can further inform decision-making as they demonstrate that costs can readily be significantly higher in the event that some assumptions are relaxed within credible limits. For discussion purposes we describe these here only for the "As Is" consequences.

Summary of Sensitivity Results

Table 4.1 Summary of Sensitivity Results (Total "As Is" Consequences in million $; 2014$)

Case	Reference	Sensitivity I		Sensitivity II		Sensitivity III		Sensitivity IV		Sensitivity V	
Vulnerable Segment		Permanent Revenue Loss		2 wk Response Delay		Cold Weather +20%GJ		II+III		Criticality: minus 10%	
Nichol to Roebuck	$ 564.83	$ 783.81	39%	$ 777.45	38%	$ 620.52	10%	$ 865.64	53%	$ 533.05	-6%
Roebuck to Delta	$ 564.83	$ 783.81	39%	$ 777.45	38%	$ 620.52	10%	$ 865.64	53%	$ 533.05	-6%
Delta to Tilbury	$ 477.44	$ 662.38	39%	$ 684.55	43%	$ 524.22	10%	$ 761.31	59%	$ 450.67	-6%
Tilbury to Fraser	$ 423.25	$ 585.91	38%	$ 626.37	48%	$ 464.85	10%	$ 696.38	65%	$ 399.31	-6%
IP Segment 1	$ 320.42	$ 443.34	38%	$ 489.61	53%	$ 351.46	10%	$ 543.36	70%	$ 302.53	-6%
IP Segment 2	$ 132.77	$ 173.13	30%	$ 288.86	118%	$ 146.55	10%	$ 317.63	139%	$ 124.42	-6%
IP Segment 3	$ 8.50	$ 8.50	0%	$ 31.98	276%	$ 9.75	15%	$ 35.08	313%	$ 7.83	-8%
IP Segment 6	$ 7.26	$ 7.26	0%	$ 26.51	265%	$ 8.31	14%	$ 29.15	301%	$ 6.71	-8%
IP Segment 7	$ 7.26	$ 7.26	0%	$ 26.51	265%	$ 8.31	14%	$ 29.15	301%	$ 6.71	-8%
IP Segment 10	$ 2.06	$ 2.06	0%	$ 6.47	214%	$ 2.26	10%	$ 7.03	241%	$ 1.96	-5%
IP Segment 13	$ 18.05	$ 18.05	0%	$ 66.29	267%	$ 20.77	15%	$ 72.84	304%	$ 16.58	-8%
Cape Horn to Coquitlam	$ 181.95	$ 243.24	34%	$ 319.49	76%	$ 199.60	10%	$ 353.21	94%	$ 172.48	-5%
Port Mann to Cape Horn	$ 181.95	$ 243.24	34%	$ 319.49	76%	$ 199.60	10%	$ 353.21	94%	$ 172.48	-5%
Nichol to Port Mann	$ 192.63	$ 257.53	34%	$ 341.90	77%	$ 211.40	10%	$ 377.93	96%	$ 182.52	-5%

Note: Percentage figures represent change relative to results from Reference Case.

Sensitivity results for selected parameters are shown Table 4.1. The cases considered are:

I. Permanent Revenue Loss. As described in Section 3, the Reference Case assumed that losses were limited to 20 years and were discounted at 7%. This sensitivity assumes that losses are permanent and are discounted at a lower discount rate of 5% to reflect that some of the damages are borne by individual consumers who have lower discount rates associated with their rate of time preference for consumption (3% in Canada).

II. Response Delay. Many uncertain factors are not readily quantified but can be adequately captured by reflecting the impacts through delays in response and relight. A delay of two weeks (additional 1 week shutdown plus 1 week additional relight time) might occur due to delays in re-establishing service coupled with longer relight requirements if resources are constrained. Conditions that might contribute to such delays include unforeseen regulatory delays or complicated circumstances that coincide with the outage. Such complicating circumstances usually involve other hazards such as bad weather, a power outage, an earthquake, a flood, or wildfire.

III/IV. Cold Weather. Demand studies show that heating demand for natural gas is very sensitive to weather variables. This sensitivity scenario assumes an additional 20% increment in gas usage in event of colder weather, and that the outage would occur during this period. Sensitivity Case III is stand-alone and IV combines the cold weather assumptions with the Response Delays inherent in Sensitivity Case II.

V. Criticality. This sensitivity is intended to show the impact of *reducing* the vulnerability of critical elements of gas use by 10%. This is modeled through a simple change in the criticality

factors, but can be achieved by a number of means such as improved targeting of public safety nets to critical uses. The sensitivities show a decrease compared to the Reference Case, but an increase in criticality would similarly increase the costs.

Worst Case Sensitivity Results for a Nichol-Roebuck Failure

For the Nichol-Roebuck failure scenario (in which 252,300 customers are impacted with total economic consequence of $565 million in the Reference Case) sensitivity analyses resulted in the following outcomes.

I. Permanent Revenue Loss. The Reference Case was based on a 20 year loss discounted at 7%/year (real). A permanent loss discounted at 5%/year (real) translates to a Total Consequence (with all other elements unchanged) of $784 million.

II. Response Delay. A delay of two weeks (additional 1 week shutdown plus 1 week additional relight time) might occur due to delays in re-establishing service coupled with longer relight requirements if resources are constrained. The additional costs translate into a Total Consequence or $777 million, representing about $15 million a day during the additional two week service disruption.

III. Cold Weather. A 20% increase in demand from residential, commercial, and firm industrial customers increases Total Consequences to $621 million.

IV. Cold Weather & Response Delays. Sensitivity Cases II and III above would together result in Total Consequences of $866 million.

V. Criticality. A 10% decrease in the most vulnerable residential, commercial, and small industrial uses reduces potential economic consequences by about 6% to $533 million.

The sensitivity analyses suggest that consequences are most sensitive to response delays. While factors related to external complicating influences cannot be controlled (e.g., earthquake, flood, severe weather, power outages), factors that are controllable (e.g., regulatory approvals) should seek to ensure safe, efficient and timely recommencement of service.

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Annexes

Annex A – Project Area Maps

Annex B – FEI Summary of Economic Consequence Approach

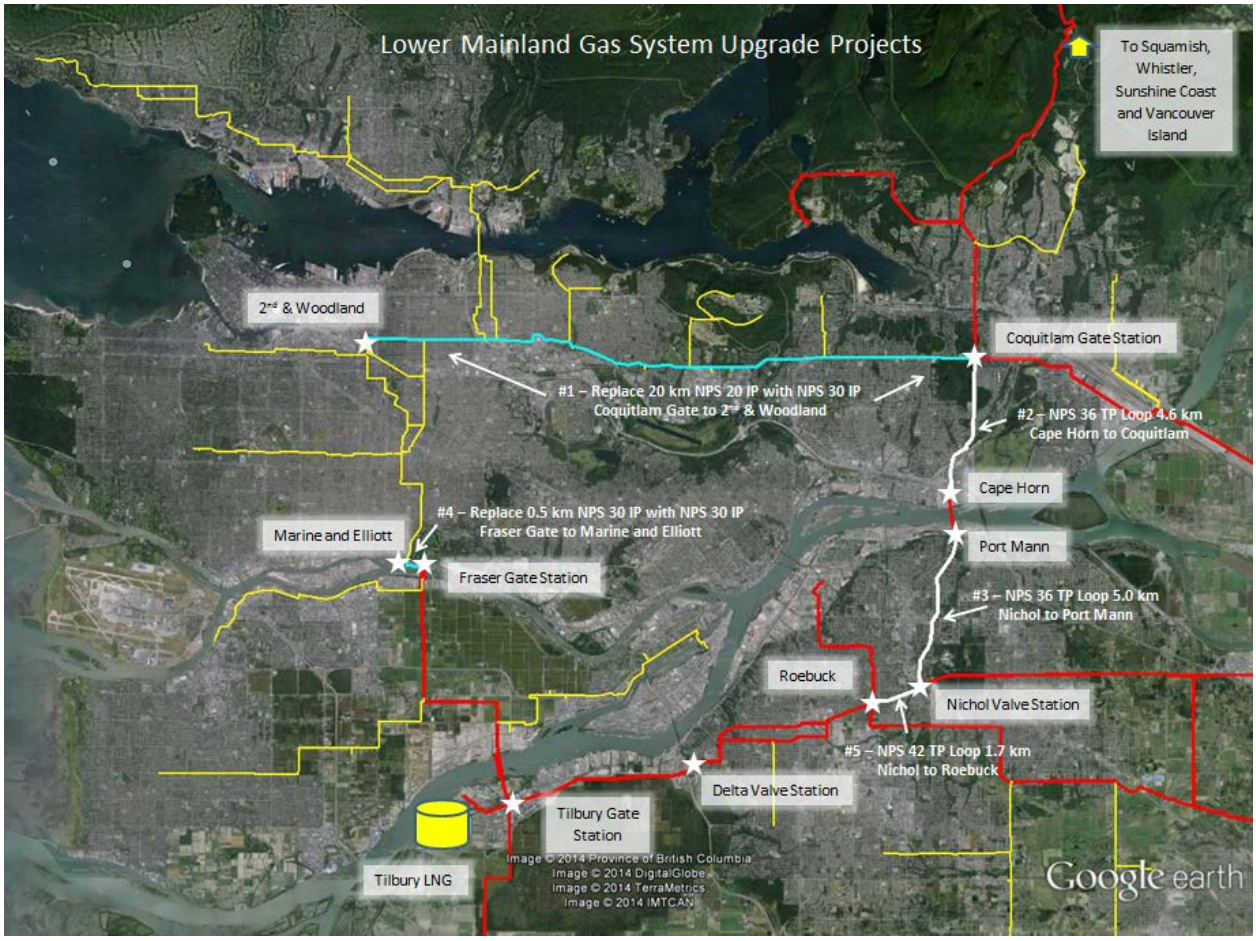
Annex C – Selected Disruptions to Energy Services in Canada

Annex A – Project Area Maps

Figure A1. Lower Mainland Gas System Upgrade Projects.

Figure A2. Schematic of IP System Map showing Analytical Segments.

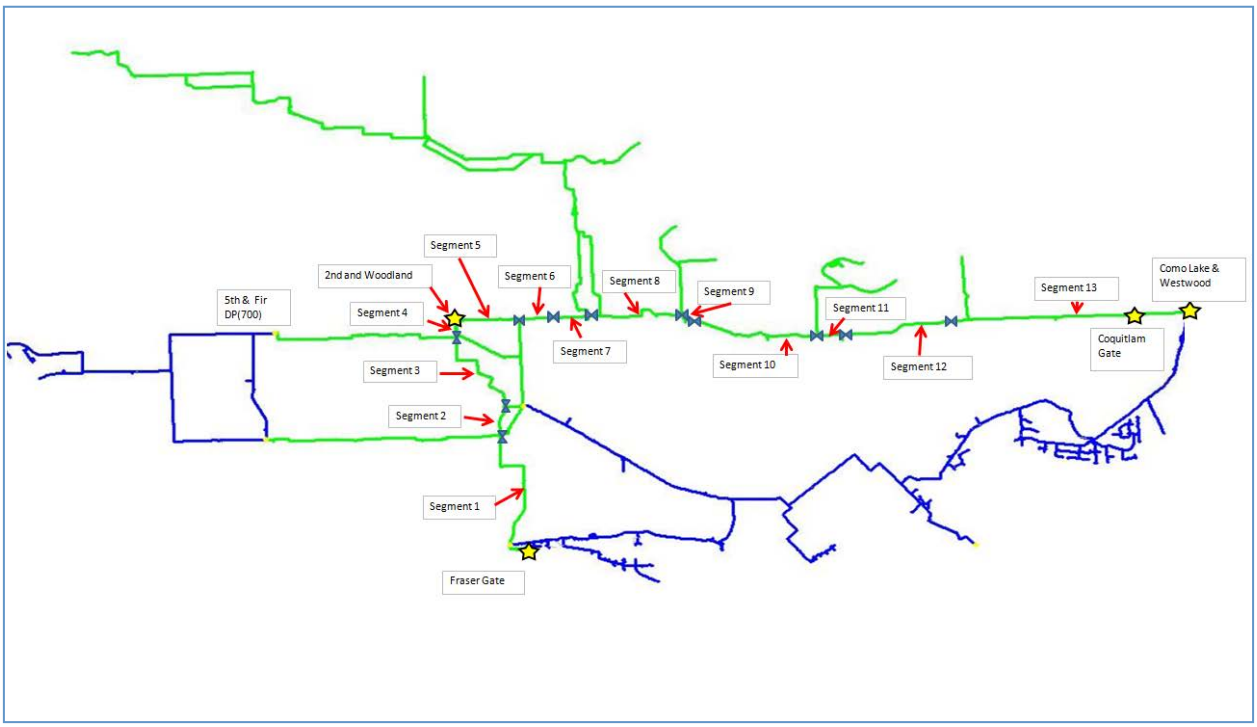
Figure A1. Lower Mainland Gas System Upgrade Projects



<u>TP System Vulnerable Segments:</u>

- Nichol to Roebuck NPS 24 (1.70 km)
- Nichol to Roebuck NPS 42 (1.70 km)
- Roebuck to Delta NPS 36 (7.43 km)
- Roebuck to Delta NPS 24 (7.25 km)
- Delta to Tilbury NPS 24 (5.32 km)
- Delta to Tilbury NPS 36 (5.36 km)
- Tilbury to Fraser Gate NPS 24 (9.74 km)
- Tilbury to Fraser Gate NPS 20 (9.67 km)
- Cape Horn to Coquitlam Gate NPS 20 (4.60 km)
- Cape Horn to Coquitlam Gate NPS 36 (4.60 km)
- Port Mann to Cape Horn NPS 36 (1.28 km)
- Nichol to Port Mann NPS 24 (5.00 km)
- Nichol to Port Mann NPS 36 (5.00 km)

Figure A2. Schematic of IP System Map showing Analytical Segments.



<u>IP System Vulnerable Segments:</u>

- IP Segment 1 – (4.76 km)
- IP Segment 2 – (0.92 km)
- IP Segment 3 – (3.24 km)
- IP Segment 6 – (1.34 km)
- IP Segment 7 – (0.54 km)
- IP Segment 10 – (3.78 km)
- IP Segment 13 – (5.15 km)

<u>IP System Other Segments (can be Isolated and are not Vulnerable):</u>

- IP Segment 4 – (0.48 km)
- IP Segment 5 – (1.81 km)
- IP Segment 8 – (2.97 km)
- IP Segment 9 – (0.20 km)
- IP Segment 11 – (0.68 km)
- IP Segment 12 – (2.98 km)

Annex B – FEI Summary of Economic Consequence Approach

This Annex summarizes the FEI approach to the determination of consequences.

The FEI Impact Chart (Figure B1) is used as the basis for considering monetary impacts associated with a failure. This Impact Chart was developed to ensure that quantitative risk assessments are completed using consistent metrics across the corporation. Public Safety, Property Damage, Product Loss and Environment consequences were not included in the analysis, because these are not considered to be impacted significantly by the LMSU project (i.e., these consequences will not vary significantly between the 'Before LMSU' and 'After LMSU cases). Therefore, the consequences included in the study are:

Service Disruption Costs: Includes socio-economic costs associated with service disruption for an extended period of time

Relight Costs: Includes costs associated with shut down, purging and relighting customers impacted by an outage

Loss of Revenue Costs: Includes loss of revenue costs associated with service interruption for all customers during the event, and for an extended period of time for a percentage of the customers.

Regulatory Response Costs: Evaluates anticipated regulatory response costs associated with a failure, and subsequent major service outage

Public Opinion Costs: Evaluates anticipated public opinion costs associated with a failure, and subsequent major service outage

End Use Customer Loyalty Costs: Evaluates anticipated customer loyalty costs associated with a failure, and subsequent major service outage

Government Relations Costs: Evaluates anticipated government relations costs associated with a failure, and subsequent major service outage.

The Service Disruption Costs, Relight Costs and Revenue Costs are all informed by the number of potential outages and the outage times in the event of a failure. The potential outages are shown in Table B1; outage times and associated relight costs are shown in Table B2.

Some modifications were made to the impact chart shown in Figure B1 to ensure that the costs are relevant to the analysis being performed. Specifically, Service Disruption, Lost Revenue, Relight and Customer Loyalty costs were modified to reflect the outcome of an analysis that targeted service interruptions of a magnitude that would occur in the event of an outage on the segments of the CTS system that are the subject of the scope of this study.

Figure B1 FortisBC Energy Inc. Impact Chart

Consequence Categories		Negligible	Low	Medium	High	Extreme
		N	L	M	H	E
Health and Safety	Public	No health and safety issues	Medical Aid or Near-Miss	Acute Injury (2nd degree burn – per person)	Severe Injury (3rd degree burn - per person)	a): 1-5 fatalities b): each additional fatality
	Employees / Contractors	No health and safety issues	Medical Aid or Near-Miss	Acute Injury (2nd degree burn – per person)	Severe Injury (3rd degree burn - per person)	a): 1-5 fatalities b): each additional fatality
Physical Damage / Economic Loss	Property Damage	No / Minor Damage to a single dwelling	Light Property Damage to a single dwelling	Moderate Property Damage to a single dwelling	Heavy Property Damage to a single dwelling	Severe Property Damage to a multi-dwelling structure
	Service Disruption (All costs excluding lost revenue)	Negligible to Short-term minor service interruption (5 dwellings <8 hours)	Loss of service to 5-10 residential or 1-2 commercial customers for 1-2 days	Service disruption to 150 residential customers (approx. 8-12 hrs)	Curtailment of 1,500 customers or a large industrial customer (7 days)	Curtailment of >9,000 customers for approx. 7 days
	Service Disruption or lack of capacity (Lost revenue due to outage or curtailment)	Negligible to Short-term minor service interruption (5 dwellings <8 hours)	Loss of service to 5-10 residential or 1-2 commercial customers for 1-2 days	Curtailment of 150 residential customers (approx. 8-12 hrs)	Curtailment of 1,500 customers or a large industrial customer (7 days)	Curtailment of >9,000 customers for approx. 7 days
	Commodity Loss	Negligible commodity loss				
	Company Damage	Minor Repair / Replacement including value of new component	Large Repair / Replacement	Replacement of a larger diameter pipeline (>NPS4) and/or replacement of district regulator	Losing secondary gate station or distribution main. Emergency repair. 2 week repair time.	Loss of gate station / loss of transmission pipeline feed. Emergency repair at critical time of year. 2 months repair time.

Consequence Categories		Negligible	Low	Medium	High	Extreme
		N	L	M	H	E
Environment	Emissions	No significant leak	Pull-out in 0.5" diameter service line operating at 60 psi blowing for 45 min.	4 in^2 hole in a NPS 6 distribution pipeline operating at 275 psi, 0.2 km between MLVs - 4 hrs isolation time	4 in^2 hole in a NPS 8 transmission pipeline operating at 700 psi, 25km between MLVs – 6 hrs isolation time	Full-bore failure in a NPS 12 transmission pipeline operating at 700 psi, 50km between MLVs – 1 hr isolation time
	Rehabilitation	No significant impact	Rehabilitation of residential / commercial sites	Repairable damage to habitats in sensitive areas	Major remediation required. Contamination of soil or water	Permanent damage to sensitive environment (major contamination)
Regulatory	Regulatory Response	No regulatory involvement	Informal meeting	Order to comply	Review Practices (including implementation costs)	Line shut-down or pressure restriction / possible fine or prosecution
Corporate Image	Public Opinion	No public record, but preparation of public communications required	Local coverage. Enhanced efforts towards pre-emptive public communications at the local area.	Regional coverage with uncontrolled releases of print / radio / television communications. Community meetings throughout franchise area (10 employees x 2 weeks involvement).	National coverage with uncontrolled releases of print / radio / television communications. Engagement of external public relations consultant for limited period of time. Implementation of corporate advocacy campaign.	Global coverage with uncontrolled releases of print / radio / television communications. Engagement of external public relations consultant for extended period of time.
	End Use Customer Loyalty	Negligible to minor customer annoyance due to planned event	More significant customer concern resulting from improper repair of property or evacuation of a limited number of customers	Customer annoyance associated with shorter-term loss of service to customers in a contained area (e.g. multiple neighbourhoods, including industrial customer impacts)	Significant customer dissatisfaction associated with medium-term curtailment or outages of full communities or smaller cities	Extensive customer dissatisfaction associated with longer-term curtailments or outages of large cities or multiple cities
	Government Relations	No impact to single incremental meeting with municipal officials (2 FEI employees x 1 day)	Strained communications, requiring additional meetings between government agencies and FEI staff in order to maintain trust.	Erosion of trust with government agencies as a safe operator that can not be rectified by enhanced communications.	Loss of influence on shaping policy / Lost lobby rights / Loss of trust.	Total breakdown of relationship with administration and government agencies. Future decisions will be made with no imput from FEI

Table B1 Potential Outages

Location: "As Is" Consequences	Outages*	Surrey	Delta	Richmond	Metro IP	Coquitlam (non-IP)	Squamish	Whistler	VI & Sunshine Coast
Nichol to Roebuck (Metro & Valley)	252,300	8,000	29,100	44,200	171,000	0	0	0	0
Roebuck to Delta	252,300	8,000	29,100	44,200	171,000	0	0	0	0
Delta to Tilbury	229,690	0	14,490	44,200	171,000	0	0	0	0
Tilbury to Fraser	215,200	0	0	44,200	171,000	0	0	0	0
Fraser Gate Station to Coquitlam Gate Station IP System									
IP Segment 1	171,000	0	0	0	171,000	0	0	0	0
IP Segment 2	98,200	0	0	0	98,200	0	0	0	0
IP Segment 3	14,100	0	0	0	14,100	0	0	0	0
IP Segment 6	12,500	0	0	0	12,500	0	0	0	0
IP Segment 7	12,500	0	0	0	12,500	0	0	0	0
IP Segment 10	2,840	0	0	0	2,840	0	0	0	0
IP Segment 13	29,620	0	0	0	29,620	0	0	0	0
Cape Horn to Coquitlam (Metro, Squamish, Whistler, VI)	163,280	0	0	0	41,400	14,200	3,970	2,612	101,098
Port Mann to Cape Horn	163,280	0	0	0	41,400	14,200	3,970	2,612	101,098
Nichol to Port Mann (Metro, Valley, Squamish, Whistler, VI)	172,572	9,292	0	0	41,400	14,200	3,970	2,612	101,098

Location: "Residual" Consequences	Outages*	Surrey	Delta	Richmond	Metro	Coquitlam (non-IP)	Squamish	Whistler	VI & Sunshine Coast
Nichol to Roebuck (Metro & Valley) ¶	81,300	8,000	29,100	44,200	0	0	0	0	0
Roebuck to Delta ¶	81,300	8,000	29,100	44,200	0	0	0	0	0
Delta to Tilbury ¶	58,690	0	14,490	44,200	0	0	0	0	0
Tilbury to Fraser ¶	44,200	0	0	44,200	0	0	0	0	0
Fraser Gate Station to Coquitlam Gate Station IP System									
IP Segment 1	0	0	0	0	0	0	0	0	0
IP Segment 2	0	0	0	0	0	0	0	0	0
IP Segment 3	0	0	0	0	0	0	0	0	0
IP Segment 6	0	0	0	0	0	0	0	0	0
IP Segment 7	0	0	0	0	0	0	0	0	0
IP Segment 10	2,840	0	0	0	2,840	0	0	0	0
IP Segment 13	0	0	0	0	0	0	0	0	0
Cape Horn to Coquitlam ¶¶	121,880	0	0	0	0	14,200	3,970	2,612	101,098
Port Mann to Cape Horn ¶¶	121,880	0	0	0	0	14,200	3,970	2,612	101,098
Nichol to Port Mann ¶¶	131,172	9,292	0	0	0	14,200	3,970	2,612	101,098

* Outages and costs for IP Segments 4, 5, 8, 9, 11, & 12 are nil in the "As Is" and "Residual" consequences.

¶: Residual impacts are after 20" Metro IP system upgrade installed; in Nichol-Fraser these include portions of Surrey, Delta, South Delta, & Richmond; 171,000 IP customers experience no consequences

¶¶: Residual impacts are after 20" Metro IP system upgrade installed; in Nichol-Coquitlam these include portions of Valley, Squamish, Whistler & Vancouver Island (VI) and Sunshine Coast 41,400 IP customers experience no consequences

Source: FEI.

Table B2 Outage Duration & Associated Relight Costs

Location: "As Is" Consequences	Outages	Time Required (hours)	Time Required (Days)	Max Repair or Shutdown Time (days)	Field Tech Cost	Training Cost	Expenses	Support	Purge Cost	Total Cost*
Nichol to Roebuck (Metro & Valley)	252,300	348	24.8	7.2	$ 16.77	$ 0.29	$ 2.42	$ 2.68	$ 0.25	$ 29.14
Roebuck to Delta	252,300	348	24.8	7.2	$ 16.77	$ 0.29	$ 2.42	$ 2.68	$ 0.25	$ 29.14
Delta to Tilbury	229,690	318	22.7	6.6	$ 15.31	$ 0.29	$ 2.28	$ 2.45	$ 0.23	$ 26.74
Tilbury to Fraser	215,200	299	21.4	6.3	$ 14.38	$ 0.29	$ 2.20	$ 2.30	$ 0.22	$ 25.21
Fraser Gate Station to Coquitlam Gate Station IP System										
IP Segment 1	171,000	277	19.8	6.2	$ 11.55	$ 0.23	$ 2.02	$ 1.85	$ 0.17	$ 20.56
IP Segment 2	98,200	180	12.8	5.0	$ 6.83	$ 0.23	$ 1.53	$ 0.27	$ 0.10	$ 12.72
IP Segment 3	14,100	115	8.2	5.0	$ 0.95	$ 0.08	$ 0.18	$ 0.05	$ 0.01	$ 1.70
IP Segment 6	12,500	110	7.9	5.0	$ 0.86	$ 0.08	$ 0.17	$ 0.05	$ 0.01	$ 1.54
IP Segment 7	12,500	110	7.9	5.0	$ 0.86	$ 0.08	$ 0.17	$ 0.05	$ 0.01	$ 1.54
IP Segment 10	2,840	79	5.6	5.0	$ 0.27	$ 0.08	$ 0.13	$ 0.03	$ 0.00	$ 0.59
IP Segment 13	29,620	124	8.9	5.0	$ 2.01	$ 0.12	$ 0.48	$ 0.08	$ 0.03	$ 3.85
Cape Horn to Coquitlam (Metro, Squamish, Whistler, VI)	163,280	224	16.0	5.1	$ 11.08	$ 0.27	$ 1.76	$ 1.77	$ 0.16	$ 19.57
Port Mann to Cape Horn	163,280	224	16.0	5.1	$ 11.08	$ 0.27	$ 1.76	$ 1.77	$ 0.16	$ 19.57
Nichol to Port Mann (Metro, Valley, Squamish, Whistler, VI)	172,572	222	15.8	5.0	$ 11.68	$ 0.31	$ 1.78	$ 1.87	$ 0.17	$ 20.55

Location: "Residual" Consequences	Outages	Time Required (hours)	Time Required (Days)	Max Repair or Shutdown Time (days)	Field Tech Cost	Training Cost	Expenses	Support	Purge Cost	Total Cost*
Nichol to Roebuck (Metro & Valley) ¶S D R	81,300	191	13.6	5.0	$ 5.68	$ 0.23	$ 0.98	$ 0.91	$ 0.08	$ 10.23
Roebuck to Delta ¶S D R	81,300	191	13.6	5.0	$ 5.68	$ 0.23	$ 0.98	$ 0.91	$ 0.08	$ 10.23
Delta to Tilbury ¶Ds R	58,690	156	11.2	5.0	$ 4.25	$ 0.23	$ 0.86	$ 0.68	$ 0.06	$ 7.90
Tilbury to Fraser ¶R	44,200	135	9.7	5.0	$ 3.34	$ 0.23	$ 0.79	$ 0.53	$ 0.04	$ 6.41
Fraser Gate Station to Coquitlam Gate Station IP System										
IP Segment 1	0	0	0.0	0.0	$ -	$ -	$ -	$ -	$ -	$ -
IP Segment 2	0	0	0.0	0.0	$ -	$ -	$ -	$ -	$ -	$ -
IP Segment 3	0	0	0.0	0.0	$ -	$ -	$ -	$ -	$ -	$ -
IP Segment 6	0	0	0.0	0.0	$ -	$ -	$ -	$ -	$ -	$ -
IP Segment 7	0	0	0.0	0.0	$ -	$ -	$ -	$ -	$ -	$ -
IP Segment 10	2,840	79	5.6	5.0	$ 0.27	$ 0.08	$ 0.13	$ 0.03	$ 0.00	$ 0.59
IP Segment 13	0	0	0.0	0.0	$ -	$ -	$ -	$ -	$ -	$ -
Cape Horn to Coquitlam ¶¶ C Sq W VI	121,880	184	13.1	5.0	$ 8.42	$ 0.27	$ 1.53	$ 1.35	$ 0.12	$ 15.20
Port Mann to Cape Horn ¶¶ C Sq W VI	121,880	184	13.1	5.0	$ 8.42	$ 0.27	$ 1.53	$ 1.35	$ 0.12	$ 15.20
Nichol to Port Mann ¶¶ S C Sq W VI	131,172	199	14.2	5.0	$ 10.19	$ 0.28	$ 1.65	$ 1.63	$ 0.13	$ 18.04

* Total Cost includes additional 30% contingencies. Outages and costs for IP Segments 4, 5, 8, 9, 11, & 12 are nil in the "As Is" and "Residual" consequences.

¶: Residual impacts are after 20" Metro IP system upgrade installed; in Nichol-Fraser these include portions of Surrey-S, Delta-D, South Delta-Ds, & Richmond-R ONLY;
171,000 IP customers experience no consequences

¶¶: Residual impacts are after 20" Metro IP system upgrade installed; in Nichol-Coquitlam these include portions of Valley (in Surrey & Coquitlam-C), Squamish-Sq, Whistler-W & Vancouver Island-VI ONLY;
41,400 IP customers experience no consequences

Source: FEI.

Annex C – Selected Disruptions to Energy Services in Canada

This Annex provides supplementary information related to natural gas and electricity disruptions in Canada (Table C1).

Natural Gas Disruptions

The Transportation Safety Board of Canada (TSBC) whose mandate is to advance marine, pipeline, rail, and air transportation safety is currently (July 2014) investigating two natural gas pipeline rupture incidents: the most recent at Otterburne, Manitoba (January 2014); and another at Buffalo Creek near Wabasca, Alberta (October 2013). In the Otterburne incident, a TransCanada pipeline rupture affected 4,000 households south of Winnipeg, with natural gas outages lasting as long as 72 hours and complicated by falling temperatures. The Wabasca rupture cut critical natural gas supplies to four oil sands producers near Fort McMurray, Alberta; local residents were unaffected.

Over the past decade, various other natural gas pipeline ruptures have been investigated by TSBC. However, most have occurred in low or sparsely populated areas, affecting no more than 1000 surrounding residents in any one incident. These include ruptures on Westcoast Energy pipeline near Buick, BC (28 June 2013); and another near Wonowon, BC (23 June 2012). Ruptures on TransCanada Pipelines occurred near Beardmore, ON (19 February 2011), near Marten River, ON (26 September 2009), Englehart, ON (9 December 2009), and near Brookdale, Manitoba (14 April 2002).

Electrical Power Disruptions

In contrast to natural gas, power outages due to electrical power disruptions have affected a large number of households in Canada. Winter conditions in particular frequently disrupt electrical power supply in areas of central and eastern Canada. Most recently (20-23 December 2013) an ice storm affected several areas of southern Ontario and Quebec, the Maritime Provinces, and parts of the northeastern US. In Michigan, the cost to Consumers Energy of restoring power to 390,000 customers was US$48 million. Also in Michigan, DTE Energy spent US$36 million restoring power to its 210,000 customers. In Toronto, power restoration was expected to cost Toronto Hydro about $10 million. In Michigan, both power utilities have recourse to insurance. In the Toronto case, the city called on the provincial government for financial assistance from Ontario's Disaster Relief Assistance Program.

Although winter weather routinely affects electrical supply in parts of Canada, the largest electrical power outage in North American history occurred 14 August 2003. In this summertime case, an Incident Analysis in 2006 found that numerous related causes (shortage of reactive power, voltage problems and flow patterns) triggered a collapse of the Eastern Interconnect electrical grid.[13] The resulting power failure impacted a wide range of critical infrastructure and emergency management sectors, while affecting some 50 million people over 24,086 km^2, in Central Canada and the United States.

[13] Public Safety and Emergency Preparedness Canada. 2006. Incident Analysis Ontario–US Power Outage: Impacts on Critical Infrastructure. The incident analysis is based on investigations by the North American Electricity Reliability Council and the Canada-US Power Outage Task Force.

The impact of the August power outage and ensuing power restrictions is estimated to have reduced Ontario's GDP by 1.4%. The outage negatively impacted 82% of small businesses in Ontario; and there was a net loss of 18.8 million work hours in Ontario and Gatineau, Quebec.[14] The economic impact of the power outage is estimated to have cost Ontario's economy between $1 billion and $2 billion.

With respect to power provision and use during the August 2003 electrical grid collapse, impacts on the affected regions can be summarized as follows:

- The sources and means of generating, transmitting and distributing power were significantly curtailed.
- Hydroelectric, fossil fuel (both oil and gas), and nuclear generating plants took varying amounts of time to resume electricity production.
- Backup generators and fuel supplies became critical in maintaining essential services.
- Major industrial and commercial energy users reduced consumption.
- The ability of the oil and gas sector to manufacture or transport its products was hindered.

With respect to natural gas, the maintenance of natural gas supply and its transportation to customers relies on the functionality of operation centers, the availability of electrical power supply, and telecommunications. To the extent that local natural gas utilities were without backup power generation capacity, the distribution of natural gas to end-users was affected. Without adequate backup power for utility systems normally reliant on electrical power (flow and pressure monitoring systems, valve control systems, etc.), natural gas distribution is compromised during an electrical power outage. During the August 2003 electrical power outage, natural gas demand in the affected areas did in fact fall. However, the reduced natural gas demand did not affect the broader national natural gas distribution system. Processed natural gas that could not be delivered to customers in the affected areas went into storage at EnCana's AECO-C Hub in Alberta and Duke Energy Union–Dawn hub in southern Ontario.[15]

[14] Statistics Canada (2003).

[15] Reported by the Canadian Association of Petroleum Producers (CAPP) in the Incident Analysis, ibid.

Table C1 Outages Related to Natural Gas and Electricity Disruptions

Energy Disruption	**Location**	**Selected Impacts**	**Deployment of Emergency Resources**
Natural Gas Outage 25-27 Jan 2014 Explosion – TransCanada Pipeline near Otterburne, Manitoba	50 km south of Winnipeg 9 communities affected 4 Rural Municipalities affected 4 Local Emergency Centres established & 2 warming shelters	About 4000 households w/o NG supply. State of Emergency declared by rural municipality of Hanover: temperatures to -20C. Outage lasting 24-72 hr; after 36 hr natural gas restored to half of households. Increased demand on electrical power system. Schools, businesses closed.	~200 Manitoba Hydro staff working 24/7 to restore natural gas service. LNG tanker trucks at all health care facilities; an additional 9 such trucks supplied gas to rural communities. Communities prioritized by local authorities for warming shelters.
Electricity Outage 20-23 Dec 2013 Ice storm	Areas of Ontario, Quebec, the Maritime Provinces, the Northeastern US, New York and Michigan	At the height of the storm: 350,000 Torontonians w/o power and 600,000 in ON. Elsewhere in Canada: about 50,000 households in QB; 53,000 in NB; and 12,000 in NS were without power. In the US: nearly 600,000 households without power. Six days after the storm, 42,000 households in Toronto, QB and NB remained without power. Gas leak emergency in Pt Hope when show plough sheared-off a Union Gas gas meter.	Ontario: around the clock warming centers for lodging and food. Ontario Hydro: Technical crews came in from Ottawa, Windsor, Michigan and Manitoba. Quebec Hydro: 500 technicians deployed to restore power. Michigan: Consumers Energy deployed 598 technical personnel. Enbridge Gas Distribution (EGD): received high volume of calls for appliance relighting, although EGD reported that its system was operating normally during the winter storm. Union Gas: Port Hope firefighters and utility employees capped and repaired the gas leak.
Electricity Outage 14 Aug 2003 Eastern Interconnect Grid overload	Ontario, and states of NY, Ohio, PA, NJ, Vermont, Connecticut MI	Largest outage in North American history 24,000 km^2 & 50 million people 16 Aug 95% restored 23 Aug grid normal	ON & QB: 713,000 workers put in 7.5 million hours of overtime. In utilities alone, 122,000 hours of overtime was added to work schedules; daily hours for overtime utility workers during second half of August averaged 19.4 hr/d.

Appendix A-6

DR. FLYNN - ASSESSING THE CAPACITY OF THE PARKWAY WEST PROJECT - UNION GAS

Assessing the Capacity of the Parkway West Project to Address a Major Vulnerability to a Critical Infrastructure

by

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Assessing the Capacity of the Parkway West Project to Address a Major Vulnerability to a Critical Infrastructure

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I. Executive Summary:

When a company provides an essential service to the public, its responsibilities extend beyond ensuring that its facilities, systems, and networks are safe, secure, and adequately maintained. As the aftermath of Superstorm Sandy has made clear, when something as important to a community as energy is at stake, the hard and soft infrastructures that supply a critical service must be made resilient.[1] Resilient infrastructure, in turn, should have: (1) designed features that allow it to withstand disruptive events, (2) redundancies that allow continuity of essential function during disruptive events even when individual parts fail, and (3) the capacity to rapidly restore essential functions in the face of major disruptive events.

Constructing resilient systems requires making upfront investments for addressing possible future contingencies. As such it serves a purpose that is analogous to insurance. Infrastructure that is built to ride out and bounce back from predictable and unpredictable shocks lowers the risk of catastrophic economic consequences. Beyond that, it also mitigates the risk of loss of life and suffering in the face of natural and man-made disruptive events.

Union Gas Limited's proposed Parkway West Project is a responsible and appropriate investment in critical infrastructure resilience. Based on my November 2012 field visits to the Dawn Hub and the Parkway Compressor Station and interviews with Union Gas company managers, it is my expert opinion that Union Gas has applied the correct resilience analysis in identifying the need to add Loss-of-Critical-Unit compression that will be located at a new site near the current Parkway facility.

Resilience analysis begins by assessing the current and projected need for the critical service a system provides. A reliable supply of natural gas to the Greater Toronto Area and Ontario is already vital to the economy and the region's public welfare. Changes underway in the flows of natural gas in Ontario and rising demand for its use in electric power generation and other services will only elevate the importance of having uninterrupted access to natural gas in the future.

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[1] In the aftermath of Hurricane Sandy, New York City Mayor Michael Bloomberg has launched a taskforce to identify "Special Initiatives for Rebuilding and Resiliency (SIRR)" with the goal of making city-wide infrastructure more resilient. New York Governor Andrew Cuomo established a NYS 2100 Commission co-chaired by Judith Rodin, President of the Rockefeller Foundation and Felix Rohatyn, that drafted a report recommending a 21st Century resilience strategy to inform the rebuilding of New York after Hurricane Sandy. http://www.rockefellerfoundation.org/uploads/files/7c012997-176f-4e80-bf9c-b473ae9bbbf3.pdf.

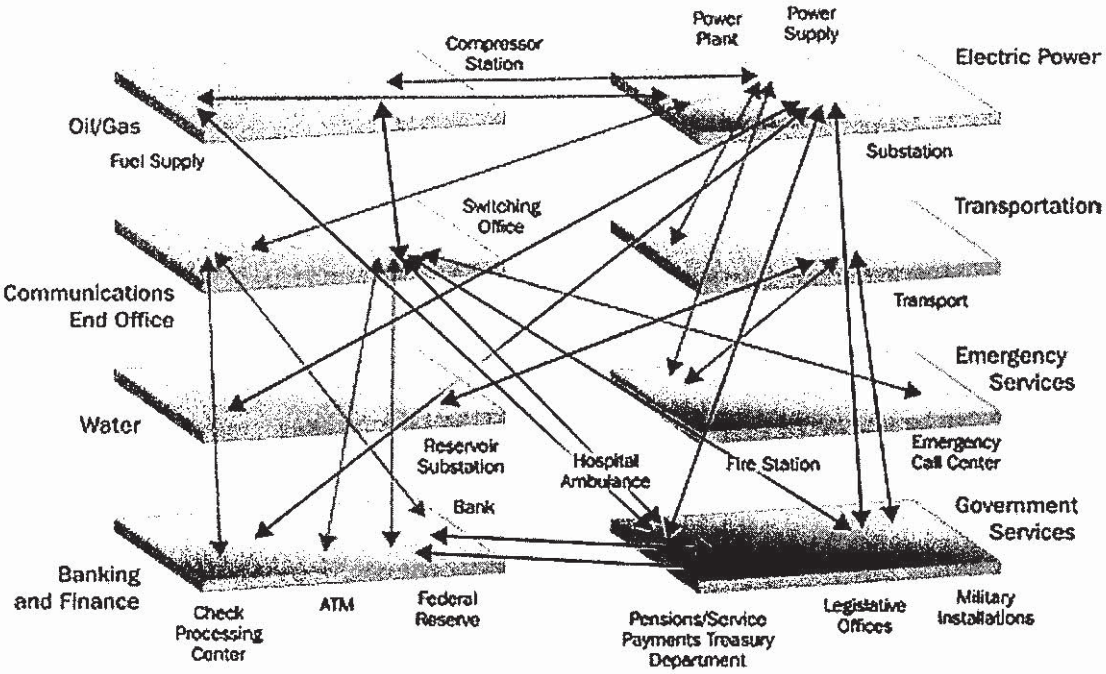
Resilience analysis next evaluates a critical system to determine if there exist vulnerabilities that could generate a major disruption. Union Gas has identified that unlike in the rest of the Dawn-Parkway transportation system, there is not sufficient redundancy at Parkway Compressor Station to meet compression needs in the event of an outage in compressor Unit A or Unit B. As the Parkway Compressor Station is situated at the end of the line of the transmission system, the consequence of a major outage at Parkway would be disastrous, particularly if it occurred in the wintertime. Hundreds of thousands of residents in the Greater Toronto Area could be left without natural gas for the many weeks or even the several months it will take to make the repairs required to restore sufficient compressor horsepower to distribute gas to homes and businesses in the region.

The final step of resilience analysis is to identify measures that would both reduce the system's vulnerability to predicted disruptive risk and help assure the rapid restoration of service in the event of an unpredicted disruption. The proposed Parkway West Project would address the need to match the appropriate level of redundancy that is embedded elsewhere in the Dawn-Parkway transportation system. Time is of the essence in getting this project underway as it will take at 2-3 years to complete.

II. Introduction

One of the central lessons of Superstorm Sandy is that inadequate investments in the resilience of energy, transportation, communications, and other infrastructure have real consequences. When these systems fail under stress, the inevitable results are costly societal and economic dislocations. A breakdown in the reliability of the energy sector is particularly disruptive, especially electric power outages and the loss of access to fuel supplies. Every major infrastructure sector is important, but there is little that can keep operating when the lights go out. Similarly, when fuel is not available to run back-up generators and vehicles, even emergency services can be compromised. (See Figure 1) And when temperatures drop and homes are unheated, people are displaced and the safety of the most vulnerable populations—the elderly, the young, the indigent, and the disabled—is jeopardized.

Figure 1: POTENTIAL CASCADING EFFECTS OF ENERGY SECTOR FAILURE



Source: Department of Homeland Security[2]

The complex interdependencies among energy and other infrastructure sectors necessitates that company managers and regulators engage in a well-considered assessment of the cost-benefit trade offs associated with resilience measures. This is

[2] National Aeronautics and Space Administration. NASA Science News. Severe Space Weather – Social and Economic Impacts. June 2009 at http://science.nasa.gov/science-news/science-at-nasa/2009/21jan_severespaceweather/

because decisions about how much to invest in mitigating risk involve not just direct costs to the energy sector, but also potential high indirect costs to other sectors. Indeed these indirect costs to the community at large can be many orders of magnitude higher than the losses faced by the energy utilities. For instance, according to the National Academies in Washington, D.C., the economic cost of the August 2003 electrical blackout that struck the Midwest, the Northeast, and parts of Canada "came to approximately $5 per forgone kilowatt-hour, a figure that is roughly 50 times greater than the average retail cost of a kilowatt-hour in the United States."[3] Following Superstorm Sandy, electric utilities in northeastern United States have come under fire for engaging in the common practice of forgoing the expense of putting in place prevention measures that would protect their equipment, and just repairing damages afterwards. Phillip Jones, president of the National Association of Regulatory Utility Commissioners acknowledge this in December 2012, noting: "We need to think now of not just restoring the grid, but how to make it more survivable." [4] This is because the aftermath of the storm highlighted that "the true cost of disruptions, in terms of gasoline lines, lost workdays and business sales, and shivering homeowners, is far higher than the simple dollars and cents spent to protect the power system." [5]

The renewed focus on resilience has helped to identify a generally overlooked risk associated with placing too much emphasis on maximizing efficiency to achieve cost savings: systems have the potential to fail very badly when faced with shocks. Efforts to trim costs typically involve identifying and reducing any excess capacity in a process or system. For example, in the area of logistics, the objective of reducing the cost of maintaining stockpiles of supplies and retail goods has led to a revolution in manufacturing and retail. Goods now arrive "just-in-time," thereby eliminating the need for storage rooms, warehouses, and excess supplies. Individual products or components, in turn, are often provided by only a small number of international suppliers who are best able to produce a quality product at the most competitive price. These efficiencies make customers and shareholders happy right up until when things go wrong and the source of goods is disrupted. As demonstrated by the Tohoku earthquake and tsunami in the March 2011 that led to the Fukushima Daiichi nuclear disaster, a local disaster can have immediate global effects. When factories near Fukushima were closed, many assembly lines around the world quickly went idle for the want of essential components. [6]

The emphasis on efficiency is rewarded under normal conditions because it brings with it lower costs. But efficient systems may end up having inadequate spare capacity to deal with an unexpected outage with very painful and expensive outcomes. Deciding where the line should be drawn with regard to maintaining or building in redundancy in order to assure reliability is a factor of both the probability of disruptive events and the

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[3] "The Electric Transmission and Distribution System as a Terrorist Target." *Terrorism and the Electric Power Delivery System*. Washington, D.C.: National Academies, 2012. 16.
[4] D. Cardwell, M. Wald, and C. Drew, "Hurricane Sandy Alters Utilities' Calculus on Upgrades," *The New York Times* (Dec 28, 2012), http://www.nytimes.com/2012/12/29/business/hurricane-sandy-alters-utilities-calculus-on-upgrades.html?emc=eta1.
[5] Ibid.
[6] Behzad Behdani, "Japanese Catastrophe and the Dark Side of Global Supply Chains." http://www.nextgenerationinfrastructures.eu/images/Japanese%20Catastrophe%20and%20the%20Dark%20Side%20of%20Global%20supply%20Chains%20(1).pdf.

consequence of the system failing. If those consequences are likely to be high in terms of economic and human costs, even a low probability event will require paying close attention to ensuring there is adequate resilience.

Constructing resilient systems inevitably involves making upfront investments for addressing potential future contingencies. As such it serves a purpose that is much like the purchase of an insurance policy. It involves committing to spending some funds now in order to advert the risk of catastrophic losses later on. In the case of infrastructure, investing in resilience also mitigates the risk of loss of life and suffering in the face of natural and man-made disruptive events.

IV. The Role of the Parkway West Project in Bolstering Resilience

In November 2012, I conducted field visits to the Parkway Compressor Station and the Dawn Hub. I also visited the Union Gas headquarters in Chatham, Ontario for interviews with senior managers who are responsible for the company's operations, maintenance, and strategic planning. Based on these field visits and interviews, my assessment is that Union Gas Limited's proposed Parkway West Project is a responsible and appropriate investment in critical infrastructure resilience. I have reached this conclusion based on my finding that Union Gas has applied the correct resilience analysis as the basis for recommending the purchase and construction of Loss-of-Critical-Unit compression at a new station near the current Parkway facility.

Step 1: Assessing the Current & Projected Need for Additional Natural Gas Compression

Resilience analysis begins by assessing the current and projected need for the critical service a system provides. A reliable supply of natural gas to the Greater Toronto Area and Ontario plays an essential role in the province's economy and the region's public welfare. This is true today, and that need is only expected to grow in time.

More than two-third's of the Ontario homes use natural gas as their main heating fuel.[7] According to Union Gas, in the Greater Toronto Area approximately 80 percent of the residences and commercial businesses depend on natural gas. So too do most schools, nursing homes, and hospitals. Due to demographic and health care trends, there are a rising number of elderly people living independently in their homes, some of which are reliant on medical devices that were once available only in hospital settings. This vulnerable population is especially dependent on a reliable supply of heat and electricity.

In January the average temperature for Toronto is -6 °C. [8] An extended outage of natural gas can quickly make homes unlivable during the winter months to include the loss of water or water damage associated with the danger of freezing pipes. If an outage leads a small business to close its doors for more than 10 days, it may never fully recover financially. According to the *Insurance Institute for Business and Home Safety*, an estimated 25 percent of small businesses disrupted due to a disaster do not reopen. [9]

While small businesses are important consumers of natural gas, Ontario is also home to many large energy-intensive businesses as well. These include major manufacturing plants that produce the province's leading international exports including motor vehicles and parts, mechanical equipment, and electrical machinery. [10] One key to Ontario's ability to sustain a projected growth in real exports at an average of 3 percent per year

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[7] Statistics Canada, "Type of main heating fuel used, by province, 2007" http://www.statcan.gc.ca/pub/11-526-s/2010001/t002-eng.htm

[8] http://gocanada.about.com/od/canadiancities1/p/dec_in_toronto.htm

[9] "Every Business Should Consider a Risk and Vulnerability Assessment," The Institute for Business & Home Safety (IBHS). See http://www.disastersafety.org/commercial_maintenance/commercial-vulnerability-assessment_ibhs/.

[10] "Top Five International Exports, 2011." See http://www.fin.gov.on.ca/en/economy/ecupdates/factsheet.html

over the next two decades [11] will be that the province is able to maintain reliable access to relatively low-cost energy supplies. As such, natural gas will figure prominently in sustaining the competitive position of Ontario's major industries.

The importance of having a reliable system for providing natural gas in Ontario is elevated by its growing use as a lower-emission energy source. For instance, natural gas is playing more of a role in electricity generation as a part of Ontario's plan to eliminate coal as a source of electricity production in the province by the end of the 2014. Approximately one-fifth of the province's electric power will be generated by natural gas. [12] Three major power plants in the Toronto area that lie east of the Parkway Compressor Station are gas-fired: Goreway Power Station (875 MW), Portlands Energy Centre (550 MW), and York Energy Centre (393 MW). These plants depend on the supply of gas that is delivered in part by the compressor units operating at the Parkway Compressor Station. If there were a major interruption to the operation of the Parkway Compressor Station, the resultant loss of generation capacity could place significant stress on the electric grid especially if it is operating at or near full capacity, as is often the case during hot summer days. The consequences of a power outage that is triggered by a disruption in the distribution of gas would be potentially compounded because so many back-up generators in the Greater Toronto Area are also fueled by natural gas.

There are also changes underway in the flows of natural gas in Ontario that will increase the tempo of operations of the Union Gas transportation system. Union Gas projects a dramatic increase in gas flowing through the Parkway Compressor Station as the patterns in the supply of natural gas to Ontario shift from western Canada to the neighboring Marcellus and Utica shale gas basins that lie to the south and east. At the same time, there is rising demand for natural gas in the Greater Toronto Area, northern and eastern Ontario, Quebec and northeastern United States. According to Union Gas estimates, by 2015, Parkway compressors will need to flow 3.4 PJ of gas or the energy equivalent of 40,000 MW of electricity on a winter day. Total daily deliveries on peak days are likely to reach 4.67 PJ of gas or the energy equivalent of 50,000 MW of electricity.[13]

To summarize, natural gas plays an important and growing role in the economy of Ontario. The reliance of the vast majority of the province's residences, particularly in the Greater Toronto Area, including vulnerable populations such as the elderly, make the reliable distribution of natural gas a critical service particularly during the winter months. This distribution, in turn, depends increasingly on the operations of the Union Gas' Dawn-Parkway System, which provides the majority of the supply of natural gas to the Greater Toronto Area.

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[11] "Composition of the Domestic Economy," in Ontario's Long-Term Report on the Economy (2010). See http://www.fin.gov.on.ca/en/economy/ltr/2010/ch2.html#ch2_4

[12] Christa Marshall, "Ontario Phases Out Coal-Fired Power" (Jan 11, 2013) See http://www.scientificamerican.com/article.cfm?id=ontario-phases-out-coal-fired-power

[13] Mark Isherwood, "Reshaping Ontario's Natural Gas Infrastructure: Connecting New Supply to Liquid & Growing Markets," LDC Gas Forums, Nov 13, 2012. See http://www.uniongas.com/storagetransportation/communications/presentations/ldcgasforum2012/index.asp.

Part 2: Analyzing for Vulnerabilities that Could Generate a Major Disruption to Natural Gas Distribution

The second step of resilience analysis is to evaluate a critical system to determine if there exist potential vulnerabilities that could lead to a major disruption. Of all the components of the Dawn-Parkway Transportation System, the failure of the Compressor Unit B at Parkway Station would be the most consequential contributor to disrupted gas service in the Greater Toronto Area. Should an accident, disaster, or sabotage result in Unit B experiencing damages that requires the unit to be replaced, there is a potential for a multi-month disruption in the distribution of natural gas in the Greater Toronto Area and to markets downstream.

The Dawn-Parkway System has an extraordinary record of reliability. The system is made up of a 23 storage pools connected to Dawn, four interconnected pipelines and 11 compressor units. This infrastructure moves more than 23.8 billion cubic meters of gas annually and that volume is expected to grow as the region requires more natural gas year round. According to Union Gas, the company has successfully maintained a 99.98 percent rate of reliability. Importantly, this impressive record has been achieved even though the major components of the system are available only 83 percent of the time. (They must be routinely taken out of service to allow technicians to perform scheduled maintenance). Close adherence to preventative maintenance routines has resulted in an impressive 95.4 percent reliability for these major components. But that still leaves 4.6 percent of the time when equipment failures and accidents lead to unplanned major component outages. The near perfect overall reliability is explained by Union Gas' longstanding practice of engineering sufficient redundancy throughout the system to allow it to continue to provide an adequate supply of gas even when there is an outage in any one major unit.

Recent and projected changes in natural gas transportation flows and demand patterns have led Union Gas to conduct a comprehensive assessment of the risk to the reliability of the Dawn-Parkway Transportation System. This assessment has revealed the Parkway Compressor Station, located at the end of its system, to be the weakest link. For the Parkway compressors to support the flow of an estimated 3.4 PJ per day of gas by 2015, and for them to be able to meet the rising demand for natural gas to support electric power generation, Compressor Unit A and Compressor Unit B have to increasingly work in parallel. This translates into a loss of redundancy. Under these circumstances, should there be a loss of the larger of the two compressors, it could lead to disruption of natural gas distribution to Torontonians for several weeks or months during peak winter conditions.

While the loss of a compressor unit at Parkway is a modestly low probability, it is by no means a zero probability, and the risk may potentially rise with time. This can be attributed to three major sources of risk.

Mechanical Failure:

Parkway Compressor Unit A delivers 20,000 HP of compression and Unit B delivers 44,500 HP of compression. Unit A is a quarter-century old while Unit B is just over 5 years old. These compressor units consist of two very sophisticated pieces of machinery: a *Rolls Royce* natural gas turbine engine and a centrifugal compressor. The turbine is very similar to the engine that powers a modern commercial airliner. Just as with any complex piece of machinery, there is always a potential for mechanical problems. For instance, there might be a destructive surge due to a failure of a control or valve. Filters can become clogged or the spare parts used in overhauls may contain flaws that are overlooked by the manufacturer. Whatever the source, should there be a catastrophic failure of the turbine or the centrifugal compressor, it can potentially take over one-year to replace. These units are custom-built and the manufacturer maintains no spares. Conducting major maintenance on the Parkway compression units is also likely to become more challenging as the year-round demand for natural gas flow through compression continues to rise. When both compressor Unit A and Unit B must operate in parallel to meet demand, technicians may struggle to find sufficient time when a unit can be taken offline to perform necessary and laborious overhaul work that typically requires many days to complete.

Accidents that cause major disruptions to natural gas transportation systems do happen as the Feb 19, 2011 explosion of the TransCanada Pipeline in Beardmore, Ontario made clear. That explosion led to a major outage of TransCanada's mainline system, a conduit that links natural gas fields in Alberta with points in central Canada and terminates at the Quebec-New Hampshire border. The explosion created a large crater and three pieces of pipe broke from the system, with pipe and other debris being ejected up to 100 m from the rupture site. Line No. 2 of the three-tube system exploded and burned for about eight hours even though operators were able to quickly close valves from a remote control room. The pipeline failure occurred in a double-submerged arc-welded pipe that was laid in 1972. It was not restored to service until August 23, 2011. Line 3 remained out for six days. Line 1 was out for 10 hours. [14]

Extreme Weather:

The risk of major natural disasters in Ontario is relatively modest when compared to other regions of North America. But the region is not immune to extreme weather events that could pose a risk to the infrastructure of the Dawn-Parkway System. Hurricane Hazel in 1954 demonstrated that while Ontario is very far inland, it can still be struck by a powerful extratropical storm. As occurred recently with Hurricane Sandy, Hazel became such a destructive inland storm because it merged with an existing powerful cold front. This caused the storm to stall over the Greater Toronto Area with the strength of a Category 1 hurricane. The deluge of rain led to rivers and streams overflowing their

[14] Transportation Safety Board, Pipeline Investigation Report P11H0011 (2011). See http://www.tsb.gc.ca/eng/rapports-reports/pipeline/2011/p11h0011/p11h0011.asp

banks throughout the region. There were 81 fatalities and over 50 bridges, sections of highway, roads, and railways were destroyed. [15]

The North American Ice Storm of 1998 highlighted another weather risk to the region. While the storm reached only Eastern Ontario, including Ottawa and Kingston, it demonstrated the havoc that can be caused by freezing rain. [16] Electrical infrastructure is particularly vulnerable, but any mechanical equipment that is exposed to the elements is at risk for being damaged. While the most important machinery involved with natural gas transportation and distribution is largely sheltered, some equipment must be open to the environment. For instance, air filters, can be damaged by weather events, which can compromise the operation of compression units.

Another potential weather risk for the Parkway Compressor Station is from a tornado. While tornadoes are small in scale, they can cause deadly destruction to whatever lies in their path. Prior to the 1970s, it was believed that tornadoes were rare events in Canada, but they are now understood to be relatively common with an average of 70 per year striking populated regions. One-third of all the tornadoes in Canada occur in Ontario. The risk is greatest in southern Ontario where seven of the nine F4-strength tornadoes that have been recorded in Canada have taken place. [17]

The risk of extreme weather must be placed against the backdrop of climate change. Increasingly, the past is not a useful guide. The overwhelming consensus among scientists is that the climate has changed.[18] Global warming is making Mother Nature more mischievous, resulting in weather events that are more frequent and extreme.

Malicious Acts:

While low probability, the risk of deliberate attacks on Parkway Compressor Station cannot be ruled out. Acts of sabotage against energy infrastructure became commonplace during the Iraq War. Between January 2004 and March 2006, insurgents carried out attacks on oil and gas pipelines that cost Iraq more than $16 billion in lost oil revenue. For much of the Iraq War, successful insurgent attacks on the electrical grid kept Iraq's average daily output at 5 to 10 percent below prewar levels despite the $1.2 billion that the United States spent to improve the country's electrical production. The terrorist skills acquired in Iraq have been catalogued and shared in Internet chat rooms. In addition,

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[15] Peter Bowyer, Remembering Hurricane Hazel. Canadian Hurricane Centre, (2004). See http://www.ec.gc.ca/ouragans-hurricanes/default.asp?lang=En&n=4343267B-1

[16] "Ice Storm of the Century," Environment Canada. See http://www.ec.gc.ca/meteo-weather/default.asp?lang=En&n=3DED7A35-1#t1

[17] "Major Tornadoes," The Atlas of Canada. Natural Resources Canada. See http://atlas.nrcan.gc.ca/site/english/maps/environment/naturalhazards/naturalhazards1999/majortornadoes/1

[18] IPCC (2007) Climate change 2007 (Intergovernmental Panel on Climate Change). In: Solomon S, Qin D, Manning M, Chen Z, Marquis MC, Averyt KB, Tignor M, Miller HL (eds) The physical science basis. Cambridge University Press, Cambridge, p 996

when foreign insurgents returned to their native lands, they brought back with them the experience of successfully targeting complex energy infrastructure. [19]

Outside of Iraq, terrorists have struck at energy infrastructure in Saudi Arabia including a thwarted attack on its largest oil refinery by two pick-up trucks driven by suicide bombers in February 2006. [20] More recently, on January 16, 2013, jihadist militants attacked the Amenas natural gas plant operated by BP in Algeria, and took dozens of hostages. According to Algerian Prime Minister Abelmalek Sellak, at least one of the militants may have been Canadian, an assertion that the Canadian government is currently investigating. [21]

One final potential scenario given the Parkway Compressor Station's proximity to Toronto Pearson International Airport, is that the facility could be damaged by a fuel-laden plane crashing into the facility, either intentionally as in the 9/11 attacks, or by a freakish aviation accident.

Part 3: Identifying Measures That Reduce the Dawn-Parkway System's Vulnerability to Disruption

The final step in resilience analysis is to identify measures that would both reduce the system's vulnerability to predicted disruptive risk and help assure the rapid restoration of service in the event of an unpredicted disruption. The proposed Parkway West Project would address this resilience imperative by insuring that there is a Loss-of-Critical-Unit available at all times to meet the gas compression needs of the Greater Toronto Area should Unit A or Unit B sustain major damage as a result of an accident, a disaster, or an act of sabotage.

The proposed investment in a Loss-of-Critical-Unit (LCU) at the Parkway Compressor Station is consistent with Union Gas's longstanding practice. Such units are in place at the other major facilities in the Dawn-Parkway system and have played an important role in achieving and maintaining the system's overall 99.98 reliability record. If the operations tempo at Parkway did not need to grow to support the rising demand for natural gas, a case could possibly be made for having Unit B assume the role of LCU during non-peak periods. But it is during peak periods when system reliability is most important, and those periods are become more frequent and of longer duration. The best way to assure the reliable distribution of natural gas to the Greater Toronto Area is to invest in an additional compressor unit to support the Parkway Station.

Locating the compressor LCU at a new facility located away from the existing Parkway Compressor Station is also an appropriate and desirable measure for advancing resilience.

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[19] Stephen Flynn, *The Edge of Disaster: Rebuilding a Resilient Nation*, (New York: Random House, 2007): 95.

[20] "Saudi Arabia: Terror Attack on Oil Refinery Foiled." *Free Republic* (March 26, 2006). See http://www.freerepublic.com/focus/f-news/1606030/posts

[21] A. Nossitier and E. Schmitt, "Algeria Defends Tough Response to Hostage Crisis as Toll Rises," The New York Times (Jan 21, 2013). See http://www.nytimes.com/2013/01/22/world/africa/algeria-hostage-siege.html?hp

This is for two reasons. First, it helps to mitigate the risk of disruption should there be major accident that damages Parkway Station. These include such low-probability but high-consequence risks as a tornado or an aircraft crashing into the facility. Second, it also has a beneficial effect in reducing the risk that terrorists might find Parkway Compressor Station to be an attractive target. This is because when compression capability is in two locations instead of just one, it requires a far more sophisticated effort to achieve the goal of disrupting natural gas distribution. Successfully going after two targets simultaneously is likely to overtax the capabilities of all but the most capable terrorist organizations. As a result, redundancy ends up providing a measure of deterrence since the primary rationale for an adversary to consider attacking critical infrastructure in the first place is to cause mass disruption on the targeted society. If an attack on infrastructure cannot achieve the goal of undermining a critical service, there is little value in carrying out that attack.

V. **Conclusion:**

In a world where disasters are becoming more frequent and intense, the competitive advantage will lie with those companies and communities that are best able to provide a continuity of critical services in the face of disruptive events. People will want to live and work, and investors will want to invest in places that are resilient. They will gravitate away from those locations that cannot provide essential needs in the face of known and unknown risks.

Over the past century, North America generally and Ontario specifically has built an impressive track record of reliably meeting the economic and social needs of their citizens. This includes having the infrastructure in place to make affordable energy consistently available to heat and power homes and operate businesses. By bolstering the resilience of the Dawn-Parkway System, the proposed Parkway West Project will make a helpful contribution to continuing that tradition.

About the Author

Stephen E. Flynn is the Founding Co-Director of the George J. Kostas Research Institute for Homeland Security and Professor of Political Science at Northeastern University.
Dr. Flynn is the author of the critically acclaimed *The Edge of Disaster: Rebuilding a Resilient Nation* (Random House, 2007), and the national bestseller, *America the Vulnerable* (HarperCollins 2004). He is a Senior Research Fellow at the Wharton School's Risk Management and Decision Processes Center at the University of Pennsylvania. Since 9/11 he has provided testimony on twenty-eight occasions on Capitol Hill.

Professor Flynn is one of the world's leading experts on transportation security and infrastructure and community resilience issues. Prior to September 11, 2001, he served as an expert advisor to U.S. Commission on National Security (Hart-Rudman Commission), and following the 9/11 attacks he was the principal advisor to the bipartisan Congressional Port Security Caucus. Dr. Flynn also advised the Bush Administration on maritime and homeland security issues and after the November 2008 election of President Barack Obama, served as the lead policy advisor on homeland security as a part of the presidential transition team. He is currently a member of the Bipartisan Policy Center's Homeland Security Project Panel, co-chaired by former 9/11 commissioners, Governor Tom Kean and Congressman Lee Hamilton.

Prior to his joining the faculty at Northeastern University, Dr. Flynn served as President of the Center for National Policy. He was selected to lead the Center after spending a decade as a senior fellow for National Security Studies at the Council on Foreign Relations. Before that, Dr. Flynn served in the Coast Guard on active duty for 20 years, including two tours as commanding officer at sea. He received several professional awards including the Legion of Merit, and retired at the rank of Commander. As a Coast Guard officer, he was assigned to the White House Military Office during the George H.W. Bush administration and as a director for Global Issues on the National Security Council staff during the Clinton administration. He is a 1982 graduate of the U.S. Coast Guard Academy where he was also a member of the faculty from 1988-1991 and 1994-2002.

Dr. Flynn is a frequent media commentator and has appeared on *Meet the Press*, *60 Minutes*, *The News Hour*, *The Today Show*, the *Charlie Rose Show*, *CNN* and on National Public Radio. Five of his articles have been published in the prestigious journal, *Foreign Affairs*. Excerpts of his books have been featured in *Time*, as the cover story for *U.S. News & World Report*, and as the subject of two *CNN* documentaries.

Flynn received the M.A.L.D. and Ph.D. degrees in International Politics from the Fletcher School of Law and Diplomacy, Tufts University, in 1990 and 1991. He was a Guest Scholar in the Foreign Policy Studies Program at the Brookings Institution from 1991-92, and in 1993-94 he was an Annenberg Scholar-in-Residence at the University of Pennsylvania. In 2009, he received an honorary doctorate of laws from Monmouth University.

Flynn is the principal for Stephen E. Flynn Associates LLC, where he provides independent advisory services on improving enterprise resiliency, critical infrastructure protection, and transportation and maritime security.

SCANDPOWER REPORT

TO BE FILED CONFIDENTIAL

Appendix A-7

CRITICAL INFRASTRUCTURE

(Provided in electronic format only due to
document size and in order to conserve paper)

Appendix A-7-1

GOVERNMENT OF CANADA
NATIONAL STRATEGY FOR CRITICAL INFRASTRUCTURE

(Provided in electronic format only due to
document size and in order to conserve paper)

National Strategy
for Critical Infrastructure

Government of Alberta

British Columbia
www.gov.bc.ca

Manitoba

New Brunswick Nouveau
CANADA

Newfoundland Labrador

Northwest Territories

Nova Scotia
Nouvelle-Écosse

Nunavut

Ontario

Prince Edward Island
CANADA

Québec

Government of Saskatchewan

Yukon
Government

Canada

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Executive summary

The goal of the *National Strategy for Critical Infrastructure* is to build a safer, more secure and more resilient Canada. To this end, the National Strategy advances more coherent and complementary actions among federal, provincial and territorial initiatives and among the ten critical infrastructure sectors listed below:

- Energy and utilities
- Finance
- Food
- Transportation
- Government
- Information and communication technology
- Health
- Water
- Safety
- Manufacturing

The fundamental concepts and principles outlined in this National Strategy flow from the *Emergency Management Framework for Canada*, which sets out a collaborative approach for federal, provincial and territorial emergency management initiatives. Consistent with this Framework, and recognizing the interconnected nature of critical infrastructure, the National Strategy fosters the development of partnerships among federal, provincial and territorial governments and critical infrastructure sectors, advances an all-hazards risk management approach, and sets out measures to improve information sharing and protection.

Critical infrastructure refers to processes, systems, facilities, technologies, networks, assets and services essential to the health, safety, security or economic well-being of Canadians and the effective functioning of government. Critical infrastructure can be stand-alone or interconnected and interdependent within and across provinces, territories and national borders. Disruptions of critical infrastructure could result in catastrophic loss of life, adverse economic effects, and significant harm to public confidence.

The National Strategy supports the principle that critical infrastructure roles and activities should be carried out in a responsible manner at all levels of society in Canada. Responsibilities for critical infrastructure in Canada are shared by federal, provincial and territorial governments, local authorities and critical infrastructure owners and operators – who bear the primary responsibility for protecting their assets and services. Individual Canadians also have a responsibility to be prepared for a disruption and to ensure that they and their families are ready to cope for at least the first 72 hours of an emergency.

Given that disasters most often occur locally, the National Strategy recognizes that, in an emergency, the first response is almost always by the owners and operators, the municipality or at the provincial/territorial level. The federal government fulfils national leadership responsibilities relating to emergency management, respecting existing federal, provincial and territorial jurisdiction and legislation. The federal government is also responsible for providing assistance to provinces/territories if the province/territory has requested the assistance.

The National Strategy is based on the recognition that enhancing the resiliency of critical infrastructure can be achieved through the appropriate combination of security measures to address intentional and accidental incidents, business continuity practices to deal with disruptions and ensure the continuation of essential services, and emergency management planning to ensure adequate response procedures are in place to deal with unforeseen disruptions and natural disasters.

To be effective, the National Strategy must be implemented in partnership among all levels of government and critical infrastructure sectors. Critical infrastructure owners and operators have the expertise and information that governments need to develop comprehensive emergency management plans. In turn, governments will share relevant information in a timely manner, respecting existing federal, provincial and territorial legislation and policies, to help owners and operators assess risk and identify best practices. This partnership approach recognizes that more resilient critical infrastructure helps foster an environment that stimulates economic growth, attracts and retains business, and creates employment opportunities. Governments bring value to the partnership through activities such as:

- providing owners and operators with timely, accurate, and useful information on risks and threats;
- ensuring industry is engaged as early as possible in the development of risk management activities and emergency management plans; and
- working with industry to develop and prioritize key activities for each sector.

The *National Strategy for Critical Infrastructure* represents the first milestone in the road ahead. It identifies a clear set of goals and objectives and outlines the guiding principles that will underpin our efforts to strengthen the resiliency of critical infrastructure. The National Strategy establishes a framework for cooperation in which governments and owners and operators can work together to prevent, mitigate, prepare for, respond to, and recover from disruptions of critical infrastructure and thereby safeguard the foundations of our country and way of life.

1. Purpose

The purpose of the *National Strategy for Critical Infrastructure* (the Strategy) is to strengthen the resiliency of critical infrastructure in Canada. The Strategy works toward this goal by setting the direction for enhancing the resiliency of critical infrastructure against current and emerging hazards.

2. Strategic objectives

With a view to enhancing the resiliency of critical infrastructure in Canada, the objectives of the Strategy are to:

- build partnerships;
- implement an all-hazards risk management approach; and
- advance the timely sharing and protection of information among partners.

3. Context

The *Emergency Management Framework for Canada* defines a collaborative approach to emergency management and establishes a federal, provincial and territorial partnership for enhancing the public safety of Canadians. The Framework identifies principles of cooperation (i.e. responsibility, comprehensiveness, partnerships, coherency of action, risk-based, all-hazards, resilience, clear communications, and continuous improvement) and it recognizes that emergency management is comprised of interdependent risk-based functions: prevention, mitigation, preparedness, response and recovery.

Based on the principles of the *Emergency Management Framework for Canada*, the Strategy presents a collaborative approach to strengthening the resiliency of critical infrastructure in Canada, ensuring that federal, provincial and territorial critical infrastructure activities are complementary and respect the laws of each jurisdiction. Consistent with the principles established in the *Emergency Management Framework for Canada*, the Strategy will be interpreted in full respect of each government's jurisdiction.

Critical infrastructure refers to processes, systems, facilities, technologies, networks, assets and services essential to the health, safety, security or economic well-being of Canadians and the effective functioning of government. Critical infrastructure can be stand-alone or interconnected and interdependent within and across provinces, territories and national borders. Disruptions of critical infrastructure could result in catastrophic loss of life and adverse economic effects.

The *Emergency Management Framework for Canada* defines resilience as the capacity of a system, community or society potentially exposed to hazards to adapt, by resisting or changing in order to reach and maintain an acceptable level of functioning and structure. The Strategy recognizes that defining 'acceptable levels' and the concept of 'criticality' is a matter of relativity. Therefore, the Strategy aims to support a collective approach to managing risks and interdependencies, and establishes a collaborative approach to strengthening the resiliency of critical infrastructure in Canada.

The Strategy is also based on the recognition that enhancing the resiliency of critical infrastructure can be achieved through the appropriate combination of security measures to address intentional and accidental incidents, business continuity practices to deal with disruptions and ensure the continuation of essential services, and emergency management planning to ensure adequate response procedures are in place to deal with unforeseen disruptions and natural disasters.

What are the risks to critical infrastructure in Canada?

The risks are increasingly complex and frequent. They include natural, intentional and accidental hazards. Recent events illustrate the importance of protecting critical infrastructure from all types of hazards: the 1996 Saguenay Flood, the 1997 Red River Flood, the 1998 Ice Storm, the terrorist attacks of September 2001, the 2003 Power Blackout, the 2003 Severe Acute Respiratory Syndrome outbreak, the 2005 London Bombings and Hurricane Katrina.

As the rate and severity of natural disasters increases, so does the possibility that disruptions of critical infrastructure could result in prolonged loss of essential services. The risks and vulnerabilities are heightened by the complex system of interdependencies among critical infrastructure, which can lead to cascading effects expanding across borders and sectors. The implications of these interdependencies are compounded by society's increasing reliance on information technologies.

Why develop a National Strategy for Critical Infrastructure?

As the risks to critical infrastructure cut across jurisdictions and sectors, the Strategy will provide a comprehensive and collaborative federal, provincial and territorial approach to enhancing the resiliency of critical infrastructure. This common approach will enable partners to respond collectively to risks and target resources to the most vulnerable areas of critical infrastructure.

How will the Strategy address international issues relating to critical infrastructure?

Canada will work with the United States and other international governments and organizations to promote a collaborative approach to strengthening the resiliency of critical infrastructure. The Strategy also recognizes that at the regional level, provinces, territories and neighbouring American states have cooperative emergency management arrangements in place. Together, federal, provincial and territorial governments and critical infrastructure sectors will identify and address international dependencies and risks.

4. The Strategy

The Strategy proposes that federal, provincial and territorial governments and critical infrastructure sectors collaborate to strengthen the resiliency of critical infrastructure in Canada. This collaboration will require the development of partnerships that respect jurisdictions and build upon existing mandates and responsibilities. To foster these partnerships, the Strategy outlines mechanisms for enhanced information sharing and information protection and it identifies the importance of a risk management approach to strengthen the resiliency of critical infrastructure in Canada.

The Strategy recognizes that primary responsibility for strengthening the resiliency of critical infrastructure rests with the owners and operators. Federal, provincial and territorial levels of government are also working to protect their own critical infrastructure and to support owners and operators in addressing this challenge.

Enhancing the resiliency of critical infrastructure can be achieved through the appropriate combination of security measures to address intentional and accidental incidents, business continuity practices to deal with disruptions and ensure the continuation of essential services, and emergency management planning to ensure adequate response procedures are in place to deal with unforeseen disruptions and natural disasters.

As the approach to strengthening critical infrastructure resiliency varies across jurisdictions, so too does the classification of critical infrastructure by sector. While recognizing that each province and territory structures its critical infrastructure program as it deems appropriate, at the national level, the Strategy classifies critical infrastructure within the 10 sectors listed below:

- Energy and utilities
- Finance
- Food
- Transportation
- Government
- Information and communication technology
- Health
- Water
- Safety
- Manufacturing

4.1 Build partnerships

Strategic objective:
Build partnerships to support and enhance critical infrastructure resiliency.

Consistent with the *Emergency Management Framework for Canada*, strengthening the resiliency of critical infrastructure requires complementary and coherent action by all partners to promote the most effective use of resources and execution of activities. Complementary approaches to strengthening the resiliency of critical infrastructure at all levels will enable concerted efforts to facilitate timely and effective prevention, mitigation, preparedness, response and recovery measures to deal effectively with disruptions. In the event of an emergency or disruption of critical infrastructure, the first point of contact is the government of jurisdiction. Should a provincial or territorial government require resources beyond its own in an emergency or response to a disruption, the federal government will respond rapidly to requests for assistance.

The Strategy recognizes that each responsible jurisdiction, department and agency, as well as critical infrastructure owners and operators, will exercise their responsibilities as they deem appropriate for strengthening the resiliency of critical infrastructure in Canada. To be effective, however, the implementation of this Strategy will require the collaboration of federal, provincial, territorial and critical infrastructure sector partners and the establishment of mechanisms to facilitate this collaboration.

Sector networks

The Strategy proposes to establish sector networks, at the national level, for each of the critical infrastructure sectors. This approach will build to the fullest extent possible upon existing coordination and consultation mechanisms. In recognition of the unique characteristics of each sector, the Strategy does not prescribe the structure of each sector network. The sector networks reflect a partnership model that will enable governments and critical infrastructure sectors to undertake the range of activities (e.g. risk assessments, plans to address risks, exercises) unique to each sector. Working with these critical infrastructure partners, each sector-specific federal department and agency will facilitate the development of sector networks to suit the needs of their stakeholders. The Strategy provides a framework for the functions of the sector networks, including:

- promotion of timely information sharing;
- identification of issues of national, regional or sectoral concern;
- use of subject-matter expertise from critical infrastructure sectors to provide guidance on current and future challenges; and
- development of tools and best practices for strengthening the resiliency of critical infrastructure across the full spectrum of prevention, mitigation, preparedness, response and recovery.

The sector networks will be composed of relevant federal departments and agencies, provinces, territories, national associations and key members of the critical infrastructure sectors. Participation in these networks is voluntary. To facilitate the exchange of information, partners will collaborate to develop a protocol to safeguard information shared through these networks.

To maintain a comprehensive and collaborative Canadian approach to enhancing the resiliency of critical infrastructure, a National Cross-Sector Forum will be established to promote information sharing across the sector networks and address cross-jurisdictional and cross-sectoral interdependencies. Specific membership will be drawn from the ten sector networks and will be representative of a broad base of owners and operators, associations, and federal, provincial and territorial governments. Partnership through the National Cross-Sector Forum will form the basis for the implementation of the national approach to critical infrastructure resiliency.

4.2 Implement all-hazards risk management approach

Strategic objective:
Implement an all-hazards approach to risk management.

The Strategy promotes the application of risk management and sound business continuity planning. While there are many acceptable approaches to the discipline of risk management, in the context of this Strategy, risk management refers to the continuous, proactive and systematic process to understand, manage and communicate risks, threats, vulnerabilities and interdependencies across the critical infrastructure community.

Having a strong situational awareness of the risks and interdependencies that confront critical infrastructure in Canada is the first step towards a comprehensive risk management process. As part of the development of emergency management plans and programs, sector-specific federal departments and agencies are expected to work with provinces and territories and critical infrastructure sectors to acquire a greater understanding of these risks and interdependencies.

To move forward with this comprehensive risk management process, federal, provincial and territorial governments will collaborate with their critical infrastructure partners to develop all-hazards risk analyses that take into account accidental, intentional and natural hazards. While governments will promote a common approach to strengthening the resiliency of critical infrastructure, and will share tools, lessons learned and best practices, stakeholders are ultimately responsible for implementing a risk management approach appropriate to their situation.

As part of the implementation of the Strategy, federal, provincial and territorial governments intend to conduct exercises and assist in the coordination of regional exercise planning across jurisdictions and with critical infrastructure sectors. The goal is to support a common approach to strengthening the resiliency of critical infrastructure. These exercises will assist partners to assess and recommend improvements to their plans, which will help assure Canadians of a swift and effective response and recovery in the face of a critical infrastructure disruption.

4.3 Share and protect information

Strategic objective:
Advance the timely sharing and protection of information among partners and key stakeholders.

Information sharing and information protection are complementary elements of a strong foundation for collaborative efforts to strengthen the resiliency of critical infrastructure. Improved information sharing, in full respect of existing federal, provincial and territorial legislation and policies, will enhance the timely exchange of actionable information on risks as well as information about the overall status of critical assets so that owners and operators, governments, and others can assess risks and take appropriate action.

Timely information sharing across governments and critical infrastructure sectors is needed to promote effective risk management and to understand and address critical infrastructure interdependencies. As requested by critical infrastructure stakeholders, improvements in information sharing will include:

- a wider range of information products (e.g. risk assessments, incident reports, best practices, lessons learned, assessment tools);
- improved delivery mechanisms (e.g. web-based critical infrastructure information);
- improved protection of shared information from unauthorized disclosure; and
- expanded production of all-hazards risk information products.

Consistent with the principles of the *Emergency Management Framework for Canada*, federal, provincial and territorial governments will aim to be as open as possible about the work each level of government does in emergency management, security and business continuity planning. Information exchange is part of a crucial and continuous process before, during and after a disruption or emergency – it enables a common operating picture among all levels of government and the critical infrastructure sectors. In turn, this leads to improved coherency of action and facilitates a comprehensive approach across the spectrum of prevention, mitigation, preparedness, response and recovery.

To improve the quality and usefulness of the information products, members of the sector networks will identify areas of emerging concern and identify priority areas for information products. It is expected that these information products will be used by critical infrastructure partners to improve the resiliency of their key assets and services.

Information Protection

In light of the many interdependencies in Canadian critical infrastructure, the inappropriate release of sensitive information that poses a risk for a province or local authority would often also constitute a risk for Canada. Exemptions from disclosure for reasons of national security and public safety already exist under federal, provincial and territorial access to and freedom of information legislation. At the federal level, the Government of Canada's *Emergency Management Act*, which came into force in 2007, included a consequential amendment to the *Access to Information Act* to give clear protection to sensitive information provided by critical infrastructure sectors.

Governments will work towards providing an appropriate level of protection to emergency management and critical infrastructure information based on sensitivity. A common information-sharing protocol to support the sharing of information provided in confidence will be developed through a collaborative approach, including all levels of government. In addition, federal, provincial and territorial governments are encouraged to collaborate to share best practices on information protection. The end result of these efforts will be the development of a more coherent approach to information sharing and information protection in Canada.

5. Review

Federal, provincial and territorial governments will work together to monitor the implementation of the Strategy and support the assessment of programs and activities targeted at enhancing the resiliency of critical infrastructure in Canada. It is expected that the collaborative approach established in the Strategy will remain evergreen and strengthen coherency of action among all levels of government and critical infrastructure sectors.

The Strategy is to be read in conjunction with the *Action Plan for Critical Infrastructure*, which will be reviewed three years after launch and every five years thereafter.

Appendix A-7-2

NATIONAL INFRASTRUCTURE ADVISORY COUNCIL STRENGTHENING REGIONAL RESILIENCE FINAL REPORT AND RECOMMENDATIONS

(Provided in electronic format only due to document size and in order to conserve paper)

National Infrastructure Advisory Council

Strengthening Regional Resilience

Final Report and Recommendations

November 21, 2013

Constance H. Lau
Working Group Co-Chair
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Working Group Co-Chair
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About the NIAC

The National Infrastructure Advisory Council (NIAC) provides the President of the United States with advice on the security and resilience of the critical infrastructure sectors and their functional systems, physical assets, and cyber networks. These critical infrastructure sectors span the U.S. economy and include the chemical; commercial facilities; communications; critical manufacturing; dams; defense industrial base; emergency services; energy; financial services; food and agriculture; government facilities; healthcare and public health; information technology; nuclear reactors, materials, and waste; transportation systems; and water and wastewater systems sectors. The NIAC also advises the lead Federal agencies that have critical infrastructure responsibilities. Specifically, the Council has been charged with making recommendations to:

- Enhance the partnership of the public and private sectors in securing and enhancing the security and resilience of critical infrastructure and their supporting functional systems, physical assets, and cyber networks, and provide reports on this issue to the President through the Secretary of Homeland Security, as appropriate.
- Propose and develop ways to encourage private industry to perform periodic risk assessments and implement risk-reduction programs.
- Monitor the development and operations of critical infrastructure sector coordinating councils and their information sharing mechanisms and provide recommendations to the President through the Secretary of Homeland Security on how these organizations can best foster improved cooperation among the sectors, the Department of Homeland Security, and other Federal government entities.
- Report to the President through the Secretary of Homeland Security who shall ensure appropriate coordination with the Assistant to the President for Homeland Security and Counterterrorism, the Assistant to the President for Economic Policy, and the Assistant to the President for National Security Affairs.
- Advise sector specific agencies with critical infrastructure responsibilities, to include issues pertaining to sector and government coordinating councils and their information sharing mechanisms.

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Executive Summary

Strengthening the resilience of regions and their critical infrastructures is essential for achieving national resilience. Over the past decade, adjacent regions and infrastructures have become more interconnected, enabling local disasters to ripple across multiple jurisdictions and sectors, causing disruption and damage over large geographic areas. Resilience is especially important in the lifeline sectors—energy, communication, water, and transportation—because they underpin the most essential functions of business, government, and communities. Much has been done to build partnerships and improve resilience nationwide. But when disaster strikes, the biggest hit is felt by the regions and local communities that must respond and confront the immediate consequences.

In February 2013, President Obama issued Presidential Policy Directive 21, making it the policy of the United States to strengthen the security and *resilience* of its critical infrastructure against both physical and cyber threats. This policy recognizes the importance of resilience in managing infrastructure risks and reaffirms that critical infrastructure security and resilience is a shared responsibility among all levels of government and owners and operators of critical infrastructure.

Improving regional resilience requires urgent action even though the full benefits may not be realized for many years. Severe weather and complex physical and cyber risks are straining aging infrastructure to perform beyond design limits. Meanwhile, our nation invests at least $1 billion each day in new and upgraded infrastructure that can make regions more resilient, provided they are designed with security and resilience in mind.[1] We have a special window of opportunity to make sure we build and rebuild infrastructures smarter to optimize resilience in each region.

Exhibit 1. Key Recommendations to Improve Regional Resilience

1. Form partnerships with senior executives from the lifeline sectors, based on the Federal government's successful executive engagement with the electricity sector.
2. Identify or develop regional, public-private, cross-sector partnerships, led by senior executives, to coordinate lifeline sector resilience efforts within a given region.
3. Designate the energy, communications, water, and transportation sectors as lifeline sectors and direct all agencies to recognize the priority of the lifeline sectors and the individuality of regions.
4. Integrate social media into public alert and warning systems and work with state and local government partners to develop social media information sharing capabilities to inform response.
5. Launch a cross-agency team to develop solutions to site access, waiver, and permit barriers during disaster response.
6. Create a strong value proposition for investment in resilient lifeline infrastructures and accelerate the adoption of innovative technologies in major infrastructure projects.

Organizing our policies, partnerships, and processes is equally important to provide flexible and agile disaster response. Decisions made by states, local jurisdictions, Federal agencies, and private businesses before, during, and after a crisis can affect the continuity of critical regional services and the effectiveness of response and recovery efforts. Recent disasters such as the Oklahoma tornados in June 2013, Superstorm Sandy in October 2012, and the North American derecho in June 2012 remind us that disasters have little regard for jurisdictional boundaries and underscore the need for a unified approach to risk management.

[1] See Appendix E: Investment in U.S. Infrastructure.

Study Objective and Approach

In April 2012, the National Infrastructure Advisory Council (NIAC) launched a study to examine how regions can become more resilient in the face of increasing risks and infrastructure interdependencies. The Council formed a Regional Resilience Working Group to examine the challenges that regions face in improving resilience and to recommend steps the Federal government should take to help regions become more resilient. To frame this topic, the Working Group posed the following questions:

1. **Best Practices**: What are the characteristics that make a region resilient and what steps can be taken by critical infrastructure owners and operators, state and local government, and the private sector to improve resilience within their region?
2. **Process Improvements**: How can public and private critical infrastructure partners best work together to improve regional resilience?
3. **Federal Role**: How can Federal government capabilities and resources help accomplish resilience goals and address any gaps that can make regions more resilient?

This study focuses on the resilience of "lifeline sectors" (energy, communications, water, and transportation) within regions that have complex multistate, multijurisdictional, and cross-sector interdependencies, and which would have large national impacts if they were to fail catastrophically. Interdependencies among lifeline sectors create a risk environment in which a disruption in one infrastructure or region can spread to other sectors and regions, often in unexpected ways.

The Working Group collected information from a variety of sources:

- 37 interviews with national leaders in resilience and disaster response, state and local emergency managers, regional resilience organizations, infrastructure owners and operators, and Federal agencies;
- Insights from State, Local, Tribal, and Territorial Government Coordinating Council studies; and
- More than 350 reports, studies, videos, news articles, testimonies, and policy directives.

The Working Group formed a Study Group to examine the regional impacts of Superstorm Sandy on the lifeline sectors and gaps in regional resilience between interdependent sectors. Though focused on a natural disaster, the event illuminated real-world infrastructure risks and lessons that would be present in any event, including accidents and terrorist acts. The Superstorm Sandy case study helped to show how regions can reduce infrastructure risks and to test initial Working Group hypotheses.

Findings

Our study revealed three fundamental principles of regional resilience that align with previous NIAC studies and recent Federal policy directives. These principles (Exhibit 2) recognize that national resilience is the logical outcome of regional resilience. Any national strategy to strengthen resilience must include all of these elements.

Exhibit 2. Principles of Regional Resilience

1. Resilience requires a whole-of-nation approach that integrates top-down policy and leadership with bottom-up community capability to withstand and survive disasters.
2. Regional resilience strategies must be tailored to the distinct needs of each region and designed to manage complex regional risks that span multiple jurisdictions and sectors.
3. Strong public-private partnerships and relationships that include senior executive involvement are the most effective and enduring strategy for achieving sustainable resilience.

The Council identified six findings of the challenges, critical needs, best practices, and essential strategies for improving resilience within regions. Full descriptions of these findings are provided in Chapter 5.

Finding 1. Lifeline sectors are top priorities for achieving regional resilience and their growing complexity creates hidden risks.

1.1 Four lifeline sectors–energy, water, transportation, and communications—are top priorities for strengthening resilience in all regions because they provide essential products and services that underpin the continued operation of nearly every business sector, community, and government agency.

1.2 The increasing interdependence and integration among lifeline infrastructures has created hidden regional risks that are not widely understood by the businesses, governments, and communities that depend upon them for essential services.

1.3 Joint regional exercises that engage public and private partners at all levels are highly effective in exposing gaps, identifying interdependencies and hidden risks, and improving response capabilities.

Finding 2. Regional resilience efforts are most successful when they are tailored to the characteristics and needs of each region.

2.1 National resilience is strengthened by the collective resilience efforts of all regions and their communities. Yet all regions are different, calling for a tailored approach to resilience that reconciles the types and density of a region's infrastructure with regional-based risk assessments.

2.2 A community's capacity to withstand a disaster is improved when regional emergency managers engage non-profit and community groups as critical partners in disaster preparation, response, and recovery.

Finding 3. Senior executive engagement creates strong public-private partnership, which is the most effective strategy for achieving long-term resilience within regions.

3.1 Public-private partnerships based on senior executive-level engagement prove to be the most robust because they enable partners to set strategic direction, establish priorities, provide resources, and exercise accountability.

3.2 Strong public-private partnerships across all levels of industry and government and active cross-sector coordination are the most important success factors in helping regions to achieve sustainable resilience.

Finding 4. Social media has emerged as a powerful but underutilized tool for communicating and collecting data during emergencies.

4.1 Social media can improve situational awareness, inform public decision-making, and mitigate rumors.

4.2 Government and business have not fully capitalized on the potential of social media in disaster response and recovery.

Finding 5. Rapid recovery of lifeline infrastructures is hindered by complex rules, regulations, and processes.

5.1 Incident response personnel in critical sectors encounter persistent problems gaining rapid access to disaster areas to repair damaged assets.

5.2 Complex laws and regulations at the Federal, state, and local level and inefficient processes for granting waivers and permits can delay interstate fleet movement and prevent the most effective and logical disaster response.

Finding 6. Without a strong value proposition, owners and operators are unable to invest in new and innovative infrastructure that can mitigate long-term structural risks within regions.

6.1 Owners and operators often find it difficult to establish the strong value proposition needed to invest in new or upgraded infrastructure without public support and the ability to recoup costs.

6.2 Regions can mitigate long-term risks by applying innovative technologies to build resilience into new and replacement structures, and rethinking systems and architectures using novel infrastructure designs that are inherently resilient.

Recommendations

The Council recommends six actions to improve regional resilience. Each recommendation is described in greater detail in Chapter 5.

Recommendation 1. The President should direct the heads of the appropriate Sector-Specific Agencies to form partnerships with senior executives from lifeline sectors, using a process modeled after the government's successful executive engagement with the electricity sector.

CEO-level executive engagement in the electricity sector has been a game changer over the last 18 months and the lessons learned can help guide the formation of similar senior executive partnerships in other lifeline sectors. As noted in four previous NIAC reports, senior executive partnerships help build key relationships, set mutual priorities, and address urgent infrastructure challenges.

To implement this recommendation, the Council recommends the following milestones.

1.1 **Within six months, the President should direct the heads of appropriate Sector-Specific Agencies to convene a meeting with CEOs or other owner/operator leadership with equivalent decisionmaking authority from each lifeline sector to explore the formation of a partnership to address high priority risks to the sector's infrastructure.**

1.2 **The U.S. Department of Energy, in collaboration with the U.S. Department of Homeland Security (DHS), should work with electricity and nuclear sector industry associations to document the process used for CEO engagement in the electricity sector** to discern lessons learned that can guide senior executive partnerships in other lifeline sectors.

1.3 **The President should task the NIAC to identify the highest priority cross-sector risks affecting national security and resilience** and produce a written report to the President within 18 months recommending potential executive-level, cross-sector action.

Recommendation 2. The Secretary of Homeland Security should facilitate efforts with governors, mayors, and local government officials to identify or develop regional, public-private, cross-sector partnerships, led by senior executives, to coordinate lifeline sector resilience efforts within a given region.

Productive executive partnerships at the Federal level can be leveraged to inform and build effective public-private partnerships at the regional level. Strong senior executive leadership at the regional level will help to identify, build, and fully integrate appropriate cross-sector regional partnerships to complement the national partnerships. The Council affirms and supports two prior recommendations on regional partnerships made by the State, Local, Tribal, and Territorial Government Coordinating Council that call for the DHS Office of Infrastructure Protection to promote and enable stronger cross-sector partnerships, and provide state and local governments with the tools to identify cross-sector interdependencies that could result in cascading effects, particularly in the lifeline sectors.

To implement this recommendation, the Council recommends the following steps.

2.1 **The Secretary of Homeland Security should facilitate the development of cross-sector partnerships within selected regions to improve the region's resilience to very large-scale events that could impact national security, resilience, and economic stability**. The Secretary should work directly with governors, mayors, and other local government leaders to assist them in building cross-sector partnerships with senior executives from the lifeline sectors located within each region. To coordinate and operationalize regional partnerships, the Secretary should work through the State, Local, Tribal, and Territorial Government Coordinating Council (SLTTGCC), and provide grant funding to states to assist with this effort.

2.2 **The Secretary of Homeland Security should initiate a pilot program with state and local governments in select regions to conduct regional joint exercises, develop risk maps of critical sector interdependencies, and extract lessons learned on regional needs and gaps for government and sector partners**. The program should actively engage regional owners and operators and government leaders in identifying and addressing critical gaps in the resilience of the lifeline infrastructures that could produce cascading disruptions throughout the region.

Recommendation 3. The President should designate the energy, communications, water, and transportation sectors as lifeline sectors and direct Sector-Specific Agencies to examine their policies, procedures, and programs to determine to what extent they recognize the priority of the lifeline sectors and the individuality of regions, amending or revising those that do not.

In designating energy, communications, water, and transportation as lifeline sectors, the President should ensure that Federal policies and programs recognize the priority status of the lifeline sectors in planning, coordination, and recovery for regional disasters. This will help to solidify the fundamental role these sectors have in maintaining the continuity of critical infrastructure services and government functions in all regions.

To implement this recommendation, the Council recommends the following steps.

3.1 **DHS should examine how the Federal government, state governments, and regional entities currently coordinate action with and provide support to the lifeline sectors in event response.**

3.2 **The Federal Emergency Management Agency (FEMA) National Response Coordination Center, Federal agencies, and state and local governments should modify their processes and plans for emergency operations to include the co-location of representatives of lifeline sectors** in their emergency operation centers during major disasters.

3.3 **The President should require that Federal agencies: a) explicitly consider and address the differences among regions when promulgating security and resilience rules, programs, or guidance**; and b) expressly state how they have customized implementation to each region if there is not generic applicability.

Recommendation 4. FEMA should integrate social media platforms into public alert and warning systems to maximize message reach, and develop training programs and guides with state and local government partners that help them capitalize on social media's potential to provide innovative information sharing and response capabilities.

To implement this recommendation, the Council recommends the following steps:

4.1 **FEMA and the Federal Communications Commission should convene a task force of senior emergency managers from lifeline sector SSAs and representatives of leading private-sector social media and technology firms**—such as Twitter, Facebook, and Google—to examine how new and emerging social media apps, platforms, and capabilities can be used to support emergency notification and response and provide greater value to the public. The task force should publish its findings in a report on best practices.

4.2 **FEMA and the Federal Communications Commission should work with social media providers to integrate social media platforms into FEMA's Integrated Public Alert and Warning System** (IPAWS), enabling social media websites and apps to push emergency alerts from state and local emergency managers directly to registered users through a trusted system.

4.3 **FEMA non-disaster preparedness funding to state, local, tribal, and territorial emergency**

management agencies should require all recipient agencies to designate and train specific personnel to use the IPAWS system to issue geographically targeted emergency alerts.

4.4 **FEMA and the DHS Science and Technology Directorate (S&T) should work through the State, Local, Tribal, and Territorial Government Coordinating Council to develop a conference or webinar series for emergency managers on innovative social media use and best practices** in state and local emergency management, including social media successes in recent large-scale disasters. These webinars will also provide a platform for emergency managers to share lessons learned directly with peers.

Recommendation 5. The Secretary of Homeland Security, working with heads of appropriate Federal agencies, should launch a cross-agency team within 60 days to develop solutions to site access, waiver, and permit barriers during disaster response and begin implementing solutions within one year.

The Council reaffirms the recommendations in its 2009 *Framework for Dealing with Disasters* study that calls for DHS to work with Federal and regional government partners and lifeline sector owners and operators to streamline fleet movement, communications, and critical site access for lifeline sector response crews. Removing these barriers offers one of the best opportunities to speed disaster response and recovery after a major event.

To implement this recommendation, the Council recommends the following steps:

5.1 **DHS's Office of Infrastructure Protection and FEMA should collaborate with state, local, tribal, and territorial governments and owners and operators to develop a commonly applied process or system to credential lifeline sector owners and operators and grant them access to disaster areas** more effectively.

5.2 **DHS should work with state and local government and infrastructure owners and operators to catalog the waivers and permits commonly required during a variety of disaster scenarios and develop a streamlined process** for rapidly issuing those permits and waivers at the Federal, state, and local level.

5.3 **DHS should work with the transportation, energy, and other lifeline sector regulators to identify actions that will expedite waivers and remove impediments to fleet movement**, including driver-hour limitations, road and weight restriction, port access restrictions, and toll crossing processes.

Recommendation 6. The President should direct the Council of Economic Advisors and the Office of Science and Technology Policy to work with Federal agencies to create a strong and enduring value proposition for investment in resilient lifeline infrastructures — and their underlying physical and cyber systems, functions, and assets — and accelerate the adoption of innovative technologies in major infrastructure projects.

Strategies that "bake" resilience into the design and construction of physical and cyber structures—the wires, pipes, roads, and rails that connect our communities—offer one of the best opportunities to reduce long-term risks to regions. Although the long-term benefits of these intelligent infrastructures far outweigh the costs, significant barriers to investment exist due to outdated frameworks for evaluating

projects and ineffective financing and investment strategies for advanced technology projects.

To implement this recommendation, the Council recommends the following steps.

6.1 **Within one year, the Department of Energy, in conjunction with the Council of Economic Advisors and the White House Office of Science and Technology Policy, should complete a pilot analysis of the value proposition for investment in infrastructure grid modernization** and recommend any incentives or alternative mechanisms for cost recovery that may be needed to encourage long-term investment in the modernization of lifeline infrastructures. Using the electricity sector as the vanguard, all lifeline sector SSAs should work with their sector partners to establish the value proposition for investment and financing in other critical sectors.

6.2 **The President should direct the National Oceanic and Atmospheric Administration (NOAA) and appropriate Federal agencies to determine how existing weather and climate forecasting models and methodologies** can be used to better communicate both long-term and short-term predictions of severe weather events to enable private, state, and local partners to fully understand potential dangers and make informed investment decisions that manage risk.

6.3 **DHS should work through Federal research organizations, academic institutions, and the national laboratories to develop Applied Centers of Excellence for Infrastructure Resilience to provide an operating environment to test and validate innovative technologies and processes** that build resilience into new large-scale infrastructure projects, integrate next-generation R&D, and share results with other designers in other regions. By partnering with lifeline sector owners and operators, these centers will leverage opportunities for real-world testing, raise awareness of new capabilities, and speed commercialization of emerging technologies.

Conclusion

Our study underscores three important realities affecting the resilience of regions:

1. We live in a dynamic risk environment of increasing complexity and interdependence of related communities, regions, and lifeline infrastructures that must be reflected in our national strategies.
2. The model for planning and decision-making must include the collective expertise, commitment, and resources of key partners, including owners and operators, Federal, state, and local government, non-profits, and communities.

"[Today] we're dealing with levels of complexity and uncertainty and scale and scope that have dwarfed what we had to deal with in the past."

—Admiral Thad Allen
USCG (Ret.), Executive VP, Booz Allen Hamilton

(National Academy of Sciences 2012)

3. Despite our best efforts, disasters will continue to occur, requiring more flexible and agile systems to rapidly respond to and recover from events.

As sectors develop interdependent supply chains that are more efficient but also more fragile, they may unintentionally create risks to other sectors, producing a regional risk environment that no one entity fully understands or can plan for. The Federal government must work with regional partners to help them strengthen resilience and address the next disaster—and the next decades of disasters. However, it

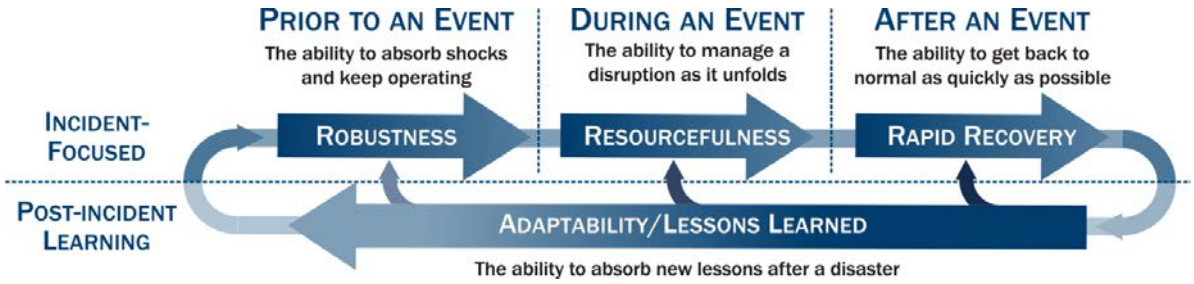
will require a paradigm shift in the ways regions think about, plan for, and fund disaster preparation, response, and recovery.

1. Regional Resilience and Lifeline Infrastructures

Businesses and communities increasingly use integrated physical and cyber systems to operate complex networks of interconnected infrastructures. As a result, an event occurring in one community or sector can cascade to other communities and sectors in ways that operators may not fully anticipate. This is particularly true of disruptions in the lifeline sectors—energy, water, communications, and transportation systems—which provide the essential services underpinning all sectors of the economy. Faced with an increasingly unpredictable threat environment that includes cyber attacks, accidents from aging infrastructure, and non-traditional weather events, security partners in the lifeline sectors and state and local government realize that building resilience at the regional level is the key to achieving national resilience.

Resilience is the ability to reduce the magnitude and/or duration of disruptive events. A resilient region is one that is able to **anticipate, avoid, absorb, adapt to, rapidly recover from, work together, and learn from a potentially disruptive event**. Our definition builds upon the definition of resilience formed in the Council's 2010 *Framework for Establishing Critical Infrastructure Goals*. It emphasizes robustness in preparing for an event, resourcefulness in mobilizing resources to respond, rapid recovery of critical services, and a concerted effort to learn from past events and build stronger capabilities for the future.

Exhibit 3. NIAC Resilience Framework



When President Obama issued Presidential Policy Directive on Critical Infrastructure Security and Resilience (PPD-21) in February 2013, he recognized the importance of resilience in managing risks to critical infrastructures. PPD-21 establishes national policy for critical infrastructure security and resilience and affirms that strengthening and maintaining resilience is a shared responsibility among all levels of government and infrastructure owners and operators in the public and private sectors. This directive represents a shift from the protection of physical and cyber assets to building the resources, skills, and capabilities to rapidly detect, respond to, and recover from a wide set of risk scenarios that face the nation's infrastructure. PPD-21 identifies 16 critical infrastructure sectors that "must be secure and able to withstand and rapidly recover from all hazards." It also recognizes the diversity and complexity of these infrastructures, the growing physical and cyber interdependence among critical sectors, and the wide range of authorities that own, regulate, and depend upon the critical services they provide.

A regional perspective reflects the needs of multiple communities and is an essential for achieving national resilience. It enables diverse stakeholders—owners and operators, state and local government, non-profit organizations, and community groups—to leverage collective resources and expertise in

addressing complex infrastructure challenges. However, this will require new ways to think about, approach, and fund resilience.

Building National Resilience from Regional Resilience

All Regions Are Different

Each region has distinctive features—geography, infrastructure configurations, demographics, economic profile, and governance structure—that define its approach to regional security and resilience. The needs of New York City are different from the needs of Moore, OK and the strategies to build resilience for the risks each faces must also be different. While certain infrastructures, such as those in the lifeline sectors, are vital in all regions, **regional partners must ultimately determine which sectors are most critical to both their region and the nation and prioritize them for security and resilience improvements.** In Houston, for example, the oil and natural gas sector and the Port of Houston are critical to the local economy *and* to the security and resilience of the nation. In New York, the banking and finance sector and the information and communication infrastructures that support it are critical to New York and financial systems worldwide. Accordingly, a tailored approach, which reconciles the types and density of the region's infrastructure with regional-based risk assessments, is best for achieving sustainable, long-term resilience.

> "I don't believe it's one size fits all. In fact, I think when that's the case, it's generally the case that one size fits none."
>
> **—Richard Reed**
> Former White House Deputy Assistant for Homeland Security (current Red Cross Vice President for Preparedness and Resilience Strategy)
>
> (National Academy of Sciences 2012)

Interconnection Creates Complexity

As the economies and infrastructures become more interconnected, **local disasters can now cascade to multiple jurisdictions and sectors**, causing disruptions and damage across larger geographic areas. Three important trends now shape critical infrastructure strategies within a region and make a regional approach to resilience imperative: increasing interdependence of related communities, regions, and lifeline infrastructures; growing complexity from the integration of physical and cyber systems; and new and increasingly severe weather patterns resulting from a changing climate.

> "While multiagency leaders—at local, state, Federal levels and across public-private sectors—understand how to build and protect infrastructures (within their areas of responsibility), they often lack awareness of security imperatives facing other sectors in adjacent geographic or mission areas."
>
> **—Dane Egli**
> Johns Hopkins University Applied Physics Laboratory
>
> (Egli 2012: *Beyond the Storms*)

As sectors optimize operations and adopt more efficient but fragile supply chains, they become increasingly dependent upon the uninterrupted operation of services in other sectors, and may unintentionally create risks to other sectors or take on risks that they do not fully understand. In addition, as sectors adopt intelligent, automated cyber systems to control physical processes, they increase the complexity of the built infrastructure and introduce new cyber risks that they may not be fully prepared to respond to. **Stronger sector interdependencies may trigger cascading events that interrupt critical**

services, impede emergency response, and threaten public safety in unexpected ways. Tightly entwined operations among critical sectors were illuminated in recent disasters, such as Superstorm Sandy, where despite excellent planning, severe energy disruptions in some areas ultimately brought transportation, communication, or water services to a halt.

Growing interdependencies will compound in the coming years by stronger and more frequent weather events. Average annual temperatures across the mainland United States have increased by 1.5 degrees Fahrenheit since the turn of the 20th century, a trend that is expected to raise sea levels, increase air and water temperatures, and lead to more frequent and intense storms and flooding (U.S. DOE and NREL 2013). The past two years have served as striking harbingers of this change: 2011 set the record at 14 disaster events that each topped $1 billion in damage, followed by 2012, where the year's total damage of $110 billion, due in most part to Superstorm Sandy, made it the second costliest year for natural disasters since 1980 (NOAA 2013).

Together, **these trends are producing a regional risk environment that no one entity fully understands or can plan for**. The nation's core infrastructure, economies, regions, and supply chains are far too interconnected for stakeholders to make resilience decisions or investments in isolation. No company, sector, or government entity can completely understand the risks they face nor optimize for resilience by working within traditional organizational or jurisdictional boundaries. These conditions have led the Federal government to adopt a whole-of-nation approach to strengthening and maintaining resilience, in which a holistic examination of risks across the critical lifeline sectors within a region reveals both structural and non-structural opportunities to improve resilience (see Exhibit 4).

Exhibit 4. Structural and Non-Structural Resilience

The resilience and security of lifeline infrastructures within a particular region is determined by both **structural** and **non-structural** factors (National Academies 2012). **Structural factors include tangible physical and cyber assets**: the configuration and capabilities of the infrastructure and systems that are present within a given area such as the location and capacity of bridges, roads, wires, pipes, cell towers, and optical fiber. **Non-structural factors include human skills and assets**: the processes, procedures, and organization of capabilities to effectively plan and manage the infrastructure and the services and products it provides. Examples include emergency response procedures, public-private partnerships, capital planning processes, communication protocols, and exercises and training.

Scale and Scope of Critical Infrastructure Pose Challenges

The energy, water, transportation, and communication sectors are highly capital-intensive and have infrastructures with long lifecycles, lasting more than 100 years or more in some cases. **Those lifecycles are nearing the end for large portions of infrastructure in many critical sectors** (ASCE 2013). Long-term resilience can be improved by changing the design, capabilities, and configuration of new assets and systems. Beyond infrastructure hardening, new technologies and network architectures often add new functionality or adaptability that strengthens resilience. In the electricity sector, for example, use of intelligent digital devices and automation in the distribution system helps to pinpoint outages, reroute power, and recover faster. Innovative structural investments can deliver exponential resilience improvements, but require substantial capital expenditures and can be difficult to justify to customers, regulators, shareholders, and the public.

Long-term capital investment in resilient infrastructure is often hard to justify because **the costs and benefits of resilience are dispersed across a wide population and displaced in time**. The full costs of disasters are often borne by a large population of businesses, government organizations, and citizens,

while investments in infrastructure that could reduce disaster costs are typically borne by owners and operators of critical infrastructure. The cost of business losses from a disaster is typically much higher than the cost of the physical damage. It has been estimated that the 9/11 terrorist attacks caused $23 billion in damage at the World Trade Center, but the costs of business interruption were estimated around $100 billion (National Academies 2012). Most important, however, is that significant infrastructure upgrades require large near-term investments that may not show commensurate resilience benefits (i.e., disaster cost avoidance) for years, if not decades. For example, costly flood prevention upgrades for electrical substations near waterways may not deliver a return on that investment until the next exceptional storm—many years later—causes large-scale flooding that the infrastructure withstands. (See Exhibit 14. Red River Floodway: Capital Investment in Infrastructure Pays Huge Dividends Over 40+ Years for another example of cost and benefit displacement). Even then, a functional and resilient infrastructure produces benefits to society that often goes unnoticed until, or unless, it breaks.

This makes first-hand disaster experience one of the greatest motivators for improvements. Investments and lessons learned from Hurricane Irene in 2011 improved response a year later during Superstorm Sandy. After Sandy left $65 billion in damages in its wake, a Rebuilding Task Force is examining innovative infrastructure designs to help the region rebuild stronger and smarter, while electric utilities in New York and New Jersey have since proposed billions of dollars in infrastructure upgrades with support from political leaders. **Disaster damage offers a small window of opportunity to build in resilient features during infrastructure repair and replacement**, and the Northeast region is wisely working in partnership to assess and build resilience to future risk. Yet regional and national resilience will not be maintained through reactionary support for infrastructure investments following large-scale events.

While resilience investments are costly in the near-term, a review of FEMA's hazard mitigation programs showed that **every pre-event dollar spent on resilience yields a $4 savings in future losses** (Multihazard Mitigation Council 2005; Center for American Progress 2013). Other studies point to potentially higher levels of savings. **With much of the nation's critical infrastructure rapidly reaching the end of its useful life, the United States faces a limited opportunity to adopt innovative, adaptive designs that will increase resilience for decades to come**. The American Society of Civil Engineers gave U.S. infrastructure a grade of D+ in 2013, estimating that $3.6 trillion is needed by 2020 to substantially improve infrastructure condition and performance. Yet the U.S. invests only about 2% of its GDP in infrastructure renewal and maintenance, one of the lowest percentages in the world and about half what it was 50 years ago (see Appendix E. Investment in U.S. Infrastructure).

> "On the microscale, making an up-front investment in safeguards that mitigate risk and consequences is far more cost-effective than paying for response and recovery after a foreseeable hazard. On the macroscale, a society's level of resilience contributes to its global competitiveness."
>
> **—Dr. Stephen Flynn**
> Founding co-director of the George J. Kostas Research Institute for Homeland Security at Northeastern University
>
> (Flynn and Burke 2011)

Particularly during a weak economy, **long-term structural resilience investments will be difficult to justify if they do not offer discrete incentives in the form of a near-term benefit or social value**—such as increased efficiency, improved service, cost savings, or environmental benefits—in addition to resilience. As a result, long-term planning for infrastructure investments and emergency preparedness can no longer be done in isolation, not by sector nor government jurisdiction. Building the business case for next-generation technologies and architecture designs will require regions to bring together

government, infrastructure, and community stakeholders to identify regional risks and critical points of failure, align common priorities in addition to resilience (including operational efficiencies, climate change adaptation, compliance, and competitive advantage), and identify the investments that provide the widest benefit.

These conditions lay the backdrop for regional planning, response, and recovery, which represents a new paradigm for disaster resilience in the nation. Even when large-scale regional events require Federal involvement, **it is still the regional relationships, partnerships, processes, and architectures that determine the extent of the damage, how far it ripples throughout the economy, and how quickly and effectively the communities recover**. Our findings and recommendations focus on opportunities for the Federal government to support the development of resilient regions across the nation and mature the Sector Partnership to support this paradigm shift in resilience.

Lifeline Sector Resilience Affects All Sectors

Although the Federal government has not yet defined lifeline sectors, the term has been used by emergency managers and planners for more than a decade. The term "lifeline sector" generally refers to a sector that provides indispensable services that enable the continuous operation of critical business and government functions, and would risk human health and safety or national and economic security if compromised or not promptly restored (see Exhibit 5). These sectors provide the most essential services that underlie a regional economy. They are distinguished from "life support" sectors, such as emergency services and public health, which are indispensable for public safety and health in specific localities.

While different stakeholders may define lifeline sectors differently, there is widespread agreement across security and resilience literature that the following four sectors fit the characteristics of lifeline sectors for every region and event:

- Energy (oil and natural gas / electricity)
- Transportation (rail, aviation, highway, public transit, and marine)
- Communications (and supporting IT)
- Water (potable water and wastewater)

Other sectors could also be considered lifeline for a particular region or event. For example, the financial services sector in New York City and the ports and shipping industry of Los Angeles and Long Beach in Southern California are uniquely critical to both the region and the nation. Emergency services, public health and healthcare, and food and agriculture sectors also provide life-sustaining functions or contribute to the continuity of essential services in specific events. The nature of a disaster or regional condition could elevate one or more sectors to become a lifeline sector, and stakeholders in each region may determine which sectors are most critical for the continuity and recovery of essential services in that region.

Exhibit 5. Defining Features of a Lifeline Sector

- Provides essential products and services that underpin the continued operation of nearly every business sector, community, and government agency.
- Typically delivers products and services that are ubiquitous in normal circumstances but can create life-threatening conditions if they are unavailable for long or even short periods of time.
- Encompasses complex physical and cyber networks that are highly interconnected within their sector, between sectors, and within and between adjacent regions.
- Its disruption or destruction can cause failures that cascade across dependent infrastructures and regions, producing a multiplier effect of impacts.

2. Lessons from Superstorm Sandy

Since this study began in April 2012, Council members witnessed several disasters in which a disruption in one infrastructure or region spread to other sectors and regions. These include a three-day disruption of 911 services in Virginia due to power outages from the June 2012 derecho; a virtual shutdown of the City of Boston when the transit system closed after the marathon bombing; massive tornados in Oklahoma that devastated whole communities; and cascading impacts due to extensive damage and disruption in the energy sector during Superstorm Sandy. These real-world events produced widespread disruption of critical services, loss of human life, and large economic losses that elevated regional events to national events requiring Federal involvement. In 2012 alone, the United States lost $110 billion to weather-related disasters—11 of which exceeded $1 billion each—making it second in disaster costs only to 2005 (the year of Hurricane Katrina) since 1980 (NOAA 2013).

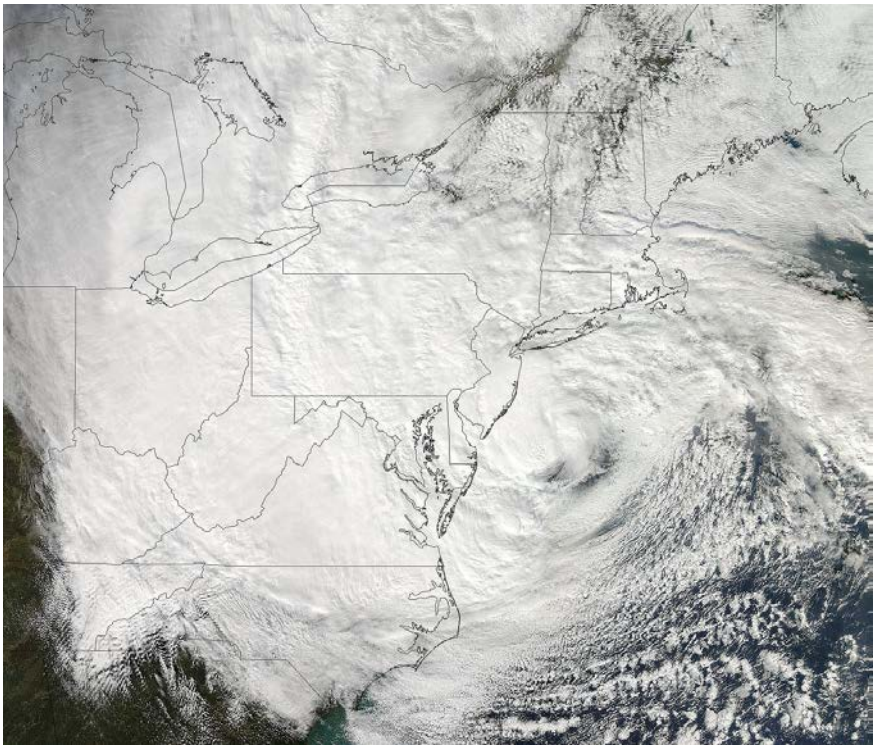
Superstorm Sandy provides an excellent (but unfortunate) example of a major natural disaster that disrupted lifeline sectors and caused widespread damage and disruption over a large geographic region. The Superstorm Sandy Case Study, conducted as part of this overall study, engaged infrastructure owners and operators and state and local government emergency managers to collect and analyze extensive data on the storm's impacts, lessons learned, and implications for regional resilience. Detailed sector-specific and cross-sector learnings are included in Appendix D. This chapter contains a distillation of key lessons learned that informed the NIAC's findings and recommendations. Additional text boxes contain mini-case studies of other regional disasters that affirm many of the lessons from Sandy.

Hurricane Sandy—one of the largest Atlantic tropical storms ever recorded—made landfall on Oct. 29, 2012 near Atlantic City, NJ as a post-tropical cyclone. For the next three days, heavy rains, 80–90 mph winds, and storm surges battered the East Coast as the storm drove inland toward Pennsylvania, causing massive flooding, widespread power outages, and severe damage to homes and infrastructure. Impacts were felt from North Carolina to Maine and as far west as Illinois. By the time the storm dissipated on Nov. 1, peak power outages totaled 8.6 million, damage estimates exceeded $60 billion, and 117 people had lost their lives. Just one week later on Nov. 7, a Nor'easter swept into the affected region with strong winds, rain and snow, and coastal flooding, giving Sandy the "superstorm" moniker. Heavy, wet snow blanketed the already damaged area, snapping storm-weakened trees and downing power lines, tacking an additional 200,000 people onto the list of more than 500,000 already without power in near-freezing temperatures (DOE 2012b; New York City 2013a and 2013b).

Exhibit 6. Key Lessons from Recent Disasters

- Strong public-private partnerships accelerate response
- Senior executive-level engagement removes critical barriers
- Increasing interdependencies harbor hidden risks
- Lifeline sector service restoration needs are critical and not fully understood
- Large-scale events reveal critical points of failure and risks of aging infrastructure
- Co-location of key partners improves coordination and decision-making
- Joint regional exercises build response muscle memory
- Strong communities reduce impacts and improve recovery
- Complex rules, regulations, and processes hinder lifeline sector response
- Innovative social media use can revolutionize response
- Business case for infrastructure investment is difficult to define
- Risk data is needed to build stronger and redefine best practices

Exhibit 7. Hurricane Sandy Approaches the East Coast on October 29, 2012



(Photo Credit: NASA Goddard Space Flight Center 2012)

Superstorm Sandy reinforced the importance of regional resilience. Prior to the storm, public and private partners worked extensively to build partnerships and exercise disaster response. But the storm also revealed new risks and failure points from the overwhelming damage. The following sections contain critical lessons that emerged from the actions of infrastructure owners and operators, state and local government, Federal agencies, and non-profit and community organizations.

Strong Public-Private Partnerships Accelerate Response

Public-private partnerships proved critical to rapid response and recovery during Superstorm Sandy. Personal relationships remained critical at the state and local level and were key success factors for coordination. When traditional communication channels were compromised, agencies used personal cell phone numbers and e-mail addresses to communicate. Creative problem-solving also stemmed from working directly with stakeholder contacts. A petroleum distributor who successfully built a relationship with a Philadelphia supplier (outside its normal operating region) was able to successfully use that relationship to source fuel for critical customers when sources within the hardest hit areas were compromised. In a prior storm, the same distributor lacked this relationship and had been cut off while trying to pre-stock critical customers with fuel. Sustaining and institutionalizing relationships will be key to future response agility. Agencies such as the Department of Energy (DOE), the Department of Transportation (DOT), and the Environmental Protection Agency (EPA) worked directly with utility owners and operators, trade associations, and state officials to expedite waivers enabling repair crews to cross state lines and transport heavy equipment through disaster areas.

"We need to understand there is no agency in government, no private sector firm, no not-for-profit or voluntary organization … [that] has the resources, the scale, and the competency to solve the complex problems we are dealing with today."

—Admiral Thad Allen
USCG (Ret.), Executive VP Booz Allen Hamilton

(National Academy of Sciences 2012)

The Federal Emergency Management Agency's (FEMA) Innovation Team—a multi-sector, cross-functional group of creative problem-solvers made up of government, industry, non-profit organizations, and community volunteers—also made its debut during the storm, enabling FEMA to tap into resources and expertise outside the agency and support a whole community approach to response. Designed to look at response problems from a broad perspective, rather than by agency or sector, and use its agility to quickly solve large, localized problems on the ground, the Innovation Team reached out to networks and volunteers to restore critical needs in hard hit areas like Red Hook, NY. Using its members' personal and professional networks, the team linked up with IT volunteer organizations to establish a mesh Wi-Fi network and a satellite communications link that enabled the community to contact family, apply for disaster assistance, and support its own response and recovery (Serino 2013).

Executive-Level Engagement Removes Critical Barriers

During Sandy, direct communication between senior executives in industry and government streamlined coordination, removed obstacles, and enabled resource and asset movement that would not have otherwise been possible. Unprecedented coordination among senior electricity executives and government leaders resulted in the largest movement of mutual aid resources ever in the electricity sector. President Barack Obama publicly declared zero tolerance for red tape, which became a catalyst for senior-level officials to identify critical resource needs and work directly with their counterparts in industry or government to rapidly move supplies and personnel without lengthy approval processes. Examples of effective senior-level coordination include the following:

- President Obama sent a Senior Assessment Team of government executives into the field to directly address and coordinate response on electricity sector issues. Members included the deputy FEMA administrator, a DOE deputy assistant secretary, a flag officer from U.S. Northern Command, and White House personnel.
- Electric utility CEOs nationwide and Edison Electric Institute (EEI) representatives participated with DOE senior leadership in daily coordination conference calls to improve situational awareness and facilitate resource deployment.
- A first-of-a-kind Energy Restoration Task Force at FEMA's National Response Coordination Center (NRCC) specifically supported power restoration and fuel availability.
- At President Obama's request, EEI embedded a representative in the NRCC for 10 days to serve as a point-person for representatives of FEMA, DOE, DHS, DOT, and U.S. Department of Defense (DOD), and coordinate with CEOs or member organizations, which represent 70% of the electricity delivered in the United States. This enabled unprecedented resource movement, including military airlifting of resources and personnel from the West Coast Federal power administrations to hard-hit areas on the East Coast.

Exhibit 8 describes a two-year, dedicated electricity sector effort to engage CEOs with Federal government executives to address national problems. This partnership largely contributed to the effectiveness of electricity sector response during Sandy, demonstrating the effectiveness of this model.

Exhibit 8. Transforming CEO Engagement in the Electricity Sector

Electricity executives once had limited engagement with the Federal government, but the Sector Coordinating Council (SCC) now includes 28 CEOs. Executive relationships were leveraged during Hurricane Sandy to speed restoration.

Catalyst: NIAC recommends senior executive engagement with Federal government

- 2008-2011: Four NIAC studies recommend senior executive engagement; one calls on the White House to establish an executive-level dialog with electricity/nuclear sector CEOs.
- Feb. 2011: Electricity CEOs write a letter to President Obama requesting a senior-level meeting.

Compelling Value Proposition: Electricity cyber threats rapidly escalate

- 2012: U.S. Secret Service (USSS) works with a trusted industry executive to connect with electricity CEOs and pilot cyber intrusion detection and response devices. Success builds CEO trust in the Federal partnership.
- Feb. 2012: Secretaries of Homeland Security and Energy convene electricity sector CEOs in July to address rising number of targeted electricity cyber threats. A CEO-level executive with appropriate security clearance acts as a facilitator and trusted partner for both industry and government during the meeting.

Executive Commitment: CEOs form Joint Electric Executive Committee to address urgent cyber issues

- July- Oct. 2012: The ad-hoc committee of about 20 senior executives, which included the senior executive facilitator, forms to address urgent cyber security issues and increase the USSS pilots. CEOs engage their next-level executives—COOs and CIOs—with the DOE and DHS Deputy Secretaries and plan tactical deliverables.

Proof of Concept: Superstorm Sandy tests efficacy of executive engagement

- Oct. 2012: The Joint Electric Executive Committee is used during Sandy to act decisively and enable companies and agencies to cut through red tape to restore power to devastated areas. CEOs meet with President Obama ahead of the storm to plan response, and daily CEO conference calls with Federal emergency managers facilitate rapid and unprecedented resource movement.

Clear and Enduring Process: Senior executive working groups formed to tackle key priorities

- Dec. 2012-Sept. 2013: The Committee formed three working groups of COOs and CIOs, which instituted regular conference calls with senior leaders from the DOE and DHS to tackle: 1) improved information sharing, 2) technology deployment, and 3) incident response. Working groups report progress and deliverables at quarterly meetings of senior Federal representatives and the Executive Committee.

Formalized and Continuous Engagement: Executives mature the Electricity Sector Coordinating Council

- Sept. 2013: The electricity sector has reconfigured the Electricity SCC to be led by senior executives. The SCC identifies key sector risks, sets priorities, and commits resources to partnership efforts.

Lessons Learned—Five success factors for public-private partnership:

1. **Senior executive-level engagement**: CEOs set strategic priorities and commit resources to them. By engaging top executives, the sector set the stage for coordinated efforts at all levels of the organization and sector.
2. **Trusted relationships**: CEOs became engaged at the urging of trusted and respected parties within the industry. Trust between industry and government built over time through several successful engagements.
3. **Simple process**: Meetings between executives and government officials had a set agenda, defined outcomes, and clear roles and responsibilities that respected participants' limited time and competing priorities.
4. **Value proposition**: A clear and growing cyber threat to the electricity sector provided the compelling catalyst for direct engagement. An established process and strong track record of success now provide the value proposition for continued engagement.
5. **Executive champion**: Executive partnership efforts were facilitated by a respected industry champion, who was trusted by both public and private sectors.

Increasing Interdependencies Create Hidden Risks

Superstorm Sandy greatly stressed the capabilities of lifeline infrastructures over a large geographic region and exposed hidden risks not well understood or foreseen by emergency managers in other sectors and government. Water sector owners and operators did not fully understand electricity restoration challenges, which made it difficult for them to communicate outages affecting critical water assets to electric utilities. The transportation sector experienced flooding when it found backup generators provided insufficient pumping capacity. Yet the most far-reaching issue of the storm was widespread petroleum shortages. It revealed a growing reliance on electricity and the fuels needed to run emergency generators that many sectors did not fully anticipate. Many owners and operators believed they had sufficient backup generation resources, but when power was not restored quickly, their fuel supplies dwindled and they were not able to replenish them. Heavily damaged refineries and terminals, combined with extensive power outages, caused unanticipated disruptions in the fuel supply chain—from pipelines and refiners to suppliers and distributors—including the following:

- Power outages to pipeline pumps and fuel terminals that could then no longer accept fuel forced the northern part of the Colonial Pipeline to shut down, effectively cutting the region off from a 2.4 million-barrel-per-day supply of petroleum.
- Without power, several refineries were unable to refine fuel for the region, receive fuel, or access their existing supply of fuel for supply and distribution.
- While refineries and supply terminals were initially offline due to a lack of power, many also suffered major water damage to primary switch gear and other internal electrical components that delayed operations long after power was restored. As of Nov. 5 (eight days after landfall), nine terminals in New York and New Jersey were still offline due to damages sustained. The second largest refinery in the region, with a 238,000-barrel-a-day capacity, was not able to begin restart until Nov. 20, more than three weeks after it shut down in preparation for the storm.
- Without commercial power, well-stocked gasoline service stations were unable to pump fuel to customers. Service stations with power quickly depleted resources as demand rose, and suppliers experiencing power outages or infrastructure damage could not refuel them.

These issues were further complicated by the SEC Regulation Fair Disclosure, which limits information sharing in the oil and natural gas sector and prevented public emergency managers from accessing data on the availability of fuel resources and causes of disruptions (U.S. Securities and Exchange Commission 2001). As a result, disruptions highlighted the region's high dependency on gasoline and diesel fuel to power backup generators and vehicles needed for restoration efforts. Backup generators at many critical facilities in other sectors had limited storage capacity, typically only a 24-hour supply of fuel, which created a large demand on distributors as restoration stretched on. In addition, requests for generators and support to obtain fuel for backup generators were not consistently prioritized by emergency management agencies, creating significant risks for cascading consequences.

Lifeline Sectors Service Restoration Needs are Critical and Not Fully Understood

Sandy emphasized that prioritizing the restoration of lifeline sector facilities is complex, condition-specific, and often difficult to communicate. Many partners and the public did not understand the criticality of some of the lifeline sectors, how lifeline sectors recover, the factors affecting priorities, and

who is involved. As a result, some utilities faced a lack of support for backup power and fuel requests from emergency managers and state and local officials who did not understand the cascading impacts of potential disruptions. In the water sector, limited recognition of water and wastewater criticality resulted in "near miss" events and service impacts that likely could have been mitigated. For example, emergency managers de-prioritized water utility requests for backup generation and fuel support in a Maryland county, resulting in 25 million gallons of raw sewage being released into a local body of water.

Misconceptions about the role of state and local government also existed in both the private sector and the public it serves. Most state and local emergency managers had worked with electric utilities to pre-determine restoration priorities, but many were served by flooded electrical distribution stations that required days to pump, dry, and clean. This required re-shuffling of priorities and increased communication with power companies to adapt to the real-time conditions and severity of Sandy. Increasing the understanding of the critical nature of the lifeline sectors and how they operate will aid in making reprioritization easier and response times faster. For example, communication services proved to be a force multiplier during Sandy that enabled community groups to leverage social networks and share information to support recovery. Pre-staging mobile cell platforms and satellite communications units proved effective to replace primary services; however to obtain them, states had to first request FEMA satellite resources under emergency declarations, which delayed mobilization of the units. Heightening the importance of all of the lifeline sectors will help aid in the removal of such barriers in the future.

Large-Scale Events Reveal Critical Points of Failure and Risks of Aging Infrastructure

Superstorm Sandy revealed critical points of failure that stemmed from unknown infrastructure weaknesses and the physical age of the components in use. In the transportation sector, subway tunnels and depots for both subway cars and buses in New York City lacked sufficient protections against extensive flooding and capacity to pump out water, which damaged electrical and communications components and aging systems. The unprecedented storm surge also exposed new critical failure points, such as stairwell entrances to subway tunnels and street-level gratings, which were overwhelmed by flooding. The sheer size and strength caused unparalleled damage for the region in almost every sector; Verizon's Vice President of National Operations Chris Levendos called it "the largest impact to our wireline infrastructure in our 100-year history" (NOVA 2013).

In addition, repair to aging infrastructures that rely on critical parts and equipment that are no longer manufactured resulted in a scramble to locate spare parts and repair delays, as did the size, weight, and cost of the replacement components. Even in newer infrastructure, many specialized components are rare or have long manufacturing lead times. Specific difficulties repairing aging and specialized equipment included the following:

- New York's 108-year-old subway system has unique and outdated parts that require extensive time and high costs to replace, which led to longer than anticipated shutdowns.
- During repairs, New York's Metropolitan Transportation Authority (MTA) used more than 80% of its equipment inventory, nearly exhausting replacement supplies, while the Port Authority Trans-Hudson (PATH) had to seek replacement parts from partners including the DOT Federal Transit Administration (FTA) and companies from as far as Louisville, KY; Pearl, MS; and Pittsburgh, PA.

- At the request of PATH, GE opened a plant in Puerto Rico specifically to manufacture replacement parts that have not been available for years.
- Critical components in the electricity sector, such as transformers, are prohibitively expensive for individual utilities to maintain as spares and have long lead times for emergency replacements.

Exhibit 9. June 2012 Derecho: Disruptions Cascade Across Multiple Lifeline Infrastructures

Event Summary: On June 29, 2012, a derecho—a widespread, long-lived, rapidly moving line of intense thunderstorms—traveled about 700 miles in 12 hours starting in Iowa and northern Illinois. Wind speeds reached 91 mph at Fort Wayne, IN; 82 mph in Dayton, OH; and between 60 mph and 80 mph in the Baltimore-Washington, DC corridor. The storm killed 13 people and caused massive power outages and property damage. More than 4.2 million customers lost power across 10 states and the District of Columbia, with the largest outages occurring in Virginia, Maryland, Ohio, and West Virginia. The majority of destruction was caused by falling trees crushing cars, homes, and buildings and bringing down power lines.

Impacts: Widespread power outages crippled the region. Without electricity, critical services from the energy, transportation, water, and communications sectors were severely disrupted for days. The storm knocked out power to several hundred traffic lights, while debris from the storm cut off primary and secondary roads causing widespread road closures. Many gas stations were unable to pump gas without power. Maryland's light rail system, buses, and other transportation services were disrupted due to damage and outages.

More than three dozen wastewater treatment facilities were without power in Fairfax County, VA following the storm, resulting in low pressure, discolored water, mandatory conservation, and boil water advisories for customers. A number of pumping stations in Montgomery County, MD had to rely on generators for more than a week.

Communications were disrupted by more than 150 downed utility poles and close to 900 downed fiber cables. Area cell phone towers were unavailable for short periods of time or working on backup generation. A backup generator failure caused four of Verizon's 911 call center locations in Northern Virginia to be unavailable for three days for residents in Fairfax and Prince William counties, and Manassas and Manassas Park. Other call centers in the area also reported 911-related problems, including lack of location information and loss of backup phone lines.

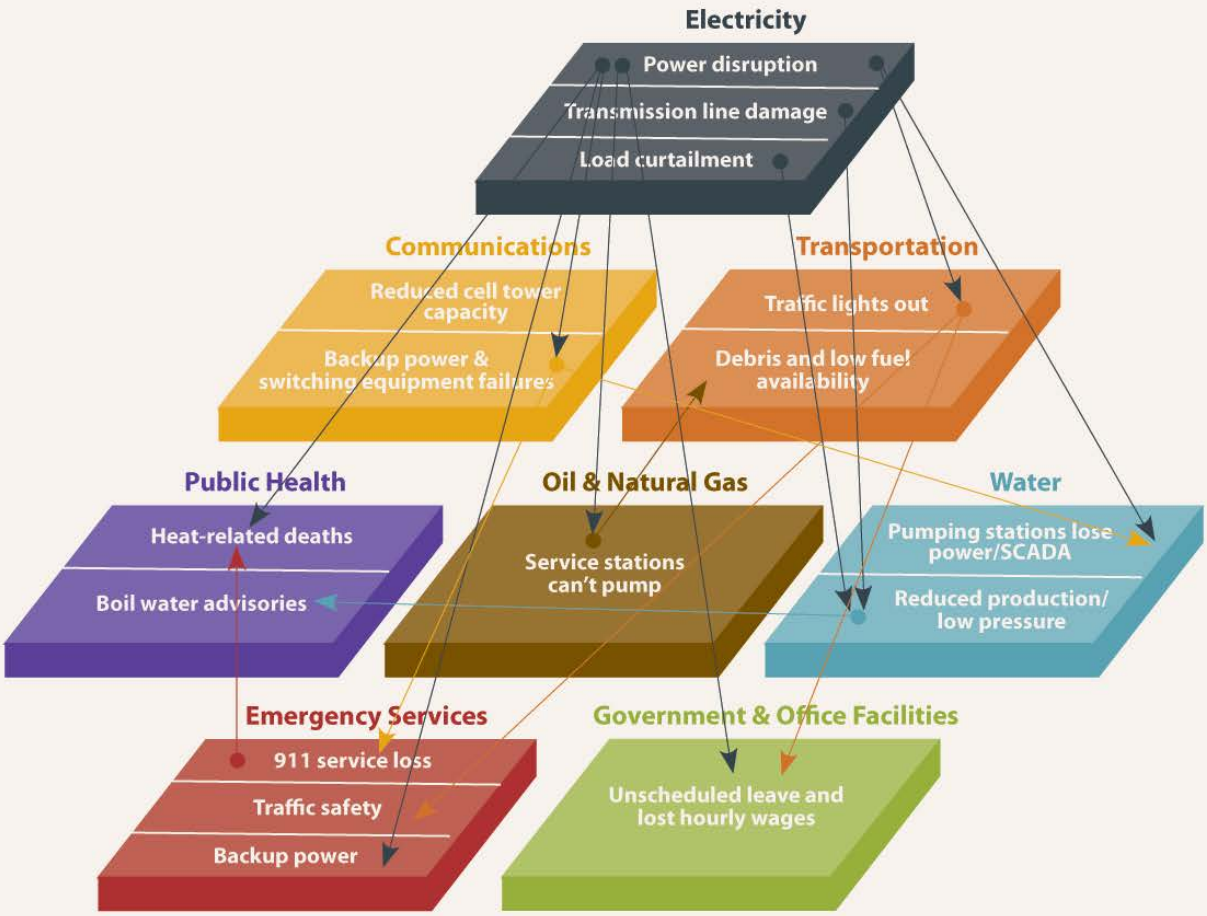
It took almost a week to restore power in some areas, while a heat wave descended on the region. Following the derecho, 34 people died from heat-related causes in areas without power.

Response & Recovery: More than 24,000 workers from Appalachian Power, Allegheny Power, Pepco, Dominion, and BGE worked on restoration, including workers from other states and Canada. Additional storms and excessive heat lengthened the time it took to restore power and other services.

Utility personnel were embedded with state and local emergency management agencies to facilitate communications and collaboration. All power was restored by July 8. Following the storm, utilities vowed to evaluate how infrastructure could be improved and in some cases were already in the process of making upgrades. Verizon also made changes to internal programs and procedures to ensure reliability of the system in the future.

Sources: Johns, et. al. 2013; NOAA 2013e; Samenow 2012; National Weather Service Forecast Office-Baltimore/Washington 2012; Brown, et. al. 2012; Paramaguru 2012; MDOT MTA 2012; Fairfax County, 2012; WSSC 2012; Verizon, 2012a; Malady, 2012; Bensen, 2012; DOC, NOAA, NWS, 2013; Mills, 2012; Pepco, 2013

Exhibit 10. Cascading Impacts of the June 2012 North American Derecho



Electricity

- 4.2 million customers in 11 states and D.C. lose electricity for up to a week as 24,000 workers repair damage
- Power lines to substations require repair before lines to critical facilities (water, hospitals, communications)
- Derecho-related power outages cost MD alone almost $600 million

Communications

- 10% of cell phone towers unreachable in the first 2 days, 2% by day 4
- Verizon: 156 downed utility poles and 897 downed copper or fiber cables
- Cell calls and data downloads strain wireless capacity, causing service disruptions
- Many cell towers on backup generators
- Backup power and switching equipment failures at multiple 911 call centers

Transportation

- 184 state roads close in MD; 20 primary and 201 secondary roads close in VA from debris
- Hundreds of traffic lights out across MD and VA
- Many must drive to find fuel, food, and hotels

Oil & Natural Gas

- Service stations lose power and ability to pump gas, creating long lines and complicating travel

Public Health

- 80 crews needed to restore power to 4 MD nursing homes without electricity or AC
- 34 people die from heat-related causes
- Low water pressure, discolored water, mandatory conservation, and a boil water advisory in Fairfax County, VA

Water

- PJM load curtailment reduces water production
- 50 Washington Suburban Sanitary Commission facilities lose power
- Fairfax County loses power to 40 of 63 wastewater pumping stations; all 63 lose SCADA communications

Emergency Services

- 911 services unavailable or unreliable for 3 days in several VA and WV counties;17 call centers lose connectivity from communication failures
- 911 calls in Fairfax increase 415% over the 3.5 hours following the storm; fire and rescue dispatch increases by 2,400%
- Public safety officials direct traffic at dark intersections

Government & Office Facilities

- Federal workers have option for unscheduled leave
- Commercial buildings close without power or transport

Co-location of Key Partners Improves Coordination and Decision-making

Co-location of key officials from lifeline sectors and public agencies in state and Federal emergency operations centers (EOCs) improved communications and accelerated public-private situational awareness, coordination, prioritization, and decision-making during Sandy. The inclusion of utility representatives in state EOCs and the FEMA National Response Coordinating Center, in many cases for the first time, was quickly recognized as a best practice. As emergency managers and private utilities worked side by side to coordinate and mutually support response, electric utilities and communications companies with co-located assets also worked together to coordinate repairs, speeding up restoration of both services. Where co-location of emergency response officials was not possible, daily conference calls between government officials and owners and operators enabled tight coordination that greatly improved cross-sector situational awareness. Successful efforts to co-locate and coordinate included the following:

- New Jersey held pre-event conference calls with private-sector stakeholders, established a private-sector desk within the EOC to coordinate resource and information requests, and invited representatives from the Fuel Merchants Association of New Jersey, which represents the state's petroleum marketing industry, into the state EOC to enable state officials to coordinate fuel requests from other critical sectors. Officials in New Jersey also had contact information for owners and operators of state- and national-level critical infrastructure and had previously issued private-sector employee identification cards to improve access for essential employees to disaster areas.
- Activating the Philadelphia EOC brought together police and fire, water, transit, and energy officials in both the public and private sectors under one roof to coordinate. Any agency that had a role in the response was requested to staff the EOC to promote information sharing, streamline decision-making, and to prioritize scarce resources.
- Safety concerns typically require that electric utilities remove live wires and complete repairs before communications providers repair lines on shared poles or assets. Because of the sheer magnitude of damage, this process slowed restoration times for communications companies such as Time Warner Cable, which worked with utilities to develop mapping software that showed where power had been turned off, clearing the way for Time Warner to begin repairs. When Time Warner reached an area first, they put the electric poles back, and vice versa, using a collective agreement.
- In daily calls led by the New Jersey Office of Homeland Security, emergency managers and owners and operators received updates on restoration across the region and coordinated a more effective response. Senior Department of Energy officials led and participated in coordination calls to facilitate power restoration to affected fuel terminals and refineries.

Joint Regional Exercises Build Response Muscle Memory

Recent experience with storms, such as Hurricane Irene in 2011, and participation in joint exercises helped government and lifeline sectors to improve emergency response plans, flood preparations, infrastructure hardening, and communication procedures. Drills and exercises keep partners engaged between events, enable knowledge transfer, and build "muscle memory" to make response automatic and well-coordinated. Exercises also offer the opportunity to define the specific roles and responsibilities of state and Federal government agencies during an emergency to limit unnecessary

duplication of efforts and enable a more effective response. Critical exercises in the Northeast region helped partners prepare for hypothetical impacts that Sandy made a reality:

- Regional water utilities in New Jersey participated in the DHS-sponsored New Jersey Exit 14 Regional Resilience Assessment Program (RRAP) the year prior to Superstorm Sandy, which provided regional hydraulic modeling and system assessments to identify vulnerabilities, interdependencies with other critical sectors, and economic and social impacts of outages in particular parts of the region. This program enabled providers to identify resilience improvements that would specifically address regional risks.
- New Jersey's recent "Running on Empty" exercise with its infrastructure bureau and regional owners and operators in 2011 presaged the petroleum disruptions the sector actually faced in Sandy. As a result, petroleum owners and operators were not caught off guard by Sandy's impacts and were able to begin organizing a response more quickly.
- DOE and the National Association of State Energy Officials (NASEO) conducted regional exercises in 2011-2012 that simulated cross-sector, multi-jurisdictional disasters, including: a mid-Atlantic hurricane, droughts, severe winter storms, solar events, and cyber attacks. The exercises included owner and operators and state and local emergency managers to examine how adjacent states and energy companies would coordinate regional disaster response.

Exhibit 11. Blue Cascade Exercises: PNWER Offers a Best Practice for Regional All-Hazards Preparation

More than a decade ago, the Pacific Northwest Economic Region's (PNWER) Center for Regional Disaster Resilience started its Blue Cascades Exercise Series to evaluate interdependencies among infrastructure and make recommendations for improvements. Since 2002, exercises have been held on a range of issues, including physical disruptions to the energy grid; physical and cyber disruptions; recovery and restoration from a major earthquake; critical infrastructures and pandemic preparedness; critical supply chains—food, fuel, water—after a major earthquake; and floods and H1N1. Participants include local, state, and Federal government; utilities; businesses; non-profits; academia; and community institutions. Following the tabletop exercises, the stakeholders develop an action plan to address issues identified. Because of their wide-ranging issues and cross-sector, cross-regional participation, PNWER's exercise programs are widely regarded as best practices for regional preparation to all-hazards events (PNWER CRDR 2013; CRDR 2010).

Complex Rules, Regulations, and Processes Hinder Lifeline Sector Response

Existing laws and regulations at the Federal, state, and local level and uneven processes for receiving waivers hindered rapid response during Sandy. Requirements for various permits, tolls, waivers, and worker credentials across states complicated movement of fleets of emergency repair crews, substantially delaying their ability to aid in recovery efforts—as a two-hour delay in fleet movement can effectively delay that crew from beginning restoration work for 24–48 hours. Sectors that used mutual aid assistance from repair crews outside the affected area relied on emergency waivers of driver-hour limits and minimum rest periods, and rapid load permitting for inter-state movement to speed response and recovery—and this sometimes required a complex and lengthy request process. Potential improvements have been suggested by regional groups:

- Nationwide or regionally consistent toll booth procedures to simplify payment processes (e.g., the East Coast's EZ-Pass system).

- Improved private-sector access to automated permitting systems to help speed fleet permits (e.g., the Pennsylvania Department of Transportation's [PennDOT] Automated Permit Routing/Analysis System [APRAS]).
- A centralized database for mobilization information that would provide utility fleets with details about state/local permitting requirements, toll road and payment protocol information, and updates on where emergency declarations have been issued and which waivers are in place as a result.

Federal, state, and local regulations—many designed to protect consumers—ultimately inhibited information sharing and limited fuel supply shipments from outside the region during Sandy. Limited visibility into regional fuel supplies made it difficult for owners and operators, government officials, and dependent sectors to assess the problem and prioritize response. State emergency managers and other critical sectors also lacked insight into the status of all links in the supply chain and the significance of disruptions, which complicated decision-making. Excellent Federal, state, and local coordination both before and during the storm swiftly delivered waivers in many cases. But sometimes the waiver process or lack of waivers significantly delayed restoration of fuel deliveries in the region. Other regulations were not easily waived and further exacerbated the disruption:

- Antitrust laws, which place limits on market-sensitive information sharing and competitive conduct, restricted the owners' and operators' ability to share information regarding their fuel supplies with government partners and other companies.
- SEC Regulation Fair Disclosure—which states that any material nonpublic information that a petroleum company discloses to another entity must also then be disclosed publicly—made petroleum companies reluctant to share sensitive supply status and operations information with state emergency managers and other sectors.
- Anti-gouging laws, established by the state to prohibit a service station from excessively raising the price of fuel (10% above normal prices in New Jersey; in New York, "unconscionably extreme" increases are barred [Yglesias 2012]) limited fuel supplies. The laws discouraged suppliers and distributors from bringing in fuel from other regions, as the increased transportation costs and subsequent fuel price increases would risk the appearance of price gouging.
- Uniform Commercial Codes, adopted by all 50 states, dictate that refineries and distributors cannot discriminate among customers and must first meet their contractual obligations. As a result, operators could not redirect fuel deliveries unless stated in existing contracts.

In addition to policy and regulatory challenges, Sandy also stressed utility mutual aid agreements and made securing sufficient response crews prior to the storm a challenge. Sandy demonstrated that when large storms follow unpredictable paths across a broad geographic region, companies tend to implement plans earlier and hold onto resources longer, forcing utilities to cast a wider net for mutual aid.

Strong Communities Reduce Impacts and Improve Recovery

The impacts of recent regional disasters are starting a culture shift toward community readiness and personal responsibility for short-term survival. Non-profit and community groups played a key role in assisting communities to respond in flexible and innovative ways and during long-term recovery from Sandy. In many cases, these organizations replaced lifeline sector services when major providers were

still performing restoration, by providing generators, transporting food and water, and replacing internet and wireless communications that were indispensable in the first few days. Some non-profits also work regularly with communities to train and prepare for disaster response, while community groups offer strong networks of individuals that can be leveraged in an event. While the potential severity and wide geographic reach of storm events is raising public awareness of the need to maintain self-sufficiency immediately following a disaster, continued support and education is needed. Building community capacity to shelter-in-place and withstand longer power and critical service outages can decrease the strain on state and local resources and improve recovery. The public needs education on disaster preparation and consistent messaging from state and local officials to build the expectation for individuals to be self-reliant for at least 72 hours following an event with major service disruptions.

Exhibit 12. Oklahoma Tornadoes: Experience and Lessons Learned Reduced Impact of Extended Disruptions

Event Summary: On May 20, 2013, an EF-5 tornado with winds between 200 and 210 mph moved about 14 miles from Newcastle, OK and ended a few miles east of Moore, OK, cutting a path 1.1 miles wide and killing 24 people, injuring hundreds, and damaging about 13,000 homes. The storm's damage is estimated at about $2 billion. The tornado was part of a string of severe weather events the state experienced in the spring and summer.

On May 31, a tornado tore through an area near Oklahoma City. The broad storm hit during rush hour and caused flash flooding. Almost two dozen people were killed, there was extensive property damage, and more than 86,000 customers lost power. At the end of July, a derecho with winds between 60 and 80 mph caused more than 100,000 homes and business to lose power primarily near Tulsa.

Impact: Following the May 20 tornado, there were widespread disruptions to cell phone and internet service, primarily due to cell tower damage and power outages. Wireless providers encouraged residents to use text messages rather than make calls. Some providers also waived voice, data, and text overage charges in the affected areas for a month following the tornado.

Businesses reported losing perishable inventory multiple times due to the number of power outages from the storms, along with losses from extended business closures due to damage or power outages. In Moore, an estimated 6,000 businesses were affected by the storm, the majority of which were small businesses. Public health services were also impacted by the severe weather. The May 20 tornado destroyed a hospital, while the July derecho forced the evacuation of 100 residents of an assisted living facility because of power outages.

Response & Recovery: Moore, OK is no stranger to tornadoes—major tornadoes ripped through the town in 1998, 1999, 2003, and 2010. Officials credited the response following the tornado to preparedness and experience. Businesses served as collection sites for donated goods and donated portions of sales to the Red Cross.

Two of Oklahoma's urban search and rescue units responded to help find survivors. An additional unit responded from Texas under a mutual aid agreement between the states. The Federal Emergency Management Agency sent three disaster survivor assistance teams, which used tablets to quickly register people and record unmet needs. In an example of private sector coordination, Moore's public affairs office reached out to a local advertising firm that supplied professionals to update social media and take reporters' requests.

Improvements in forecasting gave residents additional time to prepare in 2013. The National Weather Service issued a warning for the area including Moore 16 minutes before the tornado was expected to touch down, but it took an additional 20 minutes to reach the area, giving residents about 36 minutes' warning . The National Weather Service also used social media, such as Twitter, to issue warnings and provide information about the location of the tornadoes.

Sources: CNN 2013; Jonsson 2013; NWS 2013a; Plushnick-Masti and Murphy 2013; Murphy 2013; NWS 2013c; *Tulsa World* 2013; Smith 2013; Arnold 2013; Kirgan 2013; Grenoble 2013; Bland and Muchmore 2013; Palmer 2013; *Tulsa World* Staff Reports 2013; Anderson 2013; NWS 2013b

Innovative Social Media Use Can Revolutionize Response

Social media became a valuable communication tool during Sandy that provided new information streams to support situational awareness, provide notifications, and control rumors. It was used extensively by state and local governments as well as utilities to communicate updates to the public and help reduce panic, while confirming information and reports following the storm. For example, students from Franklin High School in New Jersey solicited feedback from Twitter to map which gas stations were closed or open and shared it on Google crisis maps, which governments and citizens used to help manage the fuel disruptions. In addition, social media served as a critical tool for organizations to survey and match community needs with resources and personnel, and enabled ad-hoc community groups to assist with emergency response outside of traditional processes. State and local governments began utilizing social media to inform and support critical operations in ways they never had before. However, social media also complicated traditional communication and was only partially used by government agencies and owners and operators, who are often learning by trial and error. Government agencies, community organizations, and infrastructure owners and operators are examining training and opportunities to better leverage social media during normal operations and disasters.

> "Social media are transforming the way rescuers and survivors respond to crises. These new tools have the power to turn traditional, top-down emergency management on its head."
>
> **—Dr. Stephen Flynn**
> Founding co-director of the George J. Kostas Research Institute for Homeland Security at Northeastern University
>
> (Testimony before the 112th Congress 2012)

Specific examples of the innovative ways social media was leveraged during Sandy include the following:

- Philadelphia's integration of social media into its Office of Emergency Management (OEM) and 311 mobile platform showed how social media could be used to reach large populations in real time and request information from citizens to improve response. The City of Philadelphia used the new "Philly311" mobile app, launched in September 2012, to share information with the public and receive non-emergency requests from residents across the city during Superstorm Sandy. More than 400 requests were made via the app, and the @Philly311 Twitter account gained approximately 2,000 followers and sent 1,000 tweets during the storm.
    - The city is now exploring opportunities to: better coordinate social media into its Joint Information Center; train and dedicate personnel to social media management to improve messaging frequency and relevance; and engage in social media "mutual aid" agreements with agencies in other states that provide personnel to monitor and aggregate social media inputs from followers in a disaster. The city is also exploring the use of platforms such as Google Forms with private-sector providers to gather information on which grocery stores, restaurants, service stations, and key businesses are operational during an event and provide that information to the public.
- The New York MTA adjusted service maps online and communicated all updates to bus, subway, commuter rail, and bridge and tunnel service via a multi-channel information push; it also posted pictures and videos of the damage to help the public comprehend the severity.
- New Jersey Transit offered free park-and-rides, shuttle buses, and ferries into Manhattan to mitigate congestion on open bridges and tunnels, and alerted customers via its website and updates on Twitter, Facebook, and the "My Transit" e-mail alert system.

Exhibit 13. Boston Marathon Bombing: Transit Shutdown Impact and Innovative Social Media Use

Event summary: During the prestigious Boston Marathon on April 15, 2013, at about 2:50 p.m., two bombs made from pressure cookers were detonated within seconds of each other near the finish line, killing three people and injuring more than 260. Almost 27,000 people run in the marathon, while more than half a million spectators line the 26.2 mile route.

As first responders rushed to help the injured, law enforcement began a massive manhunt. On April 18, the FBI released pictures of the two suspects—brothers of Chechen origin who immigrated to the U.S. and were living in Boston. That same day, the suspects are accused of killing a Massachusetts Institute of Technology police officer before hijacking a car in Cambridge. During a police chase early on April 19, one of the suspects was injured and later died. The remaining suspect escaped, and authorities instructed residents to stay inside, essentially putting the city into lockdown on Friday, April 19, until the remaining suspect was discovered around 6 p.m.

Impact: The social and economic impact was significant. Businesses near the bombings experienced millions of dollars in losses, while the combined value of tickets to canceled performances and a basketball game was more than $2 million. Financial analysts estimated that the lockdown cost between $250 million and $333 million per day based on the area's gross domestic product.

The Boston transportation sector faced a near-total shutdown. The Massachusetts Bay Transportation Authority (MBTA) suspended public buses and subway transit; Greyhound Bus closed it Boston terminal; MegaBus canceled 35 trips to and from Boston; and even taxi service was halted. Train service was suspended or modified with Amtrak stopping its service between Boston and key regional terminals, including Providence, RI and New York. Airspace over Boston was limited by the Federal Aviation Administration, but the airport remained open, and airlines waived fees for customers unable to get to the city's airport. Costs of the shutdown include $1.56 million in lost fares to MBTA, lost parking ticket revenue of about $8 million, and $180,000 in costs for canceled Amtrak service.

Response & Recovery: On April 15, an 80-person Multi-Agency Coordination Center was operated out of the state's Emergency Operations Center. Extensive event preparation included an operational plan for a wide range of incidents and a tabletop exercise in early April before the marathon. Kurt Schwartz, director of the Massachusetts Emergency Management Agency, credited the quick and effective response to the state's preparedness efforts. As Schwartz told a congressional committee in July, "There was unity of focus and unity of purpose at the command level and through the ranks all the way to the first responders on Boylston Street on April 15th and the thousand-plus police officers that participated in the state's largest manhunt on April 18 and 19."

Following the bombing, the MBTA and Boston Police Department used social media to provide information on the investigation and suspects to the public; drive users to their See Something, Say Something website and app to report new information; and communicate hospital and transit system updates to the public and media immediately after the event when cell phone service was extremely limited. Boston Police Department saw its Twitter followers swell from about 50,000 to more than 300,000 in the days following the bombing.

By putting out accurate information quickly, law enforcement established themselves as a trusted resource for information and would often "break" stories that the media would have traditionally reported first. They were also able to use tweets and posts to correct misinformation circulating on social media. Given the unprecedented nature of the event, residents released information about police searches, and law enforcement was able to quickly educate the public on the danger from such information releases.

Sources: CNN 2013; Malone 2013; Jeansonne 2013; Dedman and Schoen 2013; Green and Winter 2013; Booton 2013; Mayerowitz 2013; Schwartz 2013

Innovative ways social media was leveraged during Sandy (*continued*):

- Commuters connected with other drivers and passengers through neighborhood networks, picked up strangers, and shared taxi rides using social media to help meet HOV-3 restrictions.
- The Jersey Shore Hurricane News, a Facebook- and Twitter-based news platform originally created by a digital journalist in advance of Hurricane Irene in 2011, provided accurate news reports and crowdsourced information about food, water, gas, and shelter, and deliveries of supplies to residents, emergency responders, and community organizations. When 911 was overloaded, the New Jersey Office of Emergency Management used the platform to communicate with people requesting rescue.
- The American Red Cross' Social Engagement team used pertinent posts from its Facebook page to inform its Mass Care team's response and influence change in ground operations. In its D.C.-based social media disaster operations center, volunteers also monitored hashtags and keywords on Twitter, Facebook, and blogs to determine need and inform service delivery plans. The Red Cross also offered a Hurricane App to assist in individual recovery.
- Through social media and firefighter websites, grassroots organization Operation Breezy was able to spread the word that people were in need, resulting in volunteers coming in from around the country to help gut and pump water out of residents' homes.
- A 14-year-old girl used Facebook to found Survivors Silver Lining, which continues today to communicate needs (e.g., building supplies) and match donors with Hurricane Sandy survivors. She has also used the site to keep interest in donating alive after media attention dwindled.

Business Case for Infrastructure Investment is Difficult to Define

Critical infrastructure owners and operators in the region increasingly recognize the need for investment in innovative infrastructure upgrades, both in the short term and over longer time frames, to make infrastructures more resilient and protected against risks the region has not yet faced. However, it is difficult to justify large capital investment in resilient infrastructure without public support and the ability to recoup costs. Recent experience with losses from catastrophic events like Sandy provides tangible evidence of the economic and public health consequences of weak infrastructures. The unprecedented flooding and damage that occurred during Sandy caught many operators and public officials off guard, creating a strong business case in the public and private sectors for billions of dollars of investment in infrastructure hardening and technology upgrades. In addition, prior investment in fiber cable and undergrounding for resilience paid off for communications companies. On the same streets in lower Manhattan, tons of copper cable was corroded by saltwater, while fiber lit back up once switches came back online; even above ground, fiber did not break as often as copper.

Where the business case does exist, rate recovery for resilience investments can be a political challenge, even after large storms. Although public and political support is high for resilience investments in the immediate aftermath of a storm, that sentiment can quickly fade as time passes and rate hikes are discussed. In addition, public officials and owners and operators who wish to rebuild smarter are often uncertain what level of resilience is needed to address future risks. Utilities need a clear cost-benefit case for resilience improvements in proposals to public utility boards. Energy companies in New York and New Jersey have proposed significant grid modernization and hardening following Sandy, while some transit agencies have already identified future innovative system improvements, including the following:

- Relocate key data centers outside of flood zones and build redundant or backup control centers to transfer operations if one is damaged.
- Design reusable watertight coverings for vents and electronic equipment in the short term, and even rebuild with submersible components in the long term.
- Engage with surrounding counties to responsibly plan drainage from new developments, such as shopping malls and parking lots, to decrease drainage around critical infrastructure.

Exhibit 14. Red River Floodway: Capital Investment in Infrastructure Pays Huge Dividends Over 40+ Years

A flood in Winnipeg, the capital of Manitoba, Canada, during the spring of 1950 caused the evacuation of 100,000 residents, destroyed 10,000 homes, and resulted in about $125 million in damages (or about $1 billion in today's dollars). Following the flood, Duff Roblin, a backbencher of the minority party in the Manitoba legislature, championed the construction of a diversion channel around the city to prevent future flood damage. The plan faced heavy criticism and was nicknamed "Roblin's Folly." Despite opposition to the floodway, Roblin, then-leader of the minority party, made the project a key issue for the 1958 provincial election. Roblin won the election and, as premier, he pushed forward with construction of the floodway.

The floodway took six years to construct, cost about $63 million, and in terms of scale was the second largest earth-moving project behind the Panama Canal construction at the time. The artificial waterway was completed in March 1968 and has been operated 20 times since its first use in 1969. The floodway has prevented more than $30 billion in flood damages, according to the Manitoba Floodway Authority.

Lessons Learned: A "Flood of the Century" in 1997 threatened to exceed the Red River Floodway's capacity, but the city remained protected from damaging flood waters. Grand Forks, North Dakota, located less than 150 miles away over the U.S. border, experienced more than US$1.5 billion in damages because of the flood. The flood damaged 83% of the city's homes and 62% of the city's commercial units, and required the evacuation of 52,000 people.

As a result of the 1997 flood, the Red River Floodway was expanded to provide 1-in-700 year flood protection. The project, completed in 2009, protects more than 450,000 Manitobans, 140,000 homes, and 8,000 businesses. The expansion cost about $665 million, paid equally by the Government of Canada and the Province of Manitoba.

The floodway, commonly known as "Duff's Ditch," has been studied by representatives from other flood-prone communities. Following Roblin's death in 2010, the construction of the floodway—despite fierce opposition—was noted as his greatest accomplishment and lasting legacy.

Sources: MFA 2013a; MFA 2013b; MFA 2013c; Martin 2010; CBC News 2010; Grand Forks 2011

Risk Data is Needed to Build Stronger and Redefine Best Practices

Sandy's storm surge caught many operators and public officials by surprise, overwhelmed some critical facilities, and damaged or destroyed infrastructure. Forecasts during Sandy from the National Oceanic and Atmospheric Administration (NOAA), while accurate, were communicated in a confusing way and, as a result, were not well understood by emergency personnel and utility owners and operators (NOAA 2013a and 2013b). Outdated FEMA flood maps and NOAA SLOSH (Sea, Lake, and Overland Surges from Hurricanes) maps meant many decision-makers did not fully understand the impact of nor take

immediate action based on NOAA's predictions. Had they understood the warning language and its implications, more owners and operators would have preemptively shutdown at-risk facilities to avoid equipment damage.

Rising sea levels, larger and more frequent storms, and altered drainage patterns due to new construction mean that flood walls may no longer be high enough, and new potential failure points may emerge. City planners and utility owners and operators need updated, detailed data on forecasted impacts of climate change that could increase infrastructure risks during storm events. New modeling tools—with updated climate change and flood predictions—can help regions revise system-wide risk assessments and identify new and future failure points. Examples of the need for new data and tools include the following:

- New York is re-examining the subway system using NOAA SLOSH maps to build more accurate flooding and failure predictions that address changing street elevation and potential surge heights. This study is addressing new critical failure points from Sandy, such as stairwells and entrances that caused the majority of subway tunnel flooding, where agencies can prioritize future hardening.
- A large wastewater treatment plant in Philadelphia operates under gravitational flows, with no effluent pump. As sea levels rise during storm surges, or over time through climate change, the treatment capacity of the plant drops and creates the potential for sewage backflow. Accurate forecasts are needed to determine when and what infrastructure investments will be needed to keep this plant operating.

3. Common Characteristics of a Resilient Region

One objective of our study was to identify the characteristics of a resilient region. Several organizations and academic institutions are developing or piloting processes to help regions measure and compare their resilience in a quantitative and consistent manner. However, benchmarking measurements are complex, not yet fully developed or widely available, and may not yet provide concrete and tailored paths to improvement for regional partners across sectors. Yet our study uncovered eight key characteristics that are common to resilient regions. Interviews with regional organizations and resilience leaders, a real-world testing of resilience in the Northeast region, and a wide body of resilience research and literature point to eight characteristics that resilient regions universally exhibit.

A resilient region is like a healthy immune system: rather than preparing for every possible scenario, the region fortifies the underlying resources and capabilities that enable it to quickly mobilize and respond effectively to any disruptive event (National Academy of Sciences 2012, Allen). Much like in a human body subjected to an illness, the extent of damage and time to recover in a region often depend on the pre-existing conditions, or "health" of the region, not just the severity of the assault. For most disasters, the timing, size, location, and strength of a disaster cannot be controlled. However, the pre-existing conditions in the region are the factors that stakeholders *can* actively improve prior to a disaster. Rather than provide a quantitative measure of resilience, the following model presents the components of resilience and disaster response that a region most needs, and that stakeholders can actively control.

Like elements of an immune system, these components work together to support coordinated planning, prevention, detection, response, and recovery. As a result, these eight characteristics (in no priority order) represent practical areas where public and private stakeholders can focus their efforts and resources to improve regional resilience:

1. **Strategic Intent and Unity of Effort**: A resilient region has the strategic guidance, leadership, and organization to quickly align diverse partners toward common objectives. Resilient regions have engaged in Federal strategies, including the national policies, planning frameworks, and partnership models that encourage public and private coordination. We found such regions have strong leaders in both industry and government providing senior executive guidance that influences actions at all other partnership levels.
2. **Partnerships and Executive Engagement**: Public-private, cross-sector partnerships are the highly effective mechanism that enable regions to build and execute a resilient response. When those partnerships are spearheaded by strong engagement between senior critical infrastructure and government executives, regions can remove barriers and red tape, effectively allocate limited resources, and accelerate a coordinated response (see Exhibit 15. Characteristics of Effective Public-Private Partnerships).
3. **Elevated Priority of Lifeline Functions**: Resilient regions routinely prioritize the response and recovery of lifeline sector services in emergency response plans, supported by strong relationships among public emergency managers and lifeline infrastructure owners and operators. Partners ensure a coordinated response during an event by co-locating personnel or ensuring backup communications are available for pre-determined contacts. Pre-event exercises and relationship-building among infrastructure owners and operators and emergency services personnel prior to an event ensure a rapid and coordinated response that prioritizes and

ensures life safety. Resilient regions have strong emergency support functions that are well-coordinated at local, state, and Federal levels using standards such as the National Incident Management System.

Exhibit 15. Characteristics of Effective Public-Private Partnerships

Public-private partnerships have become somewhat commonplace throughout government. But certain partnerships are much more effective than others. The Council identified the distinguishing features of highly effective partnerships that should be pursued when developing regional partnerships.

- **Strong value proposition** in which partners recognize distinct benefits from participation that strengthens by building a strong track record of success.
- **Shared goals and objectives** that define how partners will work together to realize increased resiliency and risk management outcomes.
- **Trusted relationships** between industry and government built over time enable partners to candidly discuss sensitive matters and share information in a protected environment.
- **Mutual commitment of resources** in which partners jointly contribute their relative expertise and resources to achieve mutually beneficial goals and objectives.
- **Senior executive-level engagement** that facilitates coordinated efforts at all levels of the sector and enables CEOs to set strategic priorities and commit resources to them.
- **Simple process** for highly effective meetings between partners that includes a set agenda, defined outcomes, and clear roles and responsibilities for participants.
- **Neutral champion** who can efficiently facilitate the group partners in identifying priorities and actions, and is respected and trusted by both public and private sector partners.
- **Clear deliverables** that are well defined, actionable, and produce the desired outcomes that achieve shared goals.
- Common **metrics** to track progress and create accountability.

4. **Healthy and Active Community Resources**: Resilient communities recognize that a strong and prepared public—through citizens, community groups, and local businesses—resists victimization and instead actively contributes to public health and safety and service restoration during both immediate response and long-term recovery. A whole-of-community approach to resilience leverages the capacity of all institutions, not just critical infrastructure, to respond to an event. During Sandy, areas with strong community ties, established organizations and networks, and pre-event citizen preparation and training exhibited an innovative, nimble, coordinated, and life-saving response.
5. **Exercised Coordination and Information Sharing**: Regions that have participated in joint, cross-sector exercises have been better able to prepare for disasters, anticipate impacts, and leverage partnerships and relationships to communicate and coordinate during disaster response. Public-private, cross-sector regional exercises enable regions to test response capabilities to reveal new risks, strengthen and refine capabilities, and ensure strong communication processes and mechanisms exist prior to an event.

6. **Clear Value Proposition**: Resilient regions find clear value in investing in resilient infrastructure designs, processes, and practices. They are able to align resilience benefits with other operational and societal benefits, successfully making the case for investment to senior executives, regulators, lawmakers, and customers. A clear, shared value proposition creates opportunities for creative financing and joint investment.
7. **Intelligent Infrastructure and Innovation**: Long-term investment in new architecture designs, next-generation technologies, and innovative uses of emerging tools and capabilities such as social media will enable regions to become more resilient to new and more frequent disasters. After Sandy, sectors and communities who had already begun to design and build adaptive and innovative infrastructure with intelligent technologies ultimately faced fewer disruptions and were able to more quickly respond and restore critical services.
8. **Resilience Measurement and Risk Management**: To optimize resilience, regions have effectively brought together diverse, cross-sector partners to map interdependencies, identify vulnerabilities, and develop collaborative risk management plans that look holistically at regional risks, not in silos at sector or business vulnerabilities. State-of-the-art risk data, models, and measurement tools are critical resources to help regions examine their distinctive priorities and opportunities for strengthening resilience, and to inform regional best practices for infrastructure security and resilience.

Exhibit 16. Common Characteristics of Resilient Regions and Example Components

4. Findings

The Council finds that achieving regional resilience is the key to achieving national resilience. This cannot happen without a whole-of-nation, whole-of-community approach in which the collective capabilities of security and resilience partners at all levels of government and industry are combined to face the challenges of our complex risk environment. The common characteristics of a resilient region provide the essential building blocks for strengthening resilience. However, each region has distinct needs that must be considered in designing an effective resilience strategy. The Council's findings focus on the central role that the lifeline sectors play in achieving regional resilience and the importance of sustained public-private partnerships at the highest level.

Our study revealed three fundamental principles of regional resilience that align with previous NIAC studies and recent Federal policy directives.

Exhibit 17. Principles of Regional Resilience

1. **Resilience requires a whole-of-nation approach that integrates top-down policy and leadership with bottom-up community capability to withstand and survive disasters.** Resilience cannot be achieved only by driving improvements from the Federal government, nor by grassroots efforts alone. Both are necessary to provide a unity of effort and a whole-of-nation approach that engages all possible stakeholders and resources.
2. **Effective regional resilience strategies must be tailored to the distinct features and needs of each region and designed to manage complex regional risks that span multiple jurisdictions and infrastructure sectors.** Regions have different geographies, economies, infrastructure designs, populations, resources, risk, and needs. Building strong and resilient infrastructures and partnerships means working to meet the specific requirements of the region at hand.
3. **Strong public-private partnerships and relationships that include senior executive engagement are the most effective and enduring strategy for achieving sustainable resilience.** Partnerships are the singular element that enables coordinated response and decision-making. Strong partnerships and established relationships enable all other capabilities and resources to operate effectively and transform a response effort.

These principles recognize that national resilience is the logical outcome of regional resilience. Any national strategy to strengthen resilience must include all of these elements.

The Council identified six findings of the challenges, critical needs, best practices, and essential strategies for improving resilience within regions.

Finding 1. Lifeline sectors are top priorities for achieving regional resilience and their growing complexity creates hidden risks.

1.1 Four lifeline sectors—energy, water, transportation, and communications—are top priorities for strengthening resilience in all regions because they provide essential products and services that underpin the continued operation of nearly every business sector, community, and government agency. They typically deliver just-in-time services that are ubiquitous in normal circumstances but

can create life-threatening conditions if they are unavailable for long or even short periods of time. Their disruption or destruction can cause failures that cascade across dependent infrastructures and regions, producing a multiplier effect of impacts. We find that maintaining the continuity of services of the lifeline sectors is paramount to regional resilience.

1.2 The increasing interdependence and integration among lifeline infrastructures has created hidden regional risks that are not widely understood by the businesses, governments, and communities that depend upon them for essential services. Increasingly complex networks of interconnected physical and cyber infrastructures within and between regions have allowed disasters to ripple through adjacent regions and sectors, causing disruptions and damage across large geographic areas. Tight regional interdependencies mean that disruptions can trigger cascading events that may interrupt critical services, impede emergency response, and threaten public safety in unexpected ways. We find that public officials and infrastructure owners and operators need to better understand the operations, response, and recovery processes used within the lifeline sectors to improve regional disaster coordination and response.

1.3 Joint regional exercises that engage public and private partners at all levels are highly effective in exposing gaps, identifying interdependencies and hidden risks, and improving response capabilities. Public-private, cross-sector exercises help regions identify interdependencies and potential gaps, prepare for catastrophic events, and build cross-sector partnerships between disasters. Well-designed exercises—which include full participation by public- and private-sector partners, cross-sector and cross-jurisdictional partners, and senior executives (for catastrophic events and resource prioritization)—enable participants to "experience" unprecedented events, exposing and addressing new coordination challenges. Owners and operators of lifeline sectors need a stronger value proposition to participate in regional exercises, and greater recognition and participation from senior state and Federal officials is needed.

Finding 2. Regional resilience efforts are most successful when they are tailored to the characteristics and needs of each region.

2.1 National resilience is the collective outcome of the resilience of all regions. Yet all regions are different, calling for a tailored approach to resilience that reconciles the types and density of a region's infrastructure with regional-based risk assessments. Each region has distinctive features—geography, natural and man-made risks, demographics, infrastructure mix, and economic and governance structure—that define its approach to regional security and resilience. While certain infrastructures are vital in all regions, regional partners must determine which sectors are most critical to both their region and the nation, and prioritize them for security and resilience improvements. In Houston, for example, the oil and natural gas sector and the Port of Houston are critical to the local economy and to the security and resilience of the nation. In New York, the banking and finance sector and the information and communication infrastructures that support it are critical to New York and financial systems worldwide. Accordingly, we find that a tailored approach is best for achieving sustainable, long-term resilience.

2.2 A community's capacity to withstand a disaster is improved when regional emergency managers engage non-profit and community groups as critical partners in disaster preparation, response, and recovery. No matter the size of a disaster, it is the local businesses, volunteers, and agencies that immediately respond, making national resilience the collective output of resilient regions,

communities, and individuals. Recent disasters have precipitated a culture shift toward community readiness and personal responsibility for short-term survival. Communities and organizations who actively engage in planning and response training with non-profit and community groups prior to disasters are able to mobilize resources and assistance faster when disaster strikes.

Finding 3. Senior executive engagement creates strong public-private partnership, which is the most effective strategy for achieving long-term resilience within regions.

3.1 Public-private partnerships based on senior executive-level engagement prove to be the most robust. because they enable partners to set strategic direction, establish priorities, provide resources, and exercise accountability. Strong relationships and partnership between senior private and public executives streamline coordination, in a way not possible through other means, to efficiently address strategic infrastructure priorities and expedite decision-making during catastrophic disasters of national importance. Senior-level government and industry task forces allow leaders to cut through "red tape" and lead to effective and innovative response. As four prior NIAC studies have emphasized, senior executive-level partnerships are central to the long-term security and resilience of critical infrastructures. Engagement at the most senior levels precipitates seamless coordination throughout all levels of government and organizations. Where there is strong senior-level engagement, partnerships at operational and tactical levels become automatic and effective.

3.2 Strong public-private partnerships with relevant partners and active cross-sector coordination are the most important success factors in helping regions to achieve sustainable resilience. We find that healthy partnerships at all levels across industry and government are a defining characteristic of resilient regions. Effective partnerships are based on four fundamental building blocks: 1) trusted relationships, 2) leadership and senior executive engagement, 3) a clear value proposition, and 4) a simple process (including a focused agenda, defined deliverables, and clear roles and responsibilities). The nation is in a transformative period where institutions, business models, and funding models are being reframed to embrace public-private partnerships, make them an integral part of business operations, and use them as a vehicle for proactive engagement. As risks become more complex, organizations increasingly need the right mechanisms to bring together a range of capabilities from the public and private sector to address them. As regional and sector interdependencies increase and risks change, active regional partnerships provide a strong mechanism to develop adaptation strategies.

Finding 4. Social media has emerged as a powerful but underutilized tool for communicating and collecting data during emergencies.

4.1 Social media can improve situational awareness, inform public decision-making, and mitigate rumors. When social media is leveraged effectively, organizations increase transparency, gain recognition as a credible source, influence stakeholder decisions, and collect a new stream of real-time information that becomes valuable when other communications fail. For example, social media was indispensable for emergency managers during Superstorm Sandy and the Boston Marathon bombing to inform and influence public action and source new operational information

(see Exhibit 13. Boston Marathon Bombing: Transit Shutdown Impact and Innovative Social Media Use and surrounding text for details).

4.2 Government and business have not fully capitalized on the potential of social media in disaster response and recovery. Social media platforms enable real-time, two-way, communication between infrastructure owners and operators and the public, yet businesses and government are just learning how to effectively use available tools. When used improperly, social media enables other parties to control the conversation, shape public perception, perpetuate rumors, and question the credibility of organizations that do not engage. Any organization dealing with a complex disaster that doesn't take social media into account and proactively engage with it will face a public reality created by someone who may not be knowledgeable or consequential. We find that social media has become a permanent feature of the nation's social ecology; organizations can choose to suffer its blows, manage it effectively, or further adapt their use to realize its untapped potential to support future disaster response.

Finding 5. Rapid recovery of lifeline infrastructures is hindered by complex rules, regulations, and processes.

5.1 Incident response personnel in critical sectors encounter persistent problems gaining rapid access to disaster areas to repair damaged assets. State and local law enforcement routinely deny crews access to restricted areas because they do not consider employees of water, communication, oil and natural gas, or transportation companies to be "emergency responders." Incident response workers lack a commonly accepted credential, despite three prior NIAC studies that have called for nationwide credentialing and access protocols.

5.2 Complex laws and regulations at the Federal, state, and local level and inefficient processes for granting waivers and permits can delay interstate fleet movement and prevent the most effective and logical disaster response. Overall, coordination among Federal, state, and local government agencies and critical infrastructure owners and operators in preparing for and responding to disasters has matured and improved. Despite improvements, persistent barriers continue to impede rapid response and recovery. As noted in prior NIAC studies, regulatory issues exist in the petroleum sector, including antitrust laws and fair disclosure regulations that place limits on market-sensitive information sharing, and state anti-gouging laws that during Sandy prevented suppliers from procuring fuels from outside regions to avoid suspicion. For all lifeline sectors, widely varying permits, waivers, and processes for interstate fleet movement and toll crossing complicates or delays the movement of mutual aid repair crews.

Finding 6. Without a strong value proposition, owners and operators are unable to invest in new and innovative infrastructure that can mitigate long-term structural risks within regions.

6.1 Owners and operators often find it difficult to establish the strong value proposition needed to invest in new or upgraded infrastructure without public support and the ability to recoup costs. While state and local governments may seek larger goals of sustainability and social benefits, investment in resilient infrastructure is difficult to justify for private-sector owners and operators unless upgrades contribute to the bottom line and/or qualify for cost recovery through the rate structure or other means. The value proposition for investment is more easily established when all

stakeholders come together to align public- and private-sector goals. Regional resilience efforts should not aim just for loss avoidance because this approach misses abundant opportunities to improve the economic, social, and environmental well-being of citizens within the region. Resilience can also provide a competitive advantage for companies and regions, attracting new business that support social and economic growth. As the threat environment grows beyond the ability of the private sector to respond alone, incentives and cost recovery mechanisms for infrastructure owners and operators are needed at the Federal, state, and local level.

6.2 Regions can mitigate long-term risks by applying innovative technologies to build resilience into new and replacement structures, and rethinking systems and architectures using novel infrastructure designs that are inherently resilient. Federal and private R&D partners continue to deliver new, intelligent technologies and designs that can improve the delivery of regional services, isolate disruptions, better control interdependent systems, and exploit data analytics to optimize response and recovery. By building and rebuilding "smarter," regions can address a variety of long-term goals, including climate change adaptation and sustainability, economic growth, and operational efficiency. We find that improving resilience is a long-term proposition that must engage public and private partners to determine the best approach for designing regional infrastructures, creating investment in innovative technologies, and training a workforce that can install and use new technologies.

5. Recommendations

The Council recommends six concrete actions for the Federal government that will help build resilience within regions. While each recommendation has merit on its own, the Council believes that pursuing these recommendations as an integrated strategy will produce benefits that are greater than the sum of their parts.

Recommendation 1. The President should direct the heads of the appropriate Sector-Specific Agencies to form partnerships with senior executives from the lifeline sectors, using a process modeled after the government's successful executive engagement with the electricity sector.

Strong, trusted relationships among senior Federal leaders and senior executives of lifeline sector companies establish a high-level framework and direction that support regional and community partnerships. The Administration should make it a priority to form partnerships with lifeline sector CEOs of private infrastructure or executives with equivalent responsibilities because service disruptions within lifeline sectors can severely harm regional industries, public health, and safety.

Four previous NIAC reports have recommended the formation of senior executive partnerships between Federal leaders and industry CEOs to build key relationships, set priorities, take collective action, and commit resources to address urgent infrastructure challenges. CEO-level executive engagement in the electricity sector has been a game changer over the last 18 months and the lessons learned can help guide the formation of similar CEO partnerships in other lifeline sectors. The electricity sector partnership was used to expedite power restoration during Superstorm Sandy, help the industry better understand and prepare for cyber threats, and make key government agencies more aware of the electricity sector's capabilities to protect the electric grid (see Exhibit 8. Transforming CEO Engagement for details).

To implement this recommendation, the Council recommends the following milestones.

1.1 Within six months, the President should direct the heads of appropriate Sector-Specific Agencies to convene a meeting with CEOs or other sector leadership with equivalent decisionmaking authority from each lifeline sector to explore the formation of a partnership to address high priority risks to the sector's infrastructure.

1.2 Within one year, DHS should collaborate with electricity and nuclear sector industry associations to document the process used for CEO engagement in the electricity sector to discern lessons learned that can guide senior executive partnerships in other lifeline sectors. These senior executive partnerships should be formed within the Critical Infrastructure Partnership Advisory Council (CIPAC) framework to foster trusted, direct discussions among leaders. To ensure success, the partnerships should be built upon four fundamental principles, which were found to be the foundations for success in the electricity and nuclear sectors: 1) trusted relationships, 2) leadership and senior executive engagement, 3) a clear value proposition, and 4) a simple process. Each lifeline sector should work through its existing trade organizations to

coordinate CEO participation and work with Federal partners to identify a compelling value proposition for executive engagement.

1.3 The President should task the NIAC to identify the highest priority cross-sector risks affecting national security and resilience and produce a written report to the President within 18 months recommending potential executive-level, cross-sector action. Cross-sector risks stem from threats large enough to affect multiple sectors, and risks that arise from interdependencies and common vulnerabilities between lifeline sectors. By better identifying where risks intersect among lifeline sectors, government and industry partners can better allocate resilience resources.

Recommendation 2. The Secretary of Homeland Security should facilitate efforts with governors, mayors, and local government officials to identify or develop regional, public-private, cross-sector partnerships, led by senior executives, to coordinate lifeline sector resilience efforts within a given region.

Productive executive partnerships at the Federal level can be leveraged to inform and build effective public-private partnerships at the regional level. Strong senior executive leadership at the regional level will help to identify, build, and fully integrate appropriate regional cross-sector partnerships to complement national partnerships. The Council affirms and supports two prior recommendations on regional partnerships made by the State, Local, Tribal, and Territorial Government Coordinating Council in their 2011 report, *Landscape of State and Local Government Critical Infrastructure Resilience Activities & Recommendations*. This report recommends that the DHS Office of Infrastructure Protection promote and enable stronger cross-sector partnerships (SLTTGCC recommendation #2) and provide state and local governments with the tools to identify cross-sector interdependencies that could result in cascading effects, particularly in the lifeline sectors (SLTTGCC recommendation #3). Our recommendation is intended to implement and build upon these two SLTTGCC recommendations.

The Council recognizes that regional and local partnerships must be led by the state and local government leaders who have ultimate authority for ensuring security and resilience within their jurisdictions. These leaders should engage private sector chief executives who own and operate lifeline infrastructures within their region to build sustainable, regional cross-sector partnerships. To be most effective, the regional partnerships should include multiple jurisdictions and sectors and have a clear value proposition for private executive participation.

The inclusion of regional cross-sector partnerships among senior executives in state and local government and the private sector represents the maturation of the national partnership and recognizes that national resilience is the logical outcome of regional resilience efforts.

To implement this recommendation, the Council recommends the following steps:

2.1 The Secretary of Homeland Security should facilitate the development of cross-sector partnerships within selected regions to improve the region's resilience to very large-scale events that could impact national security, resilience, and economic stability. The Secretary should work directly with governors, mayors, and other local government leaders to assist them in building cross-sector partnerships with senior executives from the lifeline sectors located within each region. To coordinate and operationalize regional partnerships, the Secretary should work through

the State, Local, Tribal, and Territorial Government Coordinating Council (SLTTGCC), and provide grant funding to states to assist with this effort.

- To leverage effective partnerships at the national level, CEOs or other sector leadership with equivalent decisionmaking authority from the lifeline sectors should be encouraged to meet with governors, mayors, and other local leaders through state and government associations, such as the National Governors Association, U.S. Council of Mayors, National Association of Counties, and National League of Cities on the merits of and lessons learned from creating senior executive public-private partnerships.
- To coordinate and operationalize sustainable regional partnerships, the Secretary should work through the State, Local, Tribal, and Territorial Government Coordinating Council (SLTTGCC) and its network of alliances of critical infrastructure security and resilience coordinators and emergency managers, and provide grant funding to states to assist in building and strengthening regional cross-sector partnerships. Where appropriate regional partnerships do not exist, regional partners may benefit from engaging a neutral "convener," such as national laboratories, universities, or non-governmental organizations. It is important that each partnership include an executive steering committee, consisting of industry CEOs, governors, mayors, and relevant senior Federal Sector Specific Agency representative(s) to provide executive guidance and leadership on an annual or more frequent basis. Each regional partnership should be built on a shared value proposition that enables engagement across all levels within organizations and government, from executives to operators.

2.2 The Department of Homeland Security should initiate a pilot program with state and local governments in select regions to conduct regional joint exercises, develop risk maps of critical sector interdependencies, and extract lessons learned on regional needs and gaps for government and sector partners. The pilot program should actively engage regional owners and operators and government leaders in identifying and addressing critical gaps in the resilience of the lifeline infrastructures that could produce cascading disruptions throughout the region. The program should include the following elements:

- Joint Regional Cross-Sector Exercise – Each regional partnership should conduct a regional cross-sector exercise, with full participation by public- and private-sector partners at the executive and operational level, to simulate a catastrophic event across a large geographic region. The exercise should be led by the regional partners and supported by DHS experts, processes, and tools as needed. Such an exercise will allow participants to "experience" unprecedented events, identify coordination and communication challenges, and help expose hidden physical and cyber risks due to lifeline sector interdependencies. The results of the exercise should be used to create an action plan to address needs and gaps.
- Regional Risk Maps – An assessment of regional interdependencies should be conducted to create a regional risk map that helps stakeholders prioritize resilience initiatives and optimize investments on a regional scale. The assessment should identify critical infrastructure nodes that are essential for core functions within each region and recommend a plan to harden and protect them and/or provide for alternative services. In conducting these assessments, DHS should leverage the expertise and capabilities of multiple organizations (such as national laboratories, universities, cities and states, NGOs, and Federal agencies) for maximum value.
- Sharing Lessons Learned – The program should require each region to share results and lessons learned from the exercise and interdependency assessment with other regional

partnerships, while protecting sensitive information. DHS should offer to leverage its existing information sharing platforms, such as the Homeland Security Information Network (HSIN), to enable regional groups to share best practices (possibly on a sector-specific basis) and build relationships within and between regions. To foster the proactive sharing of best practices and lessons learned from exercises and past disasters, DHS should work with the SLTTGCC to, a) host an annual national conference for members of regional resilience partnerships and consortia, and b) facilitate a series of regional information sharing workshops to exchange disaster experiences and lesson learned, and document best practices for sharing, within and across regions.

Recommendation 3. The President should designate the energy, communications, water, and transportation sectors as lifeline sectors, and direct Sector-Specific Agencies to examine their policies, procedures, and programs to determine to what extent they recognize the priority of the lifeline sectors and the individuality of regions, amending or revising those that do not.

The Council commends the Administration for recognizing energy and communications systems as being uniquely critical to all critical infrastructure sectors in PPD-21. In addition, the Council recognizes that water and transportation systems also provide vital services that underpin essential functions of critical infrastructures and, if disrupted or destroyed, can create life-threatening conditions during times of crisis. By designating four sectors—energy, communications, water, and transportation—as lifeline sectors, the President should ensure that Department policies and programs recognize the priority status of the lifeline sectors in planning, coordination, and recovery for regional disasters. This will help to solidify the fundamental role these sectors have in maintaining the continuity of critical infrastructure services and government functions in all regions. However, this does not preclude other sectors from being considered as lifeline sectors in specific incidents or regions if it is deemed critical for the continuity and recovery of essential regional services, especially in the first 24-72 hours. To implement this recommendation, the Council recommends the following steps:

3.1 DHS should examine how the Federal government, state governments, and regional entities currently coordinate action with and provide support to the lifeline sectors in event response. This examination should: a) consider organization principles around working with the private sector, decision-making protocols, and Federal and state regulatory bodies, b) identify areas where processes can be streamlined and where the Federal government can facilitate resource movement or resolve long-standing process barriers, c) reinforce the Sector-Specific Agencies for lifeline sectors as the lead for resilience coordination and direct them to work with DHS and other agencies to approach owners and operators with one voice, and d) develop criteria to help identify additional sectors that may be considered lifeline within specific regions.

3.2 The Federal Emergency Management Agency (FEMA) National Response Coordination Center, Federal agencies, and state and local governments should modify their processes and plans for emergency operations to include the co-location of representatives of lifeline sectors in their emergency operation centers (EOCs) during major disasters. The practice of including operational personnel from energy, communications, and other lifeline sectors in EOCs during Superstorm Sandy improved situational awareness, streamlined communications, and expedited response and recovery.

- *State and local government*: State and local governments should make planning and coordination with the lifeline sectors a high priority.
- *Owners and operators*: Owners and operators should work through trade organizations and with state and local government partners to conduct outreach, communication, and education up front to avoid diverting resources during an event to educating partners on the basics of sector operations.

3.3 The President should direct Federal agencies to: a) explicitly consider and address the differences among regions when promulgating security and resilience rules, programs, or guidance; and b) expressly state how they have customized implementation to each region if there is not generic applicability. The mandatory express statement will help offices cultivate the practice of regional customization, and assure owners and operators that Federal resilience programs or rulings will not be implemented without applicability. Where possible, policy and guidance should leave flexibility for executives to further customize implementation to fit the characteristics and needs of their region.

Recommendation 4. FEMA should integrate social media platforms into public alert and warning systems to maximize message reach, and develop training programs and guides with state and local government partners that help them capitalize on social media's potential to provide innovative information sharing and response planning capabilities.

Based on recent experience with large-scale disasters, state and local emergency management agencies, non-profit organizations, and owners and operators have tested out new ways to use social media to communicate with the public, gather new information streams from stakeholders, and organize and streamline disaster response planning and resource movement. Because social media is a rapidly evolving tool, this recommendation includes methods to share lessons learned and best practices from pioneering organizations. To implement this recommendation, the Council recommends the following steps:

4.1 FEMA and the Federal Communications Commission should convene a task force of senior emergency managers from lifeline sector SSAs and representatives of leading private-sector social media and technology firms—such as Twitter, Facebook, and Google—to examine how new and emerging social media apps, platforms, and capabilities can be used to support emergency notification and response, and provide greater value to the public. Many private-sector social media companies have recognized the potential of their products to support disaster response and begun developing tools and capabilities for this express purpose. This task force can exchange ideas and capability requirements, while building awareness of ways that Federal, state, and local governments can leverage social media. The task force should publish its findings in a report on best practices.

4.2 FEMA and the Federal Communications Commission should work with social media providers to integrate social media platforms into FEMA's Integrated Public Alert and Warning System (IPAWS), enabling social media websites and apps to push public emergency alerts from state and local emergency managers directly to registered users through a trusted system. Agreements with social media providers can be modeled after the existing Wireless Emergency Alert system, in which participating wireless carriers send authorized alerts to cell phones based on geographic location, broadcast from cell towers in the designated emergency zone. Social

media alerts could be issued based on geographic position (through cell phone apps) and IP address locations (through web browsers) without requiring opt-in from users. Authorized state and local emergency managers use IPAWS to rapidly send verified alerts through traditional and non-traditional platforms, including TV and radio broadcasts, e-mail, cell phones, and local sirens or light boards. Expanding this service to include agreements with social media providers can broaden the reach of emergency alerts, providing a verified, unchanged social media message from emergency management agencies that reaches beyond the agency's existing social media followers.

4.3 FEMA non-disaster preparedness funding to state, local, tribal, and territorial emergency management agencies should require all recipient agencies to designate and train specific personnel to use the IPAWS system. IPAWS provides a trusted system for emergency messaging that reaches broad platforms with customized geographic targeting, but users must first be authorized and trained to effectively use the system prior to an event. This requirement will encourage broader registration in the system, ensuring capabilities are in place prior to a major event.

4.4 FEMA and the DHS Science and Technology Directorate (S&T) should work through the State, Local, Tribal, and Territorial Government Coordinating Council (SLTTGCC) to develop a conference or webinar series for emergency managers on innovative social media use and best practices in state and local emergency management, including social media successes in recent large-scale disasters. These conferences/webinars will also provide a platform for emergency managers to share lessons learned directly with peers. FEMA should leverage existing social media resources or guides from the National Emergency Management Association (NEMA) and Emergency Management Assistance Compact mission-ready packages where possible. The best practices conference series can also examine how city and state agencies are successfully using two-way communications through non-emergency 311 apps and websites to gather critical information, photos, and videos during an event and communicate to citizens using a single trusted platform, similar to the FEMA app and Disaster Reporter feature. As an outcome of the conference series, the SLTTGCC should develop a process to capture lessons learned on social media use during disasters and leverage individuals from leading public organizations to train others in municipal and state governments, NGOs, and lifeline sector owners and operators on best practices and new ideas.

Recommendation 5. The Secretary of Homeland Security, working with heads of appropriate Federal agencies, should launch a cross-agency team within 60 days to develop solutions to site access, waiver, and permit barriers during disaster response and begin implementing solutions within one year.

In this recommendation, the Council reaffirms and calls attention to the recommendations in its 2009 *Framework for Dealing with Disasters and Related Interdependencies* study that calls for DHS to work with Federal and regional government partners and lifeline sector owners and operators to streamline fleet movement, communications, and critical site access for lifeline sector response crews.

Removing these barriers offers one of the best opportunities to speed disaster response and recovery after a major event. Difficulty in efficiently moving large fleets across multiple states, gaining waivers for Federal and state regulations, complying with laws that govern information sharing and pricing in the petroleum sector, and gaining response crew access to restricted areas to begin repairs all significantly delayed service restoration in the immediate aftermath of Superstorm Sandy. These recurring,

intractable issues affect all regions and require Federal leadership to engage cross-sector and multi-jurisdictional partners to develop solutions. To implement this recommendation, the Council recommends the following steps:

5.1 DHS's Office of Infrastructure Protection and FEMA should collaborate with state and local government officials and owners and operators to develop a commonly applied process or system to credential lifeline sector owners and operators and grant them access to disaster areas. This affirms a prior NIAC recommendation (Recommendation B1A in *Framework for Dealing with Disasters*). Whether implemented regionally or nationally, DHS should develop a strategy and resources to communicate the new process or system to owners and operators and state and local law enforcement, who typically secure disaster zone access points and allow or deny access to owners and operators. DHS should consider that large-scale events require mutual aid assistance from well beyond the affected region, making national interoperability for credentialing solutions a requirement. DHS may consider supporting a pilot credentialing system or access protocols within a region before it is rolled out to other regions.

5.2 DHS should work with state and local government and infrastructure owners and operators to catalog the waivers and permits commonly required during a variety of disaster scenarios (e.g., hurricanes, earthquakes, pandemics, and accidents or attacks) and develop a streamlined process for rapidly issuing those permits and waivers at the Federal, state, and local level. Owners and operators initiate a time-consuming waiver process that is nearly identical for recurring scenarios, and a streamlined process could reduce critical response time spent on waivers, especially during non-weather events that cannot be anticipated. Owners and operators should identify existing waiver impediments based on their experience and communicate them to government partners during this process. DHS should provide resources to maintain a shared database of the permit/waiver catalogue and all processes developed.

5.3 DHS should work with the transportation, energy, and other lifeline sector regulators to identify actions that will expedite waivers and remove impediments to fleet movement, including driver-hour limitations, road and weight restriction, port access restrictions, toll crossing processes, and others. When moving fleets across multiple states, crews face different permit requirements and restrictions for every state; different toll booth payment methods and processes for every region; and Federal driver-hour limits that can add additional delays. DHS should work with state, local, tribal, and territorial governments to develop a streamlined process to remove state requirements in an emergency or issue permits several days prior to a disaster (and prior to disaster declarations) to enable response crews to pre-stage, and to develop and communicate a rapid process for fleet crews to move through all state tolls. In addition, DHS should request that Congress consider legislation authorizing the Federal waiver of Federal and state restrictions on the interstate movement of lifeline sector response fleets during very large-scale disasters.

Recommendation 6. The President should direct the Council of Economic Advisors and the Office of Science and Technology Policy to work with Federal agencies to create a strong and enduring value proposition for investment in resilient lifeline infrastructures — and their underlying physical and cyber assets, systems, functions, and networks — and accelerate the adoption of innovative technologies in major infrastructure projects.

Strategies that "bake" resilience into the design and construction of physical and cyber structures—the

wires, pipes, roads, and rails that connect our communities—offer one of the best opportunities to reduce long-term risks to regions. Although the long-term benefits of these intelligent infrastructures far outweigh the costs, significant barriers to investment exist due to outdated frameworks for evaluating projects and ineffective financing and investment strategies for advanced technology projects.

To implement this recommendation, the Council recommends the following steps:

6.1 Within one year, the Department of Energy, in conjunction with the Council of Economic Advisors and the White House Office of Science and Technology, should complete a pilot analysis of the value proposition for investment in physical and cyber grid modernization and recommend any incentives or alternative mechanisms for cost recovery that may be needed to encourage long-term investment in the modernization of all lifeline infrastructures. The analysis should identify not only where advanced technologies can avoid direct costs of infrastructure damage and loss of service, but where resilience upgrades address long-term societal needs such as climate change adaptation. By providing the value proposition at a regional level, this effort will reduce owner/operator uncertainty around the actual return on investment of advanced technologies, and build state and local government support for utility investments that deliver value in non-disaster time as well as during disaster response. Using the electricity sector as the vanguard, all lifeline sector SSAs should work with their sector partners to establish the value proposition for investment and financing in other critical sectors.

- As part of this analysis, DOE should work with owners, operators, and state and local governments to help establish the value proposition for investment in grid modernization that 1) integrates the private-sector business case with long-term resilience and societal objectives, and 2) reevaluates the current utility cost recovery framework for long-term investments in resilient infrastructure. Recent studies, including those by the White House and the GridWise Alliance, underscore the need for continued investment in grid modernization and resilience to mitigate the increasing costs of power outages due to severe weather, estimated at $18 billion to $33 billion per year. To improve electric grid resilience, investments are needed for cost-effective hardening, advanced control and intelligent grid management systems, and energy storage and microgrid capabilities that together improve flexibility, situational awareness, and operator response to all hazards.

6.2 The President should direct the National Oceanic and Atmospheric Administration (NOAA) and appropriate Federal agencies to determine how existing weather and climate forecasting models and methodologies can be used to better communicate both long-term and short-term predictions of severe weather events, enabling private, state, and local partners to fully understand potential dangers and make informed decisions that manage risk in planning and preparing for disasters. The Federal government has a clear role to play in leveraging its world-class expertise to develop more sophisticated forecasting, planning, and modeling that accurately assesses future risk to inform industry design standards and infrastructure investments in preparation for potentially larger, different, and more frequent storms or natural disasters. With a more accurate understanding of model forecasts and data, owners and operators can reduce uncertainty regarding future risks and strengthen the value proposition for investment.

6.3 DHS should work through Federal research organizations, academic institutions, and the national laboratories to develop Applied Centers of Excellence for Infrastructure Resilience to provide an operating environment to test and validate innovative technologies and processes to build resilience into new large-scale infrastructure projects, integrate next-generation R&D, and

share results with other designers in other regions. Innovative technologies that can improve the resilience and security of our nation's infrastructure are emerging from national laboratories, universities, and technology developers. However, many of these innovations have not been tested in a real-world environment that can validate their performance. Applied Centers of Excellence for Infrastructure Resilience, modeled after the Port Authority of New York and New Jersey Center, would convene relevant stakeholders (owners and operators, technology developers, designers, and engineers) to test technological applications and processes in a rigorous operational environment to determine their readiness. As major infrastructure upgrades are implemented, the Centers can collect and share lessons learned that can be applied to future infrastructure projects and provide input into industry design standards as they are updated. Funding could be provided through a combination of Federal agencies with lifeline sector responsibilities and industry cost-share. Working with the Applied Centers of Excellence, DHS should provide the data and analysis that communicates the value proposition for private-sector investment to both lifeline sector CEOs and their customers and stakeholders. In doing so, the Applied Centers of Excellence can raise awareness of new capabilities as they are being tested, and speed commercialization of technologies as they enter the market.

Next Steps

These recommendations form a comprehensive strategy for the government to improve regional resilience. To move out with this strategy, the Council recommends that the government immediately implement the foundational recommendation of creating meaningful partnerships with senior executives in the lifeline sectors by pursuing the following next steps.

- **Implement senior executive partnerships in the lifeline sectors (Recommendation 1.1).** To build or reinforce CEO- or decisionmaker-level partnerships in the other lifeline sectors, the heads of the relevant Sector-Specific Agencies should convene a meeting with sector CEOs to address high-priority risks to the sector's infrastructure. In the Transportation Sector, the government has tasked the Council with a new study to examine resilience in the Transportation Sector that will include exploration of the creation of a cross-modal CEO-level partnership with Federal leaders.
- **Identify the highest priority cross-sector risks affecting national security and resilience (Recommendation 1.3).** In parallel with the sector studies, the government should task the Council to identify the highest priority cross-sector dependencies of each of the lifeline sectors that could impact national security and resilience. These priorities would be integrated into a report to the President, with recommendations on how to mitigate these risks.

Appendix A: Acknowledgements

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Appendix B: Study Approach

This study was borne out of a growing recognition that strengthening the resilience of individual regions helps build a more resilient nation. As regional infrastructures and economies become more interconnected, disasters can more easily spread across communities and reach a scale that requires national involvement. Our study seeks to better understand how to leverage the combined capabilities of private, Federal, state, local, territorial, and tribal partners to meet regional security and resilience needs. We developed this understanding by examining regional interdependencies and impacts in a large-scale disaster, identifying best practices and lessons learned, and determining how the Federal government can best support a regional approach to building resilience.

This study builds on previous NIAC studies that examine critical infrastructure resilience. These include the 2009 *Framework for Dealing with Disasters and Related Interdependencies*, which examined the nation's ability to respond to and recover from a major disaster with prolonged loss of critical services; and the 2010 *Optimization of Resources for Mitigating Infrastructure Disruptions*, which recommended community-level assessment of infrastructure interdependencies and the adoption of national planning and analysis lessons learned to regional and community-level systems. In addition, we built upon the findings and recommendations of the Council's 2009 *Critical Infrastructure Resilience* study, which examined how to best integrate resilience and protection into a comprehensive risk management strategy, and its 2010 *Framework for Establishing Critical Infrastructure Goals*, which provided a foundation for understanding how resilience is implemented within national infrastructures.

Charge to the NIAC

On April 17, 2012, the Administration tasked the Council to perform a study to examine how regions can become more resilient in the face of increasing risks and infrastructure interdependencies. The study would specifically:

- Build on prior Council studies and incorporate a strong element of regionalization of resilience.
- Focus on the complex, interconnected regions in the Northeastern United States.
- Examine the highly interdependent lifeline sectors (energy, water, transportation, and communications) in the Northeast to gain insights that would be applicable to other regions in the United States.
- Involve Council members who have experience and expertise in one of more of the regions or sectors of interest.

The Council launched this study and by forming the Regional Resilience Working Group, consisting of Council members who have expertise in several critical infrastructure sectors, including electricity, communications, transportation, water, commercial facilities, defense industrial base, financial services, and information technology (see Appendix A for a list of members).

Objectives and Scope

This study examines the challenges that regions face in improving resilience and recommends steps the Federal government should take to help regions become more resilient. To frame this topic, the Working Group established the following objectives:

- **Best Practices:** Identify the characteristics that make a region resilient and the steps that can be taken by critical infrastructure owners and operators; Federal, state, and local government; and the private sector to improve resilience within the region.
- **Process Improvements:** Determine how public and private critical infrastructure partners can work together to improve regional resilience.
- **Federal Role:** Recommend how Federal government capabilities and resources can help accomplish resilience goals to address any gaps and help regions become more resilient.

Regional Resilience Study Approach

The Working Group gathered information and data from a rich variety of sources including focused interviews and an extensive literature review. It collected and analyzed data from the following sources:

- Interviews with 37 individuals representing state and local emergency managers, regional security and resilience organizations, national experts on resilience and disaster response, owners and operators of critical infrastructure, experts from industry and academia, non-profit groups, and Federal agencies that were critical in the response to Superstorm Sandy
- Insights from State, Local, Tribal, and Territorial Government Coordinating Council studies
- More than 350 documents and sources, including:
    - Reports and studies from Federal, state, and local governments; Congressional committees; non-profit organizations; regional resilience consortia, and academic institutions
    - Hundreds of news articles, journal articles, and media advisories
    - Videos, presentations, conference proceedings, and Congressional testimonies
    - Official government documents, including national plans, policy directives, and executive orders
- Webinars and conferences with regional government and critical infrastructure representatives on barriers to rapid disaster response

To gain real-world insights, the Working Group formed a Study Group in February 2013 to examine the impacts of Superstorm Sandy on the resilience of the lifeline sectors in Philadelphia and the Northeastern states, including impacts from New York to Washington, D.C. The Study Group did not attempt to recount all the events, impacts, and actions. Instead, it focused on the distinctive features of Sandy that led to unanticipated impacts to lifeline infrastructures and the actions taken by regional stakeholders—owners and operators, state and local government, and non-profit groups—to minimize the impact of the disaster. A detailed account of sector-specific and cross-sector learnings and Study Group findings from Superstorm Sandy is presented in Appendix D.

Appendix C: Briefing Summaries of Federal Agencies and Resilience Experts

To gain additional insight into its case study on Superstorm Sandy response, the Regional Resilience Working Group interviewed representatives from key Federal agencies representing lifeline sectors and emergency response, along with nationally recognized experts on regional resilience. Federal representatives briefed the Working Group on highlights of agency response and key lessons learned during Superstorm Sandy, as well as how those lessons will inform future regional resilience efforts. Regional resilience experts briefed the Working Group on resilience strategies and areas for improvement. Summaries of these briefings are provided here.

U.S. Department of Energy

Interviewee: William Bryan, Deputy Assistant Secretary of Infrastructure Security & Energy Restoration, Office of Electricity Delivery and Energy Reliability

The U.S. Department of Energy (DOE) has three key roles in emergency response, during both national disasters declared under the Stafford Act, and for regional disasters involving the energy infrastructure:

- Reliability: Taking steps before an event to make systems are more reliable, including R&D.
- Survivability: Taking action to ensure assets and critical components survive. For example, hardening critical choke points within systems or protecting substations from flooding.
- Resilience: Ensuring a rapid response and recovery. If the first two areas are addressed correctly, ensuring resilience is easier to accomplish.

Strengths, Challenges, and Lessons Learned from DOE's Response

- Energy sector response was marked by extensive Federal and private sector coordination. The President and Secretary of Energy met with electricity sector CEOs during their regular conference calls, and the Federal Emergency FEMA and DOE established an Energy Resilience Task Force with utility representation to coordinate response. Federal and industry partners spearheaded a mutual aid response of more than 70,000 workers.
- Legislative and regulatory challenges: Regulations slowed the movement of fuel and resources across state lines, which have widely differing state regulations, despite the rapid issuance of waivers as needed. In particular, anti-gouging laws were a deterrent for sourcing fuel from areas outside the affected region due to high transportation costs that might excessively raise fuel prices.
- Federal situational awareness challenges: Federal officials did not have good visibility into the levels and locations of fuel resources as disruptions grew and cascaded. Because Federal partners had difficulty identifying bottlenecks in fuel supply and delivery, they could not effectively offer assistance. DOE identified the need for a communication plan with fuel suppliers to comply with anti-trust laws, which limit information sharing, while ensuring situational awareness.
    - Social media emerged as an occasionally effective tool in helping to track fuel resources, but it also presents challenges, and information provided by social media is difficult to vet and validate.

- Community-level response challenges: Local communities need better access to information and power restoration estimates so they can effectively plan for fuel, food, and shelter. Not enough information was being supplied to the public about what was being done to address problems.
    - Communities need to better define their critical assets and nodes to help with appropriate prioritization of resources and power restoration efforts. However, local law enforcement typically considered electricity sector utility crews to be emergency responders following Sandy, which allowed them access to restricted areas and gave them priority when utility trucks needed fuel.
    - Communities must take an individualized approach to building resilience that reflects the weather patterns and other specific risks that they face.
    - Following a disaster, power may be restored to a neighborhood but residents may not be able to return home until electricians or pipe-fitters repair damage. Moving forward, mutual assistance for electricians and pipe-fitters may speed community recovery.

Areas for Improvement and Planned Actions

- DOE is considering permanently locating personnel in each FEMA region to better assist during events that may not be declared national disasters, but have wide impacts on the electricity system.
- DOE's White House Innovation Fellow is working to develop an interactive social media application for smart devices that allows citizens to send geo-located pictures of damage to utilities during a disaster event. It will assist utilities by providing another avenue for determining where trees are down, and where problems are located.
- More efforts are needed to educate the public and communities to better prepare for events.
- The department is working with DHS's Science and Technology Directorate to continue R&D investments for technologies that will build resilience into the grid.
- Federal partners will continue working closely with industry to identify and remove regulatory and legislative barriers to effective response, and develop technology or process solutions to existing challenges.

Department of Homeland Security, Federal Emergency Management Agency

Interviewee: Kathleen Fox, Director of the National Preparedness Assessment Division

Response efforts during Sandy showed a maturation of Federal Emergency Management Agency (FEMA) processes in the seven years since Hurricane Katrina: moving from a "pull" system that waits for resource requests from states to a system that "pushes" resources and capabilities out in advance of anticipated needs. FEMA acknowledged more work needs to be done as it prepares for larger, more complex disasters in the future.

FEMA evaluated response strengths and areas for improvement in four priority areas for FEMA: ensuring unity of effort across the Federal response; being survivor-centric; fostering unity of effort across the whole community; and developing an agile, professional, emergency management workforce.

Strengths and Lessons Learned from FEMA's Response

- To ensure unity of effort across the Federal response, FEMA:
    - Utilized expedited disaster declarations to move Federal aid into an area before the storm made landfall.
    - Used an online crisis management system to support resource requests in the field, maintain situational awareness, and track assistance delivered to survivors.
- To be survivor-centric, FEMA:
    - Implemented the Sheltering and Temporary Essential Power (STEP) program to pay for emergency repairs for electricity, heat, and hot water, allowing survivors to stay in or return to their homes. In an area such as New York City with dense population and limited supply of unused housing options, this sped up the return to normalcy and prevented the need to stay in shelters.
    - Used geospatial data analysis to identify and assist survivors in finding shelter if they could not return to their homes. The analysis included information from high watermark sensors, inundation levels, and road closure information. FEMA also increased the total amount of rental assistance available to eligible survivors to take into account the high rental costs in New York City.
    - Instituted a rapid National Flood Insurance Program claims process authorizing partial payments of up to $30,000 to cover repairs when action was necessary to protect health and safety.
    - Developed the Check Your Home mobile application and web portal that allowed survivors to view aerial imagery of their homes and know how it fared during the storm.
- To foster unity of effort across the whole community, FEMA:
    - Deployed a FEMA Innovation Team, a multi-sector, cross-functional group made up of non-profits, volunteer groups, businesses, and government, to creatively solve survivors' problems.
    - Activated the National Business Operations Center to facilitate two-way information sharing between public- and private-sector stakeholders.
    - Coordinated with faith-based and voluntary organizations.
- To deliver an agile, professional emergency management workforce, FEMA:
    - Completed the largest and most diverse personnel deployments in FEMA history, including nearly 10,000 FEMA personnel.

Areas for Improvement and Planned Actions

- Areas for improvement in ensuring a unity of effort across the Federal response:
    - Integrating Federal senior leader coordination and communications into response and recovery operations. There were challenges with accurately, clearly, and quickly communicating senior leaders' decisions to those responsible for implementing them.
    - Coordinating Emergency Support Functions (ESFs) and Recovery Support Functions (RSFs). It was the first time the two functions worked together. By not drawing upon the capabilities of supporting departments and agencies, the ESF coordinating agencies limited the Federal government's ability to help state and local jurisdictions respond quickly to complex problems. A department-centric approach and gaps in personnel recovery experience affected some RSFs' ability to provide coordinated assistance to communities.

- Areas for improvement in being survivor-centric:
    - Meeting survivors' needs during initial interactions through community relations, disaster recovery centers, and FEMA call centers. Following Sandy, disaster recovery centers did not always provide consistent services and call centers did not always have the staff or technology needed to keep pace with survivors' requests for information.
    - Ensuring all survivors have equal access to services by clarifying roles and responsibilities related to disability integration and equal rights.
    - Reducing the complexity of the Public Assistance program by implementing the alternative procedures to approve PA projects included in the Sandy Recovery Improvement Act of 2013.
- Areas for improvement in fostering unity of effort across the whole community:
    - Coordinating among states, localities, and tribes was challenging because New York City and New York State did not jointly develop resource requests or priorities before sending them to the Federal government. As a Federal agency, FEMA is set up to work with the state.
    - Sandy was the first time a tribal affairs liaison was activated under NRCC. The Sandy Recovery Improvement Act of 2013 allows tribes, as sovereign nations, to make emergency and disaster declaration requests directly to the President.
- Areas for improvement in delivering an agile, professional emergency management workforce:
    - Ensuring a qualified disaster workforce by utilizing the FEMA Qualification System that defines the training, experience, and demonstrated performance required to become credentialed in each of the disaster workforce positions. FQS was in progress during Sandy response and recovery.
    - Preparing to deploy the entire workforce under an efficient and clear process.
    - Supporting deployed personnel by securing lodging and equipping personnel.
    - Ensuring continuity of operations by balancing large deployments with the need to maintain steady-state operations.
- A Continuous Improvement Working Group is charged with coordinating and monitoring recommendations resulting from FEMA's after-action review. FEMA is also working with state and local communities by asking them to assess their current capabilities. The exercise starts a dialogue about risk and also helps FEMA to understand the type of assistance the community could need if there is an emergency. FEMA has found that successful community response starts with building relationships with stakeholders and industries within a community. Communities that spend time and resources to improve and strengthen their plans tend to be better prepared and fare better during an event.

U.S. Environmental Protection Agency

Interviewee: Dave Travers, Water Security Division Director

The U.S. Environmental Protection Agency (EPA) has primary emergency support function responsibility for the water sector and considers water to be a lifeline sector because whole communities cannot function without it. Access to water impacts other critical sectors outside of drinking water and wastewater treatment; hospitals, firefighters, and businesses all require water to provide basic services and for minimum operation. Despite its importance, water is often not seen as a priority when responding to an emergency at the local or Federal level and is given a secondary status. There is a lack

of understanding about the economic, public health, environmental impacts that can happen as a result of disruptions in the sector.

Lessons Learned from EPA's Response

- The water sector is extremely dependent on electricity. A power outage can cause a water system to lose pressure, allowing inflow and contamination. Other impacts include loss of water delivery and the ability to treat water.
- Ensuring consistent power generation to water systems remains a challenge. Some water systems did not have connections to receive generators, while others faced limited or no access to fuel supply during Sandy.
- There are ongoing generator maintenance issues, as generators are used so infrequently that problems may not be discovered until a disaster.

Areas for Improvement and Planned Actions

- Representation at Emergency Operation Centers—Staging a water sector representative at local and state EOCs can improve coordination for water sector utility response and resource allocation following an event.
- Ensuring water systems are aware of the availability of interstate assistance—In general, water sector utilities have not developed Emergency Management Assistance Compact resource packages and cost estimates. This is mainly due to a lack of understanding about EMACs capabilities for water sector requests.
- Consistent application of the National Response Framework—When the procedures are not applied consistently, it can lead to duplication of mission assignments under emergency support functions.
- Ensuring water crews have access to their own systems during an emergency—Water utility crews have reported being denied or prevented from accessing sites by emergency management and law enforcement agencies, slowing the ability to restore services.
- Improving situational awareness—Water system operational status information has been limited and sometimes delayed resulting in inconsistent situational awareness.
- Local interdependency workshops could help illustrate the importance of water as a lifeline sector and should be encouraged by the Federal government. As water systems work to become more robust, preparing for impacts from climate change should be integrated as part of an all-hazards response, especially as part of long-term planning.

Regional Resilience Expert Briefings

Stephen Flynn

Professor of Political Science, Director of the Center for Resilience Studies
Northeastern University

Key Insights on Regional Resilience

- A threat-centric approach to assessing and prioritizing critical infrastructure risk is flawed. Timely and accurate intelligence will always be limited, and by the time a threat is known, the window of opportunity to build in safeguards is likely closed.
- A resilience-centric approach ensures critical functions and services in the context of disruption. It focuses on mapping the infrastructure, the design boundaries, and governance systems; identifying critical functions; testing loss of those functions against a worst-case scenario; and adopting features, processes, and protocols that reduce the risk of disruption or speed recovery.
- Understanding infrastructure threat is still important, but resilience helps drive down threat in a more inclusive way by limiting both an attacker's capability to take out a certain infrastructure, and the extent of the consequences if they do.

Opportunities for Improvement

- A regional approach to infrastructure resilience is more effective than a national, sector-by-sector approach, because systems tend to be regional in scope, and a regional focus provides granularity and the ability to see interdependencies across sectors that are often lost at a higher level.
- A cross-sector approach enables sectors to improve their own resilience by addressing interdependencies. It requires bringing sectors together, asking the users what the consequences are of not having a service or function available, then working together to ensure continuity of critical functions, either by having users pay more for priority service or become an advocate to policymakers and regulatory boards.
- When infrastructure breaks is a good time to think about how it was designed and rebuild stronger. Owners and operators are now seeing federal support to make improvements during system repairs after large events, not simply replace in-kind.
- Regional partnerships require a neutral convener, such as universities, non-profit organizations, or national laboratories. When infrastructure systems cover multiple states and counties, it's very difficult for any one of those government representatives to convene all stakeholders.

Thad Allen

Executive Vice President
Booz Allen Hamilton
Admiral (ret.), U.S. Coast Guard

Insights on Regional Resilience

- Approaching resilience at the regional level is the best way to achieve it. Critical infrastructure within each community and region is diverse; the types, density, and risks of each sector differ, which necessitates a customized approach.
- As regions grow in density of population and density of infrastructure, they are experiencing increasing complexity from the interaction of the natural environment and the built environment, and greater consequences from events.
- Resilience is equivalent to a healthy immune system—it enables you to withstand an illness, without knowing what the specific threat may be ahead of an attack.
- Relationships are the key to a resilient community or region. They create a unity of effort in response, and almost any activity that builds these relationships contributes to community resilience.
    - The challenge is identifying and understanding the capabilities of all non-governmental stakeholders, and finding a value proposition to bring them together before an event.
- There will never be a major catastrophic event in this country that won't involve public participation. Proactively communicating information creates transparency and credibility, which is required in today's social media environment.
    - Any organizations leading a complex operation involving the public that does not take social media into account and proactively deal with it will have the entire reality of the situation created for them, often by someone who may not be knowledgeable or consequential. The organization's voice will be drowned out, or worse, silence will be taken as withholding information.

Opportunities for Improvement

- Resilience responsibilities often get delegated to the middle of organizations, but resource allocations get made at the executive level. Resilience requires an integrated, strategic approach led by CEOs.
    - A culture of resilience is needed in which each stakeholder understands that resilience is an organization-wide responsibility.
- Incident command systems that manage event response must include better representation of the private sector, non-governmental organizations, and faith-based organizations. They bring resources, passion, commitment, and the emotional glue that is necessary for resilience.
- Written strategies have dates with a short shelf-life. It is better to act with strategic intent, which embeds a common direction into every decision.
    - At the federal level, that means bringing federal programs and strategies down to the regional level and customizing them to that region.

Dane Egli

Senior Advisor, National Security Strategies
Johns Hopkins University Applied Physics Laboratory

Insights on Regional Resilience

- Critical infrastructure security and resilience is a public good (because it is non-rivalrous and non-exclusionary) and society expects it to be there. As a common pool resource—much like clean water or air—it cannot be achieved when managed in an ad-hoc fashion.
    - Resilience is currently led by independent action in a highly interdependent environment. If each stakeholder acts only to protect their assets, it leads to inefficiencies and hidden gaps.
    - Even after an event, key lessons learned are often collected in silos, which dilutes their potential effectiveness.
- Case studies reveal that highly interconnected systems and regions depend heavily on the lifeline infrastructures and have tightly woven interdependencies.
- The key to resilience (before and after an event) is bringing groups together across sectors and regions to address common risks and critical interdependencies.
    - Communities and regions need a reputable, neutral convening authority that can bring interconnected stakeholders together. Universities and non-profit organizations can serve this role.

Opportunities for Improvement

- Functional resilience requires a transformative, forward-thinking approach that focuses on building resilient designs rather than simply repairing and rebuilding. It uses large-scale optimization in a resource-scarce environment so that can accept some level of degradation and accept it in a graceful manner.
- To understand risk, communities and regions must start by mapping the functions, services, and assets that each sector in that region depends upon. When subjected to a hypothetical disaster, the resulting risk maps will help reveal hidden risks for each sector and critical points of failure that require greater attention.
    - This identifies the areas of most acute consequence for a region, and may reveal risks that are not immediately apparent to one sector.
    - A national strategy for developing risk maps and operationalizing the process are needed.

Richard Reed

Vice President, Preparedness and Resilience Strategy
American Red Cross

Insights on Regional Resilience

- National resilience is the output of community resilience; it has to start at the community level.
- Pre-event training of response personnel becomes critical at the local and community level. The problems during a disaster in Oklahoma are different from the problems in New Jersey. Having the capacity at the local level to address specific issues and concerns is critically important. The Red Cross pre-event presence at the local level creates an advantage.
- The Red Cross has greater flexibility than the Federal government on how they can engage with during a disasters, and can often mobilize faster.
    - The Red Cross has strong relationships with complementary non-profits to support a coordinated response and use resources more effectively. For example, the Red Cross might procure food, which is prepared by another non-profit with food preparation capacity, and then served by the Red Cross. Multi-Agency Resource Centers provide a good model for bringing together the strength and expertise of multiple non-profits.
    - It can leverage international support from Canada and Mexico more easily.
    - It can support state and local disasters that do not rise to the level of the Stafford Act.
- The Red Cross's Digital Operations Center now tracks and responds to social media posts to better locate and respond to survivor needs. During Sandy, operators responded directly to the public's tweets for help or information, and could alert state emergency management centers and FEMA of actionable information.

Opportunities for Improvement

- The majority of disaster events are not "black swan" events. There's a pattern of likelihood for events in each region, and few are completely unpredictable. The challenge is getting better at preparing for these events.
- The Red Cross is focusing on convincing partners in industry that they need to be more active in disaster recovery *before* an event.
    - Red Cross's Ready When the Time Comes program works with companies to train their employees in disaster preparedness, making them prepared and community-aware resources that can be deployed locally during a disaster.

Appendix D: Case Study on Superstorm Sandy

Superstorm Sandy, the combination of a massive hurricane followed by a Nor'easter, caused extensive damage over a wide geographic footprint, and offered a case study to examine impacts within a region and discern lessons learned and implications for improving resilience in any region and for any hazard. The National Infrastructure Advisory Council's Working Group on Regional Resilience formed a Study Group in February 2013 to conduct this case study of regional resilience, based on the experience with Superstorm Sandy and centered in the Philadelphia metro area and surrounding region. This included southeastern Pennsylvania, New Jersey, and New York City, and considered impacts from New York to Washington, D.C. The Working Group directed the Study Group to give special attention to the resilience of the lifeline sectors of energy (electricity and oil and natural gas), water, transportation, and telecommunication, which are vital to the continued operation of critical regional services that could risk human health and safety if disrupted or not restored promptly. The Study Group used the lessons learned that were gained during the planning and response phase of Superstorm Sandy to offer insights on how regions could improve resilience and reduce risks for all types of hazards by addressing near- and long-term infrastructure needs.

Exhibit 18. Task to the Study Group

The NIAC Working Group members requested the Study Group to conduct a case study examining the planning, coordination, and response for Superstorm Sandy as it applies to the Philadelphia region and lifeline sectors in neighboring regions to:

- Understand the regional impact on the lifeline sectors, including impacts on other critical infrastructures, state and local governments, communities, and private industry owners and operators.
- Identify failure mechanisms between interdependent sectors and gaps in regional resilience.

Scope

To accomplish this task, the study focused on the following definitions and lines of inquiry:

- The study examined how Superstorm Sandy placed stress on one or more of the lifeline sectors beyond current planning conditions.
    - The lifeline sectors were defined for the purpose of this study as oil and natural gas, electricity, water (potable water and wastewater), transportation (rail, aviation, highway, and public transit), and communications (including the supporting information technology backbone).
- The study examined the impact of physical and cyber disruptions from Superstorm Sandy on critical infrastructures, including impacts due to aging infrastructure.
- The Philadelphia study region included portions of Pennsylvania, New Jersey, Delaware, and Maryland.
    - Lifeline impacts of Superstorm Sandy were also examined in great detail in the adjoining region, including New York and Connecticut, and considered across the impacted area stretching from New York to Washington, D.C.

Approach

The study was conducted by a Study Group of 13 members (see Appendix A) representing the following:

- Energy/Electricity
- Energy/Oil and Natural Gas
- Transportation/Rail
- Transportation/Aviation
- Transportation/Highway Motor Carrier
- Transportation/Public Transit
- Water
- Communications
- State government
- City government

Each member had direct experience with emergency management operations or managing and overseeing critical infrastructure decisions. Their collective experience provided the main source of information and insight for this study.

While the Study Group closely examined Superstorm Sandy, it did not attempt to recount all the events, impacts, actions, and specific lessons learned. These accounts are well documented in news stories, after-action reports, and special studies, which can be found among this report's references in Appendix H. Instead, the Study Group focused on the distinctive features of Sandy that led to unanticipated impacts to lifeline infrastructures and the actions taken by regional stakeholders—owners and operators, state and local government, and non-profit groups—to minimize the magnitude and duration of the disaster. To gather this information, the Study Group drew upon information and data from several sources, including:

- Seven panel discussions with emergency managers and leaders from the lifeline sectors, state and local government, and non-profit groups
- Interviews with key leaders and experts involved in the response to Sandy
- Published reports, data, news stories, and in-process studies on both the impacts of Superstorm Sandy and the resilience investments it initiated
- Study Group member experience and expertise

The Study Group also conducted a one-day facilitated meeting to identify key findings and its conclusions for regional resilience based on all information and data collected throughout the study.

Overview of Superstorm Sandy

In many ways, Superstorm Sandy was an exceptional event. It began as a massive hurricane that produced record flooding from New York to Delaware, triggering extensive power outages, critical fuel shortages, and the largest mass transit disruption in the region's history. It was followed seven days later by a Nor'easter that hit much of the same region just as substantial recovery efforts were under way. Owners and operators of lifeline sectors and their government and non-profit partners faced unprecedented challenges that were met with novel and bold response and coordination.

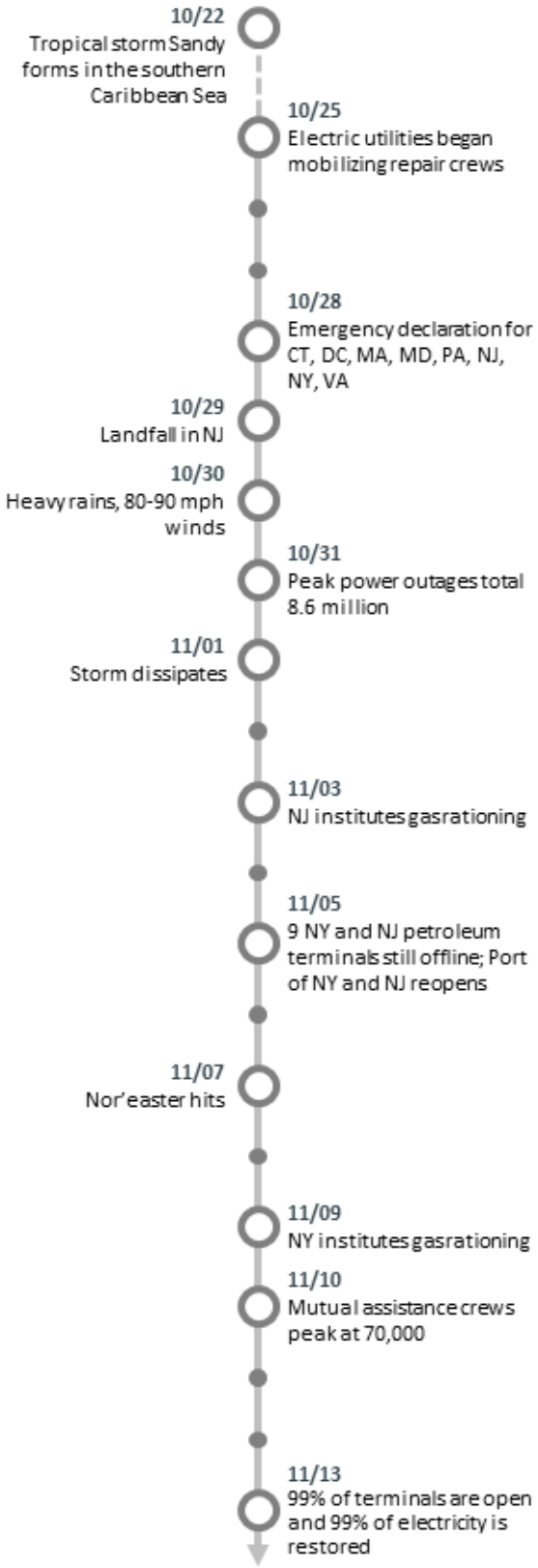
Hurricane Sandy made landfall in the United States on Oct. 29, 2012 near Atlantic City, NJ as a post-tropical cyclone. For the next three days, heavy rains, 80–90 mph winds, and storm surges battered the East Coast as the storm drove inland toward Pennsylvania, causing massive flooding, widespread power outages, and severe damage to homes and infrastructure. At its peak, hurricane-force winds extended 175 miles from the center of the storm and tropical storm-force winds extended 485 miles, making it

one of the largest Atlantic tropical storms ever recorded. Impacts were felt from North Carolina to Maine and as far west as Illinois. By the time the storm dissipated on Nov. 1, peak power outages totaled 8.6 million, damage estimates exceeded $60 billion, and 117 people had lost their lives (New York City 2013b; DOE 2013a)).

While parts of Maryland, Delaware, and Pennsylvania experienced notable storm impacts, the majority of Sandy's destruction was concentrated in New Jersey and New York. National Oceanic and Atmospheric Administration (NOAA) storm predictions issued prior to the storm were accurate, but their dense presentation and unclear communication prevented residents and asset owners from fully grasping the potential impact of the impending storm (NOAA 2013a and 2013b). Along the Jersey shore and up into Hoboken, more than 72,000 homes and businesses were damaged and severe flooding left people stranded in their homes waiting for rescue teams in boats. Atlantic City's famous boardwalk was ripped apart due to powerful waves and winds. New York City, which paradoxically received as little as ½ inch of rain in parts, was inundated by seawater that surged over Lower Manhattan's seawalls and highways and into low-lying streets, inundating tunnels, subway stations, and the electrical system that powers Wall Street. Battery Park registered a record-high storm tide of 13.88 feet and waves in New York Harbor reached a record 32.5 feet. Flooding exceeded FEMA's 100-year flood maps (last updated more than 20 years ago) by 53 percent citywide, and in some parts of the region was called a 300-year flood by the Army Corps of Engineers (New York City 2013a and 2013b). Coastal towns such as Red Hook and Breezy Point, as well as Staten Island and Long Island, were overwhelmed by storm surges and powerful waves, and damage to transportation infrastructure cut them off from the rest of the city.

As volunteer responders descended upon the hardest hit areas to aid residents and crews began to restore energy, water, communications, and transportation services, a Nor'easter swept into the affected region with strong winds, rain and snow, and coastal flooding on Nov. 7—just one week later. The heavy, wet snow blanketed the already damaged area, snapping storm-weakened trees and downing power lines, tacking an additional 200,000 people onto the list of more than 500,000 already without power in near-freezing temperatures (DOE 2013a). This

Exhibit 19. Superstorm Sandy Timeline



second blow hampered recovery efforts, making it more difficult to restore normalcy to the region.

The unprecedented nature of Superstorm Sandy was due to a confluence of factors. After evolving into a Category 1 hurricane in the Caribbean and traveling north off the U.S. East Coast, Sandy made a sharp turn toward the northwest toward the coast of New Jersey. This unusual path made the storm surge much worse for New Jersey and New York, as a cyclone's strongest winds and highest storm surge are to the front and right of its circulation. Additionally, the storm evolved atypically as a tropical cyclone merging with an intense, near-record low pressure system, causing it to dramatically increase in size before landfall (NOAA 2013a). Combined with a full moon that made high tides 20 percent higher than normal at the time it made landfall and the Nor'easter snow that followed less than a week later, Sandy had indeed become the "perfect storm" so widely forecasted. At the time of this report, more than a year after the storm, key lifeline sectors are still being repaired and returned to full capacity, and coastal homes and communities are still being rebuilt and recovered.

The successes and challenges of Superstorm Sandy are captured in the following sections of this case study, and examined for broad lessons learned and implications for resilience to all regional hazards, including events beyond storms. What follows are five lifeline sector-specific reviews and two cross-cutting reviews that each examine:

- Highlights of planning, response, and recovery
- Response, recovery, and interdependency challenges
- Sector-specific lessons learned
- Implications for resilience
- Opportunities for improvement based on the resilience implications

These seven reviews draw upon many information sources and the expertise and insights of Study Group members.

Oil and Natural Gas

Superstorm Sandy underscored the region's high dependency on gasoline and diesel fuel to power backup generators and fuel vehicles needed for restorations efforts. The combined strength and scope of the storm produced wind and flooding that caused widespread damage to terminals, pipelines, storage facilities, and truck racks from wind and flooding. Many marine terminals, refineries, and supply and distribution terminals in the region shut down due to either damage, lack of power, or both. Electrical components including control systems, switching gear, and vapor recovery units sustained flooding damage, and repairs required both time and technical expertise. Marine terminals, if operational, were still unable to receive product from barges due to debris in the New York Harbor. In addition, the northern leg of the Colonial Pipeline, which delivers as much as 15% of the region's fuel from Gulf Coast refineries, was shut down due to lack of power and the subsequent inability to receive its product at offline terminals.

An estimated 60%–65% of service stations lost power in New York and New Jersey and could not provide fuel to repair fleets or the public. As power was restored to service stations, many were unable to get fuel delivered to their station. Backup generators at many critical facilities in other sectors had limited storage capacity, typically only a 24-hour supply of fuel, thus creating a large demand on distributors as restoration stretched on.

The natural gas distribution system was devastated on New Jersey's barrier islands and took eight weeks to restore, a lengthy process that included individual home safety inspections. However, damage and disruption was not widespread in the region, and natural gas supplies even supported cogeneration at some critical sites that kept the power on. This review thus focuses mostly on petroleum industry impacts and actions during Superstorm Sandy.

Exhibit 20. Oil and Natural Gas Sector Highlights

- Superstorm Sandy exposed risks within the sector that were not understood by dependent critical sectors and government officials, due in part to their limited understanding of sector operations, distribution, marketing, and regulations.
- Without power, even well stocked gasoline service stations were unable to pump fuel to customers. Emergency managers struggled to determine which stations had both fuel and power.
- Stakeholders sought out alternative fuel supplies by leveraging distributor relationships with other fuel suppliers in nearby regions; seeking regulatory waivers; and tapping electricity restoration crews from non-impacted states to bring their own fuel tankers.
- Refineries and supply terminals that lost power also had major water damage to primary switch gear and other critical electrical components that delayed restoration long after power was restored.
- Many critical dependent sites limited to 24 hours of fuel storage required repeated daily refueling runs for generators. Regulations on fuel storage create disincentives to store greater supplies.
- Anti-gouging laws discouraged suppliers and distributors from bringing in fuel from other regions at higher costs, as the resulting price increase might give the appearance of gouging. Antitrust laws and SEC Regulation Full Disclosure (FD) place limits on sharing market-sensitive supply information, which compromised situational awareness.

Exhibit 21. Critical Elements of the NJ, NY & Northeast Fuel Supply Chain

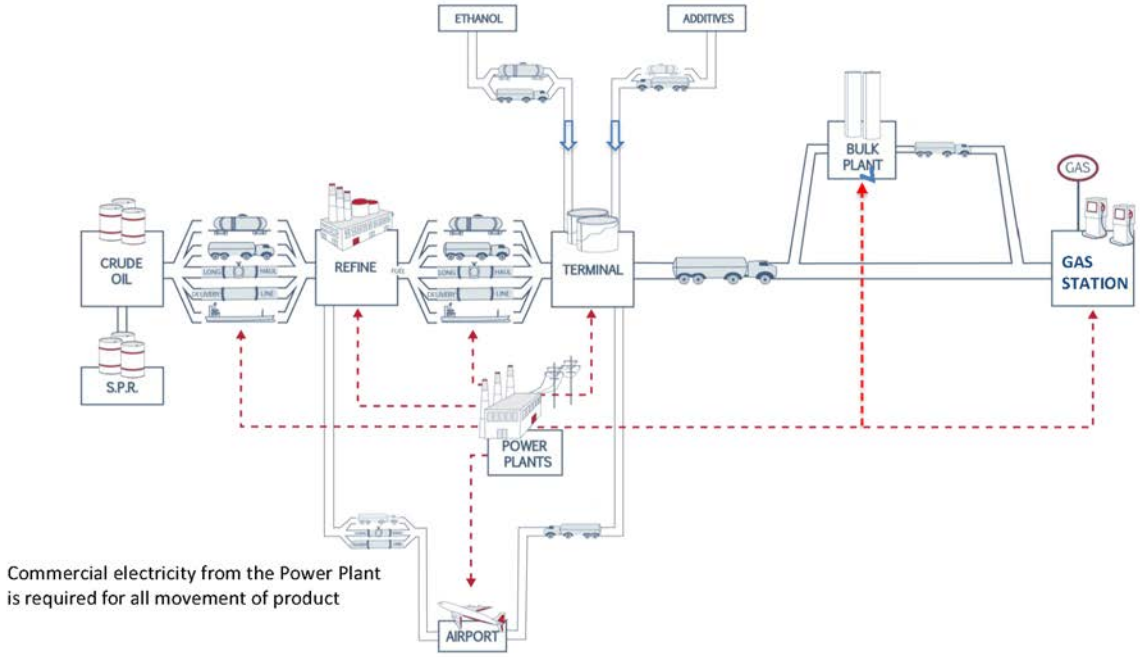


Diagram courtesy of the American Petroleum Institute. Used with express permission.

Highlights of Planning, Response, and Recovery

Although some assets on the eastern seaboard suffered significant damage, owners and operators and their government counterparts acted swiftly to remove barriers and maintain fuel availability.

Mature business continuity plans and advance coordination aided recovery efforts.
Owners and operators took the following steps to support continued operation of assets critical for business:

- Transferred operations to control systems and operation centers outside of the impacted areas.
- Evacuated personnel and key resources in the line of the storm and brought in personnel and equipment from unaffected regions to assist with repair and recovery.
- Worked with city or county government officials ahead of the storm to coordinate entry control procedures that would grant access to authorized repair crews to restart refineries, terminals, or pipelines.

City and state agencies also fueled vehicles and generators prior to the storm and some established an independent fuel supply. For example, New York City set up a fueling station at Floyd Bennett Field for city vehicles.

Owners and operators tapped alternative fuel supplies to supplement the local supply chain.
With 25% of the region's fuel-making capacity offline due to lack of power or damage from the storm surge, fuel distributors brought in supplies from outside the damage zone:

- Restoration crews coming from non-impacted states, upon hearing about local fuel shortages, brought their own fuel tankers to support the restoration efforts.

- At the direction of the president, the Department of Defense loaned ultra-low sulfur diesel from the Northeast Home Heating Oil Reserve for the first time since its creation.

Temporary regulatory waivers provided flexibility to use non-standard fuel sources.
Federal, state, and local officials issued a host of temporary waivers to increase fuel accessibility, including the following:

- Lifted U.S. Environmental Protection Agency (EPA) fuel specifications for sulfur content requirements in ultra-low sulfur diesel fuel and ethanol requirements for reformulated gasoline.
- Removed New York City-specific fuel transportation restrictions and required use of ultra-low sulfur #2 oil for heating.
- Suspended the Jones Act to allow tankers from foreign countries to supply fuel from refineries in the Gulf of Mexico.
- Allowed residential heating oil delivery vehicles to re-fuel commercial facilities, which allowed fuel suppliers to better serve critical infrastructure sites.

See "A Closer Look: Petroleum Regulations and Waivers during Superstorm Sandy" at the end of the Oil and Natural Gas section for further details.

Gas rationing suppressed public demand.
Throughout New Jersey, gas shortages caused long lines to form for many days following the storm. Governor Chris Christie instituted an odd-even gas rationing system based on license plate numbers—last used in the 1970s—to help alleviate overcrowding at gas stations while stretching supply. This was later adopted by New York City.

Daily conference calls between government officials and owners and operators and the co-location of key officials greatly improved cross-sector situational awareness.

- In daily calls led by the New Jersey Office of Homeland Security, emergency managers and owners and operators received updates on restoration across the region and coordinated a more effective response. Senior Department of Energy officials led and participated in coordination calls to facilitate power restoration to affected terminals and refineries.
- The New Jersey Regional Operations Intelligence Center (ROIC) invited representatives from the Fuel Merchants Association of New Jersey, which represents the state's petroleum marketing industry, into the state EOC, enabling state officials to coordinate fuel requests from other critical sectors.

New Jersey's recent regional exercise and drill simulated widespread petroleum distribution losses and prepared the sector for some Sandy challenges.

- The "Running on Empty" exercise with New Jersey's infrastructure bureau and regional owners and operators in 2011 presaged the petroleum disruptions the sector actually faced in Sandy. Petroleum owners and operators were not caught off guard.

Response, Recovery, and Interdependency Challenges

Severe petroleum disruptions during Superstorm Sandy underscored the sector's strong dependence on electricity—to receive, refine, pump, and distribute fuel supplies from terminals to service stations—and on the transportation sector—which oversees the pipelines, tankers, barges, railroad tank cars, and trucks used to distribute fuel supplies to customers.

Heavily damaged refineries and terminals and extensive commercial power outages caused disruptions throughout the supply chain—from pipelines and refiners to suppliers and distributors—that other sectors did not anticipate.

- Power outages to pipeline pumps and fuel terminals that could then no longer accept fuel forced the northern part of the Colonial Pipeline to shut down, effectively cutting the region off from a 2.4 million barrel per day supply of petroleum.
- Without power, several refineries were unable to refine fuel for the region, receive fuel, or access their existing supply of fuel for supply and distribution.
- While refineries and supply terminals were initially offline due to a lack of power, many also suffered major water damage to primary switch gear and other internal electrical components that delayed operations long after power was restored. As of Nov. 5, nine terminals in New York and New Jersey were still offline due to damages sustained. The second largest refinery in the region, with a 238,000-barrel-a-day capacity, was not able to begin restart until Nov. 20, more than three weeks after it shut down in preparation for the storm.
- Without commercial power, well-stocked gasoline service stations were unable to pump fuel to customers. Service stations with power quickly depleted resources as demand rose, and suppliers experiencing power outages or infrastructure damage could not refuel them.

Limited visibility into regional fuel supplies made it difficult for owners and operators, government officials, and dependent sectors to assess the problem and prioritize response.

State emergency managers and other critical sectors lacked insight into the status of all links in the supply chain and the significance of disruptions, which complicated decision-making.

- Though fuel scarcity resulted from distribution issues, not supply shortages, public emergency managers had limited visibility into supply levels in refineries and storage terminals due to anti-trust laws and disclosure regulations, making it difficult to assess whether widespread shortages existed or determine where fuel could be moved once power was restored.
- Emergency managers and repair crews had no centralized way to determine which stations had electricity, backup generators, or fuel to pump. Restoration crews wasted time searching for operational service stations.
- Fuel distributors had trouble determining which suppliers had fuel and where. Trucks often waited at terminals only to be told they had no allocation when their turn came.

State and local governments lacked full understanding of petroleum operations and restoration needs.

- In Superstorm Sandy and past events, owners and operators spent critical response time educating government partners on how the sector markets, distributes, and transfers ownership of fuel. A lack of understanding of the sector's operations and market restrictions delayed coordination on solutions.
- Government officials in some cases attempted to allocate or prioritize fuel resources.
- As repeatedly experienced in past disasters, recovery crews in this and other sectors faced difficulty obtaining re-entry into damaged zones to restore critical services.

Fuel shortages triggered cascading disruptions to critical sectors and delayed recovery.

- Other critical sectors, especially emergency services, healthcare, and other lifeline sectors, depended heavily upon fuel for both backup generation and for repair fleet vehicles.

State and Federal regulations inhibited information sharing and limited fuel supply shipments from outside the region.

Fuel refiners, suppliers, and distributors faced state and Federal regulations that created obstacles to sharing supply information and sourcing fuel from outside the region. While waivers were quickly issued for certain regulations, others are not easily waived and further exacerbated the disruption:

- **Antitrust laws**, which place limits on market-sensitive information sharing and competitive conduct, restricted the owners'/operators' ability to share information regarding their fuel supplies with government partners and other companies.
- **SEC Regulation Fair Disclosure** states that any material nonpublic information that a petroleum company discloses to another entity must also then be disclosed publicly—making petroleum companies reluctant to share sensitive supply status and operations information with state emergency managers and other sectors.
- **Anti-gouging laws**, established by the state, prohibit a service station from excessively raising the price of fuel (10% above normal prices in New Jersey; in New York, "unconscionably extreme" increases are barred). This discouraged suppliers and distributors from bringing in fuel from other regions, as the increased transportation costs and subsequent fuel price increases would risk the appearance of price gouging.
- **Uniform Commercial Codes**, adopted by all 50 states, dictate that refineries and distributors cannot discriminate among customers and must first meet their contractual obligations. As a result, operators cannot redirect fuel deliveries unless stated in existing contracts.

Oil and Natural Gas Sector Lessons Learned

1. **State and local regulations designed to protect consumers often delay the ability to procure, deliver, and prioritize fuel supplies during a major disruption**. Excellent Federal, state, and local coordination both before and during the storm swiftly delivered waivers in many cases. But sometimes the waiver process or lack of waivers significantly delayed restoration of fuel deliveries in the region. See A Closer Look: Petroleum Regulations and Waivers during Superstorm Sandy for more information at the end of this section.
2. **Superstorm Sandy exposed risks in the petroleum industry that were not understood by other critical sectors and state and local government**. Limited understanding of sector operations, distribution, marketing, and regulations at the state and local level complicated situational awareness and made it difficult to assess and address supply chain breakdowns.
    - Some believe that petroleum facility owners and operators have complete decision-making control on where fuel is delivered, when in fact they are bound by regulations and contracts.
3. **More accurate real-time information on the types of products and supply levels in petroleum fuels systems would allow** Federal, state, and local energy officials to better address potential shortages during a disaster. The American Petroleum Institute has begun developing educational materials for state and local emergency managers and government officials. See also Electricity Sector Resilience Implications #4.
4. **Regulations on atmospheric (above-ground) fuel storage are not well understood and create potential disincentives for critical sites in other sectors to store excess emergency fuel**. Growing expectations for uninterrupted electricity created high demand for reliable backup generation, yet fuel reserves typically max out at 24-hour supplies, even at critical sites. Safer underground storage is costly and raises environmental considerations.

5. **Hundreds of independent and privately owned service stations had insufficient backup generation**, contributing to limited supply for emergency responders, repair crews, and the public. Despite being stocked with fuel, service stations without electricity often did not have reliable backup power to pump fuel. State and local government officials scrambled to supply limited emergency generators to stations, and connecting them was not seamless.
6. **Interdependencies between the electricity and fuel sectors highlighted the need for increased cross-sector communication** and coordination with public emergency managers. It became critical for fuel refiners and suppliers to communicate their electricity outage issues back to a central location, where they could be tagged with priority by state authorities and electricity repair crews. Daily conference calls with Federal energy officials and industry CEOs facilitated this coordination.
    - Fuel owners and operators need to work with emergency management officials and electricity owners and operators to determine in advance where they fall in the prioritization of service restoration, enabling them to plan accordingly.
7. **Large petroleum companies successfully applied experience from previous storms and hurricane-prone regions** (such as the Gulf Coast) during Superstorm Sandy. National companies share lessons learned across their facilities, and provide personnel and expertise from outside the region to assist during restoration.
    - A distributor who successfully built a relationship with a Philadelphia supplier (outside its normal operating region) was able to successfully use that relationship to source fuel for critical customers during Superstorm Sandy. In a prior storm, the same distributor lacked this relationship and had been cut off while trying to pre-stock critical customers with fuel.
    - Several companies donated thousands of gallons of fuel to critical infrastructure during Sandy.

Implications for Resilience

Petroleum companies have identified actions they can take based on lessons from Superstorm Sandy that will increase sector resilience in the face of a growing risk environment.

8. **Joint regional exercises with state and local government and critical sectors are one of the best mechanisms to identify gaps and interdependencies**, reinforce relationships, and address regional planning challenges for resilience. Joint exercises help to build muscle memory for response and institutionalize key relationships.
    - **Fuel distributors should build relationships with suppliers in adjoining regions** to help source alternative fuel supplies during fuel disruptions. Executive involvement in fuel distribution decisions during emergency events (while maintaining contractual obligations) can improve restoration and minimize cascading disruptions.
    - Owners and operators can reinforce to government and other sector officials their responsibility to ensure they have prepositioned an adequate fuel supply for critical operations before the storm.
9. **A comprehensive review of all Federal, state, and local regulations can** identify barriers to rapid recovery and restoration in the oil and natural gas sub-sector and enable security partners to remove them.
10. Government and industry partners can draw upon successful waiver processes during Superstorm Sandy **to streamline a waiver request and issuing process** for a variety of all-hazards events.

11. **Public emergency managers require new tools to better monitor real-time fuel availability and storage levels at all points in the supply chain**. An examination of what tools and personnel resources could improve real-time information sharing and situational awareness at the regional and Federal level can improve disaster response, while working within existing limitations on information sharing required by regulation.
    - Government officials should work with owners and operators to determine the best individuals within the company (such as public relations officials) to interface with, and communicate information needs so that those representatives can better source that information within the company.
12. Owners and operators in the electricity and oil and natural gas sub-sectors, working with Federal and state governments, should **fully identify regional interdependencies to better communicate restoration processes and priorities**. This will enable coordinated restoration and enable fuel owners and operators to plan restoration efforts in light of power restoration plans.
13. **Near-term and long-term investments will harden infrastructure and standardize equipment to improve flexibility.** Industry standards for installing transfer switches or other systems needed to accept backup power at oil terminals, pipelines, and service stations can speed the connection of emergency generators to critical facilities.
    - Despite the increased regulations it may prompt, state and locally identified critical infrastructure operations and assets that require uninterrupted power must pre-position anticipated fuel storage needs beyond 24 hours of generation capacity to ensure resilience.
    - Military trucks and commercial trucks are currently not fitted with the same hardware, which limits the National Guard's ability to quickly provide additional resources.
    - Petroleum facility owners and operators may consider elevating and relocating critical electronic equipment and control rooms. Marine terminals, which are particularly vulnerable to flooding, may require flood protection upgrades.

Opportunities for Improvement

- Review, refine, and streamline the process for issuing fuels waivers to owners and operators so fuel can be sourced and delivered in alternative ways.
- Public-private cooperation to design technologies and processes to measure and report real-time information on fuel supplies.
- Incentives for government and privately owned critical sites with back-up generation capabilities to pre-position and store more than 24 hours of fuel.
- Encouragement for service stations to integrate quick-connect capabilities for emergency generators, and support states to maintain an inventory of emergency generators for dispatch during an event.
- Assistance in educating state and local officials and other sectors about oil and natural gas sub-sector operations.

A Closer Look: Petroleum Regulations and Waivers during Superstorm Sandy

During Superstorm Sandy, residents and recovery teams struggled to acquire fuel, particularly petroleum products such as gasoline and diesel. In large part, this shortage resulted from the direct hit Sandy delivered to the petroleum terminals and refineries in the New Jersey and Staten Island areas. Widespread power outages and damaged transportation arteries also made fuel production and distribution difficult. When the petroleum industry tried to work around these complications to get fuel to those who needed it, the laws and regulations that govern petroleum often prevented them from reaching a solution. To help alleviate this issue, Federal and state agencies issued a number of petroleum waivers during Sandy and the recovery process.

Exhibit 22. Federal and State Agencies Regulating ONG Activities

Federal Regulatory Bodies

- Department of Defense
- Department of Homeland Security
- Department of Transportation
- Environmental Protection Agency
- Federal Energy Regulatory Commission

State Regulatory Bodies

- State government energy offices, represented by the National Association of State Energy Officials (NASEO)
- State public utility commissions, represented by the National Association of Regulatory Utility Commissioners (NARUC)
- Governors' offices and state legislators, represented by the National Governors Association (NGA) Center for Best Practices and the National Conference of State Legislatures (NCSL)
- State and local emergency management agencies, represented by the National Emergency Management Association (NEMA) and first responders
- Local governments and associations that represent them, such as the Public Technology Institute (PTI)
- Energy Emergency Assurance Coordinators (EEAC)

(U.S. DHS and DOE 2010)

Petroleum Infrastructure and Regulations

The petroleum portion of the energy sector includes the production, transportation, and storage of crude oil; processing of crude oil into petroleum products; transmission, distribution, and storage of petroleum products; and sophisticated control systems to coordinate storage and transportation.[2] The entire petroleum supply chain is heavily regulated by both the Federal government and individual states, with the Federal government generally regulating health, safety, and environment factors, and the states regulating petroleum operations within their jurisdictions. Under normal conditions, these regulations are harmonized through collaboration between the Environmental Protection Agency, the Department of Energy, and the Interstate Oil and Gas Compact Commission.[3]

Federal Health, Safety, and Environmental Laws and Regulations

According to ConocoPhillips, the following Federal regulations apply to all oil and natural gas activities (ConocoPhillips 2012):

- **Clean Air Act**: Regulates air emissions from engines, processing equipment and other sources associated with production.
- **Clean Water Act**: Regulates produced water and storm water runoff. Regulates facilities with a reasonable potential to discharge oil to navigable waters.

[2] "A Closer Look" draws heavily upon the following sources: DHS and DOE 2010; American Petroleum Institute nd.b; and ConocoPhillips 2012. Other sources are identified in notes throughout the text.

[3] The Interstate Oil and Gas Compact Commission serves as the collective voice of member State governors on oil and gas issues and advocates states' rights to govern petroleum resources within their borders; IOGCC 2103.

- **Endangered Species Act**: Covers endangered or threatened species and their habitats.
- **Emergency Planning and Community Right-to-Know Act**: Requires operators to report chemicals stored and used above certain quantities and to submit material safety data sheets to emergency responders.
- **Environmental Response, Compensation and Liability Act**: Requires operators to report releases of certain chemicals in excess of established threshold levels.
- **Federal Land Policy and Management Act**: Establishes guidelines for the management, protection, development and enhancement of public lands.
- **National Environmental Policy Act**: Provides guidelines for environmental analysis on Federal lands and minerals and established the Council on Environmental Quality.
- **Occupational Safety and Health Act**: Requires information disclosure about chemicals used at every site.
- **Safe Drinking Water Act**: Sets standards for disposal of flowback and produced water.
- **Toxic Substance Control Act**: Requires operators to report information on a chemical's production, use, exposure and risk.

Exhibit 23. Emergency Support Function 12 (ESF 12): Energy

ESF 12 is intended to facilitate the restoration of damaged energy systems and components when activated by the Secretary of Homeland Security for incidents requiring a coordinated Federal response. When activated, the designated agency directing ESF 12 has the following scope of responsibility:

- Collect, evaluate, and share information on energy system damage and estimations on the impact of energy system outages within affected areas
- Provide information concerning the energy restoration process such as projected schedules, percent completion of restoration, and geographic information on the restoration
- Facilitate the restoration of energy systems through legal authorities and waivers
- Provide technical expertise to the utilities, conduct field assessments, and assist government and private-sector stakeholders to overcome challenges in restoring the energy system

State, tribal, and local governments have primary responsibility for prioritizing the restoration of energy facilities. Restoration of normal operations at energy facilities is the responsibility of the facility owners.

Federal and State Antitrust Laws

The petroleum industry is also subject to Federal and State antitrust laws, which place limits on information sharing within the petroleum industry, forbid anti-competitive conduct, and cannot be waived (American Petroleum Institute nd.b). The three core Federal antitrust laws include (FTC 2013):

- **Sherman Act**: Outlaws "every contract, combination, or conspiracy in restraint of trade," and any "monopolization, attempted monopolization, or conspiracy or combination to monopolize."
- **Clayton Act**: Prohibits mergers and acquisitions where the effect "may be substantially to lessen competition, or to tend to create a monopoly."
- **Federal Trade Commission Act**: Bans "unfair methods of competition" and "unfair or deceptive acts and practices." The Robinson/Patman Act amends the Clayton Act to ban certain discriminatory prices, services, and allowances in dealings between merchants.

Regulation Fair Disclosure

The Securities and Exchange Commission (SEC) in August 2000 adopted Regulation FD (Fair Disclosure) to address the selective disclosure of information by publicly traded companies. Regulation FD provides that when an issuer discloses material nonpublic information to certain individuals or entities—generally, securities market professionals and holders of the issuer's securities who may trade on the

basis of the information—the issuer must make public disclosure of that information (U.S. Securities and Exchange Commission 2004).

Although Regulation FD was intended to preserve the integrity of capital markets by restricting insider trading, there has been considerable backlash from publicly traded companies as to its interpretation and implications. The SEC addressed many of these concerns in its Final Rule on Regulation FD, effective October 2000 (U.S. Securities and Exchange Commission 2001). However, many issues remain unclear and industry may be reluctant to provide privileged information to government in situations where the disclosure might be faulted by the SEC.

National Security Authorities

The petroleum industry is also subject to laws providing the Federal government with national security authorities over energy in case of emergencies. These include (DHS and DOE 2010):

- **Defense Production Act (DPA)**: Delegates the Secretaries of Energy and Commerce under the President's authority to require the priority performance of contracts or orders relating to materials (including energy sources), equipment, or services, including transportation, or to issue allocation orders, as necessary or appropriate for the national defense or to maximize domestic energy supplies.[4]
- **Robert T. Stafford Disaster Relief and Emergency Assistance Act**: Authorizes FEMA, following a presidential declaration of emergency or major disaster, to provide assistance and require other Federal agencies to provide resources and personnel to support state and local emergency and disaster assistance efforts.
- **Merchant Marine Act of 1920 ("Jones Act"):** Directs the Secretary of Homeland Security to waive the provisions requiring the use of U.S.-flag, U.S.-built, and U.S.-crewed vessels in coastwise trade, upon the request of the Secretary of Defense. Interagency procedures have been established to expedite actions on Jones Act waiver requests during a petroleum supply disruption.
- **Ports and Waterways Safety Act**: Authorizes the Secretary of Transportation to establish vessel traffic systems for ports, harbors, and other navigable waters and control vessel traffic in areas determined to be hazardous (e.g., because of reduced visibility, adverse weather, or vessel congestion).
- **Energy Policy and Conservation Act**: Specifies that, in order to be eligible for financial assistance to assist in the development and implementation of an energy conservation plan, a state must submit to the Secretary of Energy an energy emergency planning program for an energy supply disruption that is consistent with applicable Federal and state law. The contingency plan "shall include an implementation strategy or strategies (including regional coordination) for dealing with energy emergencies."

Waivers Issued During Superstorm Sandy

On October 26 (three days before Sandy hit the New Jersey shore), DOE's Office of Electricity Delivery and Energy Reliability (OE) was designated the Federal Sector-Specific Agency directing Emergency Support Function 12 (ESF-12) activities for the energy sector under the National Response Framework (FEMA 2012). As a result, OE began issuing its *Hurricane Sandy Situation Report* on October 28. At that time, refineries and utility companies were carefully monitoring the storm and utilities were preparing

[4] "National defense" is defined in DPA to include "emergency preparedness activities conducted pursuant to title VI of the Robert T. Stafford Disaster Relief and Emergency Act and critical infrastructure protection and assurance."

for the hurricane by pre-positioning supplies, securing workers, and requesting mutual assistance support to restore power after the storm made landfall (DOE 2012b).

Department of Transportation Waivers

On October 28, the Department of Transportation's Federal Motor Carrier Safety Administration (FMCSA) issued a Declaration of Regional Emergency Notice, stating: [5]

- "The emergency exemption is issued as a result of extreme weather conditions, shortages, and interruptions in the availability and/or delivery and repair of services and property throughout the States affected in the Eastern Region to include the following: Connecticut, Delaware, the District of Columbia, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont, Virginia and West Virginia. It is effective beginning October 29, 2012.
- "This declaration of emergency provides relief for commercial motor vehicles operations while providing these emergency materials and services to customers in the above mentioned states during the emergency. This exemption applies only to those operations providing direct assistance to the emergency relief effort. Direct assistance terminates when a driver or commercial motor vehicle is used in interstate commerce to transport cargo or provide services not destined for the emergency relief effort or when the motor carrier operation dispatches such driver or vehicle to another location to begin operations in furtherance of commerce" (FMCSA 2012b).

The FMCSA also issued the following waivers via the Hurricane Sandy Information Center on its webpage:
"Due to the damages caused by Hurricane Sandy FMCSA is coordinating with Federal agencies and states on emergency declarations, waivers, exemptions, special permits, tolls and other temporary authorizations related to relief efforts in your state. Trucks bringing fuel to the impacted region must follow different state regulations. The team will coordinate information on a variety of waivers to ensure each state is on the same page on key regulatory issues that should be addressed to assist the flow of petroleum products to affected states, including:

- Driver Hours-of-Service
- Oversize and Overweight
- Low Sulfur Diesel Waivers
- Toll Waivers
- Vehicle Registration Waiver (International Registration Plan — IRP)
- Fuel Tax Waiver (International Fuel Tax Authority — IFTA)" (Federal Motor Carrier Safety Administration 2013)

A month prior to Sandy, DOT's Federal Highway Commission issued guidance on Section 1511 of the Moving Ahead for Progress in the 21st Century Act (MAP-21) that was also put in place during the storm. The guidance extends the states' authority to issue special permits to vehicles with divisible loads (e.g., relief supplies) during a Presidentially-declared emergency or major disaster under the Stafford Act (Federal Highway Administration 2013). These permits help alleviate the strict Federal oversize and weight limits placed on vehicles using the Interstate system to expedite the delivery of relief supplies to areas in need.

[5] For a complete listing and links to Federal and State motor-carrier related waivers and exemptions during Sandy, please see FMCSA "Hurricane Sandy Relief Efforts - Declarations, Waivers, Exemptions & Permits."

EPA Fuel-Related Waivers

In the event of a fuel supply emergency, only EPA[6], with the concurrence of the Department of Energy, may temporarily waive a fuel or fuel additive requirement if doing so will alleviate the fuel supply emergency.[7] Clean Air Act Section 211(c)(4)(C), which authorizes fuels waivers, specifies the criteria for granting a fuels waiver, and the conditions that must be included in a fuels waiver (see Exhibit 24). A fuels waiver can be issued only when the criteria specified in the Clean Air Act have been met. In general, these criteria allow a fuels waiver only to address a temporary emergency fuel supply shortage that exists throughout a state or region that was caused by an unusual situation, such as fuel shortages as a result of the extensive hurricane damage to refineries and pipelines.

The Clean Air Act includes a range of requirements for motor vehicle fuel depending on location (rural vs. urban) or time of year (e.g., the volatility of gasoline is controlled each year during the high ozone season of June 1st through September 15th). As a result, EPA may grant a waiver to allow use of a fuel that normally is not allowed in a particular time period or geographic area.

The process for obtaining a fuel waiver from EPA involves many steps. Except in unusual or emergency circumstances, a formal request for a fuels waiver must be made by, or on behalf of, the Governor of an affected state after consultation with EPA. The first point of contact for a state government to obtain information about a fuels waiver request is the EPA Air Enforcement Division or the Transportation and Regional Programs Division. Outside of normal business hours, the point of contact is the EPA Emergency Operations Center. EPA requests that it be contacted as soon as it appears that there may be a fuel supply shortage to allow them to provide guidance to the affected state regarding a possible fuel waiver request, and to begin an assessment of the possible fuel supply shortage in coordination with the Department of Energy.

After this assessment, EPA requires the Governor of the affected state or territory to issue a formal written request for a fuels waiver under the direction of the EPA Administrator. The request should describe how the fuels waiver criteria specified in Clean Air Act have been met, including the following:

- The nature of the Act of God or other event that caused the shortage
- An explanation of why the shortage was not foreseeable and could not have been prevented by prudent planning on the part of the suppliers of the fuel
- The type of fuel for which a shortage exists
- The geographic area that is affected
- The effect of the shortage on fuel supplies, such as the number of gasoline stations that are, or are expected to be, out of fuel
- The expected duration of the shortage
- The specific nature of the waiver being requested, including the duration, the geographic area, and the alternative fuel that would be allowed

[6] State fuels programs that are part of a State Implementation Plan (SIP) are Federally enforceable, and the requirements cannot be waived unless waivers are issued by both EPA and the state.
[7] This explanation borrows from U.S. EPA, "Fuel Waivers."

Exhibit 24. Criteria and Conditions for Fuels Waivers Specified in Clean Air Act Section 211(c)(4)(C)

(ii) The Administrator may temporarily waive a control or prohibition respecting the use of a fuel or fuel additive ... if, after consultation with, and concurrence by, the Secretary of Energy, the Administrator determines that--

(I) extreme and unusual fuel or fuel additive supply circumstances exist in a State or region of the Nation which prevent the distribution of an adequate supply of the fuel or fuel additive to consumers;

(II) such extreme and unusual fuel and fuel additive supply circumstances are the result of a natural disaster, an Act of God, a pipeline or refinery equipment failure, or another event that could not reasonably have been foreseen or prevented and not the lack of prudent planning on the part of the suppliers of the fuel or fuel additive to such State or region; and

(III) it is in the public interest to grant the waiver (for example, when a waiver is necessary to meet projected temporary shortfalls in the supply of the fuel or fuel additive in a State or region of the Nation which cannot otherwise be compensated for).

(iii) If the Administrator makes the determinations required under clause (ii), such a temporary extreme and unusual fuel and fuel additive supply circumstances waiver shall be permitted only if--

(I) the waiver applies to the smallest geographic area necessary to address the extreme and unusual fuel and fuel additive supply circumstances;

(II) the waiver is effective for a period of 20 calendar days or, if the Administrator determines that a shorter waiver period is adequate, for the shortest practicable time period necessary to permit the correction of the extreme and unusual fuel and fuel additive supply circumstances and to mitigate impact on air quality;

(III) the waiver permits a transitional period, the exact duration of which shall be determined by the Administrator (but which shall be for the shortest practicable period), after the termination of the temporary waiver to permit wholesalers and retailers to blend down their wholesale and retail inventory;

(IV) the waiver applies to all persons in the motor fuel distribution system; and

(V) the Administrator has given public notice to all parties in the motor fuel distribution system, and local and State regulators, in the State or region to be covered by the waiver.

During Sandy, state governments worked with EPA to issue the following waivers:

- October 31 – EPA Administrator issued an "October 2012 Fuel Waiver Concerning Connecticut, Delaware, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Virginia, Mississippi, Alabama, Georgia, Tennessee, South Carolina, North Carolina, and the District of Columbia" which waived Federal reformulated gasoline (RFG) requirements in Designated RFG Covered Areas (Jackson 2012a).
- October 31 – EPA waived requirements for use of Ultra Low Sulfur Diesel fuel, and to instead allow the use of high sulfur heating oil, in certain generators and pumps used for emergency purposes in New Jersey (Jackson 2012b).
- On November 1 – EPA waived the requirement for use of Ultra Low Sulfur Diesel in emergency response vehicles in New Jersey (Jackson 2012c). Related, on November 3, in response to shortages of clean diesel fuel caused by Hurricane Sandy, the IRS waived tax penalties when dyed diesel fuel is sold for use or used highway, and for the use of diesel fuel that does not meet EPA sulfur requirements, in New York, New Jersey and Pennsylvania (IRS 2012a).
- On November 2 – EPA waived the requirement for use of Ultra Low Sulfur Diesel in emergency response vehicles and equipment in the five boroughs of New York City and Nassau, Suffolk, Rockland and Westchester counties in New York, and in the Commonwealth of Pennsylvania (Jackson 2012d).
- On November 16 – EPA extended the multi-state waiver of RFG requirements in NY and NJ, and the waiver of diesel fuel requirements in NY and NJ (Jackson 2012e). Related, on November 20, in response to continuing shortages of clean diesel fuel caused by Hurricane Sandy, the IRS waived tax penalties when dyed diesel fuel is sold for use or used highway, and for the use of

diesel fuel that does not meet EPA sulfur requirements, in New York and New Jersey (IRS 2012b).

Waivers Issued During Superstorm Sandy by Component of Petroleum Industry

Facility	Waiver
Gas Stations	**Federal and State**
	• **Fuel specs** (RFG, ASTM, ULSD)
	State and Local
	• **Air quality** – Vapor recovery • **Pump labeling** – State and local governments generally require that gasoline stations place labels on their pumps disclosing gasoline ingredients, especially ethanol and methanol (Fultz 1988). The labeling waiver was issued by individual states and communities because cleaner gasoline and diesel was unavailable, while conventional fuel sometimes was.
Ports, Barge/ Shipping	**DHS**
	• Merchant Marine Act of 1920 ("Jones Act") – Certain provisions of the Jones Act
	States
	• **Vapor recovery regulations** – Part of the implementation of the Clean Air Act, vapor recovery is the process of recovering the vapors of gasoline or other fuels, so that they do not escape into the atmosphere in order to reduce noxious and potentially explosive fumes and pollution.[8]
Pipelines	**EPA**
	• Fuel specs for RFG and ULSD
	States

	• Fuel specs
	• **Air quality** regulations for:
	  ○ **Vapor containment units** – Part of vapor recovery system (see above)
	  ○ **Startup emission** – Part of EPA's requirement for states to improve startup, shutdown, and malfunction air emission provisions under the Clean Air Act (Beveridge and Diamond 2013).

Terminals	**EPA**
	• Fuel specs for RFG and ULSD
	IRS and State Revenue
	• Dyed diesel • Motor fuel tax exemption • Fuel merchant importer waiver
	States
	• **Gasoline fuel specs for ASTM** – The American Society for Testing and Materials (ASTM) D4814-13 specification describes various characteristics of automotive fuels for use over a wide range of operating conditions. It provides for a variation of the volatility and water tolerance of automotive fuel in accordance with seasonal climatic changes at the locality where the fuel is used (ASTM n.d.). • **Gasoline fuel specs for RVP** – Reid vapor pressure (RVP) is a common measure of gasoline volatility. EPA regulates the vapor pressure of gasoline sold at retail stations during the summer ozone season (June 1 to September 15) to reduce evaporative emissions from gasoline that contribute to ground-level ozone and to diminish the effects of ozone-related

[8] Each State is required by EPA to set up its own plan for implementing Federal Clean Air Act requirements; this is called a State Implementation Plan or SIP. EPA sets national standards, requirements or guidelines that the State then incorporates into State statute or administrative code. Once a requirement is established through State law, the State submits that to EPA in a SIP. Each State's SIP goes through a Federal approval, making those rules Federally enforceable. See, for example, Wisconsin Department of Natural Resources 2012.

Facility	Waiver

	health problems (EPA 2013b). States and counties can have their own RVP standards (EPA 2010).
	• **Home heating oil sulfur and biodiesel mandates** – In response to an EPA effort to reduce the sulfur content of diesel fuels, many states and local governments in the Northeast began proactively adopting higher biodiesel blends or low sulfur diesel (Amerigreen 2011).
	• **Air quality** regulations for:
	  ○ Vapor recovery
	  ○ Containment units
	  ○ **No Action Assurance (NAA)** – EPA and state emission standards for Hazardous Air Pollutants from industrial, commercial, and institutional boilers, including HVAC systems. NAA refers to non-enforcement of regulations at the agency's discretion, usually until a final rule has been set (Giles 2012).

Trucking	**Department of Transportation**

	• **Declaration of Regional Emergency** – DOT's Federal Motor Carrier Safety Administration (FMCSA), under Title 49 CFR Part 390.23, issued a Declaration of Regional Emergency Notice on October 28, 2012.
	• FMCSA coordinating with Federal agencies and states on emergency declarations, waivers, exemptions, special permits, tolls and other temporary authorizations related the flow of petroleum products to affected states, including:
	  ○ Driver Hours-of-Service
	  ○ Oversize and Overweight
	  ○ Low Sulfur Diesel Waivers
	  ○ **Toll** Waivers
	  ○ **Vehicle Registration** Waiver (International Registration Plan -- IRP)
	  ○ **Fuel Tax** Waiver (International Fuel Tax Authority -- IFTA)" (Federal Motor Carrier Safety Administration 2013).
	• **DOT-SP 15752** – DOT's Pipeline and Hazardous Materials Safety Administration (PHMSA) issued a Special Permit on November 7, 2012, authorizing "the transportation in commerce of certain hazardous materials in support of the recovery and relief in response to Hurricane Sandy" (Pipeline and Hazardous Materials Safety Administration 2012).

	States
	• Weight limits • Importer/exporter license • Commercial truck registration • Interstate fuel taxes (IFTA and IRP)
Refineries	**EPA**
	• **Fuel specs for reformulated gasoline (RFG)** – RFG is gasoline blended to burn more cleanly than conventional gasoline and to reduce smog-forming and toxic pollutants. The RFG program was mandated by Congress in the 1990 Clean Air Act amendments (EPA 2013c). • **Fuel specs for Ultra Low Sulfur Diesel (ULSD)** – The cleaner diesel fuel program reduces sulfur content, creating immediate health benefits and allowing engine manufacturers to begin using advanced emissions control systems. The diesel program regulations are located in 40 CFR Part 80 subpart I (EPA 2013d).
	States (with EPA and IRS)
	States impacted by Sandy also waived some of their fuel specs, after being so authorized by EPA and IRS

Electricity

Superstorm Sandy caused massive electricity outages that affected 21 states from North Carolina to Maine. Though much of the damage was concentrated in New York and New Jersey, Sandy's impact was extensive:

- Nearly 10 million customers lost electric power during the storm, with a peak outage of about 8.6 million on October 30 and 31, and the Nor'easter's second attack created additional outages on a compromised infrastructure that further prolonged recovery.
- In New Jersey, Public Service Electric and Gas Company (PSE&G) lost 2 million out of its 2.2 million total customers at the highest point. PECO, which supplies electricity to Philadelphia and the surrounding areas, experienced record-breaking outages: 850,000 of the 1.6 million customers lost power as the storm hit, though the majority was restored within 24 hours as Philadelphia experienced limited damage and no flooding.
- The Long Island Power Authority lost 90% of its customers during the storm. Though line and pole damage from tree limbs and wind was widespread, it was substation and switching equipment flooding and extensive saltwater damage that made Sandy unique and substantially delayed restoration. Even underground lines sustained damage from flooding.
- ConEdison lost 975,000 of its 3.3 million customers during Sandy, and flooding at ConEd's East Manhattan substation cut power to about 250,000 customers for five days, creating a notably dark skyline and new nickname for the Manhattan neighborhood below 39th Street: SoPo, or South of Power.

Exhibit 25. Electricity Sector Highlights

- The storm sent water surging over flood barriers and into low-lying areas where many plant assets are located, inundating substations and causing significant damage.
- Electricity sector response was marked by unprecedented industry and government coordination headed by senior leadership. A Senior Assessment Team of government executives worked in the field to directly troubleshoot key issues, while a first-of-a-kind Federal Energy Restoration Task Force was created specifically to streamline power restoration and fuel availability. Electric utility CEOs participated in daily conference calls with EEI and DOE senior leadership.
- Electricity sector representatives were embedded in Federal, regional, and state EOCs, many for the first time. An EEI representative was headquartered at FEMA for 10 days during the response.
- The sector mobilized 70,000 utility personnel from 80 utilities across the nation—the largest dispatch of mutual aid in the U.S. electric system. DOE engaged three power marketing administrations to assist investor-owned utilities for the first time, and airlifted their Federal resources into hard-hit areas.
- Multi-state fleet movement to support mutual aid was slowed by uncoordinated permitting, waiver, and toll movement processes.
- The large force of responders meant that fuel requirements for utility crews increased dramatically while fuel shortages worsened.
- As utilities and regions better prepare for large storms, the cost and difficulty to secure mutual aid resources rises. For unpredictable storms, utilities now have to start earlier and cast a wider net to get the resources they need.

Exhibit 26. Example Electricity Grid Structure

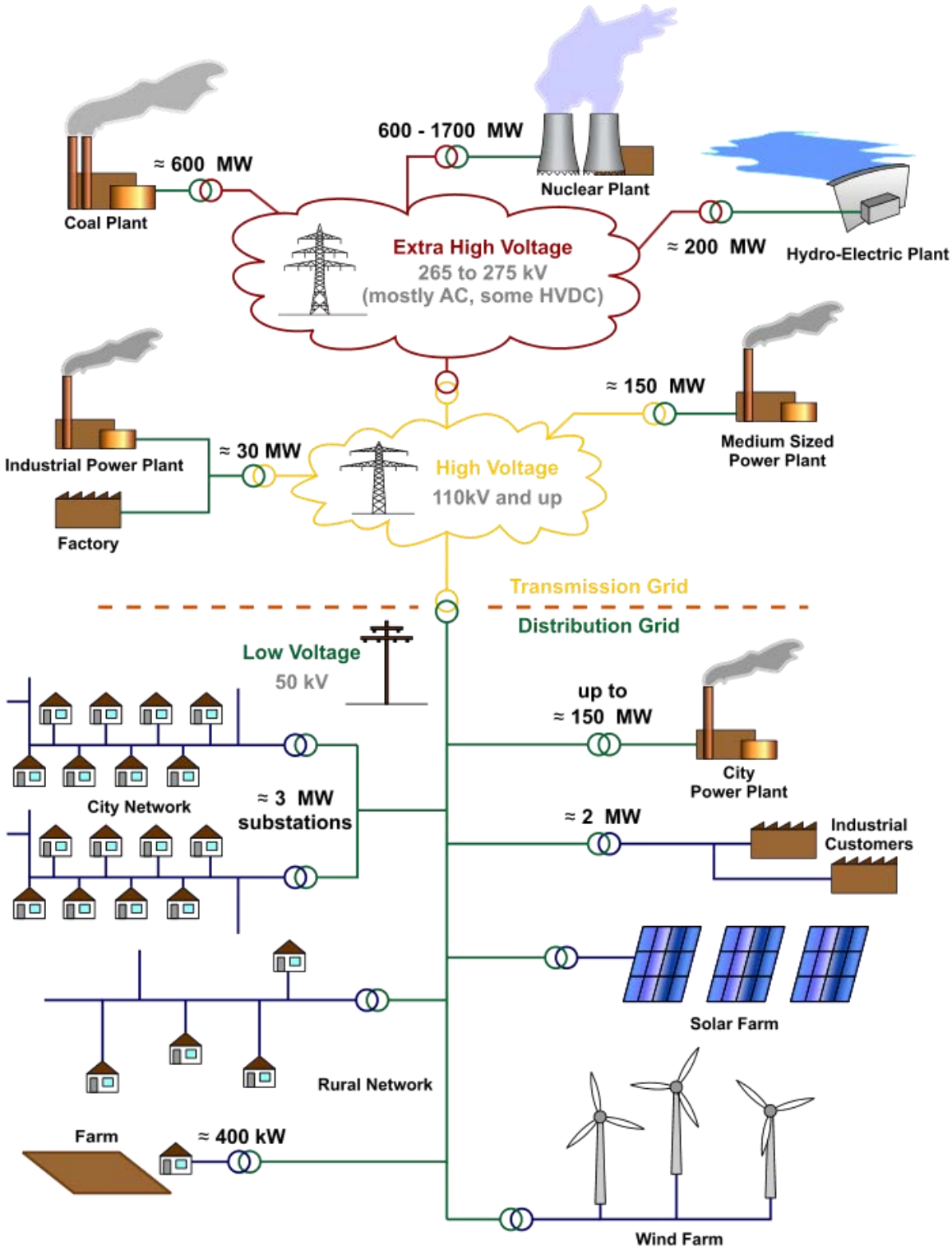


Diagram via Creative Commons.

Highlights of Planning, Response, and Recovery

Despite significant damage, an unprecedented response effort and extensive and coordination helped to speed electricity restoration in the region.

The sector mobilized the largest dispatch in history of mutual aid in the U.S. electric system.
About 70,000 utility personnel from 80 utilities across the nation assisted in recovery from Sandy. Despite significant damage, workers restored electricity to 99% of customers within two weeks. (By comparison, New York and New Jersey took 6-7 days to restore 95% of customers after Irene the prior year, but they experienced half the number of outages.) Utilities began mobilizing crews as early as five days before the storm made landfall in New Jersey. Almost every Edison Electric Institute (EEI) mutual assistance group was activated. Some utilities, however, faced challenges in bringing non-unionized repair crews on board. DOE engaged three power marketing administrations (Bonneville, Western Area, and Southwestern) to provide 235 personnel and roughly 200 pieces of equipment. It was the first time the Western Area or Southwestern Power Administration had provided mutual aid to investor-owned utilities through DOE's ESF-12 response, and the Department of Defense airlifted their equipment into the impacted region.

Task forces of senior Federal personnel increased public-private coordination and cut through red tape.
President Obama's "zero tolerance for red tape" was a catalyst for unprecedented senior-level engagement and public-private coordination.

- The president sent a Senior Assessment Team of government executives into the field to directly address and coordinate response on electricity sector issues. Members included the deputy FEMA administrator, a DOE deputy assistant secretary, a flag officer from U.S. Northern Command, and White House personnel.
- A first-of-a-kind Energy Restoration Task Force at FEMA's National Response Coordination Center (NRCC) specifically supported power restoration and fuel availability.
- Electric utility CEOs participated in daily coordination conference calls with EEI representatives and DOE senior leadership to improve situational awareness and facilitate resource deployment.
- Agencies such as DOE, DOT, and EPA worked directly with utility owners and operators, trade associations, and state officials to expedite waivers enabling repair crews to cross state lines and transport heavy equipment through disaster areas.

Utility personnel in some parts of New Jersey were classified as emergency responders for the first time.
This enabled electric utility personnel to jump to the head of fuel lines and removed access barriers to disaster areas for restoration crews.

The sector shut off power to critical equipment in the days before the storm to limit damage.
Utilities moved equipment out of flood zones, where possible, and preemptively shut down power to some stations to avoid critical equipment damage during anticipated flooding.

Recent regional investments in redundant and hardened assets within the electric *transmission* system limited Sandy's impacts; the storm mainly damaged the electric *distribution* system.
Transmission system impacts resulted mostly from loss of load as regional utilities quickly dropped from thousands of megawatts of load to merely hundreds. Utilities were in daily communication with the regional transmission organization, PJM, to coordinate and ensure sufficient voltage to bring back large lines.

Exhibit 27. A First in Response: Electricity Representation in the National Response Coordination Center

At President Obama's request, the Edison Electric Institute for the first time staged a representative at the FEMA NRCC for 10 days during Superstorm Sandy response. EEI represents 70% of the electricity delivered in the United States and plays a key role in convening senior-level personnel from investor-owned utility members and other trade organizations.

Direct, senior-level coordination enabled resource and asset movement that would not have otherwise been possible. Traditionally FEMA would be coordinating with individual utilities, without an established working relationship, to meet individual needs. The embedded EEI representative became a point-person that worked directly with representatives of FEMA, DOE, DHS, DOT, and DOD to achieve significant coordination successes, including:

- Military airlifting of resources and personnel from the West Coast power administrations to hard-hit areas on the East Coast.
- Working with U.S. Army Corps of Engineers to source sufficient pumps, generators, fuel, and heavy-duty fans to pump out and dry substations.
- Matching workforce expertise in mutual aid crews to primary needs of utilities.
- Obtaining the necessary permits, waivers, and lodging resources to move and house thousands of mutual aid personnel.
- Identifying and directing fleet crews to available fuel resources as fuel disruptions worsened.
- Sharing first-hand knowledge of electricity sector operations and restoration processes for FEMA and other agency personnel who could then better coordinate response in other lifeline sectors.

Response, Recovery, and Interdependency Challenges

Electric power provides a backbone of recovery in all other sectors. The electricity sector also depends heavily on the oil and natural gas and transportation sectors to resume service. Power restoration entirely halts without gasoline and diesel to fuel utility fleet vehicles. Utilities work with the transportation sector at the state and local level to coordinate de-energizing lines and debris removal to clear roads and provide access to areas where repairs are needed. Electric utilities also rely on communications networks to operate control systems and communicate with components and equipment at substations. Many utilities have begun investing in their own fiber to reduce dependencies on public networks. Superstorm Sandy overwhelmed the capabilities of electric utility owners and operators and highlighted key interdependency challenges.

Unprecedented flooding and damage surpassed flood barriers and exceeded utility expectations.
Despite accurate weather predictions from NOAA, many owners and operators across multiple industries did not understand the full implications of the predicted surge. The storm surge came at high tide, sending 14 feet of water over flood barriers and into low-lying areas where many plant assets are located. PSE&G, for example, lost 31 substations to water inundation. Heavy debris, including downed trees, destroyed buildings, and displaced sand, created safety hazards that slowed response times and required coordination with the National Guard and state transportation agencies to speed removal.

Multi-state fleet movement to support mutual aid was slowed by uncoordinated permitting, waiver, and toll movement processes.
See "Delays in fleet movements slowed response and recovery of the lifeline sectors" in the Transportation section for further details.

Fuel requirements for utility crews increased dramatically while fuel shortages worsened.
For example, PSE&G utility crews typically consume 15,000 gallons of fuel per day, but that requirement jumped to 75,000 gallons per day during Sandy response. The utility also used 120 buses to shuttle crew members back and forth from job sites, further increasing needs.

Limited lodging for large numbers of out-of-state repair crews created a logistics challenge.
A limited supply of hotel rooms—due to both power outages and an increase in displaced citizens—created a lodging shortage for restoration crews from outside the area. Utilities were hesitant to house restoration crews working 18-hour shifts in tent cities. In some cases, they worked with nearby hotels to prioritize power restoration in exchange for guaranteed rooms for repair crews. When mutual aid workers for PECO finished restoring power in Pennsylvania, they began assisting utilities in New Jersey, but were advised to keep the hotel rooms they had in the Philadelphia area and commute two hours to New Jersey because lodging was limited.

Rate recovery for resilience investments is a political challenge, even after large storms.
Although public and political support is high for resilience investments in the immediate aftermath of a storm, that sentiment can quickly fade as time passes and rate hikes are discussed. Utilities need a clear cost-benefit case for resilience improvements in proposals to public utility boards.

Excellent preparation across a large area of potential storm impact ended up complicating mutual aid response.
Utilities built on lessons learned from Hurricane Irene, but found that preparation for forecasted events becomes harder and more expensive as the sector gets better at it. Utilities in the storm's path requested mutual aid resources several days prior to the storm to ensure they were staged throughout the region before the storm hit, yet found their typical partners outside the region could not give resources. As the storm moved up the East Coast, utilities in the South retained repair crews as a precaution until the storm passed them. Utilities also had to pay contract repair crews to stay within the region and refuse offers from other facilities up and down the East Coast. As the storm progressed, state regulations or declarations from public officials prevented utilities from releasing idle crews to other harder-hit areas in the region until all damage and every outage in the state was addressed.

Increased demand for accurate restoration estimates creates a communication challenge for utilities.
In the last decade, electric utilities developed advanced algorithms that give an estimated time to restoration (ETR) based on a one-fault problem, which gives a highly accurate prediction for routine outages. However, storm events create multi-fault situations that make the first-fault ETR accurate for some of the population, but not all. The only alternative, the global ETR for entire system restoration, provides an imprecise estimate that limits decision-making. At PECO, for example, the first-fault ETR predicted that 630,000 customers would be restored by Nov. 1; 550,000 customers were restored as predicted, and the remaining 80,000 were affected by secondary faults that the ETR system could not accurately account for. Giving customers the global ETR of seven days, however, could have created high demand on hotel rooms and shelter space that was unnecessary for more than 85% of affected customers. Without an accurate sense of when power will be restored, communities cannot plan response effectively; however, with insufficient understanding of utility operations, customers and public leaders increasingly demand highly detailed ETRs that utilities cannot meet.

Because of size, weight, cost, or technology age, replacement components may be difficult to source and deliver.
Temporary patches enabled by regulatory waivers often only offer a solution until emergency declarations are lifted. In addition, critical components such as transformers are prohibitively expensive for individual utilities to maintain as spares and have long lead times for emergency replacements.

Electricity Sector Lessons Learned

1. **Senior leadership and executive engagement substantially streamlined coordination and removed regulatory and jurisdictional red tape**. Initial reviews of new senior task forces indicate that effective coordination, resource movement, and communications would not have occurred without such high-level engagement.
2. **A multi-pronged communications approach** engaging customers, government agencies and leaders, and the media increases public confidence and helps dependent sectors make better restoration and recovery decisions. Utilities engaged government leaders and customers before the event to prepare them for outage expectations, and used a variety of social media outlets to provide continuous real-time updates directly to stakeholders.
3. **Priority sites for restoration are not the same for every event.** The time of year, weather conditions, and location and type of event can create new "priority sites" for electricity restoration. Sandy preceded the 2012 presidential election by only a week, making polling locations a high priority for restoration by Nov. 6. In Philadelphia, PECO scrambled to make a list of exact polling locations in the city and integrate them into the restoration planning process. As fuel shortages worsened in New York and New Jersey, gas stations became critical sites that supported restoration for multiple other sectors and critical facilities.
4. To better inform restoration priorities, **owners and operators need up-to-date information from emergency managers on which sites they consider critical**, why, and what level of backup power each critical site has. When every circuit is a priority, no circuit is a priority. Before an event, utilities need a list of sites that emergency managers consider critical to the region, downstream impacts of power loss to each site, and an estimate of how long each site can operate on its backup power.
5. **For unpredictable storms, utilities now have to start earlier and cast a wider net to get the resources they need** from partners outside the storm's path. As a result, owners and operators must make preparation decisions and mutual aid requests several days prior to the storm, when its strength and impact area can change dramatically. Regulated utilities must justify the significant costs of preparation when damage is not as severe as originally predicted.
6. **Designating electricity restoration crews as emergency responders** significantly improved their access to resources and necessary sites, reducing response delays.

Implications for Resilience

1. **Electric utilities recognize an opportunity to strengthen critical energy infrastructure and accelerate grid modernization** to improve flexibility and capabilities following Superstorm Sandy.
    - PSE&G proposed a $3.9 billion effort over the next 10 years to the New Jersey Board of Public Utilities for infrastructure investments that include: hardening more than 40 stations against storm surges by raising them, installing better protections, or relocating them; strengthening distribution lines; creating redundancy and advanced loop

schemes; investing in 100% private communications fiber (from 50%); deploying smart grid technologies to better monitor system operations and coordinate repairs; and increasing automation and control throughout the grid. Investments are now being negotiated with regulators, though PSE&G is going forward with the most critical upgrades before the next storm season.

- ConEdison made a $1.2 billion immediate investment post-Sandy to improve resilience for 2013's summer storm season. They are now proposing a $1 billion plan over the next four years to: build concrete flood barriers, install flood gates, and install submersible electronic equipment; redesign two underground electrical networks in NYC to enable smart grid capabilities that de-energize customers preemptively during floods and isolate outages to enable surrounding areas to retain power; and install hundreds of remote smart switches to isolate damaged equipment, among other resilience improvements.
- State standards for tree trimming would streamline pre-event protective measures and ensure universal best practices to prevent storm damage. In New Jersey, each municipality creates its own regulations regarding tree-trimming, creating a challenge for utility crews.

2. **Streamlining permit, waiver, and toll processes for fleet movement** offer some of the best opportunities to cut restoration time following an event. While crews have optimized pole and line repair processes within safety standards, a well-documented process can help repair crews recoup critical lost restoration hours to fleet movement delays. (See Transportation Sector Lesson Learned #4).
3. **Critical lifeline facilities and assets that rely heavily on electricity must maintain and resize their own backup generation to ensure continuous and reliable operations**. If a site is truly critical and highly dependent on electricity, owners and operators at that site must work with stakeholders to test and maintain backup power sources. Despite prioritization, electric utilities cannot guarantee a time to restore for any site. For example, critical hospitals frequently invest in redundant power lines from utility providers and have a backup generator for short duration outages. Sandy revealed that critical sites should have frequently tested generators and fuel supplies that enable the facility to operate without power for several days.
4. **Improved customer and stakeholder education and outreach before an event can help set expectations for restoration and recovery**. Utilities and trade associations can improve pre-event education to emergency management officials and large customers, including lifeline sector facilities, on sector processes such as pre-emptive shutdowns, damage assessment, and prioritization to increase understanding of electricity sector challenges and encourage individuals and businesses to make resilience investments.
    - Restoration challenges specific to the event should also be communicated as damage assessments are completed. In Sandy, flooded switching stations required cleaning every single circuit by hand, involving hundreds of personnel over several days before power could be restored.
5. **Joint regional exercises** offer one of the best options to identify needed improvement outside of direct experience with a disaster. See Oil and Natural Gas Resilience Implication #1.
6. **A nationwide inventory of equipment along with regional or national shared equipment programs for spare parts can help speed repairs after infrastructure damage and** share the high cost of resilience for large but critical components. A shared inventory can expedite the process of matching facilities with the right size and hookup for generators and identify gaps. For standardized components, including large transformers, shared inventory banks can reduce time spent to source and deliver parts, increase utility resilience across the region, and reduce

the risks associated with transformer replacement (including high cost, long lead time, and no U.S. manufacturing capabilities). EEI's Spare Transformer Equipment Program (STEP) can potentially be expanded or used as a model. Public and private stakeholders can also work together to standardize other components to encourage shared spares.

7. **Updated flood maps and weather prediction data, accompanied by widely accepted best practices,** will enable owners and operators to anticipate future risks and build or harden infrastructure to a best practice commensurate with risk.

Opportunities for Improvement

The following considerations are near-term opportunities to improve resilience in the electricity sector before the next disaster or large event.

- Formalization of the process for senior executive public and private engagement for resilience, including pre-event planning and post-event response.
- Removal of barriers to investment and creation of incentives for infrastructure resilience upgrades, such as equipment hardening and smart grid capabilities, in all lifeline sectors.
- A comprehensive effort at the Federal and state levels to review, refine, and streamline the process for issuing permits and waivers to the sector for multi-state fleet movement.
- Development of national guidelines and credentialing for re-entry of all crews for each of the lifeline sectors' emergency responders and utility personnel to critical sites within impacted zones.
- Provision for security to each of the identified lifeline sector repair crews during response to reduce theft and improve public safety, and examine options to provide housing facilities (on military bases or other government facilities) when other lodging options are scarce.
- Development or extension of nationwide spare parts inventories for the electricity sector and other lifeline sectors, including transportation.

Transportation

Superstorm Sandy triggered the largest mass transit disruption in U.S. history, impacting aviation, trucking, rail, auto, and public transit networks. Unprecedented flooding in subways and the tunnels between New York and New Jersey shut down access to Manhattan and created massive traffic gridlock. Power losses prevented railway signals, switches, and trains from running, and subway pump systems from functioning. The region experienced 2,000 miles of damaged or destroyed roads, 1,000 lost trucking rigs, 700 damaged cargo containers at its ports, multi-day shutdowns at major airports from flooding, and miles of damaged or completely washed away rail track. New York State alone suffered $7.3 billion in transportation-related damages.

While the largest transportation damages and disruption occurred in New York and Northern New Jersey, transportation was affected across the Eastern seaboard. Significant damage to Amtrak trains and flooding of the airfields of some of the busiest airports in the country shut down service, disrupting shipping and travel across regions. Four out of ten of the nation's transit riders had their commutes disrupted by the storm. Southeastern Pennsylvania Transportation Authority (SEPTA) service in Philadelphia was suspended for nearly two days during the storm and Regional Rail lines sustained damage and downed trees. All highways in and around Philadelphia were closed during the storm, along with the Philadelphia International Airport.

Exhibit 28. Transportation Sector Highlights

- Flooding damaged electrical and communications components and exposed new critical failure points. Most pumps lacked sufficient capacity to pump out water on backup power.
- Critical replacement parts for aging equipment were difficult to acquire, requiring Federal coordination to track down limited spares from other transit systems.
- Repair crews found that permit, toll, or weigh station delays, however minimal, can significantly delay response efforts. Repair crews relied on driver hours of service waivers and load permits for inter-state movement, which sometimes required a complex and lengthy request process.
- Many commuters relied on alternative forms of transportation, such as a large bicycle infrastructure, and rapid short-term recovery options, such as immediate ferry service. A massive bus bridge replicated disrupted train service between Manhattan and Brooklyn.
- Social media and digital communication were extensively used to communicate service changes with the public.

Highlights of Planning, Response, and Recovery

Although the transit systems of New York and New Jersey suffered significant damage, innovative response plans and actions alleviated disruptions.

Using lessons learned from previous storms, advance planning and coordination activities limited destruction and improved response coordination.

- New York City's Metropolitan Transportation Authority (MTA), the Port Authority Trans-Hudson (PATH) system, and SEPTA took proactive steps such as suspending service to avoid wind damage and protect customers, moving buses and rail cars to higher ground, and covering subway entrances and ventilation grates.

- Airport, airline, and Federal Aviation Administration (FAA) air traffic management personnel, the Transportation Security Administration (TSA), and Customs and Border Protection representatives held conference calls to plan for evolving weather conditions.

Exhibit 29. New York City's Regional Transportation Network

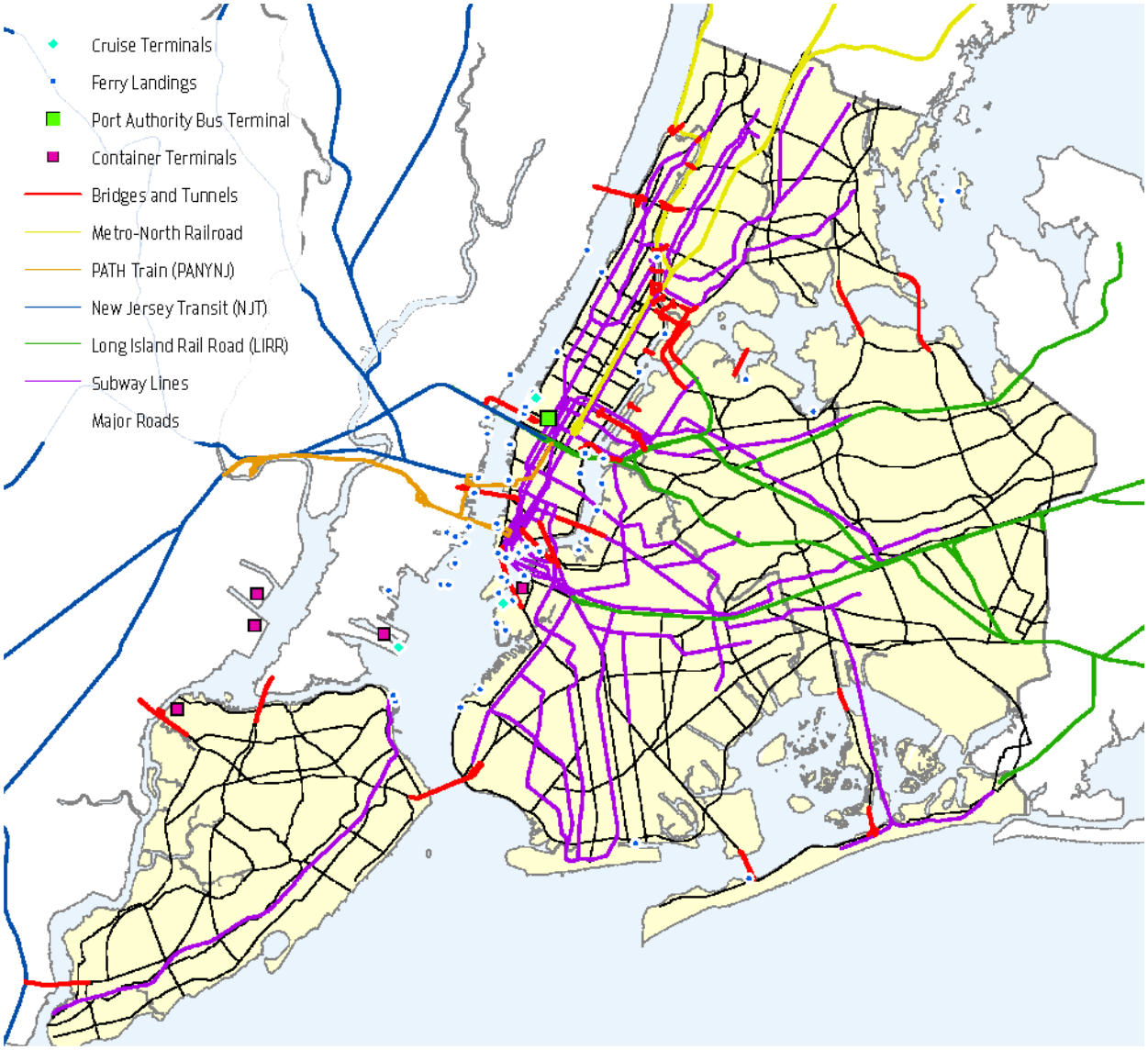


Diagram courtesy of the City of New York.

Massive bus bridges alleviated the impact of subway shutdowns.
New York's subways typically transport 5.3 million people daily. The New York Department of Transportation (NYDOT) and the MTA worked together to innovate a bus rapid transit system or "bus bridges" to replicate disrupted train service between Manhattan and Brooklyn. New temporary regulations restricted the Manhattan and Williamsburg Bridges for bus use only, regulated by the New York Police Department (NYPD). The city used 330 existing buses to transport 3,700 people per hour with three buses loading simultaneously.

Resourceful, multi-modal commuting and rapid recovery options provided needed flexibility.

- The city established emergency ferry service, including the rapid construction of new ferry landings, which are still in use for hard-hit areas, such as between Manhattan and both the Rockaways and Staten Island. Ferry usage also doubled following the storm on the East River Ferry, a recent expansion in the city's multimodal transportation network.
- A recent expansion in the city's bicycle infrastructure provided a new contingency option for commuters in Brooklyn and Queens, resulting in 30,000 bike commuters on Nov. 1—triple the typical number. The ability to get back to work quickly reduced regional economic impacts.
- Stewart International Airport, located about 70 miles from New York City (NYC), served as a logistics hub to bring in supplies for the region when LaGuardia and JFK airports were closed from flooding, even though the effort was not planned.

Transportation assets were used as warming stations and to support public safety.

Buses were used as warming stations at six locations in New York City to accommodate residents without heat, and were also used to transport residents to local shelters at night.

Social media and digital communication were extensively used to communicate with the public.

- The MTA adjusted service maps online and communicated all updates to bus, subway, commuter rail, and bridge and tunnel service via a multi-channel information push; it also posted pictures and videos of the damage to help the public comprehend the severity.
- New Jersey Transit offered free park-and-rides, shuttle buses, and ferries into Manhattan to mitigate congestion on open bridges and tunnels, and alerted customers via its website and updates on Twitter, Facebook, and the "My Transit" e-mail alert system.
- Commuters connected with other drivers and passengers through neighborhood networks, picked up strangers, and shared taxi rides using social media to help meet HOV-3 restrictions.

Transit agencies prioritized restoration of service and coordination to support other critical sectors.

Transit agencies followed restoration prioritization protocols designed to restore service first to major transit arteries and densely populated areas.

- Throughout the storm, both New York and Philadelphia ran underground trains (where possible) to transport healthcare employees and lifeline sector responders while enabling transit system assessments.
- After any storm, Philadelphia's public transit agency prioritizes restoration to the heart of the system, so that main east-west and north-south arteries can restore service immediately.
- Transit agencies give contracts for brush cutting and other cleanup to the same contractors both during disasters and normal operations, encouraging those contractors to turn down offers from private companies who may pay 2–3 times more than the city during storm recovery.
- To identify and prioritize roadway clearing, transportation agencies worked directly with county 9-1-1 operators, who coordinated dispatch of security and debris clearing crews.
- JFK airport had a fuel supply that was used to support first responders in the New York and New Jersey area.

Response, Recovery, and Interdependency Challenges

The transportation sector depended heavily on the electricity and petroleum subsectors to resume service. Switching stations and control centers required the restoration of electric power, while repair crew vehicles, buses, and aviation service vehicles all needed reliable fuel sources.

Electricity outages disabled railway signals and switches and eliminated floodwater pumping systems.

- The New York City subway system has its own pump system for normal drainage, but pumps do not have dedicated backup generators. Spare generators brought in could not provide sufficient power to prevent total flooding in some locations.
- Flooding closed airports in the region for days. There was more than 15 million gallons of water on the LaGuardia airfield, and five pump houses had no electricity or backup generation. Clearing flooded airfields became a large challenge.

Extensive flooding damaged critical equipment and exposed new failure points.

Unprecedented levels of flooding, exceeding historical predictions and flood barriers, sent brackish water from the Hudson River and salt water from the ocean surging into major vehicle tunnels and subway tunnels and stations throughout the area.

- Subway tunnels and depots for both subway cars and buses in New York City lacked sufficient protections against flooding and capacity to pump out water, which damaged electrical and communications components and aging systems.
- The storm surge exposed new critical failure points, such as stairwell entrances to subway tunnels and street-level gratings, which were overwhelmed by flooding.
- Once flooded tunnels were pumped, personnel had to manually clean, inspect, and repair electrical and electronic components, including signal systems, the electrified third rail, communications, pumps and vent systems, and fare gates.
- Salt water deposits corroded equipment that then could not be cleaned on site due to the potential for short circuiting or fire from the conductivity of the salt. The equipment had to be taken elsewhere or replaced entirely, a process slowed by a lack of power and fuel.

Critical replacement parts for aging equipment were difficult to acquire.

- New York's 108-year-old subway system has unique and outdated parts that require extensive time and high costs to replace, leading to longer than anticipated shutdowns.
- During repairs, MTA used more than 80% of its equipment inventory, nearly exhausting replacement supplies, while PATH had to seek replacement parts from partners including the U.S. Department of Transportation (DOT) and the Federal Transit Administration (FTA), as well as companies from as far as Louisville, KY; Pearl, MS; and Pittsburgh, PA.
- At the request of PATH, GE opened a plant in Puerto Rico specifically to manufacture replacement parts that haven't been available for years.
- Custom-designed parts on NJ Transit trains made damage difficult to repair.

Delays in fleet movements slowed response and recovery of the lifeline sectors, especially electricity.

Sectors that used mutual aid assistance from repair crews outside the affected area relied on emergency waivers of driver-hour limits and minimum rest periods, and rapid load permitting for inter-state movement to speed response and recovery.

- Repair crews found that permit, toll, or weigh station delays, however minimal, significantly delayed response efforts. For example, depending on the time of day, a two-hour delay in fleet movement can effectively delay that crew from beginning restoration work for 24–48 hours, depending on whether they can reach their subsequent destinations before hourly fatigue limits are reached.
- Crews must obtain load permits, which vary from state to state, for inter-state fleet movement. While emergency declarations may automatically lift some restrictions, state governors rarely declare states of emergency several days before an event, when mutual aid crews are first dispatched. When passing through a state, some fleets had to stop at multiple weigh stations,

even when their load had not changed. Requirements also differ for crossing a state vs. entering the state as an endpoint.

- Digital transponders to pay electronic tolls were needed in advance for every fleet vehicle. One utility fleet had to go through a cash-only toll en route to New York City, creating a delay to procure small bills and correct change for a fleet of drivers. A more efficient method of charging tolls would reduce fleet delays.
- Obtaining permits and toll transponders prior to response requires advance warning. Coordination in advance of Sandy helped smooth transit, but this prior warning would not be available for no-notice disasters.

Unexpected levels of flooding shut down airports and negated pre-emptive relocation of equipment to higher ground.

- Rail systems, which store rolling stock on high ground to avoid flood damage, saw some of these designated areas flood as well. In New Jersey, rail equipment was placed in more than 20 locations around the state based on information NJ Transit received about the likelihood of flooding and historical experience. Relocation decisions had to be made 12 hours prior to the storm and it was too late to execute a full system shutdown once flooding worsened.
- Personal automobiles in low-lying city streets were destroyed by flooding and could not be quickly moved.

Fuel shortages made the repair and refueling of transportation vehicles difficult.

- DHS informed aviation officials that nearby military bases had an ample supply fuel for airport ground vehicles, used to move employees onto planes and to service and fuel planes, but red tape prevented the public sector from providing fuel to the private sector, and the lack of fuel slowed airport service.
- Without adequate fuel, repair vehicles could not reach buses and rail system assets in need of repair, further delaying transit service restoration.

Lack of real-time or accurate information about road conditions led repair crews to avoid open roads.

- The 511 system that many states use to track road conditions and closures on Federal and state highways was rarely accurate or timely enough to be fully reliable.

Transportation Sector Lessons Learned

1. **Lessons learned from Hurricane Irene the prior year were effectively applied** during Superstorm Sandy. Rail cars and automobiles were moved to higher ground, and operators preemptively shut down electronic equipment to avoid damage. Relationships built during Irene were successfully used again during Superstorm Sandy.
2. **Aging portions of mass transit systems rely upon critical parts and equipment** that are no longer manufactured, and for which spare parts are not widely available. A scramble to locate spare parts within other agencies delayed repairs, and this problem will only become greater as remaining spare parts are depleted.
3. **Existing FEMA flood maps** and National Oceanic and Atmospheric Administration (NOAA) SLOSH (Sea, Lake, and Overland Surges from Hurricanes) maps for transportation and other critical infrastructure, and the associated failure predictions, **may no longer be accurate.** Rising sea levels, larger and more frequent storms, and altered drainage patterns due to new construction mean that flood walls may no longer be high enough, and new potential failure points may emerge.

4. **Employee coordination and communication can be hampered by transportation and communication outages.** One system paid employees round the clock to be housed on the property during and after the storm to facilitate immediate recovery. While costly, personnel protocols put in place prior to a storm ensure the availability of personnel resources.
5. The FTA's Emergency Relief Program's 24-month **deadline for spending recovery resources is too short for many transit systems to plan coordinated resilience investments** to occur alongside infrastructure repairs and hardening funded by the Relief Program. There is a missed opportunity to build resilience into infrastructure components that both did and did not break.

Implications for Resilience

1. **Streamlining waivers, permits, and toll payment** is needed to speed response and recovery following a disaster. Superstorm Sandy drew utility repair crews from states far outside the region, requiring extensive coordination across multiple states to enable smooth fleet movement. Superstorm Sandy revealed potentially innovative solutions that can be improved for future disasters. The All-Hazards Consortium is working this issue regionally and may offer best practices that can be replicated across the country.
    - **Tolls:** Nationwide or regionally consistent toll booth procedures may remove roadblocks and simplify payment processes. Electronic toll systems are moving toward universal transponders within regions. Easier options to move fleets through tolls may exist. The East Coast's EZ-Pass system has the ability to assign numerous license plates to one account, and uses photos of the license plates as a backup system to charge an account when a transponder is missing or broken. If coordinated, this process could be the primary process for charging fleet tolls for emergency fleets, avoiding the need for transponders altogether.
    - **Automated permitting:** Improved private sector access to automated permitting systems can speed fleet permits. The Pennsylvania Department of Transportation's (PennDOT) Automated Permit Routing/Analysis System (APRAS) and a similar system in New Jersey automate permit issuing to reduce processing time. New Jersey is exploring how to issue advance yearly permits for utilities that have standard equipment and loads.
    - **Centralized database for mobilization information:** Utility fleets would benefit from a centralized database that includes state/local permitting requirements, toll road and payment protocol information, and updates on where emergency declarations have been issued and which waivers are put in place as a result. Template procedures for issuing permits and waivers can also be shared in this database.
2. **Near-term and long-term investments in resilient infrastructure can better prepare for all hazards**. Transit agencies have identified system improvements, including the following:
    - Relocate key data centers outside of flood zones and build redundant or backup control centers to transfer operations if one is damaged.
    - Design reusable watertight coverings for vents and electronic equipment in the short term, and even rebuild with submersible components in the long term.
    - Engage with surrounding counties to responsibly plan drainage from new developments, such as shopping malls and parking lots, to decrease drainage around critical infrastructure.
3. N**ew modeling tools—with updated climate change and flood predictions—can help regions revise system-wide risk assessments and identify new and future failure points**. For example,

New York is re-examining the subway system using NOAA SLOSH maps to build more accurate flooding and failure predictions that consider changing street elevation and potential surge heights. This study is revealing new critical failure points, such as stairwells and entrances that caused the majority of subway tunnel flooding, where agencies can prioritize future hardening.

4. **A nationwide spare parts inventory** can help speed repairs after infrastructure damage to transportation systems. See the Electricity Sector Resilience Implication #7.
5. **FTA's Emergency Relief Program funding could be re-structured in a way that promotes well-planned resilience improvements.** Recipients are required to spend out relief funds within 24 months of receipt, making it difficult to design a coordinated plan to rebuild smarter and harden equipment, not simply repair it. It could also better enable system-wide equipment hardening, not just hardening of parts that sustained damage.

Opportunities for Improvement

- NOAA and other Federal agencies can provide updated weather data, SLOSH maps, climate change data, and guidance on performing engineering studies to help systems identify critical failure points and revise system standards and hardening for extreme weather events, storm surge, sea level rise, and seismic events. The Federal government can use results of its current climate adaptation study on seven transit agencies across the U.S. (including SEPTA) to determine the type of data transit agencies need to improve adaptability.
- The Federal Transit Administration could leverage its role in coordinating and facilitating mutual aid between transit systems to create a nationwide shared inventory of replacement components for aging systems.
- Emergency Relief Program requirements can be revised to promote not only repair, but system-wide hardening and replacement with more resilient equipment.

Communications

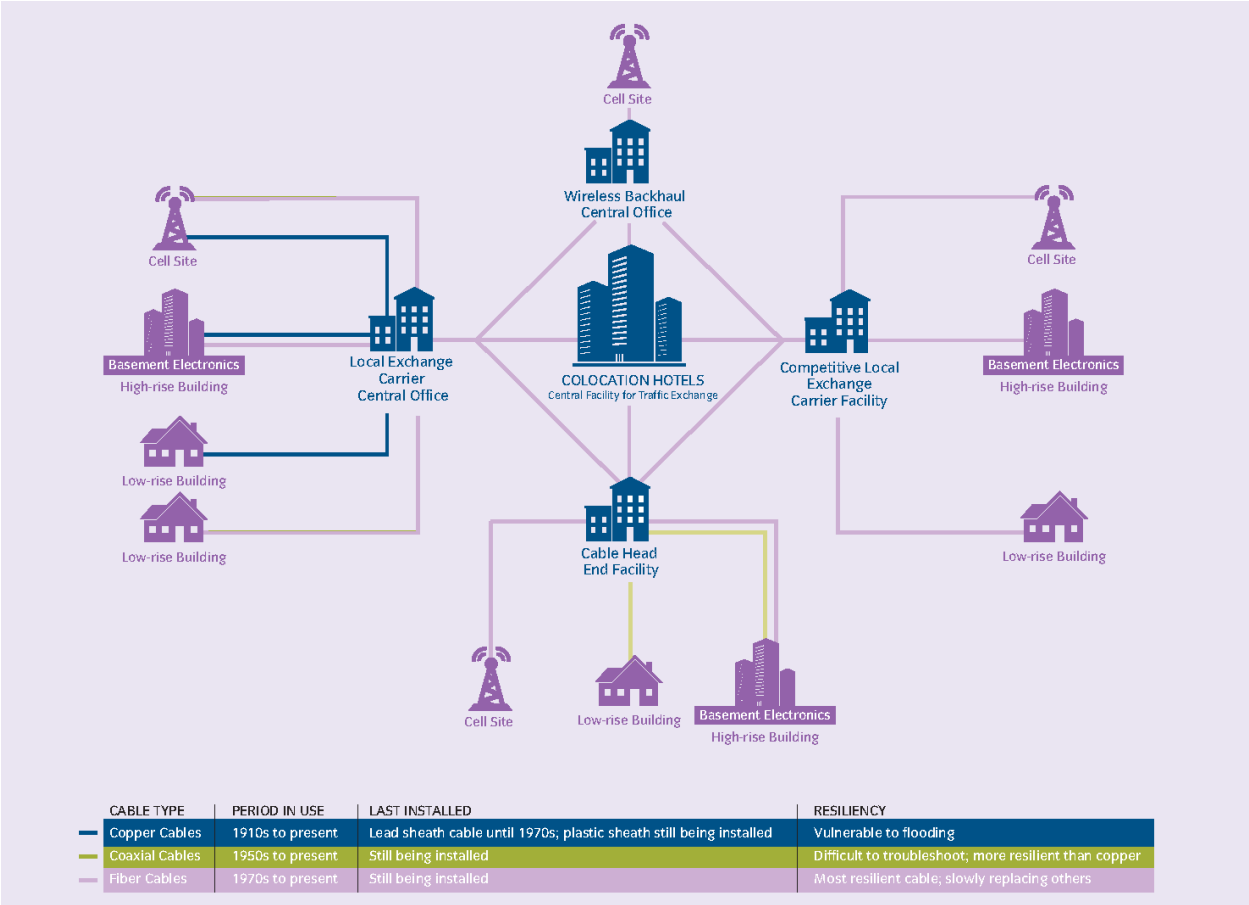
The communications sector comprises all cable, satellite, telephone (including 911 emergency lines), and internet services that government, emergency personnel, private businesses, and the general public rely on to communicate and obtain real-time information on a daily basis. During Superstorm Sandy, service disruptions were reported in 158 counties and 10 states stretching from Maine to Virginia, including Pennsylvania and the city of Philadelphia. At one point, approximately 25 percent of cell sites across these affected areas were out of commission and some 911 emergency call centers were disabled. All major cell service providers, including AT&T, Verizon, Sprint, and T-Mobile, reported significant disruptions and major broadband internet and cable operators, including Cablevision, Comcast, Cox, and Time Warner, also reported varying levels of disruption.

In harder-hit areas like New York and New Jersey, the damage to the communications sector was even more substantial. Verizon's Vice President of National Operations Chris Levendos called it "the largest impact to our wireline infrastructure in our 100-year history" (NOVA 2013). At the peak of disruption in New York City, Long Island, and Westchester, more than half a million wired telephone lines were out of service and between 15 and 60 percent of wireless service networks were inoperable, with nearly 3,500 cell sites knocked offline. While many of these service outages were linked to commercial power outages, other issues arose from fallen trees knocking out overhead wiring; flood damage to central switching offices, customer equipment rooms, and backup generators at data centers; limited to no backup power due to damage and refueling issues; and corrosion of copper cables—even those underground—from exposure to saltwater. A Barclays' analyst estimated cleanup and repair costs for communications companies to be around $600 million in the hardest hit areas alone.

Exhibit 30. Communications Sector Highlights

- Not all cell tower sites had backup generators during Superstorm Sandy. One company reported there are generators on about half of their towers, and that those with generators have an average of 1.3 generators per site with limited sharing between providers.
- Where generators were present, fuel shortages impacted the ability to provide backup power for long periods of time to cell towers, antennas, and other radios.
- Mobile cell platforms and satellite communications vehicles successfully replicated basic service in hard-hit areas, enabling communities to support their own restoration. Network providers worked well with state governments to provide cell on wheels (COWs) and cell on light trucks (COLTs).
- Satellite communications kept incident response communications open and enabled hard-hit areas to restore basic communications more quickly. One company worked with FEMA months prior to Superstorm Sandy to prepare for such an event, and had 100 satellite terminals and Wi-Fi stations pre-staged with a first right of refusal for FEMA.
- Restoring wireless service was greatly enhanced by co-location of government and communications providers to coordinate on power, fuel sources, and debris cleaning.
- Strong relationships with state and local government officials reduced access control issues for telecommunications first responders.

Exhibit 31. Components of the Communications System



CABLE TYPE	PERIOD IN USE	LAST INSTALLED	RESILIENCY
Copper Cables	1910s to present	Lead sheath cable until 1970s; plastic sheath still being installed	Vulnerable to flooding
Coaxial Cables	1950s to present	Still being installed	Difficult to troubleshoot; more resilient than copper
Fiber Cables	1970s to present	Still being installed	Most resilient cable; slowly replacing others

Diagram courtesy of the City of New York.

Highlights of Planning, Response, and Recovery

Despite the damage and service outages that the communications sector experienced during Superstorm Sandy, few areas reported complete outages or fully overwhelmed networks. This success is due in large part to the sector's planning, coordination, and on-the-ground response.

Staging fuel and repair equipment in advance facilitated faster restoration times.
Companies pre-staged repair trucks, extra poles, and fuel pods throughout the storm's projected path, and set up refueling stations throughout and around New York City immediately after the storm. Providers used satellite phones and obtained wireless priority service (WPS) and government emergency telecommunications service (GETS) credentials in advance.

Satellite communications experienced limited or no disruptions, maintaining critical services for incident responders and enabling harder-hit areas to restore basic communications more quickly.

- Lifeline sectors and emergency responders relied on multiple backup communication methods, including satellite phones and point-to-point radios, which greatly reduced the impact of traditional communications failures in the immediate aftermath of Sandy.

- Satellite company Hughes Network Systems started working with FEMA months prior to Superstorm Sandy to prepare for such an event. As a result, they had 100 satellite terminals and Wi-Fi stations that they pre-staged with a first right of refusal for FEMA.
- Hughes provided satellite systems to the Rockaways, which had little or no communications, and worked with Global VSAT Forum and Cisco to establish a satellite communications capability for a Habitat for Humanity command center in Breezy Point.
- The Red Cross relied on satellite communications in the immediate aftermath when cell service was unavailable and spotty.

Mobile cell platforms and satellite communications vehicles provided much-needed service to the hardest-hit areas.

- The New York State Department of Homeland Security worked with wireless providers to deploy cell on wheels (COWs) and cell on light trucks (COLTs), satellite communication vehicles, and charging stations and position them near central distribution sites and community centers.
- FEMA helped New York State troopers locate and acquire a Mobile Communications Office Vehicle (MCOV) that was able to support cellular, audio, and video communications through a satellite, with its own independent power source, to enable communications from Long Island.

Exhibit 32. FEMA's Innovation Team in Red Hook, NY

Superstorm Sandy saw the debut of FEMA's Innovation Team, a multi-sector, cross-functional group of creative problem solvers made up of government, industry, non-profit organizations, and community volunteers. The Innovation Team is designed to look at response problems from a broad perspective, rather than by agency or sector, and use its agility to quickly solve large, localized problems on the ground.

The Innovation Team reached out to networks and volunteers to restore critical needs in hard hit areas like Red Hook, NY, where one of 40 FEMA Disaster Recovery Centers had been established in the state. Using its members' personal and professional networks, the team linked up with IT volunteer organizations and skilled community volunteers to establish a mesh Wi-Fi network in a popular neighborhood courtyard and establish a satellite communications link. These connections not only enabled the community to contact family and apply for disaster assistance, but restored the community's ability to support its own response and recovery. FEMA Community Relations members and FEMA Corps volunteers went door-to-door with wireless-enabled tablets to help residents sign up for disaster assistance, educate them on available resources, and assess neighborhood needs. The Innovation Team enabled FEMA to tap into resources and expertise outside the agency and support a whole community approach to response.

Government-owned emergency alert networks maintained functionality and provided multiple avenues to communicate with the public.

- The Federal Communications Commission developed systems to send wireless emergency alerts to people in affected areas, facilitate "text-to- 911" on mobile phones, and improve location accuracy for mobile 911 so emergency personnel could quickly locate people in need.
- New York City operates its own CityNet, a network of city-owned fiber, its own wireless network, "NYCWIN," and its own 800MHz and other radio networks, which it used to issue emergency alert text messages before, during, and after Superstorm Sandy.
- Where cellular services were unavailable, point-to-point radios kept emergency responders in contact.

Internet Protocol (IP)-based and next-generation technologies, where used, increased the reliability of 911 services.

- Pike County, PA's new 911 system experienced no outages, even though it was out of primary power for almost a week. The new system employs a failsafe that links two facilities with fiber, enabling one center to take over for the other or handle overflow in mass call events.
- The City of Long Beach completely lost the ability to receive 911 calls locally, but was able to route 911 calls to Nassau County and through the Nassau County mobile command bus back to Long Beach. While fiber was more reliable, the extent of outages in some cities overwhelmed redundancies and re-routing capabilities.

Wireless service restoration was enhanced by information sharing between government and communications providers on power, availability, fuel sources, and debris cleaning.

- Communication providers held multiple daily calls with or a seat in New York State's emergency operations center and used real-time outage reporting protocols. Providers had a seat at the regional operations center in Hamilton, NJ to address two-way needs. Government officials provided front-end loaders to clear debris for network providers, who in turn provided mobile cell units to state governments.
- FEMA provided access to vehicles, used on Long Island, to gauge the coverage and strength of signals and provide outage reports to providers and state responders.
- The DHS National Coordinating Center for Telecommunications (NCC) and Information Sharing and Analysis Centers (ISACs) facilitated coordination as practiced during joint exercises at the Federal, state, and regional levels.
- Verizon trained field forces and developed protocols to communicate with municipal officials, which greatly improved coordination in New Jersey's more than 500 municipalities.

Strong relationships with state and local government officials reduced access control issues for communications first responders.

- Thanks to prior relationship-building efforts with the NCC, FEMA, and the state and local governments, providers worked with local officials prior to the storm to pre-determine access protocols to damaged areas.

Coordinated repairs of co-located assets between electric utilities and communications companies sped up restoration of both services.

- Safety concerns typically require that electric utilities remove live wires and complete repairs before communications providers repair lines on shared poles or assets. Because of the sheer magnitude of damage, this process slowed restoration times for companies such as Time Warner Cable, which worked with utilities to develop mapping software that showed where power had been turned off, clearing the way for Time Warner to begin repairs. When Time Warner reached an area first, they put the electric poles back, and vice versa, using a collective agreement.

Systems upgraded to fiber sustained less damage.

Verizon customers on fiber optic cable in lower Manhattan had their services restored immediately after the switches came back up. Verizon owns most of the fiber backhauls in the city, which also stayed up.

Response, Recovery, and Interdependency Challenges

The increasing dependence on communications by not only the general public but other critical sectors made the loss of communications a large barrier to response and recovery. Just as the communications sector relies on electricity for individual devices, antenna towers, central offices, switches, and other sophisticated equipment, the electricity sector relies on wireless communications to operate control systems and new smart grid technologies. To produce backup electricity for its essential services and efficiently repair damaged lines, communications providers also rely on the fuel and transportation sectors to reach generators at cell towers and enable repair crews to access hard-hit areas, just as these sectors rely on mobile devices to coordinate these efforts.

The loss of commercial power and subsequent lack of backup power caused service outages.

- A company that leases towers to cell service providers said that there are generators on about half of their towers, and that those with generators have an average of 1.3 generators per site with limited sharing between providers.
- Generators for cell towers are not required by law, are costly, and face some restrictions from zoning laws, clean air and water regulations, noise restrictions, hazardous material storage regulations, and Occupational Safety and Health Administration (OSHA) requirements.
- Where generators were present, fuel shortages limited the ability to provide extended backup power to cell towers, antennas, and other radios.
- Companies had to rely on their own fuel supplies and fuel networks, pulling on their national contracts to get fuel from outside the region. They experienced licensing issues, challenges to find fuel providers who could move fuel into cities, and required waivers for fuel trucks to cross state lines.
- Storm debris and flooding complicated access to generators in the field, some of which were destroyed by the storm. In some cases, local zoning laws restricted carriers from bringing in supplemental emergency generators.
- Repair crews were sometimes denied access to cell sites, which combined with fuel issues delayed expected times for restoration.

Damage to copper backhaul, overhead lines, and central offices delayed service restoration.

- The copper backhaul on which all cell towers depend was devastated by corrosion from saltwater, particularly in lower Manhattan. Following the storm, Verizon removed 150 tons of old copper cable from lower Manhattan and replaced it with 6,500 miles of fiber.
- Outside of New York City, downed trees took out overhead communications lines.
- Verizon experienced flooding of its central offices in lower Manhattan, damaging and corroding lines, switches, and servers located in subterranean rooms and lower floors. Time Warner Cable also had some impact on their hub sites that distribute services.

Communication gaps between key players made agile response difficult.

- Providers share poles and conduits with power companies, making non-coordinated responses slower and less efficient.
- Without strong relationships or prior points of contact at local carriers, the city of Long Beach struggled to individually contact carriers through 800-numbers and wasted time speaking with unknowledgeable customer support personnel, eventually flagging down a tech off the street, in a week-long attempt to secure cell on wheels. Though Verizon had an account manager assigned to Long Beach, communication breakdowns and impassable streets delayed the delivery of two COWs, which arrived within five days.

Communications Sector Lessons Learned

1. **Backup generation and fuel supplies for critical assets, especially cell towers, were insufficient to maintain reliable communications service**, a key element of coordinated response and recovery. Generators, where they existed and were operational, typically had only eight hours of fuel available. Refueling was difficult due to closed roads and fuel shortages, and some assets were not fully prepared to maintain service through extended power outages.
2. **State and local zoning restrictions, noise codes, and restrictions for hazardous materials storage discourage or sometimes prevent utilities from obtaining backup generators.** Though shared agreements with local governments have successfully created exceptions to local zoning laws for emergency generation, there is no requirement for backup generation for communications assets, and it is up to providers to seek the right permits or challenge zoning laws. Companies rarely share generators at this time.
3. **Efforts to source backup fuel from outside the region were slowed by Federal and state restrictions that prevented suppliers and distributors from crossing state lines.** Pre-issued waivers, permits, contracts or mutual aid agreements with the state could have sped this process.
4. **Mobile cell platforms and satellite communications units enabled communities to mobilize for response and recovery even when commercial power and communications services were unavailable.** Communications services are a force multiplier that enable community groups to leverage social networks to share information and support recovery. While in some cases it was difficult for mobile units to physically reach harder hit areas, pre-staging was effective. To pre-stage, states had to first request FEMA satellite resources under emergency declarations. Removing this barrier could help expedite the ability to mobilize units.
5. **Prior investment in fiber cable and undergrounding for resilience paid off.** On the same streets in lower Manhattan, tons of copper cable was corroded by saltwater, while fiber lit back up once switches came back online. Even above ground, fiber did not break as often as copper.
    - **Many providers are moving customer equipment, such as servers, switches, routers, and hubs, out of basements and into higher levels above the flood line.** Many providers who also experienced flooding in their central offices are also adjusting their layouts accordingly.
6. **Coordination between the electricity and communications sector facilitated a faster, more efficient response.** When cable companies and power providers coordinated on repairs, they were able to canvass larger areas more quickly by repairing shared poles. Communicating real-time information about outages to one another via government agencies worked well, but in some cases, gaps existed. Direct relationship building and coordination is needed.
7. **Strong relationships between service providers and state and local government improved coordination ahead of and during the event and reduced access issues.** Many companies assign individuals to coordinate with state government and public utilities commissions, and designate account managers to coordinate with cities. Representatives embedded in state and local Emergency Operations Centers (EOCs) can further improve situational awareness and coordinated restoration.

Implications for Resilience

1. **Providing sufficient backup generation, fuel services, and other capabilities to maintain at least a minimum level of voice and texting capabilities during emergencies is imperative**. Following disasters, wireless voice service and messaging is a primary method of communication

for the general public, emergency response agencies, and disaster relief organizations. Service providers and their state and local partners need to recognize the importance of communications to life safety and recovery and remove barriers to investment in redundant and backup capabilities.

- State and local emergency operations centers and 911 call centers should prioritize investment in backup and redundant connections with their local service providers.

2. **State governments and FEMA can work together ahead of events to resolve fuel transportation issues from regions outside the disaster area.** See Oil and Natural Gas Lesson Learned #1.
3. **Investment in redundant and hardened infrastructure can improve maintenance of critical functions in all hazards**.
    - Path diversity is critical. Satellite is fast, but expensive and not a cure-all. A mix of wire line, radio, cell, and satellite for critical sites provides redundancies for multiple hazards.
    - The use of fiber and undergrounding, while expensive, paid off and prevented much wider service loss and expensive damage.
    - Backup power is imperative, and enables the sector to be relatively self-reliant despite extended power loss. Providers are considering:
        i. Increasing state and local government coordination to remove barriers to adding backup generators
        ii. Investing in fuel cell generators that offer more reliable, long-term power
        iii. Developing technologies that use less power
        iv. Sharing backup power sources with other service providers
        v. Connecting to natural gas lines for supplemental power generation
    - Mobile cell platforms and satellite units are essential to life safety and recovery in areas with extended outages of critical services. Pre-staging can be improved.
4. **Cooperation, and potentially co-location, among service providers can provide network and data center redundancies.** Private companies rarely share resources, often because of collusion laws, but there is little mutual aid within a region as a result. Stakeholders can review existing regulations to identify opportunities to:
    - Share critical equipment, such as switching facilities, during an event where providers incur equipment damage.
    - Place multiple antennas on the same tower and co-locate some cell sites to provide redundancies among carriers.
    - Use a geographical information system to strategize resource co-location during planning, and enable real-time coordination of repairs.

Opportunities for Improvement

- FCC leadership can recommend or mandate best practices for backup generation or redundancies that enable a minimum level of voice and texting capabilities for the public during emergencies.
- The Federal government can recommend to state and local governments that waivers for local zoning laws be issued to communications providers for backup generation.
- FEMA can continue to serve as a coordinator and convener between communities, local governments, NGOs, and service providers, using its coordination in Red Hook, NY as a best practice.

Water

Excessive flooding from Superstorm Sandy devastated wastewater treatment plants in New York and New Jersey, sending more than 1 billion gallons of untreated or partially treated sewage into local waterways in the days following the storm. Of the 14 wastewater treatment plants operated by New York City, 10 had sewage releases, and 42 of 96 pumping stations that serve wastewater plants lost service due to damage or power outages.

In New Jersey, more than 200 million gallons of water from the tidal surge engulfed one of the largest wastewater treatment plants in the United States operated by the Passaic Valley Sewerage Commission. The 152-acre plant stood in four feet of water (with 15–30 feet of flooding in underground systems), sustained damage to critical machinery, and lost power for three days. Extensive dewatering of sewage sludge and critical repairs to bring the plant back to operation cost an estimated $200 million—about $50 million more than the commission's total annual operating budget.

Wastewater pumping stations at New Jersey's Middlesex County Utilities Authority were totally devastated, requiring a month of repairs before the system could handle all of the sewage sent to it. In Philadelphia, water utilities did not sustain damage, but had to quickly shut down valves and pipelines to preserve water pressure when electricity was lost at the Queen Lane Plant. Power was restored when the winds fell below 45 mph, just in time to avoid problems with the morning's peak water usage. Water utilities did a remarkable job maintaining potable water supply and distribution in the immediate aftermath; however, wastewater treatment utility damage presents an ongoing environmental hazard to affected regions. While immediate and short term water service losses are typically not critical, flooding of treatment plants from stormwater and tidal surges; power losses that result in pressure losses and the backflow of water in pipes that typically flow one direction; and sewage overflows due to flooding can all result in environmental damage in local waterways and lengthy treatment plant shutdowns that may delay recovery weeks after an event.

Exhibit 33. Water Sector Highlights

- Limited recognition of water and wastewater criticality resulted in service impacts that likely could have been mitigated and created "near miss" events. Utilities faced a lack of support for backup power and fuel requests from emergency managers who did not understand the cascading impacts of potential disruptions.
- Electricity restoration challenges were not well understood by water sector owners and operators. In some cases, electric utilities were unable to pinpoint outages affecting critical water assets without knowing which meter numbers and circuit numbers had lost power.
- Federal regulations restrict the use of very large, capital-intensive backup generators to emergency events, eliminating incentives for water sector owners and operators to invest in them.
- Despite credentialing efforts, water utility workers were often not considered emergency personnel, and faced difficulty in accessing critical facilities to assess and repair damage.
- Regional water utilities have strong relationships that facilitated coordination. Potable water utilities in northern New Jersey have interconnected pipelines and can provide service to another utility's customers—a feature unique to this region of the country.
- City planners and water and wastewaster owners and operators need detailed data on forecasted impacts of climate change—especially sea level rise—that could increase infrastructure risks during storm events.

Exhibit 34. The Water and Wastewater System in New York City

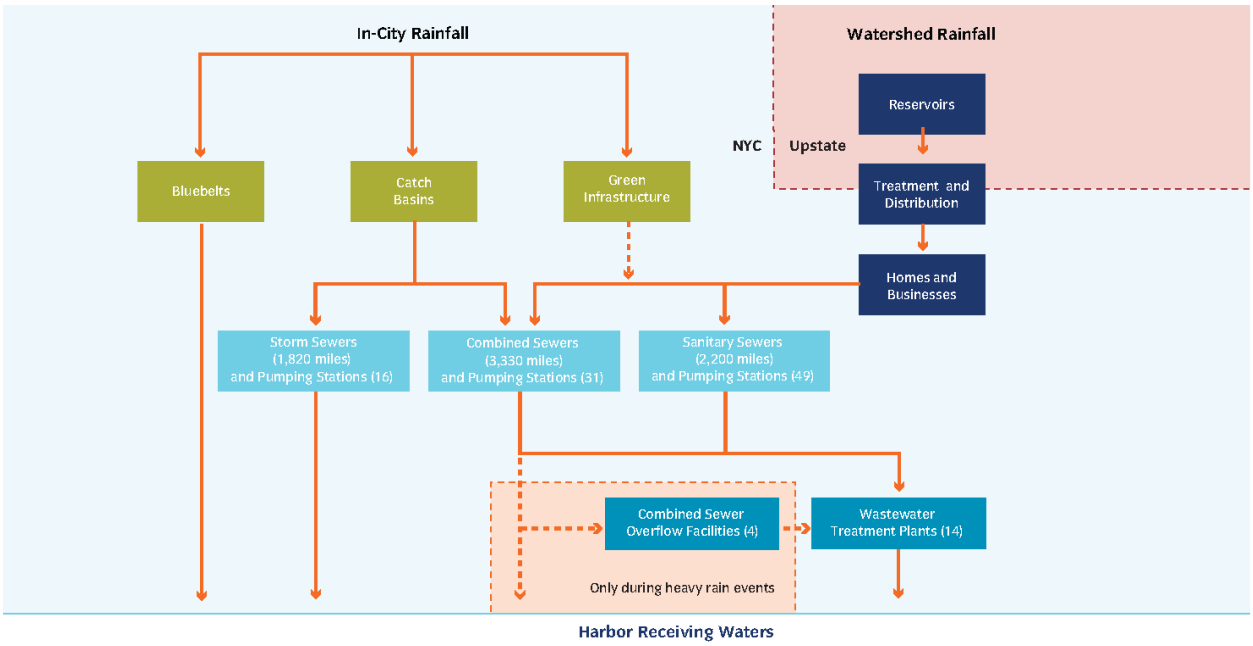


Diagram courtesy of the City of New York.

Highlights of Planning, Response, and Recovery

Multiple Water Agency Response Networks (WARNs) in nearby regions activated to provide mutual assistance to facilities in the impacted region.

When needs exceeded intrastate WARN capabilities in hard-hit states, facilities requested assistance from other state WARNs using the Emergency Management Assistance Compact (EMAC), which enables states to send personnel and resources during governor-declared states of emergency.

- Daily WARN situational awareness calls, hosted by the American Water Works Association, increased information sharing and resource requests among impacted water utilities from Florida to Maine, EMAC representatives, the U.S. Environmental Protection Agency, DHS, and the U.S. Army Corps of Engineers.
- When water and wastewater utility requests in New Jersey were not being quickly addressed, EMAC staff made direct requests to expedite deployment of generators from a Washington, D.C. water system.
- In the future, state and local emergency management officials and water utilities could benefit from a greater understanding of the EMAC capabilities to support water sector needs.

Regional water utilities have strong relationships that increased coordination during Superstorm Sandy.

Water utilities in Northern New Jersey have interconnected pipelines and can provide service to another utility's customers—a feature unique to this region of the country—which led to strong relationships and daily conference calls between regional owners and operators. Partners prepared to bring one plant, which was offline for maintenance, back online during the storm if needed.

- Because regional relationships and mutual assistance are already strong, the New Jersey WARN has not seen as much participation as other regions. Owners and operators automatically

addressed partner resource needs without a formal agreement. There is opportunity to formalize these relationships through WARN participation in the future.

Water utilities worked from emergency response checklists and plans that reinforced lessons from past events.
One utility has an ever-evolving checklist of critical personnel, roles and responsibilities, and key actions that provides the game plan personnel work from in an emergency. It is updated after each large event to enable continuous improvement.

Participation in joint regional planning and exercises prior to Superstorm Sandy increased coordination and resilience planning.
Regional water utilities in New Jersey participated in the DHS-sponsored New Jersey Exit 14 Regional Resilience Assessment Program (RRAP) the year prior to Superstorm Sandy, which provided regional hydraulic modeling and system assessments to identify vulnerabilities, interdependencies with other critical sectors, and economic and social impacts of outages in particular parts of the region. It enabled providers to identify resilience improvements that would specifically address regional risks.

Response, Recovery, and Interdependency Challenges

The water sector primarily depends on the electricity sector to run pumps that maintain pressure and prevent contamination, keep water flowing to customer taps, and process sewage to prevent wastewater from spilling untreated into waterways and flowing back through manholes and customer premises. During electricity outages, utilities need sufficient backup generation and fuel supplies to maintain pumping and treatment, preventing contamination that could cause plant shutdowns for days. There is little redundancy in water and wastewater infrastructure, much of which is more than a century old. Facilities also rely on clear roads for regular deliveries of hazardous treatment chemicals, of which they typically do not store large supplies. While bottled water can replace tap water in some cases, hospitals and other critical sites would require evacuation without steam for sterilization and water for chillers, heating, and other services.

Loss of electricity created the greatest challenge for water utilities during Superstorm Sandy, even for those equipped with backup generators, as fuel availability became an issue.
Request for generators and support to obtain fuel for backup generators was not consistently prioritized by emergency management agencies, creating significant risks for cascading consequences.
Electricity sector power restoration challenges were not well understood by water sector owners and operators.

- In Philadelphia, damage assessment and restoration was delayed by sustained high winds. The water department was unaware that electricity repair crews could not begin restoration in bucket trucks until winds dropped below 45 mph, and had to work quickly to close valves and maintain pressure throughout the system as the electricity outage proved longer than predicted.
- Electric utilities were sometimes unable to pinpoint and prioritize outages to critical water assets without knowing which meter numbers and circuit numbers had lost electricity. Water utilities scrambled to physically locate this information.

Limited recognition of water and wastewater criticality resulted in service impacts that likely could have been mitigated and created "near miss" events in which there was significant risk for critical service loss with widespread and lasting impacts.

There was limited recognition in some cases that water and wastewater utilities represent a critical lifeline sector.

- Emergency managers did not understand the cascading impacts of potential sector disruptions and de-prioritized water utility requests for backup generation and fuel support. In a Maryland county, despite utility requests for backup generation, electricity losses resulted in 25 million gallons of raw sewage being released into a local body of water.
- In Long Island, a regional hospital risked losing its water supply when one water utility generator failed and the second required maintenance. Utility requests for backup generation and fuel delivery were not considered an immediate need, despite the impending service loss and the hospital evacuation it would have required in an already hard-hit area.

Emergency support function (ESF) 3 responsibilities for the water sector are fragmented between multiple agencies in the National Response Framework.

Responsibility for water and wastewater response and recovery primarily falls under ESF-3, Public Works and Engineering, led by the U.S. Army Corps of Engineers, but with key responsibilities for the Environmental Protection Agency (EPA) and FEMA. Because no one agency manages all sector operations, water sector personnel found their needs and resource requests were sometimes triaged out of the highest priority actions during Superstorm Sandy.

Despite credentialing efforts, water utility workers were often not considered emergency personnel, and faced difficulty in accessing critical facilities to assess and repair damage.

One water utility crew had to hike through wooded trails to reach critical facilities and use back roads to bypass law enforcement barricades. Another crew recruited the National Guard to escort them through police checkpoints. Despite their tenacity, this delayed assessment and recovery.

Flooding of low-lying wastewater treatment plants caused significant damage and created treatment challenges.

During Superstorm Sandy, storm water flooded treatment plants and mixed with untreated sewage, overflowing into local waterways and low-lying streets and buildings. Wastewater treatment plants in New York and New Jersey sustained unprecedented flooding and resulting damage.

- Directed by President Obama and Gov. Christie, the U.S. Army Corps of Engineers assisted the Passaic Valley Sewerage Commission in dewatering the sewage sludge by bringing in 10 centrifuges, which each cost $30,000 per day to operate. With major damage to the plant's own sludge dewatering equipment along with other parts of their treatment process, the plant was still only partially operable two weeks after the storm.

State regulations and policies restricted assistance to privately owned water utilities.

While more than 90% of wastewater utilities in the United States are publicly owned, privately owned facilities provide identical, and equally critical, service to communities. During Superstorm Sandy, state emergency managers de-prioritized resource requests for fuel and backup generation from privately owned facilities, assuming that private utility could use their own funding and supplier relationships. This jeopardized the community served by private water utilities.

Water Sector Lessons Learned

1. **State and local government officials may lack understanding of the cascading economic and environmental impacts of operational disruptions in the water sector (especially from electricity losses) and may not appropriately prioritize water sector needs and risk mitigation activities as a result.** Past sector successes in maintaining critical water services and avoiding sewage releases means emergency managers typically do not have direct experience with large-scale loss of water and wastewater services. Because few past events have featured devastating impacts from water service loss, other critical sectors and emergency management agencies may accept risks without understanding the potential impacts. Bottled water cannot replace many services, and existing mobile bulk water units provide only 1 million gallons per day.
    - In addition, when immediate water sector needs are not met, the large service impacts may be delayed, further masking the impacts of inaction. For example, even brief losses of electricity or backup power can lead to system shutdowns that create sanitation issues and ultimately could shut the system down for a week.
2. **Federal regulations restrict the use of very large, capital-intensive backup generators to emergency events, eliminating incentives for water sector owners and operators to invest in them.** Large water and wastewater utilities require high capacity, costly generators to fully replace electricity needs. Utilities cannot recoup costs by using generators to offset peak power costs, as Federal Clean Air Act restricts large generator use to testing and emergency events. Because the next large emergency could be years or even decades away, the potential benefit is far displaced from the cost.
3. **City planners and water and wastewater owners and operators need detailed data on forecasted impacts of climate change that could increase infrastructure risks during storm events.** Over the next several decades, rising sea levels and other effects of climate change may increase the vulnerability of water and wastewater infrastructure during extreme storm events and change the landscape of U.S. waterways, where many treatment plants are closely located.
    - For example, a large wastewater treatment plant in Philadelphia operates under gravitational flows, with no effluent pump. As sea levels rise during storm surges, or over time through climate change, the treatment capacity of the plant drops and creates the potential for sewage backflow. Accurate forecasts can determine when and what infrastructure investments will be needed to keep this plant operating.

Implications for Resilience

1. **Federal and state recognition of the water sector as a lifeline sector can elevate the priority of water sector resource requests to emergency management personnel.** NIAC originally made a similar recommendation in 2009, and many utilities still face issues from lack of understanding of prioritization of water sector needs. Doing so can support improved coordination between potable water agencies, water and wastewater utilities, and state and local emergency management officials.
    - Federal, state, and potentially local EOCs should invite water and wastewater utility representatives and WARN representatives to sit in the EOC or connect virtually to help coordinate assistance to water utilities.
2. **In each of the identified lifeline sectors, repair crews should be designated as emergency responders, given priority access to necessary resources (such as fuel), and supplied with appropriate and nationally accepted credentials to enter damaged work zones.** This could

include working with state and local governments to develop guidelines for local law enforcement who typically provide security to restricted areas in a disaster.

3. **Increasing WARN membership across the United States could provide a greater reserve of resources** to support affected systems during disasters and reduce the burden on emergency management officials. Coordination through WARNs, EMAC, and state EOCs during emergency events is improving and should continue to be a priority. Greater WARN participation will also formalize and strengthen existing relationships within the sector that contribute to rapid response and recovery.
4. **Consolidating water sector responsibilities under the National Response Framework** can facilitate a high-level view of water sector risks and better meet utility resource requests
5. **Water and wastewater utilities can work with government and energy sector partners to pursue diversified backup power strategies** for long-term commercial electricity outages.
    - A comprehensive review of regulations will identify ways to remove disincentives for water and wastewater utilities to invest in large-scale backup generation.
    - Water and power companies can examine how water utility onsite generation assets can be used to increase resilience in both sectors. The Passaic Valley Water Commission is working with FEMA and electricity providers to construct primary power capabilities onsite that benefit both sectors.
    - Utilities can standardize generator connections as infrastructure is planned and upgraded and improve fuel storage capacity.
6. **Accurate climate change forecasts will help inform infrastructure changes over the next several decades** to ensure critical facilities can continue operating at capacity as environmental conditions change. See Transportation Sector Resilience Implication #3.
7. **Regional assessments and exercises will help utilities identify large-scale infrastructure investments that address specific regional risks.** The aging water and wastewater infrastructure in the U.S. offers opportunities in the near future to begin rebuilding smarter. Regional risks—such as storms, earthquakes, and tornadoes—and specific infrastructure designs will determine the best resilience investments for each individual water utility. Regional public-private assessments and exercises can help utilities identify the best long-term investments for resilience, including backup power generation, the potential for interconnections of water and wastewater systems, water and wastewater plant redesigns, and storm water management practices that reduce the impact of flooding on the wastewater system.

Opportunities for Improvement

- Develop Federal guidelines and/or a national credentialing system for re-entry of owner and operator recovery crews and utility personnel—in this and all lifeline sectors—to restricted zones that contain critical assets.
- Initiate a comprehensive review of regulations and restrictions that may create disincentives for utilities to invest in reliable backup generation.

State and Local Government

As in all major events, state and local emergency management officials became primary coordinators during Sandy, maintaining communications with private-sector stakeholders and sharing information with partners at municipal, county, state, regional, and Federal levels. States and local governments have the sole legal authority to respond to and manage all disasters and emergencies within their jurisdiction. Federal assistance can be provided, under the provisions of the Stafford Act, only when state governors request a presidential disaster or emergency declaration and accompanying federal assistance. The storm affected 24 states and caused more than $20 billion of property damage alone along the east coast. Thirteen states requested Federal assistance through major disaster and emergency declarations. Through the Emergency Management Assistance Compact (EMAC), more than 25 states deployed 2,632 personnel and resources to the impacted region.

Exhibit 35. State and Local Government Highlights

- Multiple states, counties, and municipalities brought together public- and private-sector infrastructure liaisons under one roof in emergency operations centers to improve real-time coordination and information sharing.
- Data sharing and analytics through interoperable data platforms enabled agencies to maintain situational awareness and prioritize resources.
- State and local governments extensively used social media to communicate with the public and crowdsource information.
- Federal regulation restricting information sharing in the oil and natural gas sub-sector blinded emergency managers to the availability of fuel resources.
- Unprecedented damage and flooding overwhelmed state and local resources and delayed the ability to restore critical services to priority sites.
- Personal relationships remained critical at the state and local level and were cited as key success factors.

State and local emergency management personnel tracked and shared data about the damage to state and local infrastructure, electricity outages, fuel disruptions, public transportation issues, public safety, and sheltering for those residents displaced from their homes. Widespread damage to homes and extended restoration times put a strain on shelter systems. New York and New Jersey instituted fuel rationing programs they had not put in place since the 1970s. Officials also worked closely with private-sector partners to issue permits and waivers, direct government resources as critical service outages worsened, and keep the public informed and engaged during the recovery process.

Highlights of Planning, Response, and Recovery

Planning, early mobilization, and coordination efforts by state and local governments helped to mitigate the effects Superstorm Sandy.

Public-sector regional relationships and organizations increased coordination, resource sharing, and situational awareness across jurisdictions.

Longstanding state-to-state mutual aid processes, known as the Emergency Management Assistance Compact (EMAC), and regional mutual aid agreements enabled emergency responders to share resources and coordinate a multi-jurisdictional response. Local, state, and regional groups instituted standing coordination calls before the storm hit and continued through recovery.

- For example, Philadelphia activates an emergency steering committee including city agencies, law enforcement and fire, National Weather Service, non-profit organizations, and key utility personnel. Regionally, five southeast Pennsylvania counties have common teams and equipment that are poised to respond to an event, and who coordinate through the state emergency operations center (EOC) and via phone and e-mail. Regional coordination also verifies that local governments are taking similar preparatory and response action to ensure consistency in emergency management efforts.
- FEMA Region 3 initiated conference calls two days before storm impact, and requested that New Jersey be integrated into the regional calls, despite it being in a different FEMA region.

Emergency managers and private utilities worked side by side to coordinate and mutually support response.

- New Jersey held pre-event conference calls with private-sector stakeholders and established a private-sector desk within the EOC to coordinate resource and information requests. Multiple states, counties, and municipalities also co-located private sector liaisons within EOCs. Officials in New Jersey had contact information for owners and operators of state- and national-level critical infrastructure and had previously issued private-sector employee identification cards to improve access for essential employees to disaster areas.
- Activating the Philadelphia EOC brought together police and fire, water, transit, and energy officials in both the public and private sectors under one roof to coordinate. Any agency that has a role in the response is requested to staff the EOC to promote information sharing, streamline decision-making, and to prioritize scarce resources.

State and local governments used social media effectively as a primary mechanism for information sharing with the public and media and as a tool to confirm information and reports following the storm.

Coordinated messages through social media and traditional channels reduced panic while keeping people inside and off the roads. Social media platforms also enabled crowdsourcing of information that agencies and the public used to support response.

- Students from Franklin High School in New Jersey crowdsourced feedback from Twitter to map which gas stations were closed or open and shared it on Google crisis maps.

Exhibit 36. Innovative Social Media Use in Philadelphia and Boston

Philadelphia's integration of social media into its OEM and 311 mobile platform showed how social media could be used to reach large populations in real time and request information from citizens to improve response. The City of Philadelphia used the new "Philly311" mobile app, launched in September 2012, to share information with the public and receive non-emergency requests from residents across the city during Superstorm Sandy. More than 400 requests were made via the app, and the @Philly311 Twitter account gained approximately 2,000 followers and sent 1,000 tweets during the storm.

The city is now exploring opportunities to better coordinate social media into the Joint Information Center, train and dedicate personnel to social media management to improve messaging frequency and relevance, and engage in social media "mutual aid" agreements with agencies in other states that provide personnel to monitor and aggregate social media inputs from followers in a disaster. The city is also exploring the use of platforms such as Google Forms with private sector providers to gather information on which grocery stores, restaurants, service stations, and key businesses are operational during an event and provide that information to the public.

Social media also proved critical in an entirely different type of event: the Boston Marathon bombing. City and transit police extensively used it to provide information on the investigation and suspects to the public; drive users to their See Something, Say Something website and app to report new information; and communicate to the public and media immediately after the event when cell phone service was extremely limited. It enabled department personnel to become trusted resources for information who would often "break" stories that the media would traditionally report first and refute rumors to reduce panic.

Counties and states with interoperable electronic information sharing and analysis capabilities faced fewer information sharing issues.

Most coordination challenges stem from lack of data or the ability to analyze it effectively. Data sharing and analytics was often the key to success, enabling agencies to widen visibility into cross-jurisdictional impacts, improve outreach to affected populations, prioritize resources, and maintain a consistent message.

- For example, municipalities and counties in Pennsylvania, as well as many surrounding states, use Knowledge Center incident management software to maintain situational awareness. Information is transmitted automatically to the state and also visible at the state and local levels.

States and municipalities with underground fuel storage and sufficient backup generation encountered fewer delays.

- Despite the associated cost and regulatory requirements, some municipalities have invested in underground fuel storage, which supplied emergency response vehicles and reduced the impact of fuel disruptions. However, fuel availability for personal vehicles and home generators remained a challenge.

Response, Recovery, and Interdependency Challenges

The size and scope of Superstorm Sandy and extent of damage increased the need for cooperation both within and across county and state lines. The need for up-to-date, reliable data became increasingly important as state and local government responders coordinated resources across wide geographical areas and modified response plans in real time to address unanticipated consequences of the storm.

Federal regulation restricting information sharing in the oil and natural gas sub-sector blinded emergency managers to the availability of fuel resources and causes of disruptions.

- New Jersey emergency managers did not have good visibility into petroleum availability throughout the region, whether there was an overall petroleum shortage, levels of supply at gas stations or terminals, and which service stations had fuel but no electricity, or vice versa.
- Emergency officials worked creatively with the communications and financial services sector to identify working service stations. By analyzing which stations were accessing internet and credit card systems, they could pinpoint those that likely had power and were pumping fuel.

Misconceptions about the role of state and local government existed in both the private sector and the public it serves.

- In some cases, private sector partners believed there was a master "prioritizor" in the state EOC, when in fact emergency managers were working across agencies to coordinate the deployment of public resources based on constantly changing private-sector restoration estimates.
- The public holds a misconception that the state not only regulates but can direct the resources of electric utilities after an event and is responsible for restoration.

Widespread damage and flooding taxed debris removal crews, overwhelmed backup generation resources, and negated pre-determined restoration priorities.

- Generators were scarce, required refueling every 24 hours, and often had to be shared and transported between sites while road access was still a challenge. Some generators were designed for minimal use, were old, or had not been well-maintained, leading to burnout and increased resource requests.
- Debris removal crews were in short supply relative to the damage incurred.
- Most state and local emergency managers had worked with electric utilities to pre-determine restoration priorities, but many were served by flooded electrical distribution stations that required days to pump, dry, and clean. This required re-shuffling of priorities and increased communication with power companies.
- When the Port of New York and New Jersey shut down for four days, all cargo sat offshore or was diverted to other ports. Norfolk's port was running at 185% capacity to handle overage. States also began discussing shipping sewage to other regions for processing when water treatment plant capabilities were compromised.

Ad hoc volunteer groups lacked defined roles and responsibilities, making coordination difficult.

- Although social media helped to enable ad hoc volunteer groups to assist in disaster recovery efforts, it was difficult to coordinate with these groups because they did not have a clear understanding of roles and responsibilities.

State and Local Government Lessons Learned

1. **Economic/operational interdependencies and disaster impacts do not recognize jurisdictional boundaries, requiring fluid regional coordination during catastrophic events**. The scale and scope of the storm took many responders by surprise and required a new level of cross-jurisdictional and cross-sector coordination. In some cases, private sector partners were better at working across state lines than public officials, in part due to legal and regulatory constraints, whether perceived or real.
2. **Personal relationships remained critical at the state and local level and were cited as key success factors for coordination.** When traditional communication channels are compromised,

agencies used personal cell phone numbers and e-mail addresses to communicate. Creative problem-solving also stemmed from working directly with stakeholder contacts. It is important to ensure that, with staff turnover, these capabilities and contacts are sustained and updated.

3. **Unforeseen factors can hinder restoration efforts, rapidly alter priorities, and necessitate a flexible response.** Sandy brought to light hidden risks in some sectors. Despite milder damage in Pennsylvania, a Philadelphia potable water plant that lost power didn't anticipate that repair crews in bucket trucks couldn't deploy until winds dropped below 45 mph, delaying restoration. Sandy brought fuel vulnerabilities to the forefront, as critical operations for public and private sectors were threatened by worsening fuel shortages. Timing of the event can also result in a sudden need to shift priorities, such as polling locations that needed to be operational for the presidential election a week after the storm.
4. **States may be in the best position to consolidate and share information reported on petroleum supplies.** Because antitrust legislation prevents oil companies from sharing information on supplies with each other, state EOCs need dedicated personnel to collect and consolidate as much up-to-date information as possible on fuel supplies. Some states have developed supply disruption tracking services to provide better fuel situational awareness.

Implications for Resilience

1. **Data analytics and interoperable data exchange with key partners can improve agency response to affected populations.** State and local emergency management agencies are investing in data management platforms for EOCs that can accept information seamlessly from private sector EOC systems and improve situational awareness, decision-making, and resource management. Integrating GIS capabilities for mapping and displaying problems improves impact and outage comprehension.
2. **State and local government agencies can best harness the capabilities of social media by increasing capabilities, training, and best practices sharing**. Emergency managers who use social media before, during, and after an event can establish their agency as a trusted information source and better control and respond to rumors. Increasing training and dedicated personnel for social media and improving social media policies are necessitated by growing public use of and reliance on social media as a primary communication source. The volume of information often requires constant attention.
3. **Joint public and private exercises at the regional level and improved partner outreach in non-emergencies offer one of the best opportunities to prepare for unprecedented events in regions**. They also provide the basis for regional vulnerability assessments and coordinated planning for resilience.
    - Between-event coordination and education helps to manage turnover and improve understanding of partner operations. In New York City's OEM, new employees get a ConEdison 101 course, and they work with ConEdison to provide its new employees with an OEM 101 course.
    - New Jersey's infrastructure bureau has sponsored multiple exercises since 2010 for lifeline infrastructure owners and operators. One exercise, "Running on Empty," presaged the petroleum disruptions that occurred during Sandy.
    - Exercises also offer the opportunity to define the specific roles and responsibilities of state and Federal government agencies during an emergency to limit unnecessary duplication of efforts and enable a more effective response.
4. **Building community capacity to shelter-in-place and withstand longer power and critical service outages can decrease the strain on state and local resources and improve recovery**.

The public needs education on disaster preparation and consistent messaging from state and local officials to build the expectation for individuals to be self-reliant for at least 72 hours following an event with major service disruptions.

- In addition, states and municipalities need mid- to long-term displacement plans for sheltering. Long-term disasters will require shelters to operate at full capacity for longer than three to five days. Food options with a long shelf life and access to showers, laundry facilities, and special medical equipment should be considered.

5. **Best practices and information sharing across regions can help emergency managers employ lessons learned from disasters experienced elsewhere**. Prior events such as Hurricane Irene and Tropical Storm Lee provided lessons learned that helped better prepare emergency responders for Sandy. Regions further south routinely experience large and destructive hurricanes, for example, and could offer well-established best practices for storms and many other natural disasters.
6. **Develop streamlined processes for routine public-private coordination to avoid reinventing the wheel in the next disaster.** Coordination for debris removal, issuing permits and waivers, and sharing service outage information are staples of almost every major event. Where possible, they should not represent puzzles to solve each time.
    - For example, Pennsylvania emergency managers started an initiative with PECO to establish priorities for debris removal and access to certain roads to reestablish power for critical facilities. They have currently identified 25 priority one roads that will be addressed first and 45–50 additional priority two roads.
    - There are valuable opportunities to improve EMAC coordination prior to the next event. Sending needed resources can create additional challenges when the chain of command is unclear, pre-mission assignments are not established, and accommodations for fuel, food, and housing are not determined ahead of time. States must coordinate to develop a pre-scripted mission and package for deployed teams.

Opportunities for Improvement

- Support joint public-private exercises at the regional level, including multi-jurisdictional and Federal participation.
- Facilitate best practices and information sharing for multiple types of disasters across regions.
- Provide information and training resources to help state and local governments improve community capacity and disaster preparation.

Non-Profits and Community Organizations

When Superstorm Sandy hit, non-profit and community organizations and volunteers from across the country rushed to assist those in need in the hardest hit areas of New York and New Jersey:

- Traditional non-profits, like the American Red Cross and Catholic Charities, used their resources and wide-reaching networks to pre-stage equipment and provide essential services. In the weeks following the storm, the Red Cross raised $303 million, operated 32 shelters in the area, circulated more than 300 emergency response vehicles through the region, and worked with its partner the Southern Baptist Convention to serve more than 4.8 million meals and snacks.
- Local non-disaster agencies and organizations such as Portside NewYork, Friends of Firefighters, the Bowery Residents' Committee, and the Jewish Community Council of Greater Coney Island, among others, also contributed greatly to the response, utilizing their community ties to organize and carry out response efforts at the local level.
- Additionally, Superstorm Sandy saw a large number of ad hoc volunteer organizations mobilize around local needs. Occupy Sandy was formed using the social networks established during the Occupy Wall Street movement, and within the first two weeks following the storm, gathered an estimated 5,000 to 10,000 volunteers, whose nonhierarchical methods of organizing proved useful for triage and immediate support.
- Other organizations, such as Power Rockaways Resilience, Operation Breezy, and Boots on the Ground, provided vital services such as backup power and heaters and pumping and gutting homes to prevent mold growth.

Exhibit 37. Non-Profits Highlights

- Non-profit organizations replaced lifeline sector services when major providers were still performing restoration. They provided generators, transported food and water, and replaced internet and wireless communications that were indispensable in the first few days.
- Social media and online mapping technology were critical tools used to survey community need and match needs to resources and personnel. New capabilities and creative crowdsourcing enabled organizations to troubleshoot on the fly.
- However, a lack of common data tools across organizations complicated response among hundreds of volunteer organizations.
- Ad hoc volunteer organizations sprang up throughout the region to address unmet needs and improve the agility of response at the local level. Yet a lack of historical coordination with traditional disaster response organizations and state/local government hindered response.
- Ongoing education and training can help promote individual preparedness and support a whole-of-community approach to disaster recovery.

Highlights of Planning, Response, and Recovery

Non-profit and community organizations mobilized to effectively meet large needs during response and recovery in the hardest-hit areas.

Non-profit resources and networks provided lifeline sector services when major providers were unable to rapidly get services back online.

Power

- While gas generators sat idle due to the fuel shortage, Power Rockaways Resilience formed to begin delivering hand-built, shopping-cart-sized solar generators to the hardest-hit blocks of the Rockaway peninsula. This small-scale initial effort grew, and with the help of a nationwide fundraising campaign, oversaw the widespread installation of large-scale solar generators at relief centers and volunteer hubs.
- PortSide NewYork, a non-profit in Red Hook focused on waterfront issues, organized the work of a local electrician who donated his services.

Transportation of food and water

- New York's Governor Andrew Cuomo called the non-profits of New York a "critical partner" in recovery, noting that a number of them, including the National Urban League, the Coalition Against Hunger, the Metropolitan Council on Jewish Poverty, the Bowery Residents' Committee, the Grand St. Settlement, and the Henry Street Settlement, aided in the transportation of food to shelters in Manhattan.
- A non-profit program director from the Upper West Side co-founded UWSLoves, raising money from her friends to make and personally deliver more than 1,500 hot meals and more than 3,000 sandwiches in her own kitchen for those in need on the Lower East Side, Rockaway, Coney Island, and Red Hook.
- The Red Cross deployed its mobile units through New York and New Jersey communities distributing food and water. Volunteers individually called response vehicles to verify their location, which was then submitted to a blog on the Red Cross website to keep residents in hard-hit neighborhoods up to date on where food was available.

Communications and technology

- The FEMA Innovation Team rallied local community leaders, NGOs, government, volunteers, and commercial technology providers to deploy temporary disaster networks in the Rockaways, Red Hook, and Staten Island. This just-in-time communications then empowered communities to coordinate their own volunteers, aid, and donations.
- The Red Cross has a partnership with the Armed Forces Emergency Services system (HAM radio operators) that they pre-deployed as well as satellite phone kits to key chapter locations. This was key to operations in the first couple days without cell service.
- The Information Technology Disaster Resource Center (ITDRC), a vendor neutral clearinghouse for in-kind technology resources in disaster, engaged nearly 1,000 members of the New York tech community to supplement response efforts. Volunteers provided temporary communications and technology assistance (e.g., installing computers, networks, Wi-Fi infrastructure, and internet-based phones) to communities, nongovernmental organizations (NGOs), small businesses, and fire stations.
- The independent Global Disaster Immediate Response Team (DIRT) used ground-based terrestrial antennae to restore communications to hardest-hit areas quickly—an idea they came up with on the fly.
- Occupy Sandy leveraged free and open-source tools, such as Sahana Eden, to develop a technical infrastructure and disaster management system for information sharing and response support. The group used the Sahana software as a dispatch hub for communications and to log requests for assistance, print waybills with inventories and their destinations, and track requests

for disaster relief supplies like food, water, dry goods, and cleaning supplies. The software also tracked work orders for houses needing cleaning, mold remediation, etc.

- PortSide New York provided computer equipment to enable people to apply for FEMA aid.

Social media was a critical tool for organizations to survey community needs, match needs with resources and personnel, and provide rumor control.

- The Jersey Shore Hurricane News, a Facebook- and Twitter-based news platform created by a digital journalist in advance of Hurricane Irene in 2011, provided accurate news reports and crowdsourced information about food, water, gas, and shelter, and deliveries of supplies to residents, emergency responders, and community organizations. When 911 was overloaded, the New Jersey Office of Emergency Management used the platform to communicate with people requesting rescue.
- The American Red Cross' Social Engagement team used pertinent posts from its Facebook page to inform the headquarters-based Mass Care team's response and influence change in action on ground operations. In its D.C. headquarters-based social media disaster operations center, volunteers also monitored hashtags and keywords on Twitter, Facebook, and blogs to determine need and inform service delivery plans. The Red Cross also offered a Hurricane App to assist in individual recovery.
- Through social media and firefighter websites, grassroots organization Operation Breezy was able to spread the word that people were in need, resulting in volunteers coming in from around the country to help gut and pump water out of residents' homes.
- A 14-year-old girl used Facebook to found Survivors Silver Lining, which continues today to communicate needs (e.g., building supplies) and match donors with Hurricane Sandy survivors. She has also used the site to keep interest in donating alive after media attention dwindled.
- Humanity Road used social media to coordinate their own response as well as provide rumor control; using their mobile and web-based information gathering techniques, they located and responded to rumors with fact-based information via their social network.

Organizations and individuals developed online maps and mapping technology to increase the efficiency of non-profit response and recovery efforts.

- Hurricane Hackers NYC developed a map offering National Oceanic and Atmospheric Administration (NOAA) aerial imagery of affected areas with an overlay of recovery locations. By providing this information in a centralized location, they helped connect organizations working on technology projects and resources to common online resources.
- Mormon Helping Hands developed a private tasking system and map that was made available to organizations with ground teams responding to assess and resolve issues. Though its use varied, the system provided more than 90 organizations that were surveying damage and identifying resource needs with a method for capturing assessments, coordinating responses, and tracking issues through to completion, resulting in the resolution of thousands of incidents.
- Independent technology and media organizations, such as New York Public Radio, developed interactive maps using New York City's data to target or accommodate specific needs, which made them integral to the response effort. These maps extended access to the city's data, helping to alleviate some of the burden from the city's websites when online traffic surged.
- Occupy Sandy created a centralized website and a map using Google Fusion Tables embedded in their WordPress-powered website to provide information, connect individuals with resources, collect donations, and register and direct volunteers. Individuals could visit the site to register community needs and request aid (information that was used to help allocate volunteers and

other resources) and volunteers could input their information, making it easy to segment volunteers by interest and location.

Non-profits, community organizations, and government agencies coordinated well, sometimes on the fly.

- Geeks Without Bounds (GWOB) deployed with the FEMA Innovation Team, helping to bridge the formal and informal response efforts. For example, they worked with Occupy Sandy to streamline its exchanges with FEMA and other formal organizations.
- National Voluntary Organizations Active in Disaster (VOAD) membership includes 108 organizations comprising faith-based, community-based, and other nongovernmental organizations throughout the nation. Traditional non-profits like the American Red Cross and Catholic Charities worked with VOAD to help coordinate response efforts.
- In New Jersey, Catholic Charities worked very closely with Red Cross, FEMA, and local emergency management to conduct a coordinated effort.
- The Red Cross partnered with Philadelphia's emergency alert system, ReadyNotifyPA and New York's Notify NY system to encourage people to sign up for text alerts during disasters.

Non-profits and community organizations continue to play a key role in post-storm recovery and rebuilding efforts

- Catholic Charities conducted a "Social Impact Study" in Fayerville, New Jersey, through which they collected and provided quantitative and qualitative data to the city council and state to make the case for building resilience in at-risk towns.
- At its annual meeting, Philanthropy New York focused on topics related to rebuilding and resilience post-Hurricane Sandy, and invited participation from government officials, scientific experts, and other non-profits to discuss ways that all sectors can contribute to resilience.

Response, Recovery, and Interdependency Challenges

Non-profit and community organizations depend on power and communications to mobilize and coordinate responses, but because they are used to functioning in disaster situations where failures generally occur, they have developed methods for providing these services themselves, which they employed during and after Sandy. The fuel shortages, however, did greatly impact their ability to use generators and mobile response units. While well-marked vehicles were often able to skip gas lines, unmarked volunteer and rental vehicles could not.

Lack of common data and data collection tools created inefficiencies and duplicative efforts.

- Multiple organizations conducted different data collection efforts as a means to organize their responses. However, a lack of information sharing and establishment of common data points made some of these efforts redundant.
- Several entities—including government, non-profits, ad hoc and volunteer groups, and individuals—developed "crowdmaps" to provide situational awareness, resulting in a duplication of effort because groups did not collaborate or coordinate their efforts.
- Some proprietary data collection tools developed by organizations, such as the private tasking system and map for VOAD groups, were not always ideal for use in the field.
- Data collection needs sometimes went unfulfilled, due to a lack of a designated responsibilities, limited resources, and limited communication about gaps.
- Although certain agencies had access to databases with personal contact information for thousands of vulnerable residents (e.g., elderly, sick, and disabled), in some cases, legal and

technical barriers prevented the sharing of lists across agencies. Due to the lack of a consolidated and accessible information source, city agencies and community-based organizations had to conduct outreach to locate these individuals, making the task of reaching these populations both slower and more difficult.

Uncoordinated approach for reaching out to communication companies made prioritization difficult for service providers.

- Several NGOs came to communications companies looking for support on various projects, but without necessary documentation from FEMA. Communications companies needed to prioritize where they could help, and being told by multiple NGOs that their organization was the FEMA priority made it difficult for communication companies to determine their response strategy.

Conflicts between state emergency plans and city efforts prevented a more coordinated non-profit response.

- Catholic Charities experienced discrepancy between New York State's emergency operations plan, which typically informs their response, and what the city of New York carried out under the mayor's instructions. Because of this unannounced change of plan, Catholic Charities did not always know who was in charge, where to set up operations, or how to get from one place to another, among other issues.

Lack of communication and coordination among traditional non-profit organizations and spontaneous volunteer organizations hindered some response efforts.

- Although ad hoc and volunteer groups played a significant role in response and recovery efforts and were empowered by social media to organize, collect, and share information and resources, they also found it difficult to organize and engage with traditional response stakeholders.
- Newly formed volunteer and ad hoc groups were sometimes unfamiliar with the logistics of delivering resources and long-term recovery efforts and did not know the roles and responsibilities of local and Federal governments, emergency management regulatory agencies, and organizations like FEMA, Red Cross, VOAD, and others.
- The inexperience of some community organizations with the deployment and support of emergency technology hindered, rather than helped the overall response effort.
- New York City had its Spontaneous Volunteer Management Plan in place during Sandy, but implementation proved difficult, particularly due to poor communication between the groups involved. This may have prevented some volunteers from being utilized in the best possible way.
- After the initial response effort, there were a number of agencies—traditional and ad hoc—that were working to provide food to residents in need; upwards of 30,000 to 40,000 meals per day. However, there was no coordinated effort among the different feeding agencies during Sandy that enabled these organizations to maximize their resources.

The rapidly changing storm path left some resources pre-staged outside the areas in need.

- The American Red Cross strategically placed resources between Philadelphia and New Jersey based on early predictions of where the storm would hit, but were able to move them closer to New York the night before as the storm turned. However, they placed them on the coastline, which made getting them to Long Island and Manhattan difficult.

Volunteer organizations focused on rebuilding face a number of challenges that could inhibit their participation in recovery.

- Variance in building codes and requirements in the many municipalities and inconsistencies among inspectors provides substantial difficulty for non-profits and community organizations. The underlying concern is the potential future liability for volunteer agencies as well as the possibility of leaving a survivor with a rebuilt home that becomes uninsurable, leaving the homeowner with no legal recourse.
    - FEMA flood maps are being restructured, but are not yet available to individuals who must rebuild now.
    - Waivers are needed to use out-of-state contractors, and small to medium projects have great difficulty finding contractors, due to a business focus on larger, more profitable projects.

Non-Profit and Community Organization Lessons Learned

1. **Non-profits and community organizations have the ability to provide stopgap lifeline sector services**—particularly power and communications—in times of disaster.
2. **Social media proved to be a critical mobilization tool** that enabled non-profit and community organizations to be self sufficient. However, some organizations neglected to update social media pages, which frustrated users, or required the addition of a dedicated individual or team to respond to questions or comments.
3. Where used effectively, **online maps and tools for data collection and analysis aided in the efficient prioritization of response efforts.** However, in some cases, a lack of coordination between the organizations developing these tools and compiling data sets resulted in a duplication of effort. Additionally, some organizations developed maps and tools that were ineffective while still others lacked the training and technical knowledge to use them correctly.
4. **Coordinating a "whole community" approach with disaster stakeholders yielded effective responses.** The FEMA Innovation Team, for example, enabled agencies and external partners to coordinate efforts that could not have been conducted by any one organization.
5. **Ad hoc volunteer organizations improved the agility of response at the local level, but need better coordination with traditional organizations and government agencies**. Ad hoc volunteer organizations mobilized to serve unmet needs, and leveraged their community ties and personal networks to start acting immediately. Traditional response organizations have relationships with government agencies, emergency management, and other non-profit organizations that enable them to manage large-scale logistics, while ad hoc organizations innovated ways to survey and respond to needs and collect important data. Coordinating these efforts can yield a stronger response.

Implications for Resilience

1. **Non-profits and community organizations can continue to use and improve standard, open-source tools and techniques that leverage social media** to provide them with accurate, real-time situational awareness. Best practices for incorporating nonstandard technology resources and/or solutions that may be innovated on the fly should be shared across organizations. Specific ideas include the following:
    - Online maps that can integrate data from multiple sources, potentially using crowdsourcing (e.g. MapStory) and/or integration with GPS technology.

- Smart phone technology in the field to enable volunteers to take pictures of disaster assessment immediately, send it to a case work team, and put that location on the route for case work teams. Also the use of GPS to track and communicate the location of response vehicles via a publicly accessible online map or social media outlet.
- A better portal for disaster management (e.g., ReadyResponders Network) that delivers information, such as a daily situation report, to handheld devices.
- Software that can mine data like geotagged Tweets and automatically organize it into useful information to help identify resources that are available and where, and match them up with needs.

2. **Establishing standard nomenclature and a platform for data sharing could improve information exchange and streamline data collection efforts**. Having access to real-time data is critical to response efforts, but is not something that all non-profits and community organizations can spend time and resources collecting. Establishing a platform for data sharing and a common way of expressing it could help make collected data more robust and enable its cross-utilization in different response efforts. Procedures and common protocol for data and information sharing would need to be developed to ensure accuracy.
3. **Improved pre-event coordination between non-profits/community organizations and other emergency stakeholders can improve response efficiency**. For example, long before disasters occur, Catholic Charities spends time building relationships with FEMA, its partner agencies that are part of National VOAD, and community governments—relationships that have enabled the organization to move quickly and effectively in times of crisis. Improved coordination may include:
    - Enhancing the awareness of non-profit support response efforts and resources to reduce unnecessary duplication of service and effort
    - Including non-profits in city/state emergency planning and communicating changes in plans and protocols that may impact the non-profit response (i.e., avoiding the confusion surrounding New York State's plan vs. New York City's actions that occurred during Sandy)
    - Increasing collaboration between private industries and NGOs to ensure access to resources
    - Non-profits and government working together to develop a well-planned, adequately funded disaster-response system, and government establishing a fund that would be available to non-profit human services agencies in the immediate aftermath of a disaster
4. **Establishing methods for government agencies and traditional volunteer organizations to better engage ad hoc and nontraditional community organizations** can help maximize the potential of this force. This process should leverage the benefits that these diverse groups have to offer without compromising the agility that makes them so effective. Part of this effort could involve:
    - Developing efficient methods of credentialing for nontraditional partners and ad hoc volunteers
    - Providing clear information and guidance to ad hoc organizations and nontraditional organizations about government requirements, policies, procedures, and roles, as well as methods for volunteer management and disaster case management
    - Establishing processes that enable collaboration between ad hoc technology partners and government entities and implement nonstandard resources and solutions
    - Building community relationships and trust prior to the onset of a disaster

5. **Ongoing education and training at the community level will aid in promoting preparedness and familiarity with emergency response**. Examples include the Red Cross "Ready When the Time Comes" program that trains employees of large employers in disaster response; Red Cross clubs for elementary to college-age students; and the Catholic Charities Applied Institute for Disaster Excellence, which trains volunteers in disaster response best practices and government coordination. Not only does this type of training enable citizens to better provide for themselves during storms, but it enables the community to be more responsive to needs and encourages potential volunteers to act when disaster does strike.

Opportunities for Improvement

- FEMA can work to include traditional and ad hoc volunteers as an integral part of the response team and key resource, rather than consider them a liability. This enables non-profit and community organizations to do what they do best, rather than applying cumbersome policies.
- FEMA and other Federal agencies can establish funding avenues for traditional and non-traditional volunteer organizations in times of crisis, and for community education and training to increase the community's volunteer capacity.
- FEMA and other Federal agencies can support the development of open-source tools and techniques, and include social media in existing communications and technology policies and mandates.
- FEMA and other Federal agencies can help educate non-profit and community organizations on disaster coordination to enhance pre-planning efforts and relationship-building.
- FEMA can utilize data collected by non-profit and volunteer organizations (e.g., Occupy Sandy) to set up long-term recovery communities that engage volunteer organizations. This may include coordinating with city governments and developing standard operating procedures or guidelines that every organization can benefit from.

Superstorm Sandy Case Study Group Findings

Superstorm Sandy was one of the largest natural disasters to hit the Northeast states in the past 100 years and one of its deadliest, taking 117 lives and forced 776,000 people out of their homes. It produced extensive flooding that damaged lifeline infrastructures from New York to Washington, D.C. and resulted in more than $60 billion in economic losses.

Yet considering its force and geographic scope, the response to Sandy was remarkable. The storm's magnitude and duration required a level of coordination and response that the region had never seen or practiced. In most respects, the region's owners and operators, public officials, and emergency responders successfully met the unprecedented challenges they faced.

The findings and conclusions that follow are specific to the case study on Superstorm Sandy and reflect the collective judgment of the Study Group. They form a comprehensive set of best practices, process improvements, and potential enhancements to the roles of government and private-sector partners that can help enable shared improvements in regional resilience. Overall, the case study on Superstorm Sandy revealed that three strategies were most effective in successful planning, response, and recovery during Sandy:

- **Strong public-private partnerships and relationships** that were nurtured during disasters and between disasters ("blue-sky days").
- **Effective communication at all levels** aided by the careful placement and coordination of key personnel.
- **Coordinated planning and decision-making** that synchronized the actions of public and private responders.

These core strategies, described below in the Superstorm Sandy findings and conclusions, are essential to the resilience of all regions regardless of location or the risks that they face.

Despite these successes, Sandy's strength and size exposed new weaknesses in both the physical infrastructures and the processes used to plan, respond, restore, and recover from a major regional disaster. The Superstorm Sandy findings point to the successes, remaining challenges, and lessons learned from Superstorm Sandy. They include:

1. Maintaining the Continuity of the Lifeline Sectors
2. The Importance of Partnerships and Cross-Sector Coordination
3. Regional Planning, Analysis, and Risk Management
4. Impediments to Rapid Response
5. Leveraging Communications
6. Building Community Capacity

Study Group Finding 1: Maintaining the continuity of services of the lifeline sectors is paramount to regional resilience.

Sandy confirmed that the services provided by the electricity, oil and natural gas, water, communication, and transportation sectors are indispensable, highly interdependent, and essential for public safety and the recovery of other critical infrastructures, businesses, and communities. Public emergency managers are beginning to recognize lifeline infrastructure as a key functional driver of their traditional emergency services and life safety missions.

- Sandy emphasized that **prioritizing the restoration of facilities is complex, condition-specific, and often difficult to communicate.** Many partners and the public lack a full understanding of how lifeline sectors recover, the factors affecting priorities, and who is involved. For example, while electric utilities have pre-determined restoration priorities, real-time conditions change these priorities based on the location, timing, and severity of the event. Restoration decisions in one sector greatly affect restoration plans in other sectors and impact how public emergency managers allocate resources and equipment. Utilities have historically prioritized life safety functions and assets for police, fire, and hospital services, and are often not well informed about the location or criticality of other lifeline sector assets and systems. In addition, they face increasing demands from public agencies and other sectors to add ever more assets to their priority restoration list, diluting the true priorities. Better partner coordination and education can improve asset prioritization.
- **Damage to aging and highly specialized infrastructure posed problems in recovery** because of the difficulty in locating and procuring rare or obsolete components. The replacement of a critical component of a key transit system damaged during Sandy was unavailable because it is no longer manufactured and had to be located and shipped from another system across the country. One of the largest wastewater treatment plants in the nation required replacement components for customized parts that were difficult to quickly source.
- Sandy stressed the capabilities and assets of lifeline infrastructures over a large geographic region and exposed **hidden risks not well understood or foreseen** by emergency managers in dependent sectors and government.
    - The ability of the public and private sector to assess and manage the liquid fuel supply situation during the storm was hindered by a **lack of understanding of petroleum sector operations and regulatory restrictions**. For example, antitrust laws hampered efforts by New Jersey to obtain accurate information on terminal and retail tank storage levels among various companies. Response personnel were also unable to determine which service stations had gasoline and the ability to pump it.
    - Sandy damaged, disrupted, or disabled infrastructure assets that performed well in previous storms, including Hurricane Irene, exposing **new points of failure in critical assets and facilities and weaknesses in aging infrastructure.**
    - The **vulnerability of non-critical, administrative facilities** was revealed as a result of the large storm surge.

Study Group Finding 2: Strong public-private partnerships and cross-sector coordination were the most important success factors in preparing for and responding to Sandy.

Building and nurturing relationships, both within and between regions, were frequently cited as the most important feature of successful planning and response to Sandy. Public officials and emergency responders in New Jersey were well prepared during Sandy because of the depth of their public-private relationships built over the past three years of regular coordinated preparedness activities, including regional resilience assessments and joint exercises. When fuel became scarce, distributors and individual sectors that had strong relationships with suppliers in nearby states could more quickly source and transport fuel.

- **The active engagement of senior executives from industry and government during Sandy streamlined coordination and removed obstacles** to response and recovery that sectors had faced in the past. President Obama gave explicit orders to remove red tape, and the message trickled down. Electricity sector CEOs across the region participated in daily conference calls with senior DOE, DHS, and White House leaders to coordinate the largest movement of mutual aid resources in history. Senior-level Federal task forces were dispatched to the field with the directive to find and resolve major issues.
- **Recent experience with storms, such as Hurricane Irene in 2012, and participation in joint exercises helped government and lifeline sectors** to improve emergency response plans, flood preparations, infrastructure hardening, and communication procedures. However, it is unlikely that this level of preparation exists for disasters that this region has not yet experienced
- **Preplanning was the key to success but it is getting harder to do** because when large storms follow unpredictable paths across broad geographic areas, companies tend to implement plans earlier and hold onto resources longer, stressing mutual aid agreements. Political directives to not release repair crews to neighboring states until in-state repairs were 100% complete ignored long-standing mutual aid procedures.

Study Group Finding 3: Planning, analysis, and risk management at the regional level is essential for long-term resilience

- Critical infrastructure owners and operators in the region increasingly recognize the **need for investment in innovative infrastructure upgrades**, both in the short term and over longer time frames, to make infrastructures more resilient and protected against risks the region has not yet faced. It is **difficult to justify large capital investment in resilient infrastructure** without public support and the ability to recoup costs. Recent experience with losses from catastrophic events provides tangible evidence of the economic and public health consequences of weak infrastructures. Sandy has created a strong business case in the public and private sectors for billions of dollars of investment in infrastructure hardening and technology upgrades. However, regions will be left unprepared if past experience is the primary motivator for investments. Planners should consider a variety of operational, sustainability, social, and resilience benefits when conducting benefit/cost analyses of future infrastructure investments.
    - Public officials and infrastructure owners and operators are now challenged to **rebuild smarter, but are uncertain what level to build to** that will strengthen resilience to future risks.
- Federal funding under the Stafford Act and state **disaster funding concentrates the majority of resources on the recovery phase of a disaster**, rather than preparedness. A paradigm shift is needed in the way the nation approaches and funds regional resilience.
- **Sandy's storm surge caught many operators and public officials by surprise,** overwhelmed some critical facilities, and damaged or destroyed infrastructure. Some emergency personnel did not understand or believe storm surge predictions. Forecasts during Sandy from the National Oceanic and Atmospheric Administration (NOAA), while quite accurate, were confusing and not well understood. The storm surge, or abnormal storm-related rise of water, was predicted at 6-11 feet but came at a high tide, creating a total storm tide of up to 14 feet. Had they understood the warning language and its implications, more owners and operators would have preemptively shutdown at-risk facilities to avoid equipment damage.

Study Group Finding 4: Impediments to rapid response and recovery remain despite efforts to remove them.

- Owner and operator **inability to gain access to disaster areas** during Sandy to repair critical facilities was a major barrier to rapid recovery of the lifeline sectors. The lack of a commonly accepted credential for recovery workers across municipalities, parishes, states, and Federal jurisdictions impedes recovery. Lifeline sector repair crews were not considered emergency responders by state and local law enforcement in many cases and were routinely denied access to disaster areas containing critical assets.
- **Rapid response during Sandy was hindered by existing laws and regulations** at the Federal, state, and local level and uneven processes for receiving waivers.
- **Differences in state and local laws across regions** continue to hinder rapid recovery. In Sandy, for example, the requirement for various permits and waivers across states complicated fleet movement of emergency repair crews, while concerns about violating anti-gouging regulations prevented some service stations from procuring transportation fuel supplies from more distant regions due to higher costs that would result in higher prices for consumers.

Study Group Finding 5: Effective communications at all levels, using multiple tools and methods, was pivotal to success during Sandy.

Efforts to establish strong communication channels among public and private partners before, during, and after Sandy paid off in the lifeline sectors. It was aided by the availability of standard communication equipment such as landline, cell phones, satellite, and internet communications, which, had they failed to a greater degree, may have compromised the effectiveness of communications and coordination.

- **Co-location of key officials from lifeline sectors and public agencies in state and Federal emergency operations centers** improved communications and accelerated public-private situational awareness, coordination, prioritization, and decision-making. The inclusion of utility representatives in state EOCs and the FEMA National Response Coordinating Center, in many cases for the first time, was helpful and quickly recognized as a best practice.
- **Social media,** when leveraged effectively, became a valuable communication tool and new information stream to support situational awareness, provide notifications, and control rumors. However, this tool was only partially exploited by government agencies and lifeline owners and operators. Social media platforms are

Exhibit 38. Social Media: An Emerging Tool in All Sectors

Social media was highlighted as a game-changing tool in emergency response, and lifeline sector organizations, government agencies at all levels, and non-profit organizations are using it in new and innovative ways to support response and gather new information. Examples can be found throughout, but especially in the following sections:

- State and Local Government text box: Innovative Social Media Use in Philadelphia and Boston
- Transportation: Social media and digital communication were extensively used to communicate with the public
- Non-Profit Organizations and Community Groups: Social media was a critical tool for organizations to survey community needs, match needs with resources and personnel, and provide rumor control

rapidly evolving tools, and many users learn by trial and error. For nascent users, Sandy revealed the potential of social media as a flexible, real-time, and two-way communications tool with key stakeholders.

- Despite improvements over past storms, **situational awareness and communication of conditions continued to be a challenge** during Sandy. Growing public expectation of immediate and accurate restoration estimates challenged utilities that were dealing with unprecedented damage. While public and private utilities provided frequent impact updates to state and local emergency managers, officials often did not fully understand what damage assessments meant in terms of actual service loss, nor the true threats to some critical infrastructure (such as the loss of power and pump failures at water and wastewater facilities). States and municipalities are working to install interoperable disaster management software that can accept and better analyze real-time data directly from utilities and other agencies.

Study Group Finding 6: Regional resilience relies on the capacity of individuals and communities to strengthen local readiness and personal responsibility for short-term survival.

Sandy and other recent disasters have led at-risk communities to view themselves as survivors rather than victims and build stronger community ties and survival capabilities.

- The impacts of recent regional disasters such as Sandy are starting a **culture shift toward community readiness and personal responsibility for short-term survival**. The potential severity and wide geographic reach of storm events is raising public awareness of the need to maintain self-sufficiency immediately following a disaster. Emergency managers are also recognizing the importance of the "soft sectors" in emergency response, such as child care and housing for critical response personnel who otherwise may be unable to leave their families.
- Sandy underscored the **important role that non-profit and community groups** play in assisting communities to respond in flexible and innovative ways and execute long-term recovery from disasters. Traditional non-profit organizations also work with communities to train and prepare for disaster response, while community groups offer strong networks of individuals that can be leveraged in an event. Sandy also highlighted the important role of ad hoc volunteer organizations that formed during response to fill service gaps and respond with agility.

Superstorm Sandy Case Study Group Conclusions

The Superstorm Sandy findings highlight many of the lessons on how the Northeast states can become more resilient to large regional storms. But the Sandy experience also reveals new insights that can inform public and private partners on how to make all regions more resilient for all hazards. The Superstorm Sandy Study Group conclusions listed below attempt to identify steps that can be taken to achieve this.

Study Group Conclusion 1: Maintaining the Continuity of the Lifeline Sectors

- **State and local governments should make planning and coordination with the lifeline sectors a high priority** to help maintain continuity of service and recover rapidly during disasters. This requires a unified, long-term approach that builds relationships, mutual practices, and operational understanding that is essential during disasters. It should also include coordination among decision-makers who design and invest in new infrastructure to ensure they take advantage of resilient features. Placing representatives from the lifeline sector within state and Federal EOCs should be recognized as a best practice.
- To improve regional disaster coordination and response, public officials and infrastructure owners and operators need a **better understanding of the operations, response, and recovery processes used within the lifeline sectors**. A lack of insight into lifeline sector operations can hinder response and recovery if decision-makers do not recognize the interrelationship of restoration priorities among lifeline sectors.
- Owners and operators **conduct outreach, communication, and education up front** so partners understand key priorities and operating procedures to avoid diverting resources to partner education during an event.
- **Critical infrastructure nodes that are essential for core functions within each region should be identified through collaborative planning at the regional level, then hardened and protected**. This will require public sector leadership and support, as private service providers typically work to harden their most critical infrastructure nodes, rather than optimize resilience of all critical assets across an entire region. Government leaders can convene multiple sectors and jurisdictions to help identify where these interests overlap. Individual optimization of resilience investments in the private sector can still lead to suboptimal resource investment when viewed from a regional perspective.
    - **Pilot regions could be chosen to perform cross-sector interdependency reviews** and identify critical points of failure, opportunities to build in redundancy, and improve understanding of risks within interdependent sectors. These pilot processes can formalize and optimize a review process other regions could follow, which in turn can create a process for sharing and disseminating lessons learned.

Study Group Conclusion 2: The Importance of Partnerships and Cross-Sector Coordination

- **Regional cross-sector councils for lifeline sector companies** would help coordinate planning, response, and recovery of critical infrastructures within regions. Councils should have participation from senior executives. Institutionalizing and strengthening existing relationships requires a process-based approach that frequently engages partners in non-disaster circumstances.
- **Proactive sharing of best practices and lessons learned** from past disasters and training exercises should be encouraged within and across regions to build regional resilience. Past events and well-designed exercises often reveal key lessons and new ideas that should not be limited to the affected region alone.

- **Joint exercises are one of the most effective tools** to help regions identify interdependencies and potential gaps, prepare for catastrophic events, and build cross-sector partnerships between disasters. While losses from past events can be an effective motivator for resilience improvements, regions cannot adequately prepare for future events—especially those without precedence—without exercises that expose hidden risks and coordination challenges. Drills and exercises keep partners engaged between events, encourage knowledge transfer to mitigate employee turnover, and build "muscle memory" to make response automatic and well-coordinated.
    - **Incentives are needed** to motivate owners and operators of lifeline sectors to participate in regional exercises. In turn, greater recognition and participation from senior officials in state and Federal government are needed

Study Group Conclusion 3: Regional Planning, Analysis, and Risk Management

- There is a growing recognition among planners that **more sophisticated forecasting, planning, and modeling is needed** to accurately assess future risk and inform investments to prepare for potentially larger, different, and more frequent storms or natural disasters.
    - **New and better data** on changing weather and climate patterns, rising sea levels, and potential flood zones is needed to help regions and sectors determine how to best strengthen infrastructure for emerging risks. Owners and operators recognize the changing risk environment but cannot respond without reliable data and industry-recognized best practices for building resilience into infrastructure.
- **Incentives are needed to stimulate capital investment in innovative technologies and resilient infrastructures.** Regulated industries especially still face difficulty recouping costs and justifying to utility commissions the need for pre-emptive resilience investments.
- **A regional or national shared spare parts inventory** can help speed repairs, reduce the failure risks of components with long manufacturing lead times, and mitigate the risk of aging infrastructure that relies upon obsolete parts. Systems in adjacent regions that use interoperable parts within a sector can share the expense of maintaining reserve parts—especially for large equipment such as transformers—and help owners and operators locate rare replacement parts from systems outside the region.

Study Group Conclusion 4: Impediments to Rapid Response

- **State and Federal regulations should be reviewed** to identify and remove barriers to rapid recovery, and a process for **coordinating and streamlining of waivers** and waiver authorities is needed. A playbook of waiver processes that are activated by certain emergency declarations or impending conditions can codify lessons learned and procedures from past events and prevent owners and operators from diverting time to the same lengthy waiver request processes for each similar event.
- **National access control and credentialing is needed for lifeline sector operators to be considered emergency responders** to expedite recovery in disaster areas.

Study Group Conclusion 5: Leveraging Social Media

- **Social media represents a powerful but underdeveloped tool** for improving situational awareness for operators and communicating with the public outside traditional channels. Pioneering cities and counties can offer best practices, lessons learned, and new ideas for dynamic information sharing. Agencies, sectors, and non-profits are seeking training, dedicating more individuals to social media, and exploring new uses for two-way information sharing and crowdsourcing of information during disasters.

Study Group Conclusion 6: Building Community Capacity

- **Public education and awareness is needed to raise expectations of individual and community responsibility** in an event and build a culture of preparedness. Broad community messaging in non-disaster time is needed to cultivate this culture shift and better prepare citizens both physically and emotionally for anticipated hardships following major events. This should be accompanied by honest estimates of service outages and duration from utilities and emergency management officials.

Appendix E: Investment in U.S. Infrastructure

A cursory review of available literature enabled the NIAC to determine a very rough estimate of the order of magnitude of annual infrastructure investment in the United States. There does not appear to be an accurate or consistent method of accounting of how much is invested each year in new or upgraded infrastructure in the United States. Although no Federal agency or independent organization separately tracks such information, estimates could be compiled by drawing upon a variety of sources and normalizing the data to a common definition of infrastructure and a common year of analysis. However, conducting such an analysis was beyond the scope of the Council's study. To reach a rough estimate—enough to support a ballpark understanding of the magnitude of the nation's annual infrastructure investment—we provide a synopsis of available data and a rationalization of our estimate. Five sources—the Brookings Institution, the Council on Foreign Relations, the Cato Institute, the American Society of Civil Engineers (ASCE), and the McKinsey Global Institute—provide estimates of infrastructure investment, although each uses different data sets, definitions of infrastructure, and years of analysis. Our review of these sources suggests that **between $323 billion and $2.3 trillion is invested each year in new infrastructure in the United States. This translates to $885 million to $6.30 billion each day.**

The biggest divergence in these estimates appears to be related to 1) how infrastructure investments are defined, 2) which infrastructures are included, and 3) how private sector investments are handled. Of the five estimates examined in this analysis, four are within 15% or less of each other ($323 billion to $374 billion). By contrast, the estimate by the Cato Institute is $2.3 trillion per year and includes private sector investment, estimated at five times non-defense gross fixed investment by Federal, state, and local government. The government investment by Cato Institute is $372 billion, which tracks closely with the other sources. **Considering these five estimates, it is likely that roughly $1 billion/day or more is invested in U.S. infrastructure each day.**

Below is a brief synopsis of each estimate.

Brookings Institution

According to a 2008 report from the Brookings Institution, *An Economic Strategy for Investing in America's Infrastructure*, "in 2004, total spending on transportation was at least $210 billion, total spending on drinking water and sewerage at least $76 billion, and new capital spending on energy $78 billion" (Deshpande and Elmendorf, 2008, p. 17). **This represents, for 2004, a total of nearly $364 billion in both public and private spending for the major categories of physical infrastructure. Investment per day would be about $997 million. Over the last 50 years, gross infrastructure investment has declined as a percent of the economy, and shifted from relatively new investment to operation and maintenance** (Deshpande and Elmendorf, 2008). Net investment—gross investment minus depreciation—fell from nearly 2.5% of GDP in the 1970s/80s to around 1% in the 1990s, though estimates show it has risen in the past decades (Deshpande and Elmendorf, 2008; see Exhibit 39).

Exhibit 39. U.S. Net Public Infrastructure Spending, 1929-96

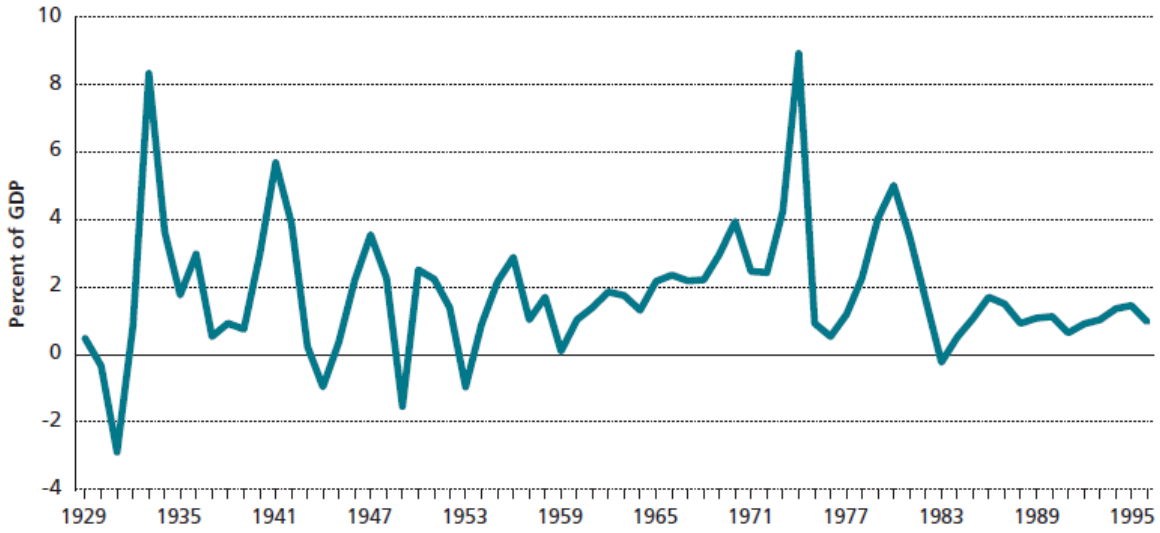


Exhibit courtesy of: Deshpande and Elmendorf, 2008 (The Brookings Institution) via Bureau of Economic Analysis 2013a
Includes highways and streets; water and sewer systems, electric and gas facilities, and airfields.

Council on Foreign Relations

The Council on Foreign Relations, in a 2012 memorandum titled "Encouraging U.S. Infrastructure Investment," states that U.S. "public infrastructure investment, at 2.4 percent of GDP, is half what it was fifty years ago" (Thomasson 2012). The recent year in question was not provided, and several other sources have cited this figure between 2008 and 2013, including The Brookings Institution in 2008 (Deshpande and Elmendorf, 2008). In 2008, real GDP was $12.88 trillion, and in 2011, real GDP was $13.44 trillion in 2005 adjusted dollars (Multipl, 2013). (GDP roughly fluctuated between these two figures during 2008-2011). **At 2.4%, that would make public infrastructure investment between about $307 billion in 2008 and about $323 billion in 2011. Investment per day would be between about $841 million and $885 million.**

Cato Institute

The Cato Institute published a study in January 2013 which compiled both private sector and public infrastructure investment in 2011. The report stated: "Most of America's infrastructure investment is provided by the private sector, not governments. Indeed, private infrastructure spending—on factories, warehouses, freight rail, pipelines, refineries, and many other items—is about four times larger than Federal, state, and local government infrastructure spending combined. If defense spending is excluded, private spending is about five times greater than government spending. [Exhibit 40, replicated her from the Cato report] shows data on gross fixed investment, which is a broad measure of infrastructure spending. In 2011 private investment was $1.818 trillion, compared to government investment of $480 billion" (Edwards 2013).

Using Cato's figures, total gross fixed investment for 2011 from both private and public sources was about $2.3 trillion dollars. Investment per day would be about $6.3 billion. However, public infrastructure investment, excluding defense, was about $372 billion in 2011, or about $1 billion per day.

Exhibit 40. Gross Fixed Investment, 2011, Billions of Dollars

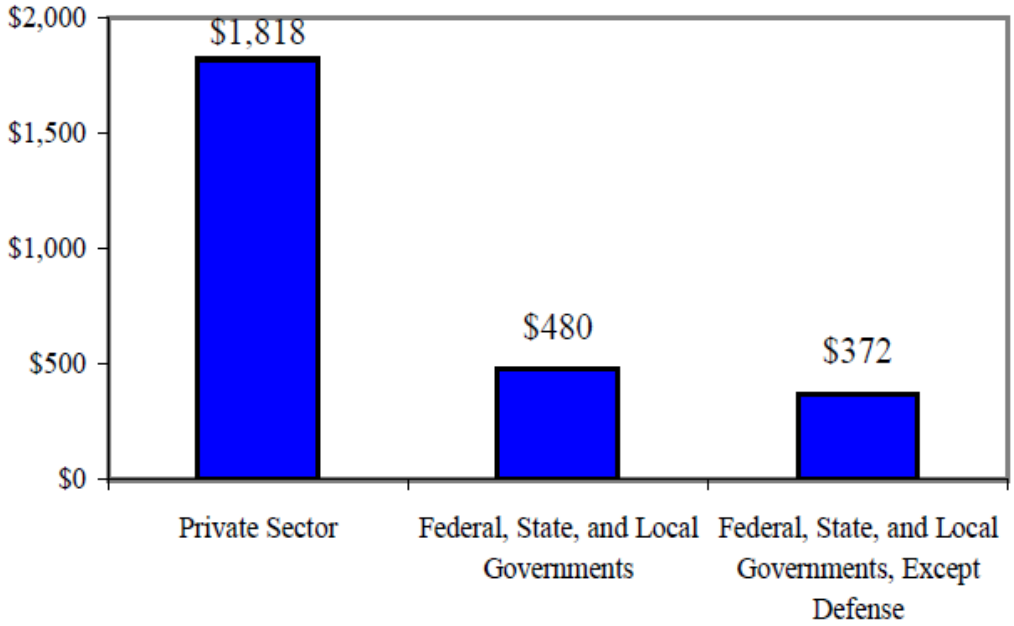


Exhibit courtesy of: Edwards 2013 (Cato Institute) via Bureau of Economic Analysis 2013b

American Society of Civil Engineers

The American Society of Civil Engineers has conducted studies known as the Failure to Act Economic Studies and an annual series known as Report Card for America's Infrastructure. These studies provide fairly specific estimates of the levels of future investment required to upgrade infrastructure for the future. They also include estimates of current levels of investment but they come from various sources and are not uniform in their infrastructure investment criteria. However, we have taken estimates for the critical infrastructure sectors for which annual investment figures were provided from the 2013 Report Card for America's Infrastructure to reach an estimate of current annual infrastructure investment.

Aviation ($3.35 billion annual infrastructure investment)

"The primary source of the FAA's [Federal Aviation Administration] capital programs and general operations is the Airport and Airway Trust Fund (Trust Fund)…. When Congress reauthorized the FAA in 2012, the AIP [Airport Improvement Program, for airports significant to national security] was authorized at $13.4 billion over four years or approximately $3.35 billion annually" (ASCE 2013, Aviation).

Bridges ($12.8 billion)

"The Federal Highway Administration estimates that to eliminate the bridge backlog by 2028, the nation would need to invest $20.5 billion annually; however, at this time only $12.8 billion is being spent annually on the nation's bridges" (ASCE 2013, Bridges)

Inland Waterways ($1 billion)

"According to the U.S. Army Corps of Engineers, maintaining existing levels of unscheduled delays on inland waterways, and not further exacerbating delays, will require more than $13 billion by 2020, while current funding levels are expected to be just $7 billion during this period" (ASCE 2013, Inland Waterways). That means, for the 7 years between 2013 and 2020, that annual inland waterways infrastructure investment will be about $1 billion.

Ports ($9+ billion)

"U.S. ports and their private sector terminal partners plan to spend more than $46 billion over the next five years on port terminal facilities, according to the American Association of Port Authorities. That equates to over $9 billion per year, of which more than one-third is spending by the port authorities themselves" (ASCE 2013, Ports).

Rail ($24.8 billion)

Freight rail investment averaged about $20 billion per year between 2009 and 2012, and Federal investment in Amtrak averages about $1.50 per American per year—or about $475 million, for a total of $20.4 billion (ASCE 2013, Rail).

Roads ($91 billion)

"While the conditions have improved in the near term, and Federal, state, and local capital investments increased to $91 billion annually, that level of investment is insufficient and still projected to result in a decline in conditions and performance in the long term" (ASCE 2013, Roads).

Transit ($52 billion)

"The expansion of transit systems in recent years has been made possible through a substantial increase in overall funding for transit – more than 36% since 2000, totaling over $52 billion from all sources in 2008" (ASCE 2013, Transit).

Schools ($10.3 billion)

"In the four years since 2008, the funding pipeline for school facilities construction has continued to slide, from a modest $16.4 billion down to a projected $10.3 billion estimated for 2012" (ASCE 2013, Schools).

Energy – Electricity ($63 billion), Oil and Natural Gos (no figures provided)

"From 2001 through 2010, annual capital investment in electricity infrastructure averaged $63 billion, including over $35 billion in generation, $8 billion in transmission, and nearly $20 billion in local distribution lines. Funding comes from a variety of sources, including government agencies, regulated utilities, private companies and developers, and nonprofit cooperatives" (ASCE 2013, Energy).

Levees (at least $415 million)

Public infrastructure investment is about $415 million annually from the USACE; no figures provided on state, local, or private investments (ASCE 2013, Levees).

Wastewater and *Drinking Water ($95 billion in 2008)*

"State and local governments incur approximately 98 percent of the capital investments annually to maintain and improve the infrastructure. In 2008, state and local governments estimated their total expenditures at $93 billion annually for wastewater and drinking water infrastructure…. Congressional

appropriations totaled approximately $10.5 billion between 2008 and 2012—about $2.1 billion annually" (ASCE 2013, Wastewater and Drinking Water). Annual infrastructure investment in 2008 was about $95 billion.

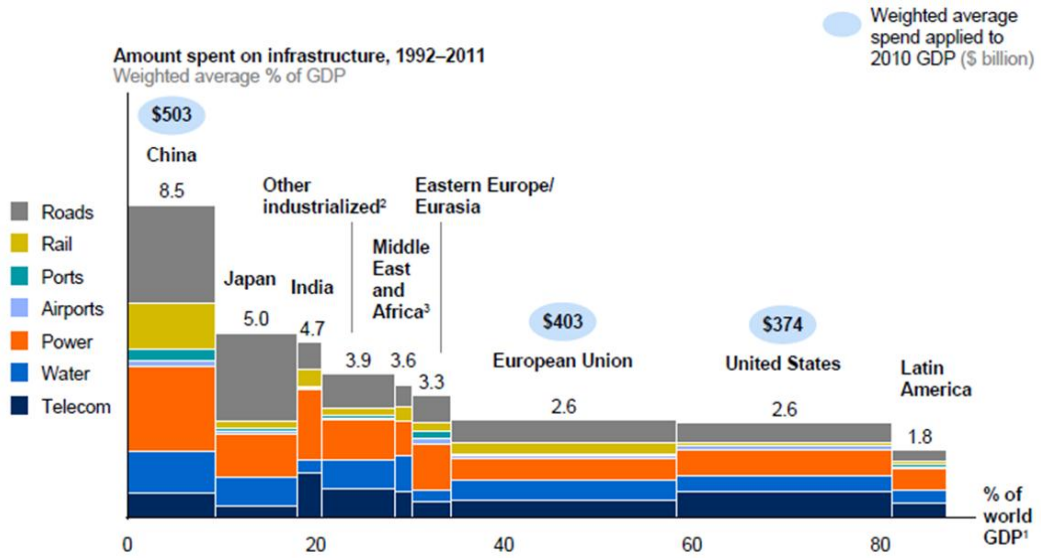
Using the ASCE figures, the annual infrastructure investment is estimated to be in excess of $363 billion, or more than $994 million each day. Because complete information was not available for all sectors, and several only provided Federal investment figures, the actual annual infrastructure investment is likely much higher.

The main purpose of the ASCE Report Card is to identify gaps in infrastructure investment. ASCE estimates that a $3.6 trillion investment in the nation's infrastructure will be needed by 2020 in order to bring the infrastructure up to a grade of "B." They estimate current likely funding of $2.0 trillion, leaving an investment gap of roughly $1.6 trillion. Roughly half of this gap ($846 billion) is in surface transportation, which is nearly 100% owned and operated by the public sector. Looking across all eleven sectors examined by ASCE, **it is estimated that about 85% of the 2020 infrastructure investment gap is for publicly owned infrastructure**.

McKinsey Global Institute

The McKinsey Global Institute (MGI) released a report in January 2013 entitled *Infrastructure Productivity: How to Save $1 trillion a Year*. Like the ASCE series, the report attempted to estimate the size of the infrastructure gap, but on a global basis. In the report, MGI estimates that the **weighted average annual spending on U.S. infrastructure from 1992 to 2011 was $374 billion, or about $1025 million per day** (McKinsey Global Institute 2013; see Exhibit 41). Infrastructures included roads, rail, ports, airports, power, water, and telecommunications.

Exhibit 41. Weighted Average Annual Spending on Infrastructure



1 Percentage of 2010 world GDP generated by the 86 countries in our analysis.
2 Australia, Canada, Croatia, Iceland, Lichtenstein, New Zealand, Norway, Singapore, South Korea, Switzerland, Taiwan (Chinese Taipei), and the United Arab Emirates.
3 Excludes unusually high port and rail data for Nigeria; including these data brings the total weighted average to 5.7 percent.
SOURCE: IHS Global Insight; GWI; IEA; ITF; McKinsey Global Institute analysis

Graphic courtesy of: McKinsey Global Institute 2013.

Appendix F: Lessons from the SLTTGCC on Regional Resilience

The Council reviewed insights from the State, Local, Tribal, and Territorial Government Coordinating Council (SLTTGCC) to examine how the national partnership engages SLTT and regional partners, and review recent work the SLTTGCC has done to inform regional resilience efforts. The SLTTGCC serves as the forum to fully integrate SLTT homeland security directors and partners as active participants in national critical infrastructure security and resilience efforts. It provides an organizational structure to coordinate across jurisdictions on state and local government critical infrastructure security and resilience guidance, strategies, and programs. SLTTGCC members and their network of SLTT alliances across the country have the jurisdiction within their states or regions to determine state and local approaches to critical infrastructure security and resilience, and to partner with private- and public-sector critical infrastructure owners and operators in each region. **This makes the SLTTGCC a key mechanism to coordinate federal resilience efforts with state and local activities in each region**.

The SLTTGCC has conducted numerous studies and published several reports that examine how SLTT governments build and sustain public-private partnerships and how they design and implement infrastructure resilience programs in their communities. The following sections review key lessons and insights from the SLTTGCC.

The Value Proposition of Regional Partnerships

In 2011, the SLTTGCC examined regional consortia across the nation to identify the value proposition for SLTT partners to join regional public-private partnership consortia. Their report, *Regional Partnerships and the Critical Infrastructure Protection and Resilience Mission*, determined that any successful partnership must offer one of the following critical benefits:

- Align critical infrastructure protection and resilience efforts to a region's common hazard or threat environment.
- Achieve a broader and holistic common operating picture of regional critical infrastructure assets and their independencies.
- Identify best practices that can be adopted in a member's own jurisdiction.
- Create new resources and funding opportunities to support regional critical infrastructure activities.
- Leverage expertise and skill sets of coalition members.
- Establish common protocols to govern interactions between owners and operators of critical infrastructure and SLTT governments.

Another SLTTGCC report, *Critical Infrastructure and Key Resources Partnerships: State Characteristics and Capabilities*, examined SLTT government-led partnership efforts to determine how they are structured and the value they provide. The majority of state programs focus on all regional issues, but take a sector-specific approach. Second in line were programs that take a cross-sector approach to multiple issues, followed by those that are formed around one specific regional issue with a cross-sector approach. No matter the design, the SLTTGCC found that sustaining an effective partnership requires that the partnership continuously demonstrate value not only to its participants (both public and private sector),

but also to the policymakers whose support may be necessary to continue the partnership (e.g. governor, state legislature, mayor). Paramount to defining value is the partnership's development and distribution of tangible and useful products, as well as increasing access to information to enable decision-making.

Some of the greatest barriers for SLTT involvement in regional organizations are time and personnel/resource barriers, and the inability to measure tangible outcomes of participation, such as resource savings, connections with the private sector, and new strategies and programs. The report concluded that many successful consortia they examined have formed in the following ways:

- Using homeland security or Urban Area Security Initiative (UASI) grants.
- Through either existing regional collaborations, or through leadership from a high-level figure.
- Following a major disruption (e.g., disaster, trade disruption) that brought the value of working together to the forefront.

SLTT Resilience Best Practices and Challenges

In 2011, the SLTTGCC examined how SLTTGCC members are leveraging their critical infrastructure partnerships and DHS Office of Infrastructure Protection tools to further advance infrastructure resilience in their regions. The study, *Landscape of State and Local Government Critical Infrastructure Resilience Activities and Recommendations*, revealed a best practice infrastructure resilience model, which includes the following four steps:

- Establish cross-sector public-private partnerships focused on the region's key lifeline sectors.
- Use those partnerships to assess each lifeline sector's interdependencies and cascading effects that could influence the sector's recovery time.
- Employ an exercise or workshop to uncover unknown sector interdependencies and test current levels of preparedness.
- Address the "outside the fence line" cascading effects on each lifeline sector that would fall to the local or state government to address through its emergency operations plan.

SLTT government resilience efforts primarily focus on four main activities: enhancing partnership development, improving emergency operations centers and integrating private-sector representatives, conducting response exercises with the private sector, and leading individual and private-sector readiness campaigns. However, SLTT governments reported that long-term incident recovery and designing resilience into the infrastructure were either not a priority or not considered under their purview.

The NIAC considered many of the challenges SLTT governments face in fostering infrastructure resilience in their communities, including the following:

- Trusted partnerships with industry and lifeline sectors take a significant amount of time and resources to establish. Owners and operators may be reluctant to share details about their restoration requirements.
- Many SLTT governments are only beginning to understand infrastructure interdependencies and cascading effects of disruptions.
- Mission responsibilities are often split between different State and local agencies, creating silos.

- Many SLTT and regional partnerships have not reached the level of maturity to transition from an infrastructure *protection* to an infrastructure *resilience* approach.

Insights from the SLTTGCC provided the NIAC with key information on resilience strategies, priorities, and needs from SLTT governments, providing direct insights from the government representatives who are responsible for forming and engaging in regional partnerships to improve national resilience.

Appendix G: Summary of Regional Resilience Organizations, Guides, and Processes

Two objectives of this study were to examine best practices and process improvements for regional resilience efforts. To gain insight into existing efforts, the Council studied two types of organizations working in regional resilience:

- Region-specific resilience consortia, non-profit organizations that bring together stakeholders to address specific cross-sector, public-private security and resilience issues in their region, exercise regional response plans, and build relationships that support disaster response.
- Cross-sector organizations and university-led initiatives that examine processes to improve regional resilience and recommend best practices and models that each region can use in building its own resilience.

The Council also examined progress from the U.S. Department of Homeland Security (DHS) Regional Resilience Assessment Program (RRAP) to understand the processes and effectiveness of multi-sector, public-private, region-specific resilience assessments.

This appendix summarizes best practices and lessons learned from these organizations, and gives a brief overview of existing models and processes that regionally based organizations have developed and piloted to assist individual regions in strengthening resilience.

DHS Regional Resilience Assessment Program

In 2009, DHS launched the Regional Resilience Assessment Program (RRAP) to analyze and assess the critical infrastructure systems, assets, and interdependencies within individual regions and identify opportunities for improvement. Recognizing the inherent individuality of regional infrastructures and risk, the RRAP projects enable regional homeland security officials and critical infrastructure partners to tailor assessments to the critical assets in their region and define opportunities to strengthen resilience. From 2009-2013, DHS conducted 35 assessments across the United States, implementing a combination of vulnerability assessments, regional analysis, and research related to the RRAP focus areas. Examples include:

- The 2009 New Jersey Exit 14 RRAP, which focused on lifeline sectors within a 10-mile radius of New Jersey Turnpike Exit 14 and service continuity during a large-scale terrorist attack
- The 2010 Atlanta Centennial Olympic Park RRAP, which focused on the security and dependencies of Atlanta's main tourist, business, and government district to inform urban design and cooperative planning.

Each year-long project helps partners identify critical cross-sector issues, operational dependencies or chokepoints, and planning and communications gaps. By offering unique opportunities for relationship building, enhanced coordination, and broader awareness among diverse interconnected stakeholders, the RRAP has catalyzed stronger and more informed public-private partnerships to tackle infrastructure security and resilience issues.

Regionally Based Resilience Capabilities and Methodologies

Dozens of regional organizations and consortia have formed across the country to solve national and region-specific security challenges and collaboratively build resilience to regional hazards. To inform its study, the NIAC examined both **region-specific consortia and the resilience models and processes developed by resilience-focused organizations** to identify common challenges and success factors for regional resilience. The study included a literature review and direct interviews with leaders from five organizations. The Council concluded that:

1. **Existing regional resilience consortia may provide best practices and lessons learned** on forming regional organizations, building public-private partnerships across sectors, conducting regional assessments and exercises, and collaboratively solving persistent regional problems.
2. **Non-profit resilience organizations have developed individual processes and models for regions to use** when building resilience that coalesce around four steps: Identify a neutral convener to lead resilience efforts and involve stakeholders early; assess and establish a baseline of regional risk; examine gaps through exercises and workshops; and develop and implement an action plan. Some of these processes are currently being piloted by U.S. regions.

The following table summarizes the region-specific consortia and regional resilience organizations the NIAC examined during this study.

Organization	Area Covered	Operating Model	Services	Notable Activities
Pacific Northwest Economic Region (PNWER) www.pnwer.org	United States: AK, ID, OR, MT, WA Canada: British Columbia, Alberta, Saskatchewan, and Yukon and Northwest Territories	Members passed legislation to form and join the organization. The board includes governors, legislators, and business leaders, and funding is provided by state/provincial governments, Federal grants, and private sponsorship.	PNWER's Center for Regional Disaster Resilience exercises infrastructure interdependencies, develops bi-annual action plans, and pilots tools and technologies for stakeholders that can apply to multiple regions.	Large-scale exercises: The Blue Cascades Exercise Series simulates large-scale disasters with impacts that cascade across the region to identify infrastructure interdependencies. The Emerald Down Exercise Series simulates full-scale cyber attacks.
All Hazards Consortium www.ahcusa.org	State-sanctioned non-profit includes DE, MD, NJ, NY, NC, PA, VA, WV, and DC	Brings together industry, universities, state homeland security and emergency management offices, and citizen leadership from across the region.	Eight working groups bring stakeholders together to plan regional multi-state workshops and summit meetings, draft white papers, and solve tactical problems in the region.	The Multi-State Fleet Movement Working Group is working to streamline waiver and permitting processes for interstate fleet movement, remove delays at toll booth crossings, and resolve fleet credentialing.

Organization	Area Covered	Operating Model	Services	Notable Activities
U.S. Resilience Project www.usresilienceproject.org	Works nationally with cross-sector owners and operators of critical infrastructure	Established to examine how private-sector best practices can be leveraged by national initiatives to increase the resilience of companies, communities, and the nation.	Aims to capture the best practices, processes, and tools from cross-sector businesses; integrate commercial best practices into national strategies and plans; and educate business and government leaders on new resilience tools.	Developed *Priorities for America's Preparedness: Best Practices from the Private Sector*, which examines existing industry best practices that could be used across sectors to better focus government resources to fill gaps.
The Infrastructure Security Partnership (TISP) www.tisp.org	2 million individuals, public agencies, and firms—trade groups, economic planners, architecture firms, standards organizations	Focuses on improving infrastructure resilience by addressing threats from a multi-hazard perspective and serving as a clearinghouse for resilience knowledge, skills, and education.	Co-founded the National Resilience Coalition to build a private-sector driven framework for national resilience that posits that State and regional risk management processes are critical to national resilience.	Developed the *Regional Disaster Resilience Guide*, a step-by-step "how-to" guide to develop an actionable plan to improve regional resilience.
Community and Regional Resilience Institute (CARRI) www.resilientus.org	Research institute started with support from the DHS Science and Technology Directorate and Oak Ridge National Lab	Formed to develop and share critical paths that any region or community may take to build its capacity to prepare for, respond to, and rapidly recover from significant disasters.	Began an 18-month effort in 2010 to create the Community Resilience System (CRS), a web-enabled process that communities can use to determine their resilience and take steps to improve.	The CRS pilot program was launched in 8 communities in 2011 with the Meridian Institute, a non-profit problem-solving organization.
American Society of Mechanical Engineers (ASME) Innovative Technologies Institute (ITI) www.asme.org	Brings together government, business, and academia to quickly work together to solve problems.	Provides market-relevant engineering and technology-based products to government, industry, and academia.	ASME-ITI created an objective business process for individual regions to build resilience with available financial and human resources.	It is piloting the Regional Resilience/ Security Analysis Process, which takes a quantitative, engineering approach to improving resilience within a region.

Keys to Successful Regional Partnerships

The following common success elements emerged from NIAC research and interviews with regional resilience organizations:

- A neutral convener is needed to bring the public and private sectors together and build trust.
    - Trust drives regional resilience by enabling information sharing and an understanding of interdependencies, which underscores resilience efforts.

- CEOs face competing priorities and need a strong business case for taking action that shows distinct benefits for their company. Regional governments too need to see an economic benefit for building resilience. Getting the right people to the table is critical.
    - Involving the private sector early in regional resilience efforts gives them ownership and ensures continued participation and implementation.
    - Successful efforts typically begin by identifying private sector needs, inviting the private sector to set the agenda and lead the effort, and working closely with supporting state representatives.
- Leadership, a clear value proposition, and a simple process drive success. Regional groups build trust over time by setting near-term targets and meeting them with tangible results.
- A resilient community or company is one in which economic growth and disaster/risk management teams are planning together.
    - Resilience isn't only about loss avoidance; it underpins growth and can be a competitive differentiator for companies *and* regions. This should be part of the value proposition for participation in joint efforts.
- Regions should focus more on their lifeline sectors and core infrastructures to better address interdependencies. Local communities often do this well, but regional coalitions may get stuck trying to address interdependencies through sector-specific efforts, which can create silos.

Regional Resilience Processes and Guides

TISP, CARRI, and ASME-ITI all provide step-by-step processes that use academic research, regional experience, and existing tools to create guides for assessing regional resilience and developing robust action plans. The NIAC concluded that:

- Regional resilience guides help commonly define regional resilience, identify the fundamental principles of regional resilience, and provide near-, medium-, and long-term recommendations for regions to develop region-specific action plans.
- Their processes are remarkably similar, and are now being piloted by community organizations. They each follow a version of this process:
    - Form a non-profit facilitating organization or coalition to lead resilience efforts.
    - Assess current resilience, typically through a baseline assessment followed by an exercise or workshop.
    - Develop a strategy for improving resilience and outline roles and responsibilities in an Action Plan.
    - Develop an implementation strategy and identify a coalition or organization to lead implementation.

Each resilience guide concluded that infrastructure interdependences are increasingly important, such that regional resilience cannot be achieved without engaging *all* stakeholders: state and local government leaders, non-profit community groups, utilities, and private businesses.

- Community resilience is intricately tied to the resilience of individual businesses and organizations that support the community, and vice versa.
- Public-private regional partnerships for resilience are essential to drive the process. Yet despite the value, participation can be a hurdle in terms of staff time, workload, and financial support for SLTT governments.

Finally, these organizations concluded that resilience improvements require significant capital, yet few models exist to channel Federal resources or shared private resources to regional partnerships or organizations. Work is needed to develop the value proposition and design funding models that direct resources toward regional efforts. A brief overview of each guide follows.

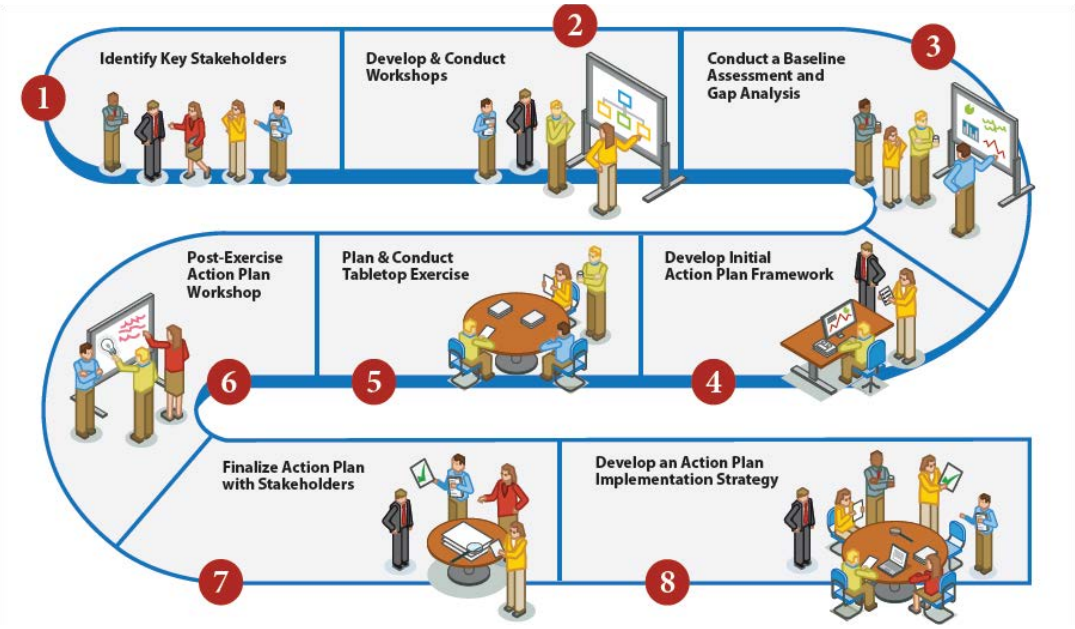
TISP Resilience Guide: Regional Disaster Resilience

More than 100 Federal, state, and local government and private sector organizations came together to develop the 2011 Regional Disaster Resilience: A Guide for Developing an Action Plan. It provides a step-by-step "how-to" guide to develop an actionable plan to improve region resilience. The guide includes:

- Near, medium, and long-term recommendations—many sector-specific—that regions can follow to develop a robust resilience Action Plan
- 14 focus areas that cover the disaster lifecycle, and a comprehensive inventory of interdependency needs, gaps, and recommendations in those areas
- A toolkit with action plan templates and assessment tools

The TISP guide offers a collaboratively developed process (see Exhibit 42) that each region can use to assess and improve resilience among all regional stakeholders.

Exhibit 42. TISP Regional Resilience Process

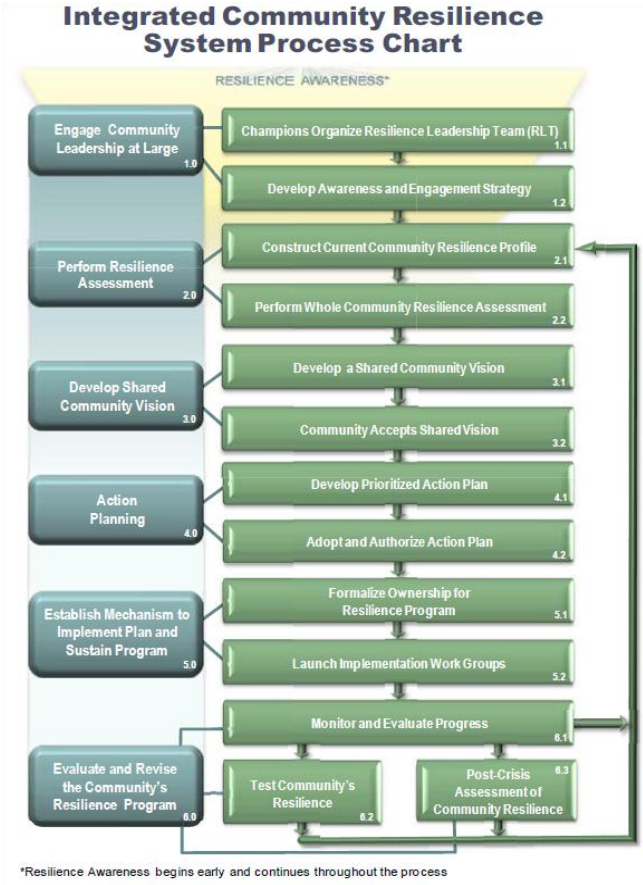


CARRI Resilience Guide: Community Resilience System

The Community Resilience System (CRS) is a six-stage process for building resilience that includes templates, checklists, and tools as well as a web-based tracking system to move through the process (see Exhibit 43). In contrast to the TISP process, CARRI's Community Resilience System focuses on smaller communities within a larger region. However, it also starts with engaging community leadership including organizing a leadership team and developing an engagement strategy. CARRI also recommends determining the current state of resilience through an assessment. The community should develop a shared vision for resilience before creating an action plan with priorities. Following plan adoption,

communities should establish a mechanism for implementation by formalizing ownership of the resilience program and launching implementation work groups. The plan should be monitored, evaluated, and revised. CARRI also advised having post-crisis assessments.

Exhibit 43. CARRI Regional Resilience Process



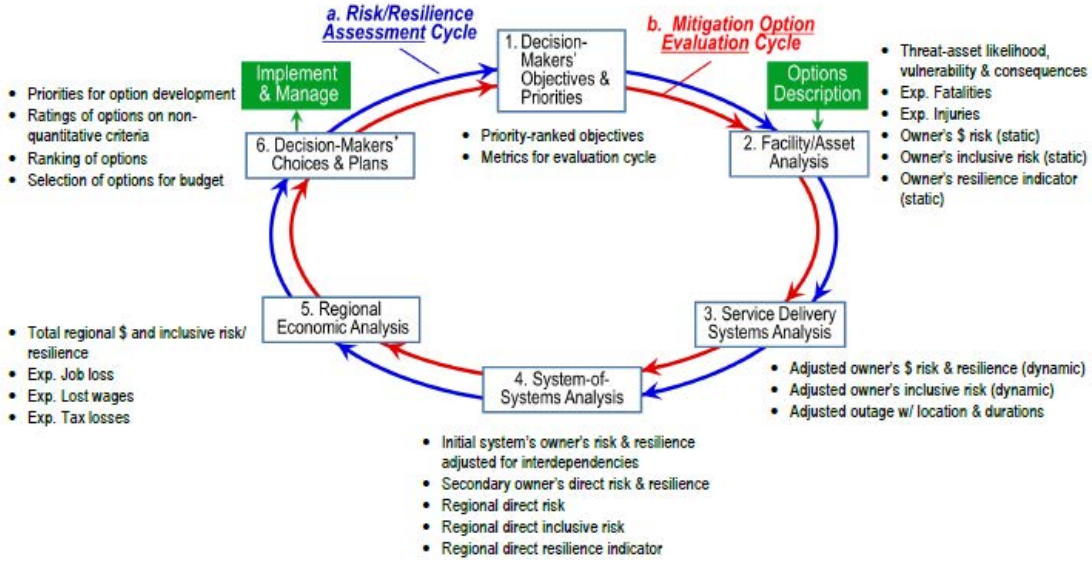
ASME-ITI Resilience Guide: Regional Resilience/Security Analysis Process (RR/SAP)

Developed under a DHS and U.S. Department of Energy contract managed by the Southeast Region Research Initiative (SERRI) of Oak Ridge National Laboratory, the process provides a quantitative, engineering approach to improving resilience (see Exhibit 44). It involves two cycles:

- Risk/Resilience Assessment Cycle—6-step cycle to:
    - Identify the most serious risk and resilience challenges facing the region and its infrastructure, public safety functions, and major industries.
    - Set a baseline for comparisons.
- Mitigation Options Evaluation Cycle—Identify new projects, programs, and/or investments to enhance the resilience, continuity, security, or other high-priority objectives.
    - Defines precisely how and how much the programs and investments would improve resilience, security, and the other criteria; what they will cost; and which would be the most valuable to the owners and to the region's citizens.

Each part of the process has been feasibility tested in four regions. The process was designed to be carried out by onsite, non-specialized, non-expert staff. However, it is still a prototype, and each phase requires additional development and field-testing.

Exhibit 44. ASME-ITI Regional Resilience/Security Analysis Process



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Appendix I: Acronym List

Acronym	Definition
AHC	All Hazards Consortium
APRAS	Automated Permit Routing/Analysis System
ASTM	American Society for Testing and Materials
CARRI	Community and Regional Resilience Institute
COLT	cell on light truck
COW	cell on wheels
CSA	combined statistical area
DHS	U.S. Department of Homeland Security
DIRT	Disaster Immediate Response Team
DOD	U.S. Department of Defense
DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
DPA	Defense Production Act
EEAC	Energy Emergency Assurance Coordinators
EEI	Edison Electric Institute
EMAC	Emergency Management Assistance Compact
EOC	Emergency Operations Center
EPA	Environmental Protection Agency
ESF	Emergency Support Function
ETR	estimated time to restoration
FAA	Federal Aviation Administration
FEMA	Federal Emergency Management Agency
FMCSA	Federal Motor Carrier Safety Administration
FTA	Federal Transit Administration
GETS	government emergency telecommunications service
GWOB	Geeks Without Bounds
IFTA	International Fuel Tax Authority
IP	Internet Protocol
IPAWS	Integrated Public Alert and Warning System
IRP	International Registration Plan
ISAC	Information Sharing and Analysis Center
ITDRC	Information Technology Disaster Resource Center
MAP-21	Moving Ahead for Progress in the 21st Century Act
MCOV	Mobile Communications Office Vehicle
MTA	Metropolitan Transportation Authority
NAA	no action assurance
NARUC	National Association of Regulatory Utility Commissioners
NASEO	National Association of State Energy Officials
NCC	National Coordinating Center for Telecommunications
NCSL	National Conference of State Legislatures
NEMA	National Emergency Management Association
NGA	National Governors Association
NGO	non-governmental organization
NIAC	National Infrastructure Advisory Council
NOAA	National Oceanic and Atmospheric Administration

Acronym	Definition
NRCC	National Response Coordination Center
NYC	New York City
NYDOT	New York Department of Transportation
NYPD	New York Police Department
OE	Office of Electricity Delivery and Energy Reliability
OEM	Office of Emergency Management
OSHA	Occupational Safety and Health Administration
PATH	Port Authority Trans-Hudson
PennDOT	Pennsylvania Department of Transportation
PHMSA	Pipeline and Hazardous Materials Safety Administration
PNWER	Pacific Northwest Economic Region
PPD-21	Presidential Policy Directive on Critical Infrastructure Security and Resilience
PSE&G	Public Service Electric and Gas Company
PTI	Public Technology Institute
RC3	Regional Consortium Coordinating Council
RFG	reformulated gasoline
ROIC	Regional Operations and Intelligence Center
RRAP	Regional Resilience Assessment Program
RSF	Recovery Support Functions
RVP	Reid Vapor Pressure
SEC	Securities and Exchange Commission
SEPTA	Southeastern Pennsylvania Transportation Authority
SLOSH	Sea, Lake, and Overland Surges from Hurricanes
STEP	Spare Transformer Equipment Program
STEP (FEMA)	Sheltering and Temporary Essential Power
TISP	The Infrastructure Security Partnership
TSA	Transportation Security Administration
USRP	U.S. Resilience Project
VOAD	Voluntary Organizations Active in Disaster
WARN	Water Agency Response Network
WPS	wireless priority service

Appendix A-8

GOVERNMENT OF CANADA
ACTION PLAN FOR CRITICAL INFRASTRUCTURE

(Provided in electronic format only due to
document size and in order to conserve paper)

Action Plan
for Critical Infrastructure

Government of Alberta

British Columbia
www.gov.bc.ca

Manitoba

New Nouveau Brunswick
CANADA

Newfoundland Labrador

Northwest Territories

Nova Scotia
Nouvelle-Écosse

Nunavut

Ontario

Prince Edward Island
CANADA

Québec

Government of Saskatchewan

Yukon
Government

Canada

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1. Introduction

The *National Strategy for Critical Infrastructure* and supporting Action Plan establish a collaborative federal, provincial, territorial and critical infrastructure sector approach that will be used to strengthen critical infrastructure resiliency.

To keep pace with the rapidly evolving risk environment, a key element of the national approach is an Action Plan that builds on the central themes of the National Strategy:

- sustainable partnerships with federal, provincial and territorial governments and critical infrastructure sectors;
- improved information sharing and protection; and
- a commitment to all-hazards risk management.

This Action Plan will be updated regularly to enable partners to anticipate and address new risks. The Strategy recognizes that each government, as well as infrastructure owners and operators, have major roles and responsibilities in strengthening the resiliency of critical infrastructure and will exercise their responsibilities as appropriate and according to the governments' respective jurisdictions. Provincial and territorial governments will also coordinate activities with their municipalities and local governments where it applies. Progress will be measured by national outcomes, including:

- strengthened resiliency of critical infrastructure in Canada;
- a better understanding of the risks to critical infrastructure; and
- swift and effective response and recovery when disruptions occur.

2. Action Plan

This Plan sets out action items in the areas of partnerships, risk management and information sharing. Given the range, complexity and linked nature of these action items, a critical path is also detailed. The Federal-Provincial-Territorial Senior Officials Responsible for Emergency Management have established priorities for the first and second years after release of the *National Strategy for Critical Infrastructure*.

Work will be undertaken across all three elements of the Strategy (partnerships, risk management and information sharing). Within years one and two, partners will focus primarily on the development of sector networks and the National Cross-Sector Forum, as well as improved information sharing. Initial activities in support of risk management will also be undertaken at this time. Their completion is tied to the establishment of the sector networks and National Cross-Sector Forum. During subsequent years, effective sector networks and improved information sharing will enable further risk management activities (e.g., development of sectoral risk profiles, guidelines for risk assessments), emergency management planning and exercises.

The Action Plan recognizes that, in an emergency, the first response is almost always by the municipalities and at the provincial and territorial level because disasters occur most often locally and because provincial and territorial governments have responsibility for emergency management within their respective jurisdiction. Should a provincial or territorial government require resources beyond their own in an emergency or critical infrastructure disruption, the federal government responds rapidly to any request for assistance.

Consistent with the *National Strategy for Critical Infrastructure* and the *Emergency Management Framework for Canada*, the following chart describes the roles and responsibilities for the Action Plan.

	Roles	Responsibilities
Federal government	Lead federal activities	• Advance a collaborative federal, provincial and territorial approach to strengthening the resiliency of critical infrastructure • Collaborate with provincial and territorial governments to achieve the objectives of the Strategy • Collaborate with national associations • Collaborate with critical infrastructure owners and operators within federal mandate in consultation with provinces and territories
Provincial/ territorial governments	Lead provincial/ territorial activities	• Advance a collaborative federal, provincial and territorial approach to strengthening the resiliency of critical infrastructure • Collaborate with federal, provincial and territorial governments to achieve the objectives of the Strategy • Coordinate activities with their stakeholders, including municipalities or local governments where it applies, associations and critical infrastructure owners and operators
Critical infrastructure owners/ operators	Collaboratively manage risks related to their critical infrastructure	• Manage risks to their own critical infrastructure • Participate in critical infrastructure identification, assessment, prevention, mitigation, preparedness, response and recovery activities

2.1 Build partnerships

In year one, the building blocks for collaborative work and information sharing will be established. Year one will focus on the development of sector networks and a National Cross-Sector Forum. Renewal of the Federal-Provincial-Territorial Critical Infrastructure Working Group will be an integral part of this Action Plan and ongoing critical infrastructure initiatives across Canada.

The enormity and complexity of critical infrastructure, the interdependencies that cross sectors and jurisdictions, and the uncertain nature of risks and natural disasters make the effective implementation of protection efforts a great challenge. The coordination mechanisms described below establish linkages among federal, provincial and territorial governments and critical infrastructure sectors. They will all be invited to participate in the sector networks and will be represented at the National Cross-Sector Forum. In addition to direct coordination between critical infrastructure partners, the structures described below provide a national framework that fosters relationships and improves information sharing and risk management within and across critical infrastructure sectors.

Sector networks will be established, building on existing consultation mechanisms. *Year 1*

A collaborative, national approach to critical infrastructure requires the collaboration of federal, provincial, territorial and critical infrastructure sector partners. As a starting point, at the national level, sector networks will be established for each of the critical infrastructure sectors.

The sector networks will provide standing fora for discussion and information exchange among sector-specific industry stakeholders and governments. The sector networks reflect a partnership model that will enable governments and critical infrastructure sectors to undertake a range of activities (e.g. risk assessments, plans to address risks, exercises) unique to each sector. These sector networks will also enable improved collaboration among critical infrastructure partners in the development and execution of risk management and information sharing activities. Each sector network will also develop sector risk profiles, support the development of tools and best practices, and advance implementation of the Strategy within their sector.

Recognizing the interconnected nature of critical infrastructure, all critical infrastructure sectors are confronted with the challenge of addressing interdependencies. Responding to a disruption in one critical infrastructure sector cannot be undertaken in isolation of other sectors. For example, all critical infrastructure sectors are dependent on human resources, government services and cyber systems. Therefore, each sector network will adopt a comprehensive approach to strengthening the resiliency of critical infrastructure, based on an integrated, all-hazards risk management approach.

In collaboration with federal, provincial and territorial governments, each sector network will also establish an approach to identifying and addressing international critical infrastructure issues. To support these efforts, each sector network will be provided with a methodology and template incorporating international factors into their sector risk profile.

Key action: Sector networks will be established for each of the critical infrastructure sectors. Members of the sector network (e.g., private sector, federal government, provincial and territorial

governments) will set priorities and direct sector-specific work plans. Development of the sector networks will build on existing consultation mechanisms. Additional details are provided in Annex A.

Timeline: Sector networks for each critical infrastructure sector will be established in Year 1.

National Cross-Sector Forum: A National Cross-Sector Forum will be established to promote collaboration across the sector networks, address interdependencies and promote information sharing across sectors. *Year 1*

To support a collaborative approach to critical infrastructure, a National Cross-Sector Forum will be established to promote collaboration across the sector networks and address cross-jurisdictional and cross-sectoral interdependencies. More specifically, the role of the National Cross-Sector Forum is to:

- provide advice and recommendations to the Federal-Provincial-Territorial Senior Officials Responsible for Emergency Management regarding policy and activities relating to critical infrastructure resiliency;
- support the implementation of a risk management approach across sectors;

- review the Strategy and its supporting Action Plan to ensure consistency with the needs of provinces and territories, and with those of critical infrastructure owners and operators, and other stakeholders;
- provide feedback and recommendations on the implementation of actions related to the Strategy; and
- facilitate a broad exchange of information between federal, provincial and territorial governments and owners and operators on critical infrastructure issues.

The National Cross-Sector Forum will also identify high priority and emerging issues and make relevant recommendations to the Federal-Provincial-Territorial Senior Officials Responsible for Emergency Management to address these issues.

Key action: The Federal-Provincial-Territorial Senior Officials Responsible for Emergency Management will develop the National Cross-Sector Forum, drawing membership from the chairs of each sector network. Additional details are available in Annex B.

Timeline: The National Cross-Sector Forum will be established in Year 1.

Federal-Provincial-Territorial Critical Infrastructure Working Group will be the standing forum for federal, provincial and territorial government collaboration on critical infrastructure resiliency matters.

Year 1

As the primary conduit for federal, provincial and territorial government collaboration on critical infrastructure matters, key roles of the Federal-Provincial-Territorial Critical Infrastructure Working Group include:

- supporting the implementation of the *National Strategy for Critical Infrastructure* and Action Plan within federal, provincial and territorial governments;
- facilitating a federal/provincial/territorial network to support critical infrastructure-related information sharing, risk management, planning and exercises;
- cooperating with the sector networks to facilitate private sector initiatives within federal, provincial and territorial jurisdictions;
- providing advice and recommendations to the Federal-Provincial-Territorial Senior Officials Responsible for Emergency Management;
- advancing a common understanding of risks and interdependencies; and
- identifying linkages among federal, provincial and territorial programs and initiatives and facilitating an exchange of information and best practices.

Key action: Renewal of the Federal-Provincial-Territorial Critical Infrastructure Working Group. Additional details are available in Annex C.

Timeline: January 2010.

2.2 Share and protect information

Building on the sector networks, partners will turn their attention towards the development of an information sharing framework that will enable federal, provincial and territorial governments and critical infrastructure sectors to produce and share a wider and more timely range of information products, in full respect of existing federal, provincial and territorial legislation and policies. Ultimately, these improvements in information sharing will assist federal, provincial and territorial governments, and the critical infrastructure sectors, with risk management.

Establish an information sharing framework to accelerate sharing, improve quality and better protect critical infrastructure information. ***Year 2***

To facilitate information sharing among critical infrastructure partners, it is proposed that an information sharing framework be established to (i) accelerate dissemination of critical infrastructure information, (ii) improve the quality of information, and (iii) better protect information. The framework will include the following elements:

- identification of existing processes for sharing and protecting critical infrastructure information;
- a plan to address gaps and anticipate new pressures and requirements;
- identification of key points of contact to improve government-to-government and government-to-sector communications;
- enhanced process for disseminating information;
- addressing legal and policy barriers to sharing information.

Better information products

Due to the complex jurisdictional issues associated with critical infrastructure, and because information is not readily available on vulnerabilities or protective measures, an accurate assessment of the state of readiness of each sector is difficult. This problem is exacerbated by the uneven quantity and quality of critical infrastructure information across federal, provincial and territorial governments, and critical infrastructure sectors.

To improve the quality of information products, federal, provincial and territorial governments will work directly with their sector experts to produce more targeted information (e.g., better risk information), in a Canadian context. The sector networks will identify areas of emerging concern and identify priority areas for information products. Owners and operators can then use that information to improve the resiliency of their assets and essential services.

Information sharing and protection protocol

To facilitate the responsible sharing of sensitive information, the Federal-Provincial-Territorial Critical Infrastructure Working Group will lead the development of a coherent approach to information protection among governments. An information protection protocol will be developed to establish mechanisms to protect sensitive information from inappropriate disclosure, and ultimately foster an

environment of trust among partners. The protocol will serve as the basis for the development of information sharing agreements. The protocol will also recognize that the sharing and disclosure of protected/classified information is governed by existing federal, provincial and territorial legislation and policies. Development of this protocol will include efforts to address related federal/provincial/territorial policy and legal barriers as well as actual or perceived gaps.

Information dissemination

A single framework is needed to enable quick exchange of information among key points of contact across the critical infrastructure sectors, taking into account the communication protocols and policies already established by the governments. Federal, provincial and territorial governments and critical infrastructure sectors will develop this process to enable timely information exchange to deal with real or potential disruptions that threaten the integrity of critical infrastructure in Canada.

Key action: Federal, provincial and territorial governments will collaborate to develop an information sharing framework. Additional detail is available in Annex D.

Timelines: An information sharing framework will be completed in Year 2.

2.3 Implement all-hazards risk management approach

While partnerships and enhanced information sharing represent the building blocks of the Canadian approach to enhancing the resiliency of critical infrastructure, these cannot be undertaken in isolation of risk management and the development of plans and exercises to address these risks.

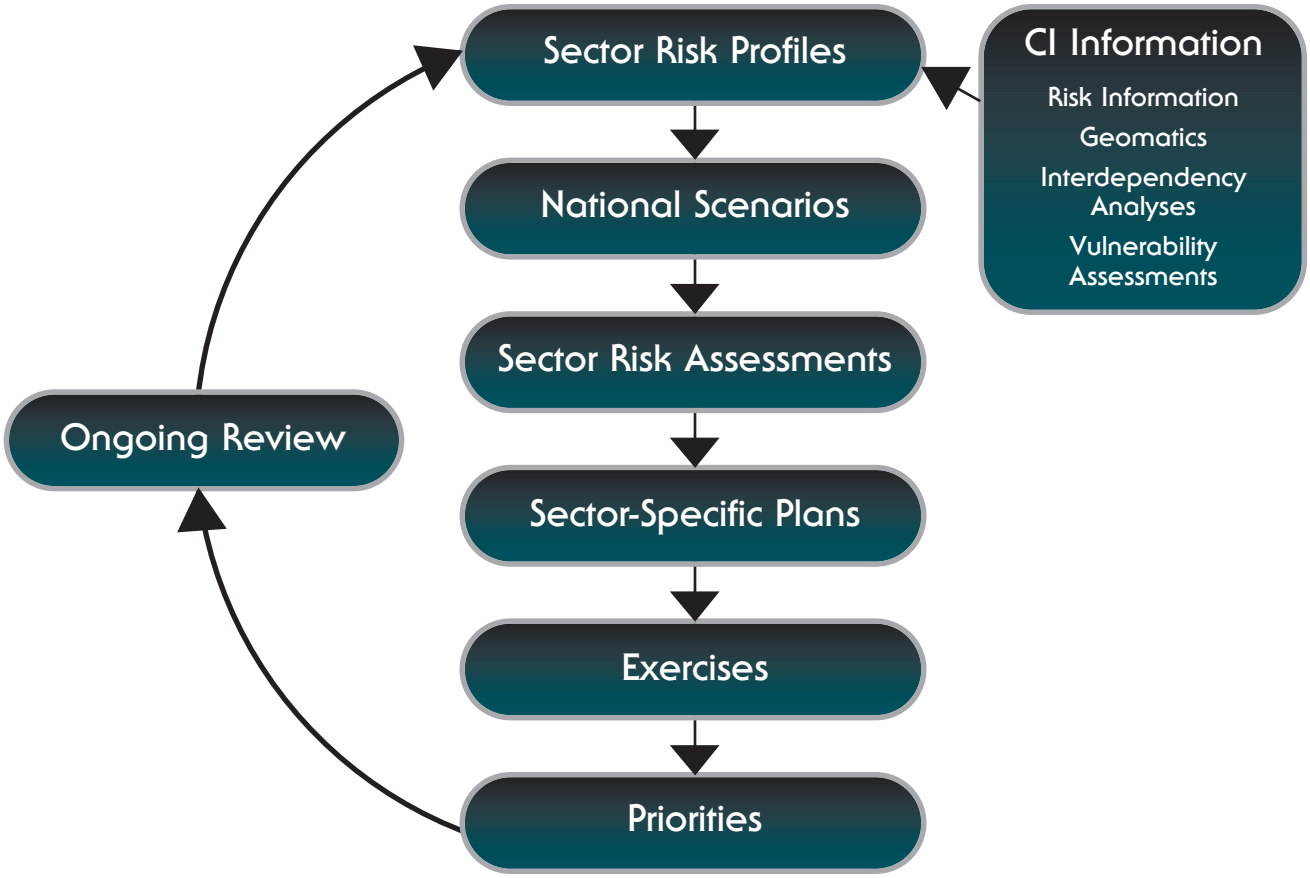
Risk assessments of critical infrastructure in Canada: Sector networks will develop risk profiles in cooperation with governments and the private sector. ***Year 2 and ongoing***

Although the Strategy promotes a common approach to enhancing the resiliency of critical infrastructure, owners and operators and all governments are ultimately responsible for implementing a risk management approach appropriate to their situation. Implementation of a risk management approach to critical infrastructure will include the development of three different types of products:

1. Sector risk profiles at the national level;
2. Risk assessments; and
3. Risk management tools and guidance.

The success of these efforts, in particular the sector risk profiles, is dependent on other elements of the Action Plan, such as the development of sector networks and improved information sharing. Information will be drawn from governmental sector risk profiles, as appropriate, to support and validate the sector risk profiles at the national level.

The sector risk profiles will be useful to each sector network in identifying priority areas of sectoral concern, research and planning, developing a sector-specific plan and assessing the effectiveness of critical infrastructure programs and activities. Each sector risk profile will be combined to provide a consolidated overview of the risks to critical infrastructure across all sectors in Canada.



As illustrated in the flow chart above, the sector risk profiles will enable the development of scenarios. Scenario-driven models will, in turn, facilitate the development of more precise sector risk assessments and sector-specific plans to address these risks. Ultimately, these risk assessments would guide priorities for each sector.

Key action: The undertaking of sector risk profiles will be managed through each sector network.

Timelines: Sector risk profiles will be completed in Year 2. Tools and guidance will be shared on an ongoing basis. Owner/operator risk assessments will be an ongoing activity.

Sector-specific work plans will be developed and shared among federal, provincial and territorial governments, and owners and operators to address risks to critical infrastructure.

Year 3 and ongoing

Sector-specific work plans will be useful to each sector network in addressing all-hazards and interdependencies confronting their critical infrastructure. Although each plan will be tailored to the structures and challenges of its sector, tools will be made available to help each sector network identify critical assets within the sector, assess risks from an all hazards perspective, and develop measures to address risks for the sector. These tools are to be developed by the designated federal sector-specific departments and agencies in coordination with relevant government and private-sector representatives. These tools will be used by the Federal-Provincial-Territorial Critical Infrastructure Working Group to evaluate whether any gaps exist in the protection of critical infrastructure on a national level and, if so, to work with the sectors to address them. It is anticipated that the sector-specific plans will continue to evolve as the critical infrastructure, threats against them, and strategies for protecting against and responding to these threats and incidents evolve.

Characteristics of effective sector-specific work plans include, but are not limited to, the following:

- *Comprehensive:* Effective plans and programs must address physical, cyber and human elements of critical infrastructure. In addition to the all-hazards component of these plans and programs, analysis should be undertaken to identify and address interdependencies within and across sectors.
- *Integrated:* In light of the shared responsibility for addressing risks to critical infrastructure, and given the widespread implications of critical infrastructure interdependencies, sector-specific work plans need to be complementary across federal, provincial and territorial governments and sectors.
- *Risk-based:* Sector-specific work plans should be based on an understanding of the risk environment and designed to allow measurement, evaluation and feedback on the effectiveness of mitigation efforts. This allows owners, operators and governments to reevaluate risk levels after the plan has been implemented.

Key action: To address the risks identified in the sector risk profiles, sector-specific work plans will be developed through the sector networks. These plans will be complementary across federal, provincial and territorial governments and sectors.

Timelines: Sector-specific work plans will be completed in Year 3. These work plans are living documents and will be updated on an ongoing basis. Owner/operator critical infrastructure plans will be an ongoing activity.

Exercises: Federal, provincial and territorial governments, in collaboration with the private sector, will conduct national exercises in support of a common approach to enhancing the resiliency of critical infrastructure. ***Ongoing***

Exercises provide:

- an efficient means to test, evaluate and improve planning;
- training in a lower-risk environment for responders, emergency managers and senior officials at all levels; and
- quality assurance of the response to disruptions.

Exercises are underway across Canada on an ongoing basis (e.g., through federal, provincial and territorial emergency managers and owners and operators). Through these exercises, federal, provincial and territorial governments cooperate with sectors to assess capabilities for responding to disruptions of critical infrastructure. The purpose of these exercises is to clarify the understanding of roles and responsibilities, address interdependencies and raise awareness of the risks to critical infrastructure.

Key action: Federal, provincial and territorial governments will conduct exercises and assist in the integration of regional exercise planning across jurisdictions and with the critical infrastructure sectors to support a common approach to enhancing the resiliency of critical infrastructure.

Timelines: Exercises will be an ongoing activity.

3. Review

Federal, provincial and territorial governments and critical infrastructure sectors will work together to monitor the implementation of the Strategy and support the assessment of programs and activities of the Strategy targeted at enhancing the resiliency of critical infrastructure in Canada.

The Action Plan will be reviewed, in collaboration with the sector networks, the National Cross-Sector Forum and the Federal-Provincial-Territorial Critical Infrastructure Working Group three years after launch and every five years thereafter.

Annex A – Sector networks

Purpose

The purpose of the sector networks is to develop national sector-specific standing fora to address sectoral and regional issues, and enable information sharing on critical infrastructure.

Recognizing the unique structures and challenges faced by each sector, the following should be considered as guidelines for the development and role of the sector networks. The sector networks will:

- promote timely information sharing;
- identify issues of national, regional or sectoral concern;
- advance a common understanding of risks and interdependencies, and implement sector-specific all-hazards risk analyses;
- support the development of sector-specific work plans to address risks and interdependencies;
- participate in exercises to test sector-specific work plans and identify new risks;
- provide guidance on current and future challenges related to the sector; and
- promote the development of tools and best practices for enhancing the resiliency of critical infrastructure.

It is expected that a sector network will be developed for each of the ten critical infrastructure sectors. Where appropriate, sub-sector networks may also be established to reflect the diversity of a particular sector. Recognizing that Public Safety Canada is responsible for leading the overall federal effort to strengthen the resiliency of critical infrastructure, the sector-specific federal government departments and agencies are set out in the table below. As required, supporting federal departments will also participate in the sector networks.

Sectors	Sector-specific federal department/agency
Energy and utilities	Natural Resources Canada
Information and communication technology	Industry Canada
Finance	Finance Canada
Health	Public Health Agency of Canada
Food	Agriculture and Agri-Food Canada
Water	Environment Canada
Transportation	Transport Canada
Safety	Public Safety Canada
Government	Public Safety Canada
Manufacturing	Industry Canada Department of National Defence

Membership

Participation in these networks is voluntary. Each sector network will develop governance processes and roles appropriate to the sector. In most cases, the sector networks will be composed of owners and operators from the sector (with a focus on national industry associations), and of relevant federal, provincial and territorial departments and agencies. Involvement of associations will be valuable in achieving effective outreach and gaining buy-in from the sector.

To facilitate the exchange of information, members of the sector network will collaborate to develop guidelines to safeguard information being shared through their network. It is also expected that each member will sign a non-disclosure agreement.

The Chair of each sector network will represent the sector at the National Cross-Sector Forum.

Annex B – National Cross-Sector Forum

Purpose

The purpose of the National Cross-Sector Forum is to maintain a comprehensive and collaborative Canadian approach to critical infrastructure by providing a standing mechanism for discussion and information exchange within and between the federal, provincial and territorial governments and the critical infrastructure sectors.

The role of the National Cross-Sector Forum is to:

- provide advice and recommendations to the Federal-Provincial-Territorial Senior Officials Responsible for Emergency Management;
- foster a complementary approach to critical infrastructure at all levels and address cross-jurisdictional and cross-sectoral interdependencies;
- recommend actions regarding research priorities, the sharing of information, the development of sector-specific plans and exercises;
- facilitate information sharing between federal, provincial and territorial governments, and owners and operators on physical and cyber security.

The National Cross-Sector Forum will provide advice and recommendations to the Federal-Provincial-Territorial Senior Officials Responsible for Emergency Management, which manages federal, provincial and territorial government collaboration on critical infrastructure matters. In turn, Federal-Provincial-Territorial Senior Officials Responsible for Emergency Management Co-Chairs will report to the Federal-Provincial-Territorial Deputy Ministers responsible for emergency management on critical infrastructure matters.

Membership

Membership will be drawn from the sector networks and will be representative of a broad base of owners and operators, associations, and federal, provincial and territorial governments. Where potential members fall under a specific jurisdiction (e.g. health care institutions, municipalities, some energy providers), the responsible government will proceed with invitations, as deemed appropriate. Membership will develop the terms of reference for the National Cross-Sector Forum, including designation of chair(s).

The chair(s) will work with the members to set agendas, determine the frequency of meetings and to manage the business of the National Cross-Sector Forum.

Procedures

- To facilitate the exchange of information, the members will sign a non-disclosure agreement and the National Cross-Sector Forum will adopt information sharing guidelines to protect information from inappropriate disclosure.
- The National Cross-Sector Forum may hold open or closed meetings.
- The National Cross-Sector Forum may invite government or private sector experts to participate in its meetings and to act as subject matter experts.

Secretariat

The Critical Infrastructure Policy Division, Public Safety Canada, will serve as the National Cross-Sector Forum's secretariat. The Division's staff will provide strategic advice, support information sharing, develop the cross-sector risk profile and provide general support to the National Cross-Sector Forum. Division staff members will also manage the preparation of documents for the meetings and prepare meeting summaries and reports.

Remuneration

The National Cross-Sector Forum members serve without remuneration, but members from outside the National Capital Region may be reimbursed for travel and living expenses associated with the meetings in accordance with Treasury Board of Canada guidelines.

Annex C – Federal-Provincial-Territorial Critical Infrastructure Working Group

Purpose

The purpose of the Federal-Provincial-Territorial Critical Infrastructure Working Group is to be the standing forum and primary conduit for federal/provincial/territorial government collaboration on critical infrastructure matters.

Objectives/Priorities

- Support the implementation of the Strategy within federal, provincial and territorial jurisdictions;
- Provide guidance and participate in the evolution and implementation of the Action Plan;
- Act as a clearinghouse for governments on critical infrastructure related issues to the Federal-Provincial-Territorial Senior Officials Responsible for Emergency Management;
- Facilitate federal/provincial/territorial networking to support critical infrastructure information sharing, risk management, critical infrastructure planning and exercises;
- Identify critical infrastructure issues of regional or jurisdictional concern;
- Advance a common understanding of critical infrastructure risks and interdependencies;
- Encourage participation in exercises to test sector-specific work plans and identify new risks;
- Provide guidance on current and future challenges related to critical infrastructure; and,
- Identify linkages among federal, provincial and territorial programs and initiatives and facilitate sharing of information and best practices.

Membership

Membership in the Working Group is open to all governments for participation in accordance with their needs and as their resources permit. All governments are members of the Federal-Provincial-Territorial Critical Infrastructure Working Group regardless of their presence at meetings; no decision will be made without the sharing of information and the opportunity for all members to comment.

It has been agreed that all decisions will be made by consensus.

The Working Group will be co-chaired by a representative from the Emergency Management and National Security Branch of Public Safety Canada and a provincial/territorial representative determined by group consensus.

Reporting

The Co-Chairs (Public Safety Canada and a provincial/territorial representative) will report to the Federal-Provincial-Territorial Senior Officials Responsible for Emergency Management on critical infrastructure matters.

Working Group Secretariat

Public Safety Canada will serve as the secretariat for the Federal-Provincial-Territorial Critical Infrastructure Working Group by organizing meetings, as identified by the Co-Chairs, and will be responsible for preparing and distributing material.

Annex D – Information sharing framework

Purpose

The following outlines a way forward for producing a wider range of relevant critical infrastructure information products and sharing them in a timely manner.

Challenges

Currently, critical infrastructure protection is hampered by (i) uneven understanding of risks and vulnerabilities, (ii) insufficient sharing of information and (iii) limited integration of existing information into coherent situational awareness.

Information sharing framework

To facilitate information sharing among critical infrastructure partners, the Action Plan proposes that an information sharing framework be established to provide a clear structure for the process of establishing information sharing relationships. In respect of existing federal, provincial and territorial legislation and policies, three key features of this framework are: 1) the information protection protocol, 2) development of better information products and 3) information dissemination.

1. Information Protection Protocol

As a starting point, an information protection protocol is needed to facilitate sharing of sensitive critical infrastructure information between governments and critical infrastructure sector owners and operators. It will provide guidance for the protection of sensitive information in support of more accurate and timely information sharing between organizations by setting out the principles that underpin information protection. It will also assist organizations in the development of information sharing agreements or memoranda of understanding on information sharing and protection. Development of this protocol will include efforts to address federal, provincial and territorial policy and legal barriers on protected/classified material.

Purposes for which shared critical infrastructure information may be used

The protocol will apply to the exchange of critical infrastructure information that is shared in confidence by critical infrastructure sector owners and operators. Examples of uses of critical infrastructure information include but are not limited to:

- managing response to an emergency;
- establishing policies and programs respecting emergency management and critical infrastructure in both physical and cyber dimensions;
- conducting exercises and providing training related to critical infrastructure;
- developing information products and tools to support national-level, sectoral and cross-sectoral initiatives (e.g., all-hazards risk assessments, high-level risk profiles);
- developing all-hazards risk and vulnerability management tools; and
- analyzing interdependencies between critical infrastructure sectors.

2. Better information products

Due to the complex jurisdictional issues associated with critical infrastructure, and the lack of information on interdependencies, vulnerabilities or protective measures, it is difficult to develop accurate assessments of the state of readiness of each sector. This problem is exacerbated by the uneven quantity and quality of critical infrastructure information across federal departments and agencies, provinces, territories and critical infrastructure sectors.

To improve the quality and usefulness of the information products, members of the sector networks will identify areas of emerging concern and identify priority areas for information products. It is expected that these information products will be used by critical infrastructure partners to improve the resiliency of their key assets and services.

The sector networks will advise the National Cross-Sector Forum on areas of emerging concern and identify priority areas for information products. For example, it is expected that the National Cross-Sector Forum will recommend to the Federal-Provincial-Territorial Senior Officials Responsible for Emergency Management areas that require new or updated information products.

3. Information dissemination

As a starting point in the development of the information sharing framework, information dissemination will be improved for (i) emergency situations and (ii) regular situations.

Emergency situations

During an emergency, quick exchange of information among key points of contact across the critical infrastructure sectors is needed. To accomplish this, connections between federal, provincial and territorial points of contact and with owners and operators under their respective jurisdiction need to be strengthened. Federal, provincial and territorial governments will collaborate to develop this process to enable timely information exchange to deal with disruptions – real or perceived, imminent or actual, a natural disaster or terrorist activity – that threaten the integrity of critical infrastructure.

Regular situations

The federal government currently sponsors security clearances for key stakeholders in some critical infrastructure sectors who require access to information related to the resiliency of their critical infrastructure. On an ongoing basis, Public Safety Canada, its portfolio partners and sector-specific federal departments will examine the need to expand the availability of these security clearances for each of the critical infrastructure sectors. In addition, the Federal-Provincial-Territorial Critical Infrastructure Working Group will consider other options for improved information dissemination (e.g., scrubbing sensitive information to allow for regular unclassified distribution).

For less sensitive information, a secure, web-based, critical infrastructure information sharing portal will also be developed. Development of this portal will leverage existing mechanisms, where appropriate, to reduce duplication and streamline processes. Creation of this portal will be an iterative process and three general development phases can be outlined. The first development phase will involve:

- consulting with stakeholders to determine their information sharing needs;
- constructing the information sharing portal to support sharing of unclassified information; and
- initially populating the portal with unclassified information.

Initially, the information sharing portal will only support the sharing of public, unclassified information (Public Layer). The first phase of development will be completed within one year of Strategy approval.

The goal of the second phase is to begin populating the portal with information related to all aspects of critical infrastructure. This second phase will reflect the Strategy's all-hazards approach and will include adding information products such as physical and cyber threat assessments, tools for risk assessments, interdependency assessments and other unclassified information products.

The final phase of development will involve implementing the secure, web-based, user authentication and information sharing system (Secure Layer). The Secure Layer will support two-way information sharing of classified information, including risk assessments. The Secure Layer will include discussion forums, workspaces, exercise calendars, and other information sharing tools. This Layer will facilitate communication between sector network members, National Cross-Sector Forum members and other critical infrastructure stakeholders.

Timeline: *Information sharing framework*

Action	Lead
Year 1	
Establish information sharing protocol	Federal-Provincial-Territorial Critical Infrastructure Working Group
Compile inventory of information currently being shared	Special Working Group of the Federal-Provincial-Territorial Critical Infrastructure Working Group
Identify information gaps and anticipate new requirements	Special Working Group of the Federal-Provincial-Territorial Critical Infrastructure Working Group
Develop statement of requirements for the information sharing portal	Public Safety Canada
Year 2	
Establish the Public Layer of the information sharing portal	Public Safety Canada
Develop and test secure, web-based user authentication	Public Safety Canada
Implement the Secure Layer of the information sharing portal	Public Safety Canada
Ongoing	
Enhance information dissemination	Federal-Provincial-Territorial partners, sector networks
Populate Public and Secure Layers of the information sharing portal	Federal-Provincial-Territorial partners, sector networks

Annex E – Risk management

Managing risk is a shared responsibility of all critical infrastructure stakeholders to continuously, proactively and systematically understand, manage, and communicate risks and interdependencies across the critical infrastructure community. Moving forward with this comprehensive risk management process requires federal, provincial and territorial governments to collaborate with their critical infrastructure partners.

While the Strategy promotes a common approach to enhancing the resiliency of critical infrastructure, and the sharing of tools and best practices, owners and operators and each jurisdiction are ultimately responsible for implementing a risk management approach appropriate to their situation.

Implementation of a risk management approach to critical infrastructure will require the development of three different types of products:

1. Sector risk profiles at the national level;
2. Risk assessments; and
3. Risk management tools and guidance.

The success of these efforts, in particular the sector risk profiles, is dependent upon other elements of the Action Plan such as the successful establishment of the sector networks and improved information sharing and development.

Timelines

Sector risk profiles should be completed in Year 2. Tools and guidance will be provided as soon as sector networks are established and new tools will be developed on an ongoing basis. Owner/operator risk assessments, where they exist, should be an ongoing activity.

Sector risk profiles

It is essential that all of the key critical infrastructure partners within a sector have an accurate and common understanding of their risk environment. These sector risk profiles will provide a global understanding of this risk environment through an analysis of:

- existing practices;
- key risks to each sector;
- common vulnerabilities within a sector;
- key interdependencies; and
- the risk tolerance of each sector.

Depending upon the nature of each sector and the structure of its sector network, sub-sector risk profiles may also be undertaken. These in turn will be incorporated within the broader sector risk profile.

The profiles will be useful to each sector network in identifying priority areas for collective action, issues of concern to particular sectors, priorities for research, development of a sector-specific work plan and assessing the effectiveness of critical infrastructure programs and activities.

Once completed, each network will provide its profile to the National Cross-Sector Forum. Each sector or sub-sector profile will be combined to provide a consolidated overview of the risks across all sectors. This consolidated profile will support interdependencies analysis and also be made available to each sector network. The undertaking of sector risk profiles at the national level will be managed through each sector network.

Timelines

The sector risk profiles will be living documents. Each sector risk profile should be completed in Year 2 and revised on an ongoing basis. To ensure the most up-to-date information is available to each sector network, sector risk profiles should be submitted to the National Cross-Sector Forum annually.

Risk assessments

A risk assessment is a detailed analysis of threats, vulnerabilities and impacts to a particular critical infrastructure asset, site or system. These assessments will provide a detailed and specific understanding to each critical infrastructure site owner/operator of their particular risk environment. Though considered an important activity to enhance the resiliency of critical infrastructure, the Strategy does not impose a requirement on owners and operators to undertake risk assessments.

Risk assessments can be used by owners and operators to support the development of sector-specific work plans to address the highest risks on a priority basis, as well as to develop and implement site-specific emergency plans, such as business continuity plans.

The Strategy does not impose a single risk assessment methodology on critical infrastructure partners. There are a number of respected assessment methodologies and the needs and capabilities of each sector and critical infrastructure owner/operator are diverse. Nevertheless, some consistency is needed to ensure that, at minimum, assessments have certain commonalities to support comparison within and across sectors. It is expected, therefore, that each owner/operator's risk assessment will contain at least:

- identification of the critical assets and systems to be covered by the risk assessment;
- an assessment of risks (natural, intentional and accidental);
- an assessment of vulnerabilities;
- an assessment of the impacts of disruptions to critical infrastructure; and
- an assessment of interdependencies.

Undertaking risk assessments is the responsibility of the owner/operator. To support the assessment process, and as part of improving information development and sharing, sector-specific risk information will be provided to each sector network for distribution to its members. It is expected that most owners/operators will have already undertaken risk assessments to some degree. As part of the sector risk profile development process, each sector network will assess the degree to which its critical infrastructure has been subject to a risk assessment by its owners/operators.

Risk assessments for assets, sites or systems will neither be shared broadly across the sector network nor used to create a central inventory of critical infrastructure. A trusted information sharing environment, supported by the Information Protection Protocol, will be created (see Annex D). It is expected that owners/operators will share risk-related information with relevant government officials and other owners/operators to support broader risk assessment and emergency planning activities.

Timelines

As the Strategy does not impose a requirement on owners/operators to undertake assessments, there is no deadline for the completion of risk assessments. Each sector network may, however, establish recommendations for risk assessments as it deems appropriate.

Risk management tools and guidance

To improve collective understanding of risk management, tools, guidelines, methodologies and plans will be made available. Public Safety Canada, with the support of sector networks and of the National Cross-Sector Forum and the Federal-Provincial-Territorial Critical Infrastructure Working Group, will provide these tools.

It is expected that these tools will include a common lexicon of risk management concepts, risk assessment methodologies, educational and awareness materials, and guidelines for implementing a risk management program.

The development of the risk management 'tool box' will begin with a survey of available materials. Where no suitable materials have been found to address an identified need, new tools will be developed in priority order.

It is expected that these tools will be distributed through each sector network and via the web-based critical infrastructure information sharing portal (see Annex D).

Timelines

The development and dissemination of risk management tools will be an ongoing process.

Appendix A-9

FEI SYSTEM CAPACITY PLANNING
SINGLE POINT OF FAILURE IMPACT ON CUSTOMERS

Failure of Both TP36 and TP24 - Delta Valve Stn to Tilbury **Total customers** **229690**

Rate	Rate Description	South Delta	Richmond	Metro
1	Residential	13098	38428	151945
2	Small Commercial <2000GJ	1260	5164	16545
3	Large Commercial >2000GJ	81	422	1676
23	Large Commercial (trans)	20	109	514
4	Seasonal	2	0	8
5	Large Volume >5000 GJ	1	21	101
25	Large Volume (trans)	0	39	186
6	Natural Gas Vehicle	15	3	5
22	Large Volume Curtailable (trans)	9	2	9
27	Large Volume Interruptible (trans)	4	12	11
		14490	**44200**	**171000**

Failure of Both TP24 and TP20 - Tilbury to Fraser Gate **Total customers** **215200**

Rate	Rate Description	Richmond	Metro
1	Residential	38428	151945
2	Small Commercial <2000GJ	5164	16545
3	Large Commercial >2000GJ	422	1676
23	Large Commercial (trans)	109	514
4	Seasonal	0	8
5	Large Volume >5000 GJ	21	101
25	Large Volume (trans)	39	186
6	Natural Gas Vehicle	3	5
22	Large Volume Curtailable (trans)	2	9
27	Large Volume Interruptible (trans)	12	11
		44200	**171000**

Appendix A-10

DYNAMIC RISK
QUANTITATIVE RISK ASSESSMENT OF LMIPSU PROJECTS

Quantitative Risk Assessment of LMSU Projects

November 13th, 2014

Submitted to:

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Quantitative Risk Assessment of LMSU Projects

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4.1. RISK RESULTS 17

1. Executive Summary

A high level quantitative risk assessment was conducted to assess the potential benefits of FortisBC Energy Inc. (FEI)'s proposed Lower Mainland System Upgrade (LMSU) project. The reinforcements that FEI is proposing for its Coastal Transmission (CTS) and Intermediate Pressure (IP) systems are required in order to address capacity, integrity, operational flexibility deficiencies, and existing security of service vulnerabilities. The objective of the risk assessment was to estimate the risk reduction benefit of undertaking the system reinforcements associated with the LMSU project.

The differential Loss of Service risk was quantified to establish a 'Δ Risk' value, where Δ Risk is defined as the risk differential between the existing pipeline configuration and the configuration represented by the proposed LMSU project in consideration of the Loss of Service impacts. This analysis was conducted under design conditions to represent a reasonable worst case scenario. The potential operating risk reduction expressed in annual terms as a result of the LMSU project[1] is estimated to be $2.72 MM/yr.

The potential annual operational risk reduction associated with replacing the existing Coquitlam NPS 20 IP pipeline operating at 1200 kPa with an NPS 30 IP pipeline operating at 2070 kPa and the addition of capacity at Coquitlam Gate Station achieved by looping the NPS 20 Tranmission Pressure (TP) pipeline between the Cape Horn Valve Station and Coquitlam Gate Station with a NPS 36 TP pipeline is estimated to be $2.46 MM/yr.

The potential annual operational risk reduction associated with looping the existing NPS 24 TP pipeline between Nichol and the Port Mann Valve Station with a NPS 36 TP pipeline and looping the existing NPS 24 TP pipeline between Nichol Valve Station and Roebuck Valve station with a NPS 42 TP pipeline, is estimated to be $0.265 MM/yr.

[1] Excluding the Fraser Gate 30IP pipeline Seismic Upgrade.

2. Background

FEI is planning to undertake a reinforcement of its Lower Mainland System in order to address capacity, integrity, and operational flexibility issues, and existing security of service vulnerabilities. Currently both the Fraser Gate Station (Fraser GS) and the Coquitlam Gate Station (Coquitlam GS) are required to meet Metro IP demand throughout the year. Failure upstream, at, or downstream of either gate station will result in a loss of gas supply to a large number of Lower Mainland system customers. The degree of supply overlap varies throughout the year depending on load. The Lower Mainland Gas System Upgrade reinforcements, if undertaken, will provide the capacity and operational flexibility to fully supply the Metro IP system from either the Fraser GS or the Coquitlam GS. This will improve overall system resiliency and therefore reduce the potential consequences of a failure upstream, at, or downstream of either gate station.

The Lower Mainland System Upgrade (LMSU) Project has been developed to address among other issues, these vulnerabilities. The LMSU project consists of 5 major system upgrades, described as follows:

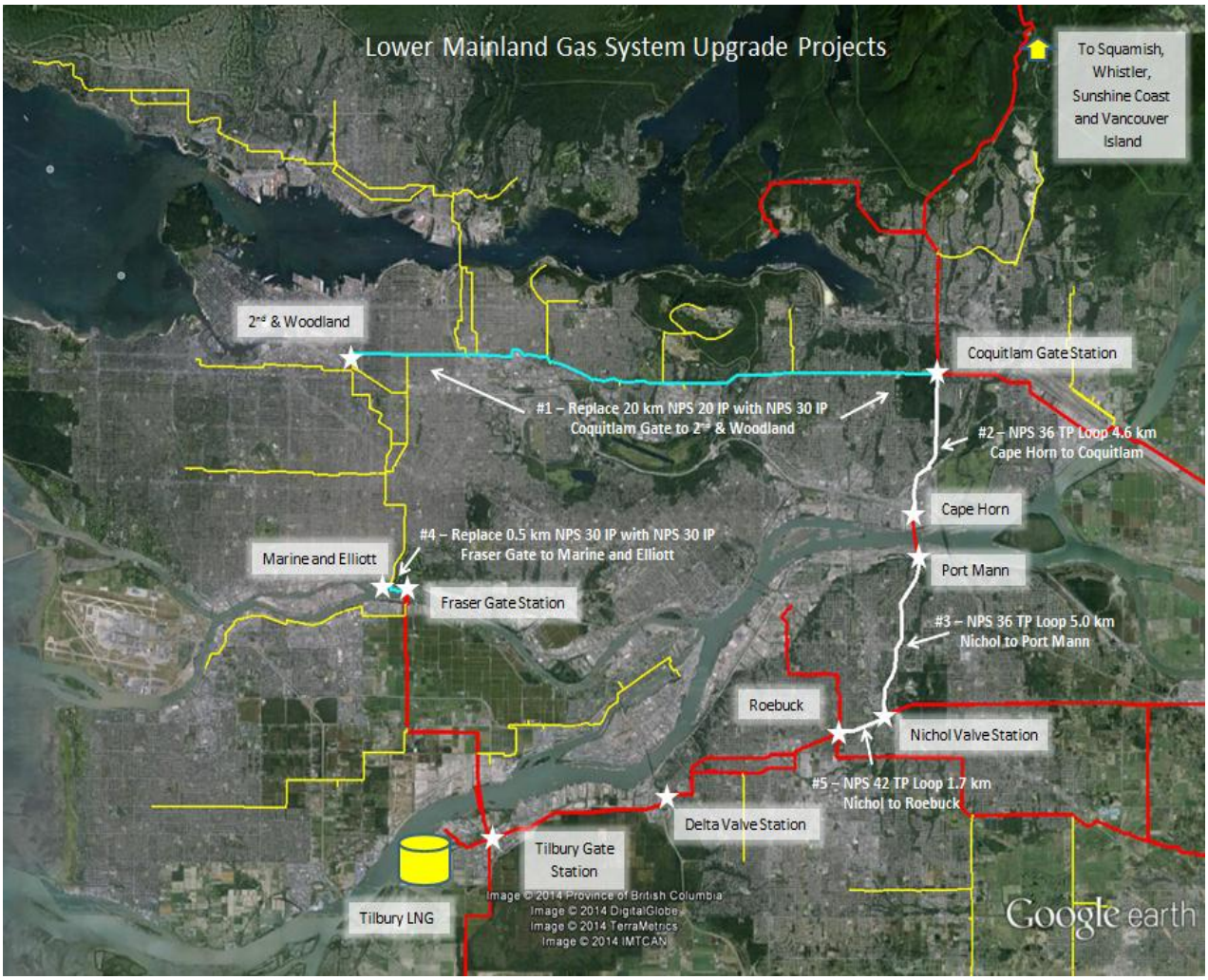
1. Upsizing and operating pressure increase of a planned replacement of 20 km of NPS 20 IP pipeline (1200 kPa) with NPS 30 IP pipeline (2070 kPa) from Coquitlam GS to 2nd & Woodland;
    - This replacement is required, as the existing pipeline is approaching the end of its service life (See “508mm Intermediate Pressure Pipeline Quantitative Reliability Assessment”, July 4, 2014);
2. Replacement of 0.5 km NPS 30 IP pipeline (1200 kPa) from Fraser GS to East Kent & Elliott;
    - This replacement is required due to seismic concerns;
3. Looping of the existing NPS 20 TP pipeline (4020 kPa) between Cape Horn and Coquitlam GS with an NPS 36 TP (4020 kPa) pipeline;
    - This loop is required to meet capacity for new core customers and industrial loads as well as capacity requirements at Coquitlam GS if full Metro IP supply redundancy is to be achieved;
4. Looping of the existing NPS 24 TP (4020 kPa) pipeline between Nichol Valve station and Port Mann crossing with a NPS 36 TP (4020 kPa) pipeline;
    - This loop is required to address capacity for new industrial loads as well as single point of failure risk; and,

5. Looping of the existing NPS 24 TP pipeline (4020 kPa) between Nichol Valve Station and Roebuck Valve Station with a NPS 42 TP (4020 kPa) pipeline;

    - This loop is required to address capacity for new industrial loads as well as single point of failure risk.

The above facilities are shown in Figure 1.

Figure 1: Lower Mainland Gas System Upgrade Projects



3. Approach

In order to estimate the risk benefit associated with carrying out the various components of the LMSU Project, a high level Quantitative Risk Assessment (QRA) has been performed to characterize the ΔRisk between 'Before LMSU' and 'After LMSU' pipeline configurations. Risk is evaluated on operator-controlled property (i.e., inside fenced facilities), as well as on the pipeline right-of-way.

A quantitative evaluation of risk can be represented by the product of failure frequency, and consequences of failure:

$$R = FF \times C$$

Equation 1

Where,

R = Risk (Units of Consequence/yr)

FF = Failure Frequency (failures/yr)

C = Consequence

In the current analysis, the units of consequence being used are $ associated with interruption of service. Therefore, the units of risk in Equation 1 are $/yr, and the risk represents the economic risk associated with the potential for loss of service.

The primary risk change between 'Before LMSU' and 'After LMSU' is due to the provision of security of supply to Metro IP customers.

The public safety risk for existing pipelines is the same in both the before and after scenarios and therefore has been omitted from the analysis. For the purposes of this assessment, the new TP pipeline loops have been designed to mitigate public safety risk.

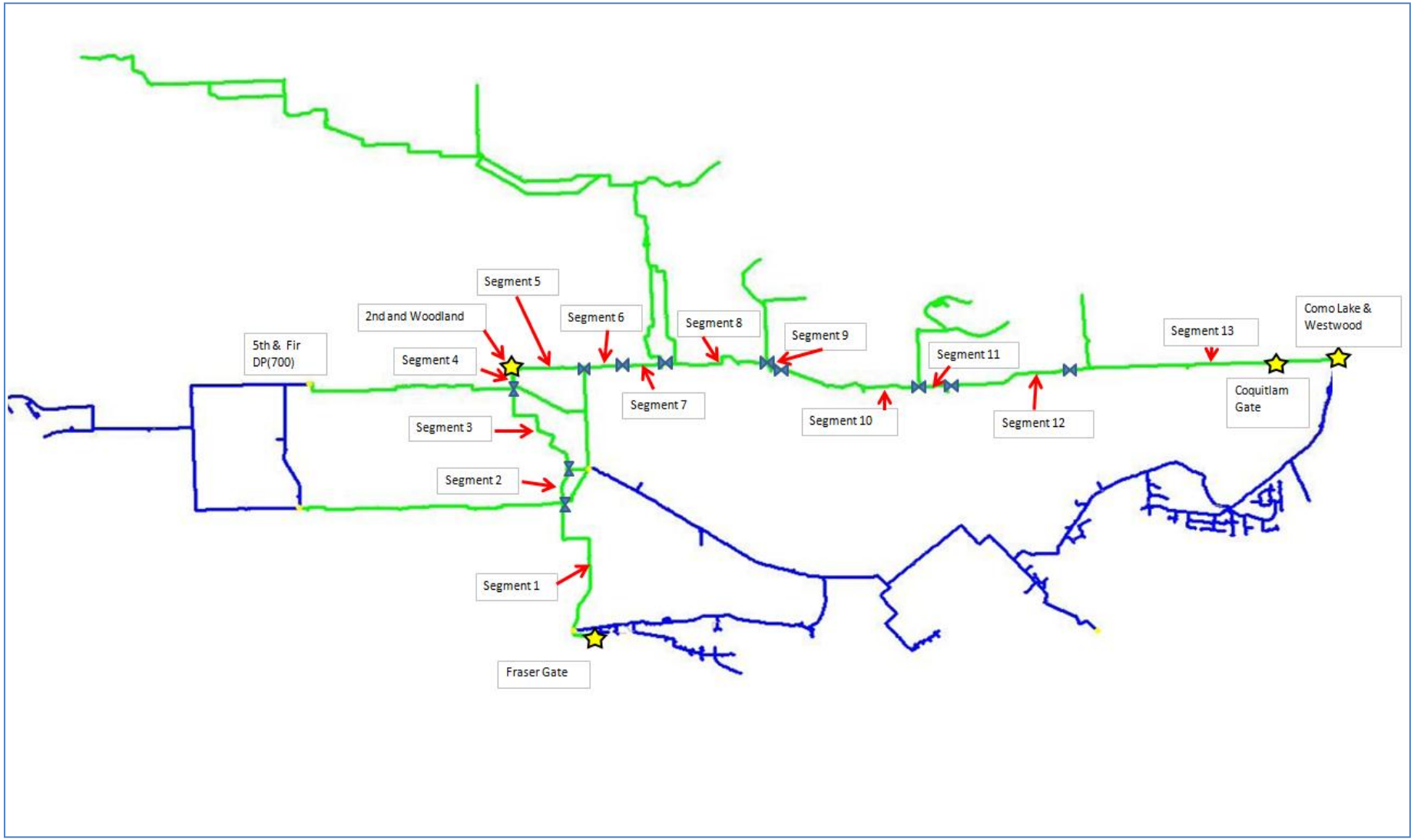
The planned seismic reinforcement on the Fraser NPS 30 IP pipeline immediately downstream of Fraser Gate Station, required primarily for public safety reasons, has been assumed complete in both the before and after scenarios and has therefore been excluded from this assessment.

The pipeline segments and associated facilities that have been considered in this analysis are summarized below. Segments marked with an asterisk have been considered, but do not change in the before and after risk cases because they can be isolated without impacting customers. For the location of the TP segments see Figure 1 above and for the IP segments (see Figure 2).

- Nichol to Roebuck NPS 24 (1.70 km)

- Nichol to Roebuck NPS 42 (1.70 km)
- Roebuck to Delta NPS 36 (7.43 km)
- Roebuck to Delta NPS 24 (7.25 km)
- Delta to Tilbury NPS 24 (5.32 km)
- Delta to Tilbury NPS 36 (5.36 km)
- Tilbury to Fraser Gate NPS 24 (9.74 km)
- Tilbury to Fraser Gate NPS 20 (9.67 km)
- IP Segment 1 - (4.76 km)
- IP Segment 2 - (0.92 km)
- IP Segment 3 - (3.24 km)
- IP Segment 4* - (0.48 km)
- IP Segment 5* - (1.81 km)
- IP Segment 6 - (1.34 km)
- IP Segment 7 - (0.54 km)
- IP Segment 8* - (2.97 km)
- IP Segment 9* - (0.20 km)
- IP Segment 10- (3.78 km)
- IP Segment 11* - (0.68 km)
- IP Segment 12* - (2.98 km)
- IP Segment 13- (5.15 km)
- Cape Horn to Coquitlam Gate NPS 20 (4.60 km)
- Cape Horn to Coquitlam Gate NPS 36 (4.60 km)
- Port Mann to Cape Horn NPS 36 (1.28 km)
- Nichol to Port Mann NPS 24 (5.00 km)
- Nichol to Port Mann NPS 36 (5.00 km)

Figure 2: Schematic of IP System Map Showing Analytical Segments



3.1. Failure Likelihood Approach

In order to calculate risk, the output from the failure frequency analysis must be relevant to the consequence analysis. Therefore, the results of a failure frequency analysis must specify more than frequency of occurrence; instead, the frequencies of occurrence must be tied to an outcome, with outcome being related to magnitude of release. Because risk is defined as the economic risk associated with a loss of service, the definition of 'failure' must be tied to a loss-of-containment event that is of sufficient magnitude that it will preclude in-service repair.

Failure frequency estimates were completed by performing an analysis of industry failure incident data, utilizing the US Department of Transportation (US DOT) Pipeline Hazardous Materials Safety Administration (PHMSA) Gas Transmission failure incident database.

The rationale for using the PHMSA Gas Transmission Incident database is summarized below:

- Provides the ability to identify segment lengths and failures on High Consequence Area (HCA) pipelines, which corresponds with the urban environment of the portion of the CTS system that is within the scope of the analysis;
- Provides the ability to establish failure severity (i.e. failures that would result in pipeline shut-down, and curtailment of throughput), which enables estimation of event frequencies that correspond with the primary risk being considered in this analysis;
- Provides the ability to establish failures on pipe and facilities, which are both present in the CTS system within the scope of the analysis;
- PHMSA data for HCA pipelines relates to pipelines operated and maintained in similar manner to CTS pipelines (IMP programs); and
- PHMSA data is based on a variety of pipeline sizes and ages which give a time averaged failure rate.

Various sorts and filters were performed on the PHMSA Gas Transmission Incident Database so that the incident data would be derived from pipeline systems that replicate FEI's Coastal Transmission System (CTS) and IP system as closely as possible. The types of sorts and filters performed, and the rationale for performing these sorts and filters are summarized in Table 1.

Table 1: PHMSA Gas Transmission Incident Database Sorts and Filters

Database Sort / Filter	Rationale
Incident data collected for time period January 1, 2010 through May 29, 2014	- Represents gas transmission systems in which modern assessment procedures are being implemented (similar to operations on CTS)
Database filtered so that it represents natural gas transmission systems only	- Corresponds with the CTS product stream composition - Corresponds with mileage database, which was specific to natural gas pipelines
Database filtered so that it represents onshore systems only (excludes offshore systems)	- Corresponds with the CTS onshore environment - Corresponds with mileage statistic for onshore gas transmission pipelines
Only incidents that are characterized as having occurred in Class 3 or Class 4 locations, or alternatively, which are designated as 'could be HCA' were counted	- Corresponds with the urban environment of the portion of the CTS system that is within the scope of the analysis

The PHMSA incident database is a large, statistically sound sample base that represents over 31,500 km of urban environment onshore natural gas transmission pipeline systems, which contains over 4200 separate incidents. By contrast, the National Energy Board (NEB) maintains a failure database[2], however it contains only 20 failure incidents in which the product stream is characterized as 'Gas'. It is not readily apparent from inspection of this database, which of these 20 incidents occurred on onshore pipeline systems in urban environments. Furthermore, the NEB incident database contains only those failure incidents that are characterized as 'ruptures'. Therefore, it is likely that this database does not include incidents that can be characterized as leaks that are large enough to result in a loss of service. In addition, pipeline incident failure statistics that are published by the US DOT are 'record-level data' (i.e., data from each incident is provided on its own line), as opposed to aggregate data. Record-level data lends itself much better to mining information and confirming that the information is relevant to each threat being studied.

Once the PHMSA incident database was pre-filtered as described above, an analysis of each of the 402 separate incidents was made to ascertain which of those incidents represented releases of sufficient magnitude that they would likely result in a loss of service. The database fields listed in Table 2 summarize the PHMSA database fields that were reviewed, and the

[2] National Energy Board website, https://www.neb-one.gc.ca/sftnvrnmnt/sft/pplnrptr/index-eng.html accessed November 13, 2014.

assessment criteria that were applied in establishing which incidents represented those that should be included in the count of incidents that are likely to have resulted in a loss of service.

In order to express failure frequency in normalized terms (i.e., failures per unit length of pipeline per year of service), consistent with the parameter 'FF' in Equation 1, the raw count of incidents that were obtained from the PHMSA Gas Transmission Incident database, as outlined above, is divided by two parameters:

i. Years of Operation; and,
ii. Length of Pipeline System

$$FF_{PHMSA} = \frac{FC}{Y \times L}$$

Equation 2

Where,

FF_{PHMSA} = Normalized Failure Frequency (Failures / km.yr) determined from PHMSA incident database;

FC = Count of incidents corresponding to loss of service (as defined above)

Y = Years of Operation represented in the incident database. In this case, it is the period from January 1, 2010 to May 29, 2014, or 4.405 years.

L = Length of Pipeline System represented in the incident database. This is the length of pipeline system represented by the PHMSA Gas Transmission database after the filters described in Table 1 have been applied. This was determined from the PHMSA Annual Mileage Database. Mileage data were retrieved for the years 2010, 2011, 2012, and 2013, and filters were applied so that they represented HCA mileage in onshore, natural gas transmission pipelines. The lengths for each of these years were averaged, yielding a value of 19,853 miles (31,950 km).

Incidents that are reported in the PHMSA Gas Transmission Incident database include those that occur on operator-controlled property (i.e., incidents that take place inside fenced facilities), as well as those that occur on the pipeline right-of-way. This is consistent with the physical makeup of the CTS pipeline system segments that are within the scope of the study, in that each pipeline segment consists of both right-of-way elements as well as associated facilities. The normalized failure frequency values that are determined from the PHMSA incident data are therefore representative of *pipeline systems*, consisting of both pipeline right-of-way and associated facilities. The estimate of failure frequency for each CTS segment, representative of both pipeline right-of-way and facilities, is therefore determined by multiplying the normalized failure frequency estimate (determined from Equation 2) by the CTS segment length.

Based on the analysis described above, the normalized failure frequency value derived from an analysis of the PHMSA Gas Transmission Incident Database (i.e., FF_{PHMSA} in Equation 2) was determined to be 4.106×10^{-04} failures/km.yr. This number is derived from combining a failure rate of 9.364×10^{-05} failures/km.yr from incidents occurring on operator-controlled property, with 3.170×10^{-04} failures/km.yr occurring on right-of-way. All of these failures represent loss of containment incidents that are of sufficient magnitude that they would be likely to result in a loss of service. For all pipeline segments, with the exception of those segments in which there exists a potential for concomitant failure to occur (which are addressed in the following Section), the value of 4.106×10^{-04} failures/km.yr is the normalized failure frequency value that was used as the basis for determining failure rates for each of the pipe segments, as follows:

$$FF_{Seg,\mathrm{Base}} = 4.106 \times 10^{-04} \times L_{Seg}$$

Equation 3

Where,

$FF_{Seg,Base}$ = Failure frequency of a segment (failures/yr);

L_{Seg} = Segment length (km)

Table 2: PHMSA Gas Transmission Database Fields Evaluated and Criteria Applied

Column	Field Name	Description of Field	Criteria Applied
AM	Shutdown Explain	Explanation if no shutdown occurred	Review information in this unconstrained field to help establish the circumstances associated with the incident.
AN	Shutdown Date_Time	Date and time of any shutdown	In the absence of any 'Mandatory Count' field associated with a given incident, then any incident resulting in a loss of service less than 4 hours should not be counted
AR	Ignite_Ind	Commodity ignite (yes / no)	Any incident in which 'Yes' is populated in this field is a Mandatory Count
AS	Explode_Ind	Commodity explode (yes / no)	Any incident in which 'Yes' is populated in this field is a Mandatory Count
AT	Num_Pub_Evacuated	Number of general public evacuated	Any incident in which the number populated in this field is >0 is a Mandatory Count
CI	Item_Involved	Item involved in accident	In the absence of any 'Mandatory Count' field associated with a given incident, then any incident involving the following should not be counted: Relief Line, Auxiliary Piping (e.g., drain lines), Tubing
DF	Release_Type	Type of accident	Any incident in which 'Rupture' is populated in this field is a Mandatory Count
DG	Puncture_Axial	Mechanical puncture – approx. size–axial (in.)	Any incident in which the axial extent of the puncture is greater than 1 is a Mandatory Count
DH	Puncture_Circum	Mechanical puncture – approx size – circ (in.)	Any incident in which the circumferential extent of the puncture is greater than 1 is a Mandatory Count
DI	Leak_Type	Leak type	In the absence of any 'Mandatory Count' field associated with a given incident, then any incident identified as 'Pinhole' or 'Seal or Packing' should not be counted
DJ	Leak_Type_Other	Leak type other – details	Review information in this unconstrained field to help establish the circumstances associated with the incident.
DO	Release_Type_Details	Type of accident – other details	Review information in this unconstrained field to help establish the circumstances associated with the incident.

Column	Field Name	Description of Field	Criteria Applied
DV	HCA _Fatalities_Ind	Number of fatalities	Any incident in which 'Yes' is populated in this field is a Mandatory Count
EA	Est_Cost_Gas_Released	Estimated cost of gas released	Any incident in which a value of greater than $100,000 is entered in this field is a Mandatory Count
EC	Est_Cost_Prop_Damage	Estimated property damage	Any incident in which a value of greater than $100,000 is entered in this field is a Mandatory Count
EE	Ext_Cost_Emergency	Estimated emergency response costs	Any incident in which a value of greater than $100,000 is entered in this field is a Mandatory Count
FQ	Accident_Identifier	Method for detecting release	Review information in this unconstrained field to help establish the circumstances associated with the incident.
FR	Accident_Details	Details of accident	Review information in this unconstrained field to help establish the circumstances associated with the incident.
GQ	Cause_Details	Details of cause of accident	Review information in this unconstrained field to help establish the circumstances associated with the incident.
GR	Cause_Details_Other	Other details of cause of accident	Review information in this unconstrained field to help establish the circumstances associated with the incident.
GU	Visual_Exam_Details	Details of visual examination of failure piece	Review information in this unconstrained field to help establish the circumstances associated with the incident
GS-KP	Multiple Fields Queried	Threat-specific cause details	Review information in these unconstrained fields to help establish the circumstances associated with the incident.
NG	Root_Cause	Root cause of failure	Review information in these unconstrained fields to help establish the circumstances associated with the incident.
UP	Narrative	Narrative of failure	Review information in these unconstrained fields to help establish the circumstances associated with the incident.

3.1.1 Consideration of Concomitant Failure

Four of the pipe segments in the 'Before LMSU' case are looped by adjacent pipelines, as follows:

- NPS 36 Roebuck to Delta to Tilbury pipeline looped by the NPS 24 Roebuck to Delta to Tilbury pipeline (operating at 4020 kPa);
- NPS 24 Roebuck to Delta to Tilbury pipeline looped by the NPS 36 Roebuck to Delta to Tilbury pipeline (operating at 4020 kPa);
- NPS 24 Tilbury to Fraser Gate pipeline, looped by the NPS 20 Tilbury to Fraser Gate pipeline (operating at 4020 kPa); and
- NPS 20 Tilbury to Fraser Gate pipeline, looped by the NPS 24 Tilbury to Fraser Gate pipeline (operating at 4020 kPa).

For each of the Roebuck to Tilbury and Tilbury to Fraser Gate pipe segments, pipeline looping has created sufficient redundancy such that failure of only one of the looped pipelines will not cause a loss of service, but rather, a loss of both of the looped pipelines is required in order for an outage to occur.

Nevertheless, a failure scenario that needed to be addressed in the risk assessment was that of 'concomitant failure'. This failure scenario is unique to natural gas transmission pipelines, and occurs when the explosive decompression associated with catastrophic failure of one pipeline uncovers an adjacent pipeline. In the event that the natural gas release ignites, the second (intact) pipeline can be exposed to damaging radiant heat of a trench fire, which can cause it to fail.

The potential for concomitant failure to occur (resulting in a simultaneous outage in both looped pipelines) is predicated on a separation distance between pipelines that is equal to or smaller than the radius of the blast crater that would be created by the explosive decompression associated with a catastrophic failure. A method for determining this separation distance was developed by Acton et al.[3] Using this method, and assuming a mixed soil type, the minimum separation distance for the prevention of concomitant failure was determined for each of the loop sections, as summarized in Table 3.

While the detailed design of the LMSU projects has not been completed, it has been assumed that this infrastructure will be designed in such a manner that the risk of concomitant failure in the 'After LMSU' scenarios is insignificant.

[3] Acton, M.R, Jackson, N.W., and Jager, E.R., "Development of Guidelines for Parallel Pipelines", Proceedings of the 8th International Pipeline Conference, IPC2010-31287, September, 2010.

Table 3: Minimum Separation Distance to Prevent Exposure

Scenario	Distance (m)
Exposure of the NPS 36 Roebuck to Delta to Tilbury pipeline, by a failure on the NPS 24 Roebuck to Delta to Tilbury pipeline operating at 4020 kPa	6
Exposure of the NPS 24 Roebuck to Delta to Tilbury pipeline, by a failure on the NPS 36 Roebuck to Delta to Tilbury pipeline operating at 4020 kPa	7
Exposure of the NPS 24 Tilbury to Fraser Gate pipeline, by a failure on the NPS 20 Tilbury to Fraser Gate pipeline operating at 4020 kPa	5
Exposure of the NPS 20 Tilbury to Fraser Gate pipeline, by a failure on the NPS 24 Tilbury to Fraser Gate pipeline operating at 4020 kPa	6

Based on the above guidelines the following was determined:

- There is a 2.81 km length of the NPS 36 Roebuck to Delta to Tilbury pipeline where the NPS 24 Roebuck to Delta to Tilbury pipeline is closer than the guidelines provided in Table 3;
- There is a 3.11 km length of the NPS 24 Roebuck to Delta to Tilbury pipeline where the NPS 36 Roebuck to Delta to Tilbury pipeline is closer than the guidelines provided in Table 3;
- There is a 1.33 km length of the NPS 24 Tilbury to Fraser Gate pipeline where the NPS 20 Tilbury to Fraser Gate pipeline is closer than the guidelines provided in Table 3; and
- There is a 4.06 km length of the NPS 20 Tilbury to Fraser Gate pipeline where the NPS 24 Tilbury to Fraser Gate pipeline is closer than the guidelines provided in Table 3.

On each of the existing Roebuck to Delta to Tilbury and Tilbury to Fraser Gate pipeline segments, a loss of service may occur in one of two ways:

1) By means of a failure in any one of the common station facilities associated with the pipeline segments; or,
2) By an ignited rupture that occurs in a looped section, in a pipeline that is closer than the minimum distance prescribed in Table 3 to the adjacent pipeline.

However for the new TP pipeline loops a loss of service will only occur by means of a failure in any one of the common station facilities associated with the looped pipeline segments.

For these pipeline segments, the frequency of occurrence of loss of service was therefore determined in accordance with the following expression:

$$OF_{LS} = \left[\left(FF_{PHMSA,Stations} \times L_{Seg}\right) + \left(IPRF \times L_{Loop,SegA,B}\right) + \left(IPRF \times L_{Loop,SegB,A}\right)\right]$$

Equation 4

Where,

OF_{LS} = The outage frequency for the segment of pipeline (i.e., the Roebuck to Delta to Tilbury or the Tilbury to Fraser Gate pipeline segments) in which there is a portion of that segment where there are two looped pipe segments (referred to as Segment A and Segment B) (outages/yr)

$FF_{PHMSA,Stations}$ = Normalized failure frequency from incidents occurring on operator-controlled property

(9.364x10^{-05} failures/km.yr)

L_{Seg} = Average length of the two pipeline segments in which there is a portion of those segments that are adjacent to one another (i.e., 12.69 km for the NPS 36 and NPS 24 Roebuck to Delta to Tilbury segment, or 9.71 km for the Tilbury to Fraser Gate segment)

IPRF = Ignited Pipeline Rupture Frequency. An analysis of the PHMSA incident database indicated that 2 ignited pipeline ruptures on pipelines occurred over the 31,950 km system length over the time period from January 1, 2010 to May 29, 2014, (4.405 years), yielding an Ignited Pipeline Rupture Frequency value of 1.421x10^{-05} (ignited pipeline ruptures/km.yr).

$L_{Loop,SegA,B}$ = Length of loop where Segment A is closer to Segment B than the values prescribed for Segment A in Table 3.

$L_{Loop,SegB,A}$ = Length of loop where Segment B is closer to Segment A than the values prescribed for Segment B in Table 3.

3.2. Determination of Consequences

Because the objective of the risk assessment was to show a change in outage-related risk between the 'Before LMSU' and 'After LMSU' pipeline configurations, a determination of all outage-related consequences that would be impacted by the LMSU project were determined. Current FEI hydraulic models of the distribution systems were used to assess the potential numbers of customers which would be impacted as a result of supply disruptions on each of the pipeline segments or facilities supplying the Metro IP system. Estimates of outage durations were also calculated for each of these segments. The estimated number of customers impacted, maximum outage time and the associated economic impact of these potential

outages is presented for each segment in Tables 4 to 6. The detailed methodology and results of this consequence analysis are contained in a separate report.[4]

[4] Ruitenbeek, H.J., "Economic Consequence Analysis of Hypothetical Natural Gas Service Interruptions in the British Columbia Lower Mainland", November, 2014.

4. Risk Assessment Results

4.1. Risk Results

Loss of service risk was calculated for each segment in accordance with the approach described in Equation 1, and the results are summarized below.

The loss of service risk reflective of today's system has been estimated to be $3.054 million/year as indicated in Table 4. Table 5 shows the remaining loss of service risk to the customers served by the CTS, Fraser Gate IP system and Coquitlam Gate IP system following system reinforcements contemplated by the LMSU projects and has been estimated to be approximately $333 thousand/year. Table 6 indicates the loss of service risk remaining following the system reinforcements contemplated by Coquitlam Gate IP pipeline upgrade and the Cape Horn to Coquitlam TP loop installation to be approximately $598 thousand/year. These calculations assume the Fraser Gate NPS 30 IP pipeline seismic upgrade has been completed.

The potential risk reduction associated with the system reinforcements contemplated by the LMSU projects is calculated to be the difference between the $3.054 million/year risk associated with today's system and the remaining risk of $333 thousand/year following the LMSU projects. This results in a risk reduction of approximately $2.72 million/year.

The potential risk reduction associated with the system reinforcements contemplated by the Coquitlam Gate IP pipeline upgrade and the Cape Horn to Coquitlam TP loop installation is calculated to be the difference between the $3.054 million/year risk associated with today's system and the remaining risk of $598 thousand/year following completion of the Coquitlam Gate IP pipeline upgrade and the Cape Horn to Coquitlam TP loop installation. This results in a risk reduction of approximately $2.46 million/year.

The potential risk reduction associated with the system reinforcements contemplated by the remaining two pipeline installations (Nichol to Port Mann TP loop and the Nichol to Roebuck TP loop) is calculated to be the difference between the remaining $598 thousand/year risk associated with completion of the Coquitlam Gate IP pipeline upgrade and the Cape Horn to Coquitlam TP loop installation and, the remaining risk of $333 thousand/year associated with completing all of the LMSU Projects. This results in a risk reduction of approximately $265 thousand/year.

Table 4: Loss of Service Risk of Existing Pipeline System Configuration[5]

Segment	Segment Length (km)	Number of Customers Impacted	Maximum Outage Time (days)	Total Impact (million$)	Probability of Failure (failures/ year)	Total Risk ($/year)
Nichol to Roebuck NPS 24	1.70	252,300	24.8	564.83	6.98E-04	394,260
Roebuck to Delta NPS 24/36	7.34 (avg)	252,300	24.8	564.83	7.53E-04	425,116
Delta to Tilbury NPS 24/36	5.34 (avg)	229,690	22.7	477.44	5.19E-04	247,956
Tilbury to Fraser NPS 20/24	9.70 (avg)	215,200	21.4	423.25	9.86E-04	417,121
IP Segment 1	4.76	171,000	19.8	320.42	1.95E-03	626,243
IP Segment 2	0.92	98,200	12.8	132.77	3.78E-04	50,153
IP Segment 3	3.24	14,100	8.2	8.50	1.33E-03	11,311
IP Segment 4	0.48	0	0	0	1.95E-04	0
IP Segment 5	1.81	0	0	0	7.43E-04	0
IP Segment 6	1.34	12,500	7.9	7.26	5.50E-04	3,997
IP Segment 7	0.54	12,500	7.9	7.26	2.22E-04	1,611
IP Segment 8	2.97	0	0	0	1.22E-03	0
IP Segment 9	0.20	0	0	0	8.21E-05	0
IP Segment 10	3.78	2,840	5.6	2.06	1.55E-03	3,193
IP Segment 11	0.68	0	0	0	2.79E-04	0
IP Segment 12	2.98	0	0	0	1.22E-03	0
IP Segment 13	5.15	29,620	8.9	18.05	2.11E-03	38,137
Cape Horn to Coquitlam NPS 20	4.60	163,280	16.0	181.95	1.89E-03	343,658
Port Mann to Cape Horn NPS 36	1.28	163,280	16.0	181.95	5.26E-04	95,644
Nichol to Port Mann NPS 24	5.00	172,572	15.8	192.63	2.05E-03	395,471
Total						**3,053,871**

[5] Assumes the Fraser Gate NPS 30 IP pipeline seismic upgrade has been completed.

Table 5: Loss of Service Risk with LMSU Reinforcements Installed[6]

Segment	Segment Length (km)	Number of Customers Impacted	Maximum Outage Time (days)	Total Impact (million$)	Probability of Failure (failures/ year)	Total Risk ($/year)
Nichol to Roebuck NPS 24/42	1.70	81,300	13.6	111.98	1.59E-04	17,826
Roebuck to Delta NPS 24/36	7.34 (avg)	81,300	13.6	111.98	7.53E-04	84,248
Delta to Tilbury NPS 24/36	5.34 (avg)	58,690	11.2	60.59	5.19E-04	31,465
Tilbury to Fraser NPS 20/24	9.70 (avg)	44,200	9.7	34.87	9.86E-04	34,365
IP Segment 1	4.76	0	0	0	1.95E-03	0
IP Segment 2	0.92	0	0	0	3.78E-04	0
IP Segment 3	3.24	0	0	0	1.33E-03	0
IP Segment 4	0.48	0	0	0	1.95E-04	0
IP Segment 5	1.81	0	0	0	7.43E-04	0
IP Segment 6	1.34	0	0	0	5.50E-04	0
IP Segment 7	0.54	0	0	0	2.22E-04	0
IP Segment 8	2.97	0	0	0	1.22E-03	0
IP Segment 9	0.20	0	0	0	8.21E-05	0
IP Segment 10	3.78	2840	5.6	2.06	1.55E-03	3,193
IP Segment 11	0.68	0	0	0	2.79E-04	0
IP Segment 12	2.98	0	0	0	1.22E-03	0
IP Segment 13	5.15	0	0	0	2.11E-03	0
Cape Horn to Coquitlam NPS 20/36	4.60	121,880	13.1	106.27	4.31E-04	45,777
Port Mann to Cape Horn NPS 36	1.28	121,880	13.1	106.27	5.26E-04	55,864
Nichol to Port Mann NPS 24/36	5.00	131,172	14.2	128.91	4.68E-04	60,353
Total						**333,091**

[6] Assumes the Fraser Gate NPS 30 IP pipeline seismic upgrade has been completed.

Table 6: Loss of Service Risk with Coquitlam Gate IP Pipeline Upgrade and Cape Horn to Coquitlam TP Loop Installed[7]

Segment	Segment Length (km)	Number of Customers Impacted	Maximum Outage Time (days)	Total Impact (million$)	Probability of Failure (failures/ year)	Total Risk ($/year)
Nichol to Roebuck NPS 24	1.70	81,300	24.8	111.98	6.98E-04	78,166
Roebuck to Delta 24/36	7.34 (avg)	81,300	13.6	111.98	7.53E-04	84,284
Delta to Tilbury 24/36	5.34 (avg)	58,690	11.2	60.59	5.19E-04	31,465
Tilbury to Fraser 20/24	9.70 (avg)	44,200	9.7	34.87	9.86E-04	34,365
IP Segment 1	4.76	0	0	0	1.95E-03	0
IP Segment 2	0.92	0	0	0	3.78E-04	0
IP Segment 3	3.24	0	0	0	1.33E-03	0
IP Segment 4	0.48	0	0	0	1.95E-04	0
IP Segment 5	1.81	0	0	0	7.43E-04	0
IP Segment 6	1.34	0	0	0	5.50E-04	0
IP Segment 7	0.54	0	0	0	2.22E-04	0
IP Segment 8	2.97	0	0	0	1.22E-03	0
IP Segment 9	0.20	0	0	0	8.21E-05	0
IP Segment 10	3.78	2840	5.6	2.06	1.55E-03	3,193
IP Segment 11	0.68	0	0	0	2.79E-04	0
IP Segment 12	2.98	0	0	0	1.22E-03	0
IP Segment 13	5.15	0	0	0	2.11E-03	0
Cape Horn to Coquitlam 20/36	4.60	121,880	13.1	106.27	4.31E-04	45,777
Port Mann to Cape Horn	1.28	121,880	13.1	106.27	5.26E-04	55,864
Nichol to Port Mann	5.00	131,172	14.2	128.91	2.05E-03	264,642
Total						**597,756**

[7] Assumes the Fraser Gate NPS 30 IP pipeline seismic upgrade has been completed.

Appendix A-11

DESIGN BASIS MEMORANDUM

FILED CONFIDENTIALLY

Appendix A-12

WALL THICKNESS SELECTION REPORT

FILED CONFIDENTIALLY

Appendix A-13

ENGINEERING DRAWINGS
COQUITLAM GATE STATION

FILED CONFIDENTIALLY

Appendix A-14

ENGINEERING DRAWINGS
EAST 2ND & WOODLAND STATION

Provided in electronic format only due to document size and to conserve resources

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(accessible by opening the Attachments Tab in Adobe)

Appendix A-15

ENGINEERING DRAWINGS
IP/DP DISTRICT STATIONS

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Appendix A-16

ENGINEERING DRAWINGS
IP/IP INTERFACE STATIONS

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Appendix A-17

COQUITLAM GATE IP ROUTE SELECTION DETAILS

Route Selection Details

December 2014

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1. ROUTE SELECTION

The route selection process for the NPS 30 Coquitlam Gate IP pipeline which is presented in detail in Section 3.3.4 follows industry practice. Specific consideration is given to the recommendations of CSA Z662-11 Oil and Gas Pipeline Systems which is the standard specification for the design, construction, operation, and maintenance of Canadian pipelines. In this appendix, the route options are analyzed, evaluated, ranked and a preferred option is selected. Maps of the various route options that were evaluated as well as detailed maps of the preferred route options are attached to this appendix.

1.1 *ROUTING PROCESS FLOW DIAGRAM*

Pipeline routing is an iterative process which starts with a wide 'corridor of interest' and then narrows down to a more defined route at each design stage as more data is acquired, resulting in a final alignment and 'right of way' (ROW).

The first stage involves the identification of one or more pipeline corridors, which are located and geographically sized to encapsulate sufficient area in which all feasible route options can be identified.

The second stage, after one or more corridors has been identified, involves gathering available data pertaining to feasible route options within the corridor.

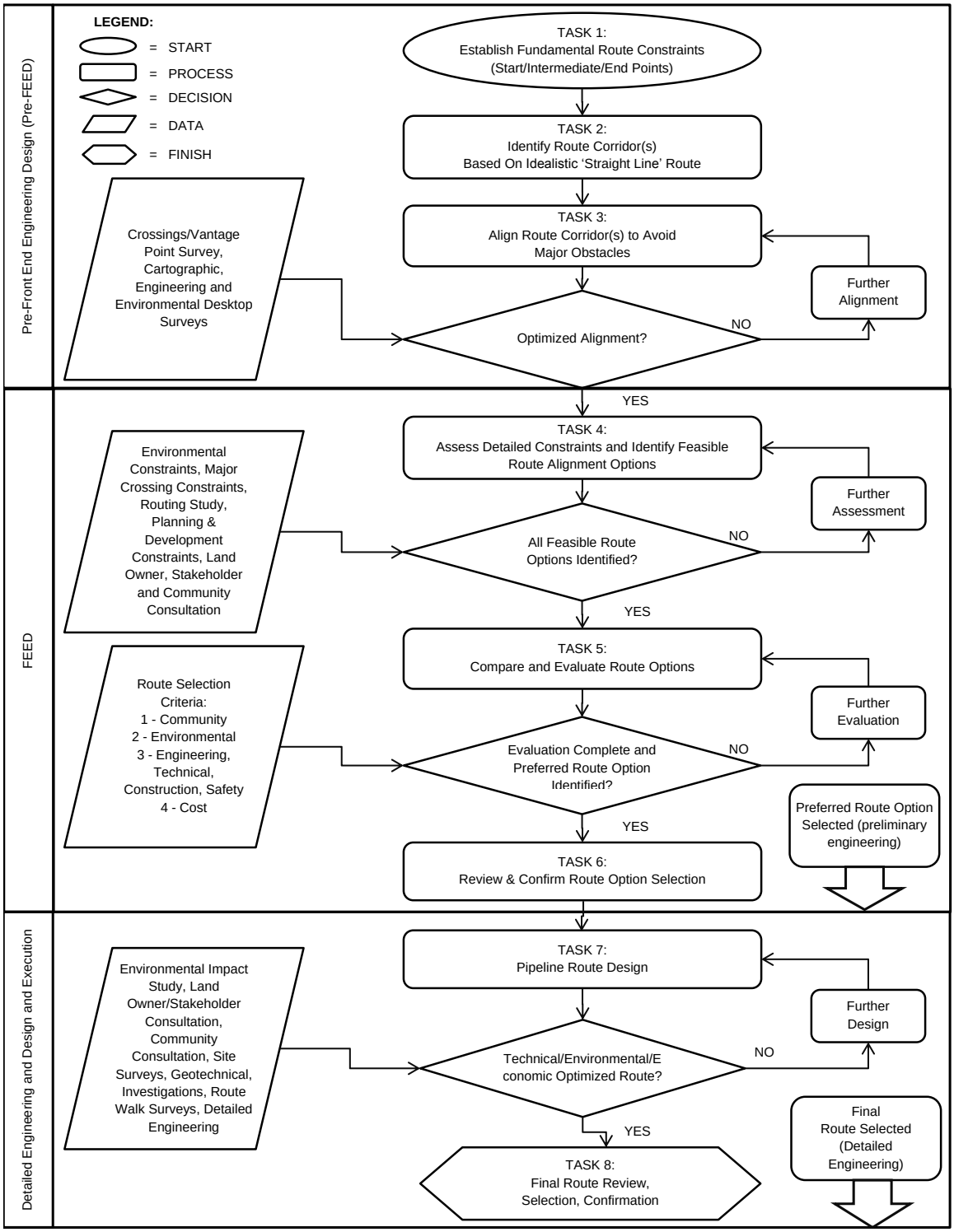
Stages one and two have been completed and the selected preferred route alignment is presented in this appendix.

The third stage involves detailed routing and engineering of the selected alignment to achieve a fully engineered and defined pipeline.

The route selection process including corridor identification, preferred route option selection, detailed route design process, and the subtasks involved within these overall project engineering phases, is summarized in Figure 1.

Figure 1: Route Corridor Selection – Process Flow Diagram.

PIPELINE ROUTING PROCESS FLOW DIAGRAM



2. ROUTE OPTIONS ANALYSIS AND EVALUATION

The route options detailed in the Application section 3.3.4.4 are analyzed, reviewed against the evaluation criteria and a preferred option is selected in the following sections.

2.1 *SECTION 1 - MARINER WAY TO POIRIER ST.*

The existing NPS 20 Coquitlam Gate IP pipeline route is along the centre of Como Lake Avenue. Replacement of this pipeline in place is limited due to the proximity of other utilities. Mundy Park is located on the south side of Como Lake Avenue and the Chineside and Harbour Chines areas are located to the north. Chineside and Harbour Chines do not have any contiguous east west corridors through the neighbourhood and crossing Mundy Park would result in considerable environmental impact. Therefore, from Coquitlam Gate station, Como Lake Avenue is the only option to route the proposed NPS 30 Coquitlam Gate IP pipeline.

For a map of the route options for this section see attachment “Coquitlam IP-Section 1-Coquitlam – Poirier” in section 4.

Construction on Como Lake Avenue would close the centre two lanes with temporary closure of a third lane to facilitate construction vehicle movements. Traffic capacity would therefore be reduced; however, access would remain open to the properties on both the north and south side of Como Lake Avenue where this is feasible.

There is a route option to the south of Como Lake Avenue. The initial portion of this option adjacent to Mundy Park would also be routed on Como Lake Avenue. It would, however, include a section which is offset one street south of Como Lake Avenue on Regan Avenue between Montrose Street and Poirier Street. Montrose Street is the first direct roadway south to the first east west corridor along Regan Avenue. There are existing utilities on both the north and south side of Regan Avenue. The proposed NPS 30 IP pipeline would likely be constructed along the centre of the street which would close the street to all vehicular traffic during construction. Since these houses do not have lane access residents would have to park remotely and access their properties on foot.

Route Option 1 is the shorter alignment at 2,250 m. Route Option 2 is approximately 9% longer at 2,450 m.

2.1.1 Community and Stakeholder Impacts

2.1.1.1 *Health and Safety*

Option 1 would involve pipeline construction on Como Lake Avenue in proximity to road users and residential and commercial accesses. Option 2 would also involve pipeline construction on Como Lake Avenue and include a section on Regan Avenue which is a residential street offset one block to the south. On Como Lake Avenue the construction process would likely close the

centre lanes with traffic flow maintained in the outer lanes adjacent to the cordoned off construction zone. Access and egress to and from the construction zone for workers, materials and equipment would also occur in proximity to other road users. The short section of Option 2 located on Regan Avenue would reduce the construction required in close proximity to moving traffic and result in a more isolated and, therefore, safer construction zone. However, any potential benefit in terms of health and safety is offset by the additional length of Option 2 and the lack of residential lanes which would require residents to access their homes adjacent to the construction zone. Both options share a similar route for the majority of the alignments and therefore would have similar Health and Safety risks.

- Option 1: moderate impact, good route choice (3)
- Option 2: moderate impact, good route choice (3)

2.1.1.2 ***Socio-Economic***

Option 1 would require multiple lane closure on Como Lake Avenue during construction which would negatively impact traffic movement, bus routes and commercial access along this road. However, the construction plan would strive to maintain access to properties and businesses on the north and south side of Como Lake Avenue, and maintain one lane operational in each direction, which would minimize the traffic impact. Option 2 would require complete closure of sections of residential streets that would restrict local traffic movement and parking. The impacted residences would not have lane access. Therefore, residents would have to park remotely and access their homes on foot. The impact of Option 2, due to the lack of lane access, would be more profound compared to Option 1.

- Option 1: moderate impact, good route choice (3)
- Option 2: high impact, poor route choice (2)

2.1.1.3 ***Land Ownership and Use***

Options 1 and 2 would involve construction and installation of the pipeline within municipal roadway adjacent to other third party utilities. The routing analysis has determined that there is sufficient space to construct the proposed pipeline while maintaining access to other adjacent buried utilities. However, there are locations where the proposed pipeline would cross existing utilities which could result in some access restrictions. Both options would have similar considerations in terms of land ownership and land use.

- Option 1: moderate impact, good route choice (3)
- Option 2: moderate impact, good route choice (3)

2.1.2 Environmental Impacts

2.1.2.1 *Ecology/Cultural Heritage*

Options 1 and 2 are of approximately similar length and for the most part would be located along the same running line as the existing NPS 20 IP pipeline within municipal roadway. There would be low risk of encountering environmental constraints or undisturbed archaeological sites. Therefore, both route options would incur negligible impact to ecology and cultural heritage during construction.

- Option 1: very low impact, best route choice (5)
- Option 2: very low impact, best route choice (5)

2.1.2.2 *Human Environment*

Option 1 would install the pipeline on Como Lake Avenue which is a heavily trafficked transportation corridor with higher associated levels of background vehicle noise and emissions. However, the pipeline construction would incur some additional nuisance factor to the human environment on this route. In addition to the shared alignment on Como Lake Avenue, Option 2 would also involve pipeline construction along a residential street that would restrict street parking and, due to the absence of lane access, require residents to park remotely and access their homes by foot. Option 2 would incur a higher impact compared to Option 1 because of the lack of residential lane access and greater sensitivity to noise and other construction impacts.

- Option 1: moderate impact, good route choice (3)
- Option 2: high impact, poor route choice (2)

2.1.3 Technical Considerations

2.1.3.1 *Engineering*

Option 1 would maintain a direct alignment along Como Lake Avenue which minimizes lateral directional changes and the requirement for locating and designing 90 degree pipeline bend assemblies. Option 2, which is located on Como Lake Avenue and Regan Avenue, would require the design of bend assemblies to achieve the necessary route alignment and navigate numerous adjacent utilities. Option 1 would involve engineering challenges given the density of subsurface adjacent utilities along this route including buried power lines. Option 2 presents similar routing and engineering challenges in terms of underground adjacent utilities but would also require additional site investigations, detailed routing and engineering to design the bend assemblies to achieve the necessary lateral alignment changes.

- Option 1: low impact, better route choice (4)
- Option 2: moderate impact, good route choice (3)

2.1.3.2 ***Construction***

Option 1 would maintain a direct alignment and avoid lateral movement of the construction process from Como Lake Avenue onto adjacent side streets. The density of buried utilities and service connections encountered on each route option would be similar and, therefore, construction productivity would be the same for both options. Also, both options are approximately the same length which would result in similar sized overall construction footprints. However, Option 2 would require the construction to turn laterally from Como Lake Avenue onto the Regan Avenue and then turn back to Como Lake Avenue. This would require complex tie-in procedures as the installation of 90 degree pipeline bend assemblies would have to be installed at extra depth to cross underneath and avoid numerous third party utilities on Como Lake Avenue. This would incur additional construction challenges compared to Option 1.

- Option 1: low impact, better route choice (4)
- Option 2: moderate impact, good route choice (3)

2.1.3.3 ***Operation***

Both route options would install the pipeline within municipal roadway with numerous other adjacent utilities which could constrain future access for maintenance. Option 1 would locate the pipeline generally along the centre of Como Lake Avenue which is a heavily trafficked transportation corridor. Compared to Option 2, which is partially located on residential streets, it would be more difficult to readily access the pipeline, due to the additional traffic management restrictions on Como Lake Avenue, if pipeline inspection, maintenance or repairs were required.

- Option 1: high impact, poor route choice (2)
- Option 2: moderate impact, good route choice (3)

2.1.3.4 ***System Interface***

Option 1 would require the construction of a short lateral pipeline to connect to the existing district station at Poirier Street & Como Lake Avenue. Option 2, given its alignment adjacent to the existing station does not require the construction of a lateral pipeline connection. Therefore, Option 1 involves more complexity while Option 2 provides for a more direct interface.

- Option 1: moderate impact, good route choice (3)
- Option 2: very low impact, best route choice (5)

2.1.3.5 ***Adjacent Infrastructure***

Option 1 and Option 2 would encounter numerous adjacent above and below ground utilities and service connections. Both options would require the same approach to ensure that the pipeline construction and installation would not impact the adjacent utilities and also that the proximity to adjacent utilities would not compromise the future integrity of the pipeline and

access for maintenance and operation activities. Both options would, therefore, have the same impact considerations.

- Option 1: moderate impact, good route choice (3)
- Option 2: moderate impact, good route choice (3)

2.1.3.6 *Natural Hazards*

Based on existing understanding of the location and environment in which the route options are proposed, both alignments are at low risk from natural hazards and are considered very low impact route choices.

- Option 1: very low impact, best route choice (5)
- Option 2: very low impact, best route choice (5)

2.1.4 Cost

The construction productivity on both options would be low as the pipe must be pulled into the excavated trench under a high density of utility service connections. Therefore, because Option 1 is the shortest route alignment it is also the least expensive route option.

2.1.5 Route Options Scoring and Selection

The relative scoring of these route options in Table 1 reflects the impacts and considerations outlined in the previous discussion in terms of Community and Stakeholder, Environmental and Technical impacts and considerations. Option 1 is the lowest overall impact and least cost route option and is selected as the preferred option through this section of corridor.

Table 1: Mariner Way to Poirier St. Route Options Screening Matrix

Metro IP Route Selection: Mariner way to Poirier (Coquitlam East)					
	Option	1		2	
	Length (m)	2250		2455	
Impact and Vulnerability Considerations	**Weight**	**Como Lake Ave**		**Como Lake Ave + Montrose St + Regan Ave + Poirier St**	
		Score	Weighted Score	Score	Weighted Score
Community/Stakeholder					
Health and Safety	15	3	45	3	45
Socio-Economic	15	3	45	2	30
Land Ownership and Use	5	3	15	3	15
Environmental					
Ecology	5	5	25	5	25
Cultural Heritage	5	5	25	5	25
Human Environment	15	3	45	2	30
Engineering/Technical					
Engineering/Design	5	4	20	3	15
Construction	10	4	40	3	30
Operation	10	2	20	3	30
System interface	5	3	15	5	25
Adjacent Infrastructure	5	3	15	3	15
Natural Hazards	5	5	25	5	25
Totals	**100**		**335**		**310**
Ranking		**1**		**2**	
Relative Cost		**100%**		**112%**	
Cost Ranking		**1**		**2**	

2.2 *SECTION 2 - POIRIER ST. TO ROBINSON ST.*

This section of pipeline connects the district station at Poirier Street with the district station at the intersection of Clarke Road & Robinson Street in Coquitlam. There is a lateral IP pipeline extending from the NPS 20 Coquitlam Gate IP pipeline on Como Lake Avenue north along Robinson Street to supply the existing district station and an IP customer located further north.

For a map of the route options for this section see attachment “Coquitlam IP-Section 2- Poirier-Clarke-Robinson” in section 4.

Three route options are defined within this section of corridor for installation of the NPS 30 Coquitlam Gate IP pipeline. Option 1 is routed on Como Lake Avenue parallel to the existing NPS 20 IP pipeline. There are utility service connections to homes on both sides of the road which would create a high density of utility service crossings. Similar to the previous section (Section 1) it is anticipated that the construction would be confined primarily to the centre two lanes of this four lane roadway.

Option 2 is offset 1 to 2 blocks to the south of Como Lake Avenue following parallel residential streets. The density of utility services along Grover Avenue is similar to Como Lake Avenue. Grover Avenue is narrow and the proposed pipeline would be constructed along the centre of the roadway requiring complete closure of the street. The houses along Grover Avenue between Schoolhouse Street and MacIntosh Street have access from lanes behind the houses for the most part. At MacIntosh Street the route turns south onto Regan Avenue and continues to Guiltner Street where it turns north to Como Lake Avenue to connect with the existing lateral pipeline on Robinson Street. The density of utility crossings is less between MacIntosh & Robinson Street as the storm and sanitary services are located in the lanes at the rear of the houses. Similar to Grover Avenue, all of these streets are narrow and the pipeline construction would require the complete closure of the streets.

Option 3 is routed to the north and west of Como Lake Avenue around the west side of Miller Park through Port Moody. This route travels north through the Harbour Chines community on Poirier Street, Harbour Drive and Gatensbury Road as it drops down into Port Moody. The utility density is high along Poirier Street but less so along Harbour Drive and Gatensbury Road. All of the streets impacted by construction along this route are two lanes which would be closed resulting in significant access issues, particularly along Gatensbury Road.

Option 1 is the shortest alignment at 2,445 m. Option 2 is 16% longer at 2,840 m and Option 3 is 4,565 m and approximately 87% and 60% longer than Options 1 and 2 respectively.

2.2.1 Community and Stakeholder Impacts

2.2.1.1 *Health and Safety*

Route Option 1 on Como Lake Avenue would involve pipeline construction in proximity to road users and residential and commercial accesses. Options 2 and 3 would involve pipeline construction along two lane residential streets located to the north and south of Como Lake Avenue. On the two lane streets the construction activities would occur within isolated sections of street and there would be no traffic movement or parking adjacent to the construction. Option 2 has lane access; however, safe access and egress for local residents on Option 3 would be challenging in the residential streets with no lane access. Options 1 and 2 are within 16% in terms of length. However, any potential benefit afforded by the more isolated construction zone on Option 2 in terms of reduced health and safety risk is offset by the additional length. Option 3, due to the significant additional length (which would result in the longest construction timeframe) and access restrictions for local residents, would have greater health and safety risk to the community, stakeholders and construction personnel along the route.

- Option 1: moderate impact, good route choice (3)
- Option 2: moderate impact, good route choice (3)
- Option 3: high impact, poor route choice (2)

2.2.1.2 *Socio-Economic*

Option 1 would require multiple lane closure to facilitate pipeline construction which would result in traffic flow restrictions. However, these impacts would be partially mitigated as the preliminary traffic impact analysis in Appendix A-18-1 suggests that with a single lane operating in each direction Como Lake Avenue could operate satisfactorily for most of the day. Also, access would remain open to properties and businesses on the north and south side of Como Lake Avenue. Options 2 and 3 would require complete closure of residential streets which would restrict traffic movement and parking. Some residences along these routes do not have lane access therefore residents would have to park remotely and gain access on foot. Options 1 and 2 are approximately similar in length and, utilizing prudent traffic management and construction staging, would incur the least socio-economic impact. Option 3 is significantly longer then Options 1 and 2 (87% and 60% respectively) and the construction would isolate a number of residences with no alternative access route. Therefore, this route option would incur the highest relative socio-economic impact due to the greater negative impacts to daily life for local citizens.

- Option 1: moderate impact, good route choice (3)
- Option 2: moderate impact, good route choice (3)
- Option 3: high impact, poor route choice (2)

2.2.1.3 *Land Ownership and Use*

Options 1, 2 and 3 would involve pipeline installation within municipal roadway adjacent to numerous other third party utilities and have similar impact considerations in terms of proximity, access requirements to construct the proposed pipeline and operation and maintenance requirements for both the pipeline and other adjacent utilities.

- Option 1: moderate impact, good route choice (3)
- Option 2: moderate impact, good route choice (3)
- Option 3: moderate impact, good route choice (3)

2.2.2 Environmental Impacts

2.2.2.1 *Ecology*

Option 1, due to its location on Como Lake Avenue, would have the least environmental impact considerations. The likelihood of finding contaminated sites during pipeline construction is always a major consideration, especially in areas with potential sources of contamination e.g. existing or past site of a gas station. However, the Environmental Constraints Study identified only one potential contaminated site along this section of route corridor. Option 2 would require pipeline construction parallel, and to the south of, Como Lake Avenue and in proximity to Como Lake Park, Porter Street Elementary, Mountain View Park and Burquitlam Park which would

increase the potential risk of negative environmental impacts to these areas during construction. Option 3, located to the north of Como Lake Avenue, is significantly longer and would be located in proximity to the east and north side of Miller Park for most of the route which would result in the highest risk of potential environmental impact during construction.

- Option 1: very low impact, best route choice (5)
- Option 2: moderate impact, good route choice (3)
- Option 3: high impact, poor route choice (2)

2.2.2.2 *Cultural Heritage*

Options 1, 2 and 3 would be located within paved roadway and due to the low risk of encountering archaeological sites these options would incur very low risk of impacts to cultural heritage during construction.

- Option 1: very low impact, best route choice (5)
- Option 2: very low impact, best route choice (5)
- Option 3: very low impact, best route choice (5)

2.2.2.3 *Human Environment*

Option 1 would involve construction on Como Lake Avenue which is a heavily trafficked transportation corridor. In contrast, Options 2 and 3 would involve pipeline construction along quieter residential streets. Option 2 is longer (approximately 16% longer than Option 1) and would have a greater impact on the local human environment in terms of noise, increase local emissions and nuisance factors. Option 3 is significantly longer compared to Options 1 and 2 and would have the highest relative impact to human environment from construction activities.

- Option 1: low impact, better route choice (4)
- Option 2: moderate impact, good route choice (3)
- Option 3: high impact, poor route choice (2)

2.2.3 Technical Considerations

2.2.3.1 *Engineering*

Option 1 maintains a direct alignment along Como Lake Avenue for installation of the pipeline which minimizes the requirement for designing and locating pipeline bend assemblies within roadway. Options 2 and 3 would require the installation of numerous 90 degree bend assemblies to achieve the necessary alignment and navigate other adjacent buried utilities. Options 2 and 3 would require additional site investigations, detailed routing and engineering compared to the more direct alignment of Option 1.

- Option 1: low impact, better route choice (4)
- Option 2: moderate impact, good route choice (3)
- Option 3: moderate impact, good route choice (3)

2.2.3.2 ***Construction***

Option 1 maintains a direct alignment on Como Lake Avenue for installation of the pipeline. Option 2 is longer and follows parallel streets offset one to two blocks south of Como Lake Avenue. Option 3 is the longest route alignment and follows an erratic route with steep gradients encountered and numerous acute alignment changes. Each route option would be constructed using traditional open trench construction methods.

Option 2 is 16% longer than Option 1; however, there are fewer utility service connections on this route which would result in less construction constraints compared to Option 1 and greater construction productivity. Option 3 is the longest route resulting in the largest construction footprint which would be located entirely on residential streets. This route is also the furthest removed from Como Lake Avenue which would result in the most restrictive route in terms of access for construction equipment and materials. There are also steep gradients on sections of this route which would further constrain the pipeline construction activities.

- Option 1: moderate impact, good route choice (3)
- Option 2: low impact, better route choice (4)
- Option 3: high impact, poor route choice (2)

2.2.3.3 ***Operation***

In terms of operation, all three route options would be installed within municipal roadway. Option 1 would locate the pipeline generally along the centre of Como Lake Avenue which is a heavily trafficked transportation corridor and, compared to Option 2 and 3 which are located on residential streets, it would be more difficult to readily access the pipeline in the event of any future inspection or repairs due to traffic management constraints.

- Option 1: high impact, poor route choice (2)
- Option 2: moderate impact, good route choice (3)
- Option 3: moderate impact, good route choice (3)

2.2.3.4 ***System Interface***

Options 1, 2 and 3 would each require the construction of IP/IP interface stations to connect to the existing IP infrastructure supplying the district station at Clarke Road & Robinson Street and IP customer further north. Options 1 and 2 would interface with the existing IP infrastructure at Como Lake Avenue & Robinson Street. Option 3 would interface with the existing IP

infrastructure in the vicinity of the existing Robinson Street station. However, in all cases similar IP/IP interface station would be required resulting in the same system interface challenges.

- Option 1: moderate impact, good route choice (3)
- Option 2: moderate impact, good route choice (3)
- Option 3: moderate impact, good route choice (3)

2.2.3.5 *Adjacent Infrastructure*

Options 1, 2 and 3 would encounter numerous adjacent buried utilities and present the same challenges in terms of pipeline construction in proximity to other existing buried infrastructure. Each option would require similar approaches to avoid impacting adjacent infrastructure whilst providing suitable offset for future access to the pipeline and other utilities.

- Option 1: moderate impact, good route choice (3)
- Option 2: moderate impact, good route choice (3)
- Option 3: moderate impact, good route choice (3)

2.2.3.6 *Natural Hazards*

Based on the route analysis all three alignments would be at low risk from natural hazards and are low impact route choices.

- Option 1: low impact, better route choice (4)
- Option 2: low impact, better route choice (4)
- Option 3: low impact, better route choice (4)

2.2.4 Cost

Option 2 is the least cost route option. Option 1 is shorter than Option 2 but approximately 15% more expensive due to the higher density of utility service connections which would reduce construction productivity. Option 3 is significantly longer than Options 1 and 2 and would involve challenging construction; this option would be prohibitively expensive and is not considered a viable route option.

2.2.5 Route Options Scoring and Selection

The total scores and relative ranking of these route options in Table 2 reflects the impacts and considerations outlined in the previous discussion. Due to its considerable additional length and resulting impacts Option 3 is not a viable route option. Option 1 is the shortest route; it is 16% shorter than Option 2 and provides the smallest feasible footprint. Option 1 is also the lowest overall impact route and offers advantages with respect to environmental (human environment)

and engineering considerations over Option 2. Therefore, Option 1 is selected as the preferred route option for this section of route corridor that best achieves a safe, environmentally acceptable, economic and practical route.

Table 2: Poirier St. to Robinson St. Route Options Screening Matrix

Metro IP Route Selection: Poirier to Robinson (Coquitlam West)

	Option	1		2		3	
	Length (m)	2445		2840		4565	
Impact and Vulnerability Considerations	**Weight**	**Como Lake Ave**		**Como lake Ave + School House St + Grover Ave + MacIntosh St + Regan Ave + Guiltner St + Smith Ave**		**Poirier St + Harbour Dr + Gatensbury Rd + St John St + Clarke Rd**	
		Score	Weighted Score	Score	Weighted Score	Score	Weighted Score
Community/Stakeholder							
Health and Safety	15	3	45	3	45	2	30
Socio-Economic	15	3	45	3	45	2	30
Land Ownership and Use	5	3	15	3	15	3	15
Environmental							
Ecology	5	5	25	3	15	2	10
Cultural Heritage	5	5	25	5	25	5	25
Human Environment	15	4	60	3	45	2	30
Engineering/Technical							
Engineering/Design	5	4	20	3	15	3	15
Construction	10	3	30	4	40	2	20
Operation	10	2	20	3	30	3	30
System interface	5	3	15	3	15	3	15
Adjacent Infrastructure	5	3	15	3	15	3	15
Natural Hazards	5	4	20	4	20	4	20
Totals	**100**		**335**		**325**		**255**
Ranking		**1**		**2**		**3**	
Relative Cost		**115%**		**100%**		**188%**	
Cost Ranking		**2**		**1**		**3**	

2.3 *SECTION 3 - ROBINSON ST. TO UNDERHILL AVE.*

This section of pipeline connects the lateral offtake on the NPS 20 Coquitlam Gate IP pipeline at Como Lake Avenue & Robinson Street (which supplies the district station at Clarke & Robinson in Coquitlam) to the district station at Underhill Avenue & Broadway in Burnaby. This section of the pipeline corridor moves from Coquitlam into Burnaby. Three route options are defined within this section of corridor for installation of the NPS 30 Coquitlam Gate IP pipeline.

For a map of the route options for this section see attachment “Coquitlam IP-Section 3-Clarke-Robinson-Underhill” in section 4.

Option 1 is located on Como Lake Avenue and Broadway parallel to the existing NPS 20 IP pipeline. There would be a long trenchless construction near the intersection of Como Lake

Avenue & Clarke Road as there is significant east west utility congestion in this portion of roadway which prevents the development of a constructible alignment using typical trenched construction practices. There is also a trenchless crossing of Stoney Creek as the route moves west, and a bored crossing of Gaglardi Way. The route then enters a utility right of way in a corridor shared with power lines and the existing NPS 20 IP pipeline west of Gaglardi Way. There would be a bored crossing at Production Way as the pipeline moves west along the Broadway right of way (south of the Burnaby 200 Conservation) area to Underhill Avenue. A significant portion of this route would encounter minimal other utilities resulting in relatively good construction productivity.

Option 2 is routed to the south of Como Lake Avenue and Broadway and follows parallel streets offset a number of blocks. The roadways encountered are typically local residential streets and connector roads. They are generally two lanes with utility services along the road sides which would allow for the installation of the pipeline along the centre of the existing road. There are portions of the route with both high density utility crossings (in areas with houses on both sides of the street) and areas with less utility crossings (near various apartment and condo units) which would result in a mix of slow and very slow pipeline construction productivity.

Option 3 is routed to the north of Como Lake Avenue and Broadway and follows Robinson Street, Chapman Avenue, Underhill Avenue and existing pipeline corridors through some forested sections to the south of Burnaby Mountain and along Gaglardi Way.

Option 1 is the shortest alignment at 3,830 m. Option 2 is approximately 40% longer at 5,300 m and Option 3 is approximately 35% longer than Option1 at 5,180 m.

2.3.1 Community and Stakeholder Impacts

2.3.1.1 *Health and Safety*

Option 1 would involve pipeline construction along Como Lake Avenue and Broadway roadway for approximately 50% of the alignment length. The remainder of the route would be located in the utility right of way adjacent to Gaglardi Way and the undeveloped Broadway road corridor. Option 1 would involve two long trenchless crossings on Como Lake Avenue and Broadway which would not be required on Options 2 or 3. Option 2 would involve pipeline construction along residential streets and collector roads in proximity to road users and commercial and residential accesses. Option 3 would involve pipeline construction along residential streets, existing utility and third party pipeline right of way and within Gaglardi Way roadway.

Option 1 is the shortest alignment and would include trenchless construction on Como Lake Avenue. However, a significant portion would be located in undeveloped areas which would minimize the potential health and safety risk to the general public. Options 2 and 3 are 40% and 35% longer than Option 1 respectively and, due to the significantly greater length, larger overall construction footprint and proximity to residential and industrial areas and industrial facilities, would incur greater health and safety risk compared to Option 1.

- Option 1: moderate impact, good route choice (3)
- Option 2: high impact, poor route choice (2)
- Option 3: high impact, poor route choice (2)

2.3.1.2 ***Socio-Economic***

Option 1 would require multiple lane closures on Como Lake Avenue and Broadway (to Gaglardi Way) with impacts to traffic movement and some access restriction. However, most access would remain open to properties on the north and south side of Como Lake Avenue. On the west side of Gaglardi Way the alignment enters an undeveloped section of Broadway road corridor with minimal traffic impacts and access restrictions.

Option 2 would require complete closure of residential streets and traffic collector routes with impacts to traffic movement, parking and access restriction impacts to residential, commercial and business premises. A short section of Option 3 would impact residential neighbourhoods. However, the majority of the route is along Gaglardi Way and through forest paths to the south of Burnaby Mountain.

Option 1, utilizing prudent traffic management and a tailored construction approach, would mitigate the traffic impacts and access restrictions to an acceptable level. Option 2, due to the traffic movement restriction on the collector roads serving commercial areas and the significantly longer alignment would have the highest relative socio-economic impact. Option 3, due to the significant portions of the alignment through lower density and undeveloped areas, would incur the least socio-economic impact.

- Option 1: moderate impact, good route choice (3)
- Option 2: high impact, poor route choice (2)
- Option 3: low impact, better route choice (4)

2.3.1.3 ***Land Ownership and Use***

Options 1 and 2 would involve installation of the pipeline within municipal roadway with least impact to land ownership and use. Option 3 would involve installation of the pipeline within some municipal roadway but would also include installation of the pipeline within or adjacent to shared utility corridors and parallel to existing third party pipeline right of way. Option 3 would require a wider temporary workspace in which to construct the pipeline and acquisition of an easement with suitable access rights necessary for pipeline operation and maintenance.

- Option 1: moderate impact, good route choice (3)
- Option 2: moderate impact, good route choice (3)
- Option 3: high impact, poor route choice (2)

2.3.2 Environmental Impacts

2.3.2.1 *Ecology*

Option 1 would be partially located within municipal roadway and undeveloped Broadway road right of way; it would also impact undeveloped green space to the west of Gaglardi Way and Burnaby Mountain Trail to the south of Burnaby Mountain Conservation Area. There are a number of streams which flow north to south and would have to be crossed by the pipeline. Environmental impacts would be managed through careful construction practices and appropriate use of trenchless constructions techniques.

Option 2 would avoid the area immediately to the south of Burnaby Mountain Conservation Area and also some of the stream crossings by adopting an alignment along roads and streets to the south of Broadway which would minimize environmental impact risk. However, Option 2 would impact the Stoney Creek Trail system but to a lesser degree.

Option 3, which adopts an alignment to the north of Broadway along Gaglardi Way and to the south of Burnaby Mountain, would have the greatest potential environmental impact risk because it is a relatively undisturbed natural area which would require clearing and grading, and would encounter the most stream crossings with the greatest impact risk from spills, surface water runoff and sediment control issues during construction.

- Option 1: moderate impact, good route choice (3)
- Option 2: low impact, better route choice (4)
- Option 3: high impact, poor route choice (2)

2.3.2.2 *Cultural Heritage*

Options 1 and 2, due to their respective alignments within areas which have been disturbed by roads, trails, residential, commercial and industrial development, including other utility and pipeline infrastructure, would have the least risk of encountering archaeological sites. Option 3, which adopts an alignment to the north of Broadway along Gaglardi Way and the south of Burnaby Mountain, would have a higher impact risk because it is a relatively undisturbed area with a greater likelihood of disturbing unknown archaeological sites.

- Option 1: low impact, better route choice (4)
- Option 2: low impact, better route choice (4)
- Option 3: moderate impact, good route choice (3)

2.3.2.3 *Human Environment*

Approximately 50% of Option 1 would be installed on Como Lake Avenue which is a heavily trafficked transportation corridor with associated high levels of background noise and emissions

and the remainder of the route would be installed within undeveloped municipal road right of way which currently supports an urban trail. Option 2 would impact a mix of residential streets and collector roads serving the industrial and commercial area between Broadway and Lougheed Highway. Option 3 would impact fewer residential streets and a major traffic corridor (Gaglardi Way) but portions of the route would also be located within forested areas to the south of Burnaby Mountain.

Option 1 is the shortest route option and construction of the section of the route not on Como Lake Avenue would impact the Burnaby Mountain Urban Trail, between Production Way and Underhill Avenue, during the construction period. There would be some tree impacts but the area would be reinstated after construction to pre-construction conditions which would minimize potential aesthetic and visual impacts.

Option 2 is significantly longer than Option 1 (40% longer) and would incur higher human environment impacts because the pipeline construction would occur within more residential areas which would be more sensitive to the construction noise and other nuisance factors.

Option 3 is approximately the same length as Option 2 and would impact residential streets and public trails along the south side of Burnaby Mountain. The pipeline right of way would require clearing and grading in the forested sections which would negatively impact the public trails in the area and result in aesthetic impacts that would be permanently visible after construction. Route Options 2 and 3 would result in the highest relative impact in terms of human environment considerations.

- Option 1: moderate impact, good route choice (3)
- Option 2: high impact, poor route choice (2)
- Option 3: high impact, poor route choice (2)

2.3.3 Technical Considerations

2.3.3.1 *Engineering*

Option 1 would facilitate a direct alignment on Como Lake Avenue for installation of the pipeline but would involve challenging trenchless crossings of Clarke Road (because the density of subsurface utilities prohibits open trench construction), Stoney Creek and Gaglardi Way. There would be considerable engineering effort required to support the trenchless crossing engineering and planning. Option 2 would also require shorter trenchless crossings, and the alignment would include the design and installation of numerous pipeline bend assemblies to affect the many alignment changes in residential streets along its route which would require additional routing and design effort. Option 3 would install the pipeline in an area with other existing third party pipelines and overhead power lines. There is also potential for further additional third party pipelines to be installed in this area in the future. These factors would

present engineering challenges that would have to be considered in the detailed routing and engineering process.

Option 1 is the shortest and most direct alignment. However, the trenchless crossings at Clarke Road, Stoney Creek and Gaglardi Way would present significant additional site investigation, routing and design challenges compared to the other route options. Options 2 and 3 are longer than Option 1 but would be constructed using less trenchless techniques and employ more conventional open trench construction.

- Option 1: high impact, poor route choice (2)
- Option 2: moderate impact, good route choice (3)
- Option 3: moderate impact, good route choice (3)

2.3.3.2 ***Construction***

Option 1 maintains a direct alignment on Como Lake Avenue for installation of the pipeline but would require a long trenchless crossings under Clarke Road, and shorter trenchless crossings under Stoney Creek and Gaglardi Way. Option 2 would involve shorter trenchless crossings and numerous pipeline bend assemblies within residential streets and some shorter bored trenchless crossings. Option 3 would involve pipeline construction adjacent to other existing pipeline corridors and crossing beneath high voltage overhead power lines. On balance, all three Options would return similar overall productivity. However, Option 1 is shorter than Option 2 and 3 by approximately 40% and 35% respectively which would result in a significantly reduced overall construction footprint.

- Option 1: low impact, better route choice (4)
- Option 2: moderate impact, good route choice (3)
- Option 3: moderate impact, good route choice (3)

2.3.3.3 ***Operation***

Option 1 would be located on Como Lake Avenue and an undeveloped section of Broadway road right of way. Option 2 would be located in municipal road ways comprising residential streets and collector roads south of Option 1. Option 3 would be located adjacent to an existing third party pipeline; it would cross underneath overhead high voltage power lines and also traverse in proximity to an existing oil tank farm and associated service pipelines.

Options 1 and 2 would install the pipeline adjacent to other utilities and would maintain adequate access to the pipeline for future operation and maintenance. Option 1, however, would also involve longer trenchless crossings which would install sections of the pipeline deeper and could restrict access at these locations in the future. Option 3 would install the pipeline adjacent to sensitive third party infrastructure which could potentially incur more

restrictions in terms of access to the pipeline for future operation and maintenance compared to the other route options.

- Option 1: high impact, poor route choice (2)
- Option 2: moderate impact, good route choice (3)
- Option 3: high impact, poor route choice (2)

2.3.3.4 ***System Interface***

Option 1 would require the construction of a short lateral pipeline to connect to the existing district station at Underhill Avenue & Broadway. Option 2, given the alignment adjacent to the existing district station, would not require the construction of a lateral pipeline. Option 3 would involve the construction of the longest lateral pipeline to interface with the existing district station.

- Option 1: moderate impact, good route choice (3)
- Option 2: low impact, better route choice (4)
- Option 3: high impact, poor route choice (2)

2.3.3.5 ***Adjacent Infrastructure***

Option 1 would encounter a higher density of below ground adjacent utilities particularly at the intersection of Clarke Road & Como Lake Avenue, including the Evergreen Line Sky Train elevated guide way, where it would be necessary to install the pipeline at extra depth using trenchless methods. Option 2 would be installed in municipal roadway adjacent to other existing buried utilities. Option 3 would be located adjacent to existing third party pipelines, it would cross underneath overhead high voltage power lines and also traverse in proximity to an existing oil tank farm and associated service pipelines. Possible future upgrade or expansion to the existing oil storage facility and pipeline infrastructure in this area could result in operation burdens in excess of those required by the other options, and risk to longevity and safe operation of the pipeline.

Comparing the higher density of buried utilities encountered on the shorter Option 1 to the lower utility density but relatively greater length of Options 2 and 3, and the proximity of Option 3 to existing power lines, existing third party pipelines and an oil storage tank farm and service lines, Option 1 and 2 would result in moderate impact route choices while Option 3 would constitute a relatively high impact route choice.

- Option 1: moderate impact, good route choice (3)
- Option 2: moderate impact, good route choice (3)
- Option 3: high impact, poor route choice (2)

2.3.3.6 *Natural Hazards*

Options 1 and 2 would be located predominantly within roadway with low risk of impact from natural hazards. Option 3 would also include sections installed within roadway; however, a long section would be installed along the southern edge of Burnaby Mountain with greater risk of impact from natural hazards such as soil movement, erosion or subsidence.

- Option 1: low impact, better route choice (4)
- Option 2: low impact, better route choice (4)
- Option 3: high impact, poor route choice (2)

2.3.4 Cost

Options 2 and 3 would have relatively similar construction productivity compared to Option 1 but are approximately 40% and 35% longer respectively. On this basis Option 1 would be the least expensive route option for open trench pipeline construction. However, the longer trenchless crossings required on Option 1, compared to the other options, offsets any gains afforded by the reduced length. As a result, Option 3 is the least expensive followed by Option 2 and Option 1 which are approximately 7% and 13% more expensive respectively.

2.3.5 Route Options Scoring and Selection

The relative overall scoring and ranking of these options in Table 3 reflects the impacts and considerations outlined in the previous discussion. Options 2 and 3 are 40% and 35% longer than Option 1 respectively. Option 1 would result in the smallest footprint feasible and offers advantages compared to Option 2 in terms of lower Health and Safety, Socio-Economic and Human Environment impacts. Compared to Option 3, Option 1 offers reduced impact in most categories. Option 1 is, therefore, selected as the preferred option that best achieves a safe, environmentally acceptable, economic and practical route.

Table 3: Robinson St. to Underhill Ave. Route Options Screening Matrix

Metro IP Route Selection: Robinson to Underhill (Burnaby East/Coquitlam West)

	Option	1		2		3	
	Length (m)	3830		5300		5180	
Impact and Vulnerability Considerations	**Weight**	**Como Lake Ave + Broadway + Gaglardi Way + Broadway**		**Robinson St + Smith Ave + Fairview St + Cottonwood Ave + Whiting Way + Perth Ave + North Rd + Cameron St + East Lake Dr + Underhill Ave**		**Robinson St + Chapman Ave + North Rd + Pipeline Trail + Gaglardi Way + Transmountain Trail + Underhill Ave**	
		Score	Weighted Score	Score	Weighted Score	Score	Weighted Score
Community/Stakeholder							
Health and Safety	15	3	45	2	30	2	30
Socio-Economic	15	3	45	2	30	4	60
Land Ownership and Use	5	3	15	3	15	2	10
Environmental							
Ecology	5	3	15	4	20	2	10
Cultural Heritage	5	4	20	4	20	3	15
Human Environment	15	3	45	2	30	2	30
Engineering/Technical							
Engineering/Design	5	2	10	3	15	3	15
Construction	10	4	40	3	30	3	30
Operation	10	2	20	3	30	2	20
System interface	5	3	15	4	20	2	10
Adjacent Infrastructure	5	3	15	3	15	2	10
Natural Hazards	5	4	20	4	20	2	10
Totals	**100**		**305**		**275**		**250**
Ranking		**1**		**2**		**3**	
Relative Cost		**113%**		**107%**		**100%**	
Cost Ranking		**3**		**1**		**2**	

2.4 *SECTION 4 - UNDERHILL AVE. TO BAINBRIDGE AVE.*

This section of pipeline connects the district station at Underhill Avenue & Broadway with the district station at Bainbridge Avenue & Broadway in Burnaby. There is an existing lateral IP pipeline at Arden Avenue that supplies two district stations (Aubrey & Arden station and University & Nelson station) and another IP customer located to the north of the NPS 20 Coquitlam Gate IP pipeline route. The proposed NPS 30 Coquitlam Gate IP pipeline must interface with this lateral. Three route options are defined within this section of corridor.

For a map of the route options for this section see attachment “Coquitlam IP-Section4-Underhill-Bainbridge” in section 4.

Option 1 would install the pipeline in Broadway parallel to the existing NPS 20 IP pipeline. There would be a trenchless crossing required just west of Underhill Avenue where existing third party pipelines connect an existing tank farm on the north side of Broadway with a storage facility on the south side of Broadway. It is proposed to cross Eagle Creek in the Broadway

roadway where the creek is confined to a pipe culvert. East of Eagle Creek, the pipeline construction productivity increases as there are fewer properties both north and south of Broadway. West of Eagle Creek the construction productivity is reduced. Broadway is only two lanes in this area and it is likely the entire road would be closed along this section to facilitate construction. There would be some access issues but the construction could be staged to mitigate most of them.

Option 2 is routed on Broadway for the initial portion of the alignment (similar to Option 1) and to the south of Broadway on Lougheed Highway for the remainder of this option alignment. There would be a conflict with the Lougheed Sky Train station and it is likely that a major trenchless crossing would be required in the vicinity of the Sky Train for the Eagle Creek crossing which includes a deep ravine at this location. Construction along the Lougheed Highway section would facilitate greater pipeline construction productivity; however, both west bound lanes would be closed for a period of time to accommodate the construction which would result in significant traffic impacts.

Option 3 would involve a route to the north of Broadway to circumvent Burnaby Golf Course.

2.4.1 Route Options Scoring and Selection

Option 1 is 2,205 m in length, Option 2 is 2,990 m in length and Option 3 is approximately 3,990 m in length. Options 2 and 3 are 36% and 82% longer than Option 1 respectively. They offer no significant advantages over Option 1 and are both approximately 80% more expensive. The greater lengths and higher costs effectively eliminate them as preferred options.

2.5 *SECTION 5 - BAINBRIDGE AVE. TO SPRINGER AVE.*

This section of pipeline connects the district station at Bainbridge Avenue & Broadway with the district station at Springer Avenue & Broadway in Burnaby. Three route options are defined within this section of corridor for installation of the NPS 30 Coquitlam Gate IP pipeline.

For a map of the route options for this section see attachment “Coquitlam IP-Section 5-Bainbridge-Springer” in section 4.

Option 1 follows Broadway parallel to the NPS 20 Coquitlam Gate IP pipeline. East of Kensington Avenue there is significant utility density which would result in construction challenges and low construction productivity. West of Kensington, Broadway widens and the alignment improves. As Broadway is two lanes for much of this route most of it would be closed to through traffic during construction. If the pipeline is constructed on the north or side of the roadway, other utilities permitting, a single lane of traffic could be maintained open to provide local access to homes and businesses.

Option 2 parallels Broadway to the south on Lougheed Highway. At this point along the highway there is some open space along the north side as the Sky Train guiderail is located

predominantly on the south side of the highway reducing potential conflict. This route has the advantage of avoiding access issues to homes and businesses since the houses along Lougheed Highway have rear access via a parallel service road. It is likely that the north two westbound lanes of the highway would have to be closed to facilitate the pipeline construction. A traffic impact assessment was completed for this section of route on Lougheed Highway and is included in Appendix A-18-5. The assessment finds that west of Sperling Avenue the traffic volumes displaced during construction would be higher and suitable detour routes are not readily available.

Option 3 parallels Broadway to the north along Halifax Street. There are houses along both sides of the street for a majority of the route; however, all of them have lane access. All of the streets are two lane collectors and would be completely closed in staged sections as construction progressed.

Option 1 is the shortest alignment at 2,665 m. Option 2 is 10% longer at 2,910 m and Option 3 which is the longest at 3,470 m is 30% and 20% longer than Options 1 and 2 respectively.

2.5.1 Community and Stakeholder Impacts

2.5.1.1 *Health and Safety*

Option 1 is the shortest route and its location along Broadway would mean the construction zones could be isolated with traffic diverted onto Lougheed Highway. Where feasible a single lane on Broadway would be maintained open to permit local access to properties and residences.

Option 2, due to its location on Lougheed Highway, would incur significant traffic disruption and require specialized traffic management to ensure safe movement of the pipeline construction process along a major traffic corridor. Both westbound lanes on Lougheed would be closed which would partially isolate the construction zones from the traffic and other road users.

Option 3 would involve pipeline construction on residential streets which would restrict traffic and pedestrian movement in the vicinity of the construction zone. In terms of Health and Safety, each of the options would facilitate local isolation of the construction zones, restrict access to the work site and maintain safe access and egress for construction equipment, materials and personnel.

Options 1 and 2 are the within 10% in terms of length and are considered equal in terms of health and safety risk. Option 3, due to the greater length, would result in relatively higher health and safety risk.

- Option 1: moderate impact, good route choice (3)
- Option 2: moderate impact, good route choice (3)
- Option 3: high impact, poor route choice (2)

2.5.1.2 ***Socio-Economic***

Option 1 would require lane closures on Broadway throughout the construction period which would negatively impact local access and traffic movement along this corridor. However, depending on the location of below ground utilities, the pipeline could be constructed on the north side of the roadway and maintain a single lane open to provide some local access to homes and businesses.

Option 2 is routed along Lougheed Highway which would require complete closure of two lanes (possibly increasing to three lanes to accommodate some construction activities) and would result in significant traffic flow disruption. A preliminary traffic analysis has been completed that suggests the pipeline could be constructed on Lougheed Highway between Bainbridge Avenue and Sperling Avenue intersections with manageable impacts to traffic. The excess east/west traffic volumes on Lougheed Highway in this area would either queue on the highway corridor or divert to the adjacent streets (e.g. Broadway) during construction. West of Sperling Avenue the traffic volumes are generally higher, excess traffic displaced during construction would therefore be higher and suitable detour routes are not readily available. It is unlikely that full closure of all west bound lanes would be feasible. The reduction of the lanes to single lanes in each direction during construction will result in a significant deterioration in traffic performance because there is no alternative route with sufficient capacity to accommodate the traffic volumes that would be displaced from Lougheed Highway during peak construction.

Option 1, utilizing prudent traffic management and tailored construction planning, would mitigate some socio economic impact by maintaining local access where possible on Broadway. Through traffic, however, would be diverted to Lougheed Highway which would add to the current peak traffic congestion along this parallel traffic corridor. Option 2 would result in a very high socio-economic impact due to the significant traffic disruption during construction on Lougheed Highway. Option 3 is 30% longer than Option 1 and would involve complete closure of residential streets which would negatively impact local traffic movement and parking; however, all residences impacted would have lane access which would partially mitigate the construction impact.

- Option 1: moderate impact, good route choice (3)
- Option 2: very high negative (unacceptable) impact, unviable route choice (1)
- Option 3: moderate impact, good route choice (3)

2.5.1.3 ***Land Ownership and Use***

Options 1, 2 and 3 would be installed in municipal roadway adjacent to other third party buried utilities. The pipeline route on Lougheed Highway would be installed adjacent to the above ground Sky Train guide way. However, as the pipeline would be constructed on the northern west bound lanes and the Sky Train guide way is to the south of Lougheed then sufficient offset would exist to avoid the pipeline construction equipment encroaching into the Sky Train

exclusion zones. These options would have similar moderate impacts in terms of land ownership and use.

- Option 1: moderate impact, good route choice (3)
- Option 2: moderate impact, good route choice (3)
- Option 3: moderate impact, good route choice (3)

2.5.2 Environmental Impacts

2.5.2.1 *Ecology/Cultural Heritage*

Options 1, 2 and 3 would be located within existing roadway resulting in low impact route choices.

- Option 1: low impact, better route choice (4)
- Option 2: low impact, better route choice (4)
- Option 3: low impact, better route choice (4)

2.5.2.2 *Human Environment*

Option 1, located on Broadway, would impede access for local residents during construction and result in construction activities adjacent to residences. Broadway is a main traffic corridor but the pipeline construction would incur short-term negative impacts to the overall environment. Option 2 would involve pipeline construction along a heavily trafficked highway with negligible impact in terms of local emissions or aesthetics; however, there would be some nuisance factors in addition to the socio-economic impact due to the resultant wider traffic disruption throughout the area ensuing from the traffic impacts from construction on Lougheed Highway. Option 3 would impact residential parking and, due to the longer alignment length through residential neighbourhood, would position the pipeline construction activities in closer proximity to more residences with higher relative impact in terms of noise, emissions, inconvenience and nuisance factors.

- Option 1: moderate impact, good route choice (3)
- Option 2: low impact, better route choice (4)
- Option 3: high impact, poor route choice (2)

2.5.3 Technical Considerations

2.5.3.1 *Engineering*

Options 1 and 2 would be similar in terms of engineering considerations due to the relatively straight alignments and wider roadways in which to install the pipeline. Option 3 also includes

straighter pipe runs; however, there are a number of acute angle directional changes which would require more engineering considerations in terms of pipeline design.

- Option 1: low impact, better route choice (4)
- Option 2: low impact, better route choice (4)
- Option 3: moderate impact, good route choice (3)

2.5.3.2 *Construction*

Options 1 and 3, due to significant utility density that would be encountered in some sections, present the same construction challenges and would deliver similar levels of construction productivity. Comparatively, Option 2 would facilitate higher productivity and ease of pipeline construction as there is lower utility density on Lougheed Highway and the presence of a service road along a short section of this route could facilitate construction to occur off the highway itself in some areas. Options 1 and 2 have relatively similar construction footprints; Option 3 is the longest alignment (30% longer than Option 1 and 20% longer than Option 2) which would result in the largest construction footprint.

- Option 1: moderate impact, good route choice (3)
- Option 2: low impact, better route choice (4)
- Option 3: high impact, poor route choice (2)

2.5.3.3 *Operation*

Options 1 and 3 would be more accessible compared to Option 2 should maintenance of the pipeline be required. On Lougheed Highway it would be necessary to shut down the highway to gain access to the pipeline.

- Option 1: moderate impact, good route choice (3)
- Option 2: high impact, poor route choice (2)
- Option 3: moderate impact, good route choice (3)

2.5.3.4 *System Interface*

Given the proximity of all three options to the district stations at Broadway & Bainbridge and at Broadway & Springer the same IP system interface upgrades would be required resulting in similar system interface requirements and tie-in challenges to the existing IP infrastructure.

- Option 1: low impact, better route choice (4)
- Option 2: low impact, better route choice (4)
- Option 3: low impact, better route choice (4)

2.5.3.5 *Adjacent Infrastructure*

Options 1 and 3 would encounter significant adjacent buried utilities and would require similar approaches to affect safe pipeline construction and installation whilst providing sufficient proximity to existing adjacent utilities for future safe operation and maintenance access. Option 2 would encounter less adjacent utilities; however, currently available space within the highway corridor could be used to install large diameter trunk water, storm sewer or sanitary sewer pipelines which would involve future construction adjacent to the NPS 30 IP pipeline. As a result Options 1 and 3 would be high impact route choices and Option 2 would be a moderate impact route choice.

- Option 1: high impact, poor route choice (2)
- Option 2: moderate impact, good route choice (3)
- Option 3: high impact, poor route choice (2)

2.5.3.6 *Natural Hazards*

Due to their location within existing roadway with minimal natural hazard considerations the three options are low impact route choices.

- Option 1: low impact, better route choice (4)
- Option 2: low impact, better route choice (4)
- Option 3: low impact, better route choice (4)

2.5.4 Cost

Option 2, due to the higher construction productivity and relatively short alignment, would be the least expensive route option. Option 1 is 10% shorter than Option 2 but any cost savings from the shorter alignment length is offset by the reduced construction productivity due to the higher density of adjacent utilities and service connections. Option 3 is similar to Option 1 in terms of construction productivity but is significantly longer and, therefore, substantially more expensive to construction compared to Options 1 and 2.

2.5.5 Route Options Analysis

The overall relative scoring of these options in Table 4 reflects the impacts and considerations outlined in the previous sections. Option 2 is preferred in terms of construction productivity as it is the least expensive option. However, traffic disruption during morning and evening peak rush hour, due to lane closures west of Sperling Avenue, would be significant. There is no alternative traffic route with sufficient capacity to sustain the volumes of traffic which would be displaced by the construction on Lougheed Highway. Option 3 offers no advantages and is approximately twice as long as Option 1 which would result in the largest overall construction

footprint. Option 1 is therefore selected as the preferred option that best achieves a safe, environmentally acceptable, economic and practical route.

Table 4: Bainbridge Ave. to Springer Ave. Route Options Screening Matrix

Metro IP Route Selection: Bainbridge to Springer (Burnaby East)

	Option	1		2		3	
	Length (m)	2665		2910		3470	
Impact and Vulnerability Considerations	**Weight**	**Broadway**		**Baingridge Ave + Lougheed Hwy + Springer Ave**		**Broadway + Cliff Ave + Halifax St + Holdom Ave**	
		Score	Weighted Score	Score	Weighted Score	Score	Weighted Score
Community/Stakeholder							
Health and Safety	15	3	45	3	45	2	30
Socio Economic	15	3	45	1	15	3	45
Land Ownership and Use	5	3	15	3	15	3	15
Environmental							
Ecology	5	4	20	4	20	4	20
Cultural Heritage	5	4	20	4	20	4	20
Human Environment	15	3	45	4	60	2	30
Engineering/Technical							
Engineering/Design	5	4	20	4	20	3	15
Construction	10	3	30	4	40	2	20
Operation	10	3	30	2	20	3	30
System interface	5	4	20	4	20	4	20
Adjacent Infrastructure	5	2	10	3	15	2	10
Natural Hazards	5	4	20	4	20	4	20
Totals	**100**		**320**		**310**		**275**
Ranking		**1**		**2**		**3**	
Relative Cost		**111%**		**100%**		**134%**	
Cost Ranking		**2**		**1**		**3**	

2.6 *SECTION 6 – SPRINGER AVENUE TO BOUNDARY ROAD*

This section of pipeline connects the lateral offtake and district station at Springer Avenue & Broadway with two NPS 20 lateral offtakes (from the NPS 20 Coquitlam IP pipeline) at Boundary Road that supplies the North Shore and the district station at 2nd Avenue and Boundary Road.

For a map of the route options for this section see attachment "Coquitlam IP-Section 6-Springer-Boundary" in section 4.

Five route options are analyzed in this section of corridor to install the NPS 30 Coquitlam IP pipeline. Of these, three are primary option alignments with two options composed of sub options, or partial variations, to the primary option. Many of the roadways in this area contain numerous existing utilities and there is limited space to add an additional pipeline. Lanes were

considered for pipeline construction; however, this would prove very challenging as restricted width and overhead wire connections to residential properties present extreme challenges to construction. Due to the irregular street layout it is very challenging to find an efficient route through this area of Burnaby. There are several areas that severely restrict routing opportunities including:

- Brentwood Town Centre;
- Cemeteries between Halifax Street and Graveley Street; and
- The Willingdon Community Centre Park area east of Gilmore Avenue.

The route parallel to the NPS 20 Coquitlam Gate IP pipeline along Springer Avenue is the only feasible route that facilitates a tie-in to the existing lateral pipeline (which extends north along Springer Avenue), and Halifax Street is also the only feasible route to progress west. The only other east west route is eight blocks north on Parker Street which would incur a significant and inefficient deviation.

Option 1 involves installing the NPS 30 Coquitlam Gate IP pipeline in the same streets as the existing NPS 20 IP pipeline where feasible. The existing NPS 20 IP pipeline is located on Brentlawn Drive (east of Brentwood Town Centre), in the lane adjacent to the Town Centre northern property boundary, and on Halifax Street and 2nd Avenue west of the Town Centre. Many of the roadways in this area contain numerous existing utilities resulting in limited space to add an additional NPS 30 pipeline. This is the case along Brentlawn Drive, the lane adjacent to the Town Centre and Halifax Street west of Douglas Road where existing utilities, including the existing NPS 20 IP pipeline, results in lack of space to install the proposed NPS 30 IP pipeline.

Option 1 would, therefore, involve installing the pipeline along Ridgelawn Drive (south of Brentlawn Drive) to the east of Brentwood Town Centre. Consultation with the Town Centre development team confirmed that there is no opportunity to route the proposed NPS 30 IP pipeline within the Town Centre property due to planned redevelopment that will extend to the property boundary. Therefore, it would be necessary to install the proposed NPS 30 IP pipeline in the same lane as the existing NPS 20 IP pipeline which is located adjacent to the north property boundary of the Town Centre. The lane is already congested with existing above ground and buried utilities. To install the NPS 30 IP pipeline it would be necessary to first relocate approximately 500m of overhead power line to below ground. Temporary workspace would be required within the Town Centre property to install a 500 m long temporary bypass pipeline (to facilitate removal of the existing NPS 20 IP pipeline prior to installation of the NPS 30 IP pipeline) and also accommodate construction of the NPS 30 IP replacement pipeline.

West of Brentwood Town Centre, Option 1 would follow Halifax Street, parallel to the existing NPS 20 IP pipeline, to Douglas Road at which point the route turns north to join Graveley Street. Halifax Street, to the west of Douglas Road, is congested with other utilities including the existing NPS 20 IP pipeline. The Option 1 route alignment is direct; it would replace a significant portion of the proposed NPS 30 IP pipeline (approximately 60%) in the same streets as the existing NPS 20 IP pipeline, and avoid construction in the residential areas north of

Brentwood Town Centre. Where possible, this route avoids the lower density residential areas in favour of the higher density residential and commercial zoned areas between Halifax Street, Douglas Road and Graveley Street.

Option 1a is a sub-option involving an altered alignment west of Brentwood Town Centre to avoid the congestion on Halifax Street by adopting a longer alignment on Graveley Street.

Lougheed Highway was considered as a potential route option to avoid Brentwood Town Centre. As the pipeline construction would close 2 to 3 lanes in one direction during construction, a traffic impact assessment was completed for Lougheed Highway and is included in Appendix A-18-5. The analysis determined that the total closure of all west bound lanes does not appear feasible as there are no suitable continuous parallel routes for traffic to detour to and the resulting traffic disruption would be prohibitively severe. The reduction of all lanes to single lanes in each direction will result in significant deterioration in traffic performance because there are no alternative routes with sufficient spare capacity to absorb the volume of traffic that would be displaced. Preliminary consultation with the City of Burnaby also confirmed that extended lane closures on Lougheed Highway in the Brentwood area would likely not be permitted unless there were no other feasible route options. The main concern would be the significant traffic impacts to the arterial street network in the area from pipeline construction work reducing traffic lanes; especially at the intersection of Willingdon Avenue & Lougheed Highway which is at capacity during peak hours. This could necessitate night work which would be highly disruptive to residents in the vicinity. Furthermore, any work along the arterial street system could also divert traffic onto local residential streets which would create undesirable longer term impacts if commuters find that shortcutting through local streets to be preferable. In addition to the potential traffic impacts, the presence of numerous buried utilities, Sky Train support structures, elevated guide way and Brentwood elevated Sky Train station would present significant construction constraints which further ruled this out as an option during the initial options screening process.

Option 2 would install the pipeline to the south of Lougheed Highway through industrial and commercial service areas and adjacent to residential towers. This alignment is the longest and would involve two major trenchless crossings of Lougheed Highway in addition to pipeline construction along highly trafficked feeder routes that also support commercial accesses. Generally, this route has less utility service connections compared to Option 1 and 1a and construction productivity would be higher. Beta Avenue, Dawson Street, Madison Avenue and Douglas Road are all traffic collectors; therefore, impacts to traffic during construction would be substantial. With planned construction staging it would likely be possible to keep one lane open on the four lane collector roads. The pipeline construction would also impact access to numerous commercial properties. While most would have some form of access, typical access off Beta Avenue, Dawson Street and Madison Avenue would be severely restricted by the trenchless construction across Lougheed Highway. This area south of Lougheed Highway, which would be traversed by Option 2, is zoned for medium to high density residential and mixed use development. Residential towers are currently under construction between Lougheed Highway and Dawson Street and there is potential for this area to undergo significant

future redevelopment in transitioning from the current industrial and commercial services development to medium and high density residential and mixed use development.

Option 3 examines a route along residential streets one to two streets north of the existing NPS 20 IP pipeline alignment to avoid the Brentwood Town Centre routing constraints. Many of the roadways in this area contain numerous existing utilities resulting in limited space to add an additional NPS 30 pipeline. This is the case along Brentlawn Drive where existing utilities, including the existing NPS 20 IP and DP pipelines, results in lack of space to install the proposed NPS 30 IP pipeline. The construction of the proposed NPS 30 IP pipeline in lanes would be very challenging due to the restricted width, other adjacent buried utilities and services, and the presence of overhead electricity services to homes which effectively ruled them out as feasible options. Three route options were examined to get through the Brentwood area, north of Brentwood Town Centre, between Delta Avenue and Fairlawn Avenue:

1. Ridgelawn Drive between Delta Avenue and Beta Avenue and Brentlawn Drive between Beta Avenue and Fairlawn Drive;
2. Highlawn Drive between Delta Avenue and Fairlawn Drive; and,
3. Southlawn Drive between Delta Avenue and Fairlawn Drive.

Highlawn Drive is shorter than the Southlawn Drive option. Highlawn Drive would also avoid a deep crossing of the existing NPS 20 IP pipeline on Beta Avenue and risk of damage to the existing utilities on Brentlawn Drive (due to the type of utility and construction proximity) which would be encountered on the Ridgelawn Drive and Brentlawn Drive option. Therefore, Highlawn Drive was selected as the best route option to get through the Brentwood area north of the Brentwood Town centre between Delta Avenue and Fairlawn Drive.

As Brentlawn Drive and Graveley Street represents the most direct east west corridor between Fairlawn Drive and Boundary Road, Options 3 would adopt this alignment to continue west past Brentwood Town Centre to Boundary Road. West of Fairlawn Drive there is more space between the existing utilities to accommodate the proposed NPS 30 IP pipeline. Halifax Street is the only contiguous east west roadway to the south of Graveley Street. However, at the junction with Gilmore Avenue a very high density of existing buried utilities would prohibit the construction of the proposed NPS 30 IP pipeline. North of Graveley Street, William Street is the first contiguous east west roadway north of the Willingdon Community Centre Park, which Graveley Street passes to the south. William Street is six blocks north of the existing pipeline route and presents a significant additional length to interface with the existing district stations to the west. West of Ingleton Avenue there is no paved roadway in the Graveley Street right of way. The right of way is currently gravelled and this is advantageous as there are no access or traffic issues related to this section of route.

Option 3a is a sub-option of Option 3 involving a reroute through Brentwood School property and Brentwood Park which would avoid Highlawn Drive but impact a residential lane, school playground and community park and greater length of Midlawn Drive.

Option 3 is the shortest route at 2,665 m. Options 1, 1a and 3a are approximately 20% longer at 3,200 m, 3,250 m and 3,200 m respectively. Option 2 is 3,640 m in length and approximately 37% longer than Option 3 and 14% longer than Options 1, 1a and 3a.

2.6.1 Community and Stakeholder Impacts

2.6.1.1 *Health and Safety*

The pipeline construction activities would occur within a cordoned (fenced) off construction zone allowing access for construction personnel only and movement of vehicles and equipment to and from the construction zone as the construction progresses. Option 1 and 1a would involve construction on local residential streets and the lane adjacent to Brentwood Town Centre which would require temporary workspace along the outer extremity of the Town Centre parking lot area. Option 2 would involve construction through residential and industrial and commercial areas south of Lougheed Highway with pipeline construction occurring adjacent to road users and commercial premises. Option 2 would also require two trenchless crossings of Lougheed Hwy on Beta Avenue and Madison Avenue which are heavily trafficked junctions. Options 3 and 3a would close residential streets to facilitate the pipeline construction activities.

In terms of health and safety, Options 1, 1a, 3 and 3a would involve pipeline construction through the lower density residential areas where the construction zones would be confined to isolated streets with restricted traffic and controlled pedestrian movement; this ability to isolate the construction zone and control third party proximity and access would help to mitigate the health and safety risk to the adjacent residents and general public during construction. Option 2, south of Lougheed, Highway would incur relatively higher risk because the route is longer and the construction would occur in more densely populated and highly trafficked areas; it would be necessary to manage traffic movement adjacent to the construction zones and also progress construction activities in proximity to other road users including pedestrians and cyclists while maintaining commercial accesses operational.

- Option 1: moderate impact, good route choice (3)
- Option 1a: moderate impact, good route choice (3)
- Option 2: high impact, poor route choice (2)
- Option 3: moderate impact, good route choice (3)
- Option 3a: moderate impact, good route choice (3)

2.6.1.2 *Socio-Economic*

Options 1 and 1a are routed along residential streets, the lane adjacent to Brentwood Town Centre and collector roads with residential tower development, and some commercial and business premises, west of the Town Centre. Option 2 includes a section of pipeline route located south of Lougheed Highway along four lane primary collector traffic routes and through

a commercial area including residential tower blocks and numerous industrial and commercial accesses.

Option 2 is the longest route and would require the closure of two or three lanes to facilitate construction on Dawson Street and potential full closure of Beta Avenue and Madison Avenue to accommodate trenchless pipeline construction which would negatively impact traffic movement, parking and commercial access during normal business hours; these streets are primary collector routes for the area and traffic impacts would be substantial. However, depending on the location of below ground utilities, the pipeline could be constructed on the north side of Dawson Street and maintain a single lane open to provide limited access to some local businesses.

Options 3 and 3a would be located in residential streets north of Lougheed Highway and Brentwood Town Centre. Impacts would include complete closure of residential streets during construction which would restrict street parking. However, the majority of residences have lane access which would partially mitigate the negative impacts during construction.

Potential socio-economic impacts increase for each route option from the northern most to the southernmost alignments; this is due to the additional length of Option 2 (the southernmost alignment) and the greater impact incurred by the pipeline construction to traffic flow, movement and parking restriction, and also the potential isolation of local business access routes and access and egress restrictions to residential towers. As such, Options 3 and 3a would both be low impact route choices. Options 1 and 1a would incur a relatively higher impact, and Option 2 would incur the highest impact.

- Option 1: moderate impact, good route choice (3)
- Option 1a: moderate impact, good route choice (3)
- Option 2: high impact, poor route choice (2)
- Option 3: low impact, better route choice (4)
- Option 3a: low impact, better route choice (4)

2.6.1.3 ***Land Ownership and Use***

Options 1 and 1a would install the pipeline within municipal roadway. Additional workspace would also be required within Brentwood Town Centre to accommodate the pipeline construction along the lane adjacent to the north of the Town Centre property. This would require the Company to acquire temporary workspace as the laneway width alone is insufficient to accommodate the construction processes. Options 2 and 3 would install the pipeline within municipal roadway with no requirement for temporary workspace to accommodate the construction. A section of Option 3a is routed within a lane parallel to a contiguous school property and public park space and would require temporary workspace to accommodate the pipeline construction along the lane. This would require the Company to acquire temporary

workspace, or procure (or expropriate) right of way if it was necessary to install the pipeline within the school property. Stakeholder feedback from the School Board indicated that it would not be possible to acquire a right of way or temporary construction workspace through the Brentwood School grounds.

Options 2 and 3 would incur the lowest potential impact as they would be located completely within municipal roadway. Options 1 and 1a would restrict the above ground mall parking along the Town Centre north property boundary and also restrict access to the below ground parking and service entrances during site preparation and pipeline construction. Option 3a, based on the School Board feedback would constitute a very high impact route option in terms of the acquisition of temporary workspace or permanent right of way to accommodate the proposed NPS 30 IP pipeline.

- Option 1: moderate impact, good route choice (3)
- Option 1a: moderate impact, good route choice (3)
- Option 2: low impact, better route choice (4)
- Option 3: low impact, better route choice (4)
- Option 3a: very high negative (unacceptable) impact, unviable route choice (1)

2.6.2 Environmental Impacts

2.6.2.1 *Ecology*

Options 1, 1a, 2 and 3 would install the pipeline in municipal roadway with low risk of direct environmental impacts. However, the likelihood of encountering contaminated sites during pipeline construction in an urban environment is a major consideration. Options 1, 1a and 2 would install the pipeline through some areas with a history of commercial activities and, therefore, present greater potential to encounter contaminated sites during construction. Option 3, located in residential streets, would have the lowest risk of encountering existing unidentified contaminated sites and would present the lowest overall environmental impact. Option 3a would install the pipeline through a school ground and a public park (Brentwood Park). Therefore, the pipeline construction activities would, compared to the other route options, result in a higher impact through the park which would require site clearing, including tree removal, to facilitate the pipeline installation.

- Option 1: moderate impact, good route choice (3)
- Option 1a: moderate impact, good route choice (3)
- Option 2: moderate impact, good route choice (3)
- Option 3: low impact, better route choice (4)
- Option 3a: high impact, poor route choice (2)

2.6.2.2 ***Cultural Heritage***

Options 1, 1a, 2, 3 and 3a would be located within existing roadway and lanes and, due to the low risk of encountering archaeological sites; these options would incur minimum impact risk.

- Option 1: very low impact, best route choice (5)
- Option 1a: very low impact, best route choice (5)
- Option 2: very low impact, best route choice (5)
- Option 3: very low impact, best route choice (5)
- Option 3a: very low impact, best route choice (5)

2.6.2.3 ***Human Environment***

The route options analysed would involve pipeline construction activates occurring in residential neighbourhoods, densified urban areas and commercial areas in proximity to the general public (residents, pedestrians, road users, etc.). Resulting impacts would include noise, local emissions, and short term impacts including visual, disturbance and nuisance factors from the pipeline construction. The relative length of each option, and the environment in which the pipeline is routed, will dictate the overall impact.

Option 1 is similar in length to Option 1a but it would avoid Graveley Street immediately to the north and west of Brentwood Town Centre. Instead, Option 1 would route the proposed NPS 30 IP pipeline parallel to the existing NPS 20 IP pipeline along Halifax Street, which is a primary collector route for traffic from the surrounding area and residential towers. Option 2 is the longest route option with a significant portion of the alignment passing through an industrial and commercial services area with existing and ongoing residential tower development south of Lougheed Highway. Option 2 would avoid the residential areas north of Brentwood Town Centre. However, Option 2 bisects an area that would be significantly impacted by the pipeline construction occurring during business hours; particularly adjacent to the residential towers and the businesses which are located along this alignment on Beta Avenue and Madison Avenue. Options 3 and 3a are located in residential streets parallel to but offset one to two streets north of the existing NPS 20 IP pipeline alignment. Option 3a avoids Highlawn Drive but instead includes a portion through Brentwood School and Brentwood Park.

Options 1a and 3 would be constructed predominantly along residential streets which would result in the highest impact in terms of noise, emissions and nuisance impacts. Options 1 and 3a are closely aligned with Options 1a and 3; however, these options involve sections that are routed so as to avoid some of the residential streets impacted by Options 1a and 3. Option 1 would, therefore, result in a lower impact. However, while Option 3a would avoid some of the residential streets impacted by Option 3, it would instead impact a school playground and a public park which would increase the overall impact of this alignment. Option 2 is routed through the commercial zone south of Lougheed Highway and would avoid most of the residential streets impacted by the other options north of Brentwood Town Centre. The pipeline

construction would instead occur in a more heavily trafficked commercial area with higher levels of background noise and emissions. The resulting impact from pipeline construction activities would, therefore, be lower. However, Option 2 is the longest alignment by approximately 1 km and would impact the residential towers south of Lougheed Highway at Beta Avenue, Madison Avenue and Halifax Street.

- Option 1: moderate impact, good route choice (3)
- Option 1a: high impact, poor route choice (2)
- Option 2: moderate impact, good route choice (3)
- Option 3: high impact, poor route choice (2)
- Option 3a: high impact, poor route choice (2)

2.6.3 Technical Considerations

2.6.3.1 *Engineering*

Options 1 and 1a would be located within municipal roadway in residential streets, collector roads and in the lane adjacent to Brentwood Town Centre. The pipeline design, for the sections of the route alignment in the lane adjacent to the Town Centre and Halifax Street, would have to address future development construction activities associated with multi-story building construction including potential piling, blasting, excavation, foundation forming and ground settlement. These activities present future threats to the pipeline integrity which are difficult to quantify at this stage for inclusion in the pipeline design process. Further to these engineering considerations adjacent to the Town Centre, Option 1, compared to Option 1a, would require additional engineering effort to address the crossing of a large diameter culvert on Halifax Street and pipeline construction and installation parallel to a large diameter sewer main on Halifax Street and Douglas Road.

Option 2 adopts an alignment to the south of Lougheed Highway which would require two significant trenchless crossings at Beta Avenue and Madison Avenue. These trenchless crossings would not be required on the other route options.

Option 3 would be located in residential streets adjacent to other buried utilities and services. Option 3a would require longer pipeline installation on Delta Avenue compared to Option 3, this presents challenges given the existing underground services and in particular the recent installation of a large diameter steel water line.

Options 1 and 2 would present significantly more engineering challenges which would require additional site investigations, and greater routing and design effort, compared to Options 1a. Options 3 and 3a would be designed for traditional open trench pipeline construction without the need to analyse non-standard pipeline installation techniques.

- Option 1: high impact, poor route choice (2)
- Option 1a: moderate impact, good route choice (3)
- Option 2: high impact, poor route choice (2)
- Option 3: low impact, better route choice (4)
- Option 3a: low impact, better route choice (4)

2.6.3.2 ***Construction***

Options 1 and 1a would involve severely restricted construction in the lane adjacent to Brentwood Town Centre which would require overhead power line relocation and the construction of a 500m temporary bypass pipeline to facilitate removal of the existing NPS 20 IP pipeline prior to installation of the proposed NPS 30 pipeline.

Option 2 is routed south of Lougheed Highway through commercial and industrial areas that have less service connections and would deliver higher construction productivity compared to the other options through the residential areas. Option 2, however, is the longest route (approximately 14% longer than Options 1, 1a and 3a and 37% longer than Option 3). This option would result in the largest overall footprint and would also include two trenchless crossings under Lougheed Highway at Beta Avenue and Madison Avenue.

Options 3 and 3a would involve open trench construction on residential streets where there is a higher density of existing buried utilities and service connections to residences.

Comparatively, Options 1 and 1a would involve the most constrained construction in the lane adjacent to Brentwood Town Centre. Option 2, due to the greater length, two trenchless crossings of Lougheed Highway, onerous traffic management and the requirement to maintain commercial and business access open throughout the construction is also a very challenging route. Option 3 would encounter numerous closely aligned utilities and service connections which would reduce overall construction productivity. However, this alignment is the shortest of the route options considered and it is the most direct alignment with the smallest overall footprint. Option 3 is, therefore, considered the least impact route by also avoiding the construction challenges encountered by Options 1, 1a and 2. Option 3a would provide the same advantages as Option 3 including greater working space in which to construct the pipeline through the school ground and park.

- Option 1: moderate impact, good route choice (3)
- Option 1a: moderate impact, good route choice (3)
- Option 2: high impact, poor route choice (2)
- Option 3: low impact, better route choice (4)
- Option 3a: low impact, better route choice (4)

2.6.3.3 *Operation*

Options 1 and 1a would install the pipeline within municipal roadway and the lane adjacent to the north property boundary of Brentwood Town Centre. The future development of the Town Centre property adjacent to the lane could severely restrict future access for operation and maintenance of the pipeline. Option 2 would align the pipeline in an area with significant ongoing and planned infrastructure development. Over the lifetime of the pipeline potential modifications to road design and layout patterns including development adjacent to the pipeline, installation of further adjacent buried utilities and other third party activities could impact the integrity of the pipeline and ability to adequately access the pipeline for operation and maintenance. Options 3 and 3a would also install the pipeline within municipal roadway. There is a high density of existing services along these streets, however, the current routing analysis indicates that there is sufficient sub surface space to install the proposed NPS 30 IP pipeline and maintain adequate access for future operation and maintenance.

- Option 1: high impact, poor route choice (2)
- Option 1a: high impact, poor route choice (2)
- Option 2: high impact, poor route choice (2)
- Option 3: moderate impact, good route choice (3)
- Option 3a: moderate impact, good route choice (3)

2.6.3.4 *System Interface*

There will be a critical interface required between the proposed NPS 30 IP pipeline, the existing district station at East 2nd Avenue & Boundary Road and the two NPS 20 lateral pipelines (which connect to the existing NPS 20 IP pipeline in the vicinity of Boundary Road) that supply North Vancouver. The interface will require a new IP/IP station that will be located in the existing FEI operations compound located at East 2nd & Boundary Road. Options 1, 1a, 2, 3 and 3a are all routed on Graveley Street on approach to Boundary Road; therefore, the requirements to interface each route option with the existing IP infrastructure would be similar and each involve the same level of complexity.

- Options 1, 1a, 2, 3 and 3a: moderate impact, good route choice (3)

2.6.3.5 *Adjacent Infrastructure*

The construction of Options 1 and 1a would be severely constrained by existing pole mounted overhead power lines and telecommunication lines, existing buried utilities and the existing NPS 20 IP pipeline in the 500m long lane adjacent to Brentwood Town Centre. It would be necessary to relocate the powerline and telecommunication lines underground, and then remove the existing NPS 20 IP pipeline, prior to construction and installation of the proposed NPS 30 IP pipeline. The presence of a transverse culvert and large diameter sewer main on Halifax Street further compounds the risks presented by these options. It would be critical that

sufficient offset is maintained between the proposed NPS 30 IP pipeline and adjacent infrastructure. However, the constrained environment presented by the limited road allowance, particularly in the lane adjacent to Brentwood Town Centre, and the presence of numerous other utilities, would limit the available space and increase the potential risks to the integrity and safe operation of the pipeline at this location.

Option 2 would encounter the least number of adjacent utilities and utility service connections resulting in greater proximity and lower risk to the pipeline integrity and safe operation. However, the potential for significant future redevelopment south of Lougheed highway could result in future installation of adjacent below ground infrastructure which would require careful monitoring to protect the pipeline integrity.

Options 3 and 3a would be installed within municipal roadway with numerous existing adjacent utilities including distribution gas, water, storm sewer and sanitary sewer. The routing analysis completed indicates that there is sufficient space to avoid damage to the existing utilities during construction and also achieve necessary utility offsets after installation of the proposed NPS 30 IP pipeline. Option 3a would encounter the least number of adjacent utilities for the portion of the route installed in Brentwood School and Brentwood Park; however, this advantage is offset by the preceding portion of this route that would be installed in Delta Avenue which contains numerous adjacent buried utilities.

- Option 1: high impact, poor route choice (2)
- Option 1a: high impact, poor route choice (2)
- Option 2: low impact, better route choice (4)
- Option 3: moderate impact, good route choice (3)
- Option 3a: moderate impact, good route choice (3)

2.6.3.6 *Natural Hazards*

The soil conditions could vary as the pipeline route progresses from Burnaby to Vancouver. Each of the route options could be impacted by the presence of less competent soils which would present potential risk to the pipeline from ground subsidence and settlement. These risks will be identified during the detailed pipeline design process through further site investigations. They will be recorded in the project risk register and mitigated during the pipeline detailed design phase.

- Options 1, 1a, 2, 3 and 3a: moderate impact, good route choice (3)

2.6.4 Cost

Options 1 and 1a would require temporary workspace to construct the pipeline in the narrow lane adjacent to Brentwood Town Centre and would also require the relocation of utility poles, overhead power lines and telecommunication infrastructure. Option 2 is the longest route option

and would include two trenchless crossings of Lougheed Highway. Option 3, compared to Options 1, 1a and 2 is the shortest alignment, would be constructed using open trench construction techniques and would not require temporary working space to facilitate pipeline construction. Option 3a is similar to Option 3 but would also include a section of pipeline in the existing lane north of Brentwood School and Brentwood Park; this would result in higher construction productivity compared to Option 3 but the cost savings is offset by the requirement for temporary construction workspace within the school and park properties. Options 3 and 3a are similar cost route options. Options 1, 1a and 2, for the reasons outlined, would incur higher construction cost and are approximately 17% to 26% more expensive.

2.6.5 Route Options Scoring and Selection

The relative scoring of these options in Table 5 reflects the impacts and considerations discussed in the previous sections. Option 3 would impact residential streets and scores lower in terms of human environment (noise, dust, nuisance factors). However, this route would avoid the very challenging construction along the Brentwood Town Centre lane (Option 1 and 1a) and would also avoid the substantially longer Route Option 2 alignment through the industrial and commercial areas to the south of Lougheed Highway. As such, Option 3 scores higher compared to Option 1, 1a and 2 in most other categories including socio-economic, land ownership and use, engineering, construction and long term pipeline operation and maintenance.

Option 3 is estimated to be approximately the same cost as Option 3a and compares with respective scores of 335 and 310. However, discussions with the School Board regarding the potential of a route alignment through the Brentwood School property, or acquisition of temporary construction workspace to facilitate installation of a pipeline in the lane adjoining the school indicated that Option 3a is not a viable option.

Options 1 and 1a score lower compared to Option 3 primarily in technical criteria due to the constraints associated with designing, installing and operating the pipeline in the lane adjacent to Brentwood Town Centre. Options 1 and 1a would avoid impacting Highlawn Drive, Midlawn Drive, Fairlawn Drive and Brentlawn Drive which are impacted by Option 3. Instead, however, these options would impact Ridgelawn Drive, the narrow lane adjacent to Brentwood Town Centre and Halifax Street or Graveley Street. Due to the consistent urban development north of Lougheed Highway, throughout this section of corridor, there is, unfortunately, no route option that does not impact to residential streets and neighbourhoods.

Option 2, which is partially located south of Lougheed Highway on Dawson Street, would avoid the residential neighbourhoods to the north of Brentwood Town Centre which are impacted by Options 1, 1a and 3. Similar to the other route options, Option 2 would impact some residential streets east of Brentwood Town Centre including Sperling Avenue, Halifax Street and Ridgelawn Drive. Option 2 is also the longest alignment (approximately 37% longer than Option 3 and 14% longer than Options 1, 1a and 3a) with the largest overall footprint, two trenchless crossings under Lougheed highway and the Sky Train guide way and prolonged construction

which would impact industrial and commercial areas and primary collector traffic routes. This results in lower scores in most categories (higher relative businesses and traffic impacts, safety risks and more technical, construction and operational challenges) which yield the lowest ranked route option.

Option 3 would result in the lowest overall relative impact and is the least cost option. Therefore, this is the selected preferred route option.

Table 5: Springer Ave. to Boundary Rd. Route Options Screening Matrix

Metro IP Route Selection: Broadway and Springer to Boundary Road (Burnaby West)

	Option	1		1a		2		3		3a	
	Length (m)	3200		3250		3640		2665		3200	
Impact and Vulnerability Considerations	**Weight**	**Springer Ave + Halifax St + Ridgelawn Dr + Brentwood Mall Lane + Halifax St + Douglas Rd + Graveley St**		**Springer Ave + Halifax St + Ridgelawn Dr + Brentwood Mall Lane + Willingdon Ave + Graveley St**		**Springer Ave + Halifax St + Ridgelawn Dr + Beta Ave + Dawson St + Madison Ave + Graveley St**		**Springer Ave + Halifax St + Delta Ave + Highlawn Dr + Midlawn Dr + Fairlawn Dr + Brentlawn Dr + Graveley St**		**Springer Ave + Halifax St + Delta Ave + Brentwood School + Brentwood park + Midlawn Dr + Fairlawn Dr + Brentlawn Dr + Graveley St**	
		Score	Weighted Score	Score	Weighted Score	Score	Weighted Score	Score	Weighted Score	Score	Weighted Score
Community/Stakeholder											
Health and Safety	15	3	45	3	45	2	30	3	45	3	45
Socio-Economic	15	3	45	3	45	2	30	4	60	4	60
Land Ownership and Use	5	3	15	3	15	4	20	4	20	1	5
Environmental											
Ecology	5	3	15	3	15	3	15	4	20	2	10
Cultural Heritage	5	5	25	5	25	5	25	5	25	5	25
Human Environment	15	3	45	2	30	3	45	2	30	2	30
Engineering/Technical											
Engineering/Design	5	2	10	3	15	2	10	4	20	4	20
Construction	10	3	30	3	30	2	20	4	40	4	40
Operation	10	2	20	2	20	2	20	3	30	3	30
System interface	5	3	15	3	15	3	15	3	15	3	15
Adjacent Infrastructure	5	2	10	2	10	4	20	3	15	3	15
Natural Hazards	5	3	15	3	15	3	15	3	15	3	15
Totals	**100**		**290**		**280**		**265**		**335**		**310**
Ranking		**3**		**4**		**5**		**1**		**2**	
Relative Cost		**123%**		**117%**		**126%**		**100%**		**101%**	
Cost Ranking		**5**		**3**		**4**		**1**		**2**	

2.7 *SECTION 7 – BOUNDARY RD. TO WOODLAND DRIVE STATION (TERMINUS)*

This section of pipeline connects the district station, and the lateral pipeline offtake supplying North Vancouver, at Boundary Road in Burnaby with the district station at East 2nd Avenue & Slocan Street and the pipeline terminus station at East 2nd Avenue & Woodland Drive.

For a map of the route options for this section see attachments "Coquitlam IP-Section7-1-Boundary-Slocan" and "Coquitlam IP-Section7-2-Slocan-Woodland" in section 4.

Five route options are analyzed within this section of corridor through Vancouver. Of these, three are primary option alignments with two comprising sub options, or partial variations, to the primary option. The street layout in this section of route corridor is conducive to a direct and efficient route alignment through this area. However, each alignment presents major construction constraints due to the presence of either mature trees, existing subsurface utility services or heavy traffic encountered on each option.

The route options considered are relatively straight alignments between Boundary Road and the pipeline terminus at Woodland Drive. Option 1 on East 1st Avenue is the most direct and therefore the shortest route. The other options are offset north and south by only a few blocks and are slightly longer but within 10% of the shortest Option 1 alignment.

Option 1 is located along East 1st Avenue from Boundary Road to Woodland Drive and continues south on Woodland Drive to the pipeline terminus at 2nd & Woodland station. This route is the most efficient in terms of constructing pipeline (productivity). However, it is a major arterial traffic route for vehicular access from the Trans Canada Highway 1 to downtown Vancouver. The pipeline would be installed on the north side of the existing median, within the west bound traffic lane, with construction requiring the shutdown of both west bound lanes. The construction would shut down the road in sections which would likely comprise a number of blocks or from major intersection to major intersection. The eastbound lanes would be reconfigured to support two-way traffic. A traffic impact assessment was completed for this section of route corridor on 1st Avenue and is included in Appendix A-18-6.

As this is a major arterial traffic corridor there is currently no parking along East 1st Avenue so access to the houses along East 1st Avenue would not change during construction. There are trees situated between the road curb and the pavement and also along the centreline of the median located between the east and west bound lanes. However, the space afforded by the median would facilitate construction activities while minimising tree impacts. A major trenchless crossing would be required under the Trans Canada Highway 1 at East 1st Avenue. Smaller bored crossings would be required at Rupert Street, Renfrew Street, Nanaimo Street, Victoria Drive and Commercial Drive.

Options to East 1st Avenue between Nanaimo Street and Woodland Drive were identified by stepping to the south and north. Due to the presence of the NPS 20 Coquitlam Gate IP pipeline and other utilities along East 2nd Avenue the installation of a parallel NPS 30 pipeline is not viable. East 3rd Avenue is the first parallel traffic corridor encountered to the south which would facilitate construction between Highway 1 and Woodland Drive.

Option 1a is a sub-option of Option 1 combining East 1st Avenue from Boundary Road to Kamloops Street and East 3rd Avenue from Kamloops Street to Woodland Drive. This option provides a good alignment for the final portion of the East 1st Avenue Option due to the absence

of a median along East 1st Avenue between Nanaimo Street and Woodland Drive, and the potential traffic management difficulties and constrained construction space along this section of East 1st Avenue as it crosses Victoria Drive and Commercial Drive. This route option encounters numerous buried utilities and service connections and a very mature and well established tree canopy on East 3rd Avenue between Nanaimo Street and Woodland Drive which presents significant construction and natural hazards constraints. A major trenchless crossing would be required under the Trans Canada Highway 1 at East 1st Avenue, similar to Option 1. Smaller bored crossings would be required at Rupert Street and Renfrew Street. To accommodate the pipeline construction East 3rd Avenue would be closed in sections so no parking would be available on the street. All properties have lane access so access would still be possible.

Option 1b is also a sub-option of Option 1 which combines a route on East 1st Avenue from Boundary Road to Slocan Street and along East 2nd Avenue from Slocan Street to Woodland Drive. Due to the presence of the NPS 20 Coquitlam Gate IP pipeline and other utilities along East 2nd Avenue the installation of a parallel NPS 30 pipeline is not viable for the whole length of East 2nd Avenue. However, between Slocan Street and Woodland Drive station the existing NPS 20 IP pipeline could be isolated, safely purged of natural gas and removed to facilitate installation of the replacement NPS 30 IP pipeline on the same running line. This option also provides a good alignment for the final portion of the East 1st Avenue Option due to the absence of a median along East 1st Avenue between Nanaimo Street and Woodland Drive. This option, however, encounters numerous buried utilities and services and a very mature and well established tree canopy on East 2nd Avenue between Nanaimo Street and Woodland Drive which, similar to Option 1a, presents significant construction and natural hazards constraints. A major trenchless crossing would also be required under the Trans Canada Highway 1 at East 1st Avenue. Smaller bored crossings will be required at Rupert Street and Renfrew Street. To accommodate the pipeline construction East 2nd Avenue would be closed in sections so no parking would be available on the street. All properties have lane access so access would still be possible.

Option 2, located on East 3rd Avenue (between Highway 1 and Woodland Drive), was analyzed as an option to routing the pipeline on East 1st Avenue. In contrast to East 1st Avenue, East 3rd Avenue is a residential street with mainly local traffic movement and residential street parking. There are existing buried utilities and services present but space exists to install the NPS 30 Coquitlam Gate IP pipeline with sufficient proximity to adjacent utility services. There is a greater quantity of more mature and established trees between the curb and the sidewalk along this street compared to East 1st Avenue.

Option 3 is a route along Graveley Street which is one block north of East 1st Avenue. This alignment is similar to East 3rd Avenue in that the presence of well-established trees and numerous buried utilities and service connections would result in lower productivity and greater risk of tree impacts compared to East 1st Avenue.

A tree impact analysis was completed for this section of route corridor through Vancouver which investigated the potential tree impacts from construction on Options 1, 1a, 1b, 2 and 3. The Street Tree Assessment Report is included in Appendix A-19.

Additional route options were investigated along Grant Street and East 5th Avenue. These are very similar to Options 2 and 3 but, as they are further from the original route, they are less efficient in terms of routing and also offer no advantage.

Additional route options were also investigated further north along Kitchener Street and Charles Street. While these routes have an increased right of way width, the paved surface of these roads is only slightly wider than the other route option roadways; the additional right of way width results in greater distance between the sidewalk and the property lines of the residential properties, but does not create any additional space for the installation of a pipeline which must be installed within the confines of the paved road surface. These options would also result in a longer pipeline route at greater cost and would offer no advantage over the options already considered.

Option 1, 1a, 1b, 2 and 3 lengths are 3,990 m, 4,115 m, 3,890 m, 4,390 m and 4,340 m respectively.

2.7.1 Community and Stakeholder Impacts

2.7.1.1 *Health and Safety*

The route options considered would involve pipeline construction and installation activities on East 1st Avenue which is a major traffic corridor or on residential streets parallel to East 1st Avenue. Options 1 and 1a, in particular, would require specialized traffic management to ensure safe movement of the pipeline construction process on the East 1st Avenue traffic corridor. However, the construction activities would be separated from the moving traffic by a wide central median for a significant portion of the route. Option 1b would combine East 1st Avenue from Boundary Road to Slocan Street and East 2nd Avenue from Slocan Street to Woodland Drive. To construct this option it would likely be necessary to remove sections of the existing NPS 20 IP pipeline on East 2nd Avenue prior to installation of the proposed NPS 30 IP pipeline. The configuration of the Metro IP system could facilitate abandonment of this section of the existing NPS 20 IP pipeline prior to construction which would mitigate the risks associated with construction beside a live gas pipeline. Options 2 and 3 would involve more construction activities along East 2nd Avenue, East 3rd Avenue or Graveley Street which are residential streets. These options would all be constructed in an urban environment and in each case the construction zone would be cordoned off with security fencing and movement of traffic, construction personnel and residential access would be controlled to mitigate health and safety risk. Option 1b would involve additional health and safety risk associated with handling the old NPS 20 IP pipeline as it would be cut into sections and removed from the trench prior to installation of the new NPS 30 IP pipeline.

- Option 1: moderate impact, good route choice (3)
- Option 1a: moderate impact, good route choice (3)
- Option 1b: high impact, poor route choice (2)
- Option 2: moderate impact, good route choice (3)
- Option 3: moderate impact, good route choice (3)

2.7.1.2 ***Socio-Economic***

Options 1, 1a and 1b would involve closure of both west bound lanes on East 1st Avenue resulting in significant traffic disruption. The traffic impact assessment analysed the potential disruption to traffic flow and concluded that maintaining one west bound lane open (on the east bound side) and prudent traffic management would mitigate the construction impact on East 1st Avenue to a manageable level. Diverted traffic would instead use Hastings Street and Broadway which are parallel traffic corridors with surplus capacity. Options 2 and 3 would impact residential parking and access on East 3rd Avenue and Graveley Street, but lane access to most houses would mitigate these impacts during construction.

Option 1 construction would occur entirely on East 1st Avenue and would have the greatest socio-economic impact in terms of direct traffic disruption and commuter delays on East 1st Avenue and indirect impacts to Hastings Street and Broadway as surplus traffic which would divert to avoid the construction and instead add to the traffic volumes using these parallel routes. Options 1a and 1b involve less construction on East 1st Avenue and, therefore, would have reduced traffic impacts. Options 2 and 3 would impact local residential street parking only and incur relatively lower socio-economic impacts.

- Option 1: high impact, poor route choice (2)
- Option 1a: moderate impact, good route choice (3)
- Option 1b: moderate impact, good route choice (3)
- Option 2: low impact, better route choice (4)
- Option 3: low impact, better route choice (4)

2.7.1.3 ***Land Ownership and Use***

All of the options would be installed within municipal roadway. Options 1 and 1a would install the NPS 30 IP pipeline within roadways with a lower density of existing utilities and sufficient remaining space to install future third party utilities. Options 1b, 2 and 3 route configurations would install the pipeline in roadways adjacent to numerous other utilities which could limit space to install additional municipal utility infrastructure if required.

- Option 1: low impact, better route choice (4)

- Option 1a: low impact, better route choice (4)
- Option 1b: moderate impact, good route choice (3)
- Option 2: moderate impact, good route choice (3)
- Option 3: moderate impact, good route choice (3)

2.7.2 Environmental Impacts

2.7.2.1 *Ecology*

Along this section of the pipeline corridor the residential streets have mature trees with extensive canopies. On East 2nd Avenue and East 3rd Avenue, between Nanaimo Street and Woodland Drive, there are larger mature trees with extensive canopy development. To accommodate the pipeline installation on the residential streets, trees would be at risk of damage during the pipeline construction. Option 1, due to greater distance between the trees afforded by the central median along East 1st Avenue, would accommodate the pipeline construction with less risk of tree damage. Options 1a and 1b, however, would have a higher risk of damaging the established trees along the section of the route on East 3rd Avenue and East 2nd Avenue from Nanaimo Street to Woodland Drive. Options 2 and 3 would involve the longest sections of pipeline construction on residential streets and would have high risk of potential tree damage. The route options would also encounter a number of sites containing potential ground contamination. Option 1 would be installed on East 1st Avenue adjacent to a number of medium to high risk sites resulting in the highest risk of encountering contaminated ground during construction.

- Option 1: moderate impact, good route choice (3)
- Option 1a: high impact, poor route choice (2)
- Option 1b: high impact, poor route choice (2)
- Option 2: high impact, poor route choice (2)
- Option 3: high impact, poor route choice (2)

2.7.2.2 *Cultural Heritage*

The route options would be located within municipal road allowance with low risk of encountering sensitive sites.

- Option 1: low impact, better route choice (4)
- Option 1a: low impact, better route choice (4)
- Option 1b: low impact, better route choice (4)
- Option 2: low impact, better route choice (4)

- Option 3: low impact, better route choice (4)

2.7.2.3 *Human Environment*

In addition to the human environment impacts from increased local emissions, noise, parking disruption and other construction nuisance factors, the options that would involve more pipeline construction on the narrower residential streets (Options 1b, 2 and 3) would also incur risk of tree damage. The tree impacts are detailed in the Street Tree Assessment report included in Appendix A-19. In terms of human environment the long term aesthetic and visual impacts from tree damage or removal would be more profound compared to the relatively short term impacts from pipeline construction activities.

Option 1 would accommodate the pipeline construction with least risk of tree damage along the heavily trafficked East 1st Avenue corridor. Some of the tree canopies on East 1st Avenue have already been modified to facilitate larger traffic such as municipal service vehicles. Option 1a would also involve pipeline construction along East 1st Avenue but would include a section on East 3rd Avenue that would incur a higher risk of impact to trees. Options 1b, 2 and 3 would locate the pipeline construction along significant lengths of residential streets which, coupled with potential tree impacts, would result in relatively high impact route choices compared to Options 1 and 1a that are considered low and moderate impact route choices respectively.

- Option 1: low impact, better route choice (4)
- Option 1a: moderate impact, good route choice (3)
- Option 1b: high impact, poor route choice (2)
- Option 2: high impact, poor route choice (2)
- Option 3: high impact, poor route choice (2)

2.7.3 Technical Considerations

2.7.3.1 *Engineering*

The route options identified within this section traverse from East 1st Avenue at Boundary Road to East 2nd Avenue at Woodland Drive. Each option would cross Highway 1 at East 1st Avenue which would require a long trenchless pipe installation to avoid impacting Highway 1 operation. This crossing presents the main engineering challenge which is common to all options. There are also various acute alignment directional changes common to all route options. Option 1b would require the abandonment and removal of the existing NPS20 IP pipeline prior to construction and installation of the replacement NPS 30 IP pipeline; this would involve additional engineering challenges not associated with any of the other options.

- Option 1: moderate impact, good route choice (3)
- Option 1a: moderate impact, good route choice (3)

- Option 1b: high impact, poor route choice (2)
- Option 2: moderate impact, good route choice (3)
- Option 3: moderate impact, good route choice (3)

2.7.3.2 ***Construction***

The route options considered would each involve a long trenchless crossing from east of Highway 1 to west of the intersection of East 1st Avenue & Rupert Street. This would minimize pipeline construction impacting Highway 1 operation and the traffic access and egress at the local Highway 1 on and off ramps. After the common Highway 1 crossing the route options adopt east-west alignments on different avenues. Option 1 would be located along the northern edge of the boulevard in the west bound lanes of East 1st Avenue. Option 1a would combine East 1st Avenue from Highway 1 to Kamloops Street and East 3rd Avenue from Kamloops Street to Woodland Drive, and Option 1b would combine East 1st Avenue from Highway 1 to Slocan Street and then East 2nd Avenue from Slocan Street to Woodland Drive. Option 2 would be located on East 3rd Avenue and Option 3 would be located on Graveley Street.

These options are within approximately 10% in terms of length resulting in a negligible difference in terms of overall construction footprint. The main factor differentiating these options, in terms of construction, is productivity and the extent and nature of the construction challenges that would be encountered along each alignment. Option 1 would avail of the extra width afforded by both west bound lanes, and the lower density of buried utility services, to deliver the highest construction productivity. Option 1a would encounter more construction constraints on East 3rd Avenue resulting in lower construction productivity. Option 1b on East 2nd Avenue, due to the requirement to first remove the existing NPS 20 IP pipeline, would be the most challenging route option requiring the most time and resources to first remove the existing pipeline and then install the NPS 30 IP pipeline. Options 2 and 3, due to the presence of established tree canopies, numerous adjacent buried utilities and services, lamp posts and narrower road widths would also result in significant construction constraints and slow construction. However, Option 2 would encounter less utility constraints compared to Option 3 and, therefore, would result in improved construction productivity.

- Option 1: low impact, better route choice (4)
- Option 1a: moderate impact, good route choice (3)
- Option 1b: high impact, poor route choice (2)
- Option 2: moderate impact, good route choice (3)
- Option 3: high impact, poor route choice (2)

2.7.3.3 ***Operation***

High traffic volumes and the resulting traffic management challenges involved with isolating East 1st Avenue would constrain access to the buried pipeline should it be required for future

operation and maintenance purposes. Conversely, on the other route options, which would be located on the less trafficked residential streets, access challenges in terms of traffic disruption and management would be significantly less. However, because of the existing utilities in the residential streets, sufficient space to access and expose the proposed NPS 30 IP pipeline with enough clearance to complete inspection and repair could be constrained. In all cases there would be numerous, but manageable, potential constraints; therefore, operational impacts are considered moderate for each of the options which results in good route choices.

- Option 1, 1a, 1b, 2 and 3: moderate impact, good route choice (3)

2.7.3.4 ***System Interface***

Options 1, 1a and 3, in addition to an IP/IP interface station, would also require a short lateral pipeline to interface with the IP system that is connected to the existing NPS 20 IP pipeline at Slocan Street & East 2nd Avenue. Options 1b and 2 would be located on East 2nd Avenue and East 3rd Avenue respectively and would also require an IP/IP station to interface with the IP system at Slocan Street; however, these options would not need any new lateral pipeline construction.

- Option 1: moderate impact, good route choice (3)
- Option 1a: moderate impact, good route choice (3)
- Option 1b: low impact, better route choice (4)
- Option 2: low impact, better route choice (4)
- Option 3: moderate impact, good route choice (3)

2.7.3.5 ***Adjacent Infrastructure***

Options 1 and 1a would be installed predominantly on East 1st Avenue with fewer adjacent utilities which would maximize the clearance to the proposed NPS 30 IP pipeline. This would reduce the risk to the integrity and safety of the pipeline from adjacent infrastructure. Options 1b, 2 and 3 would encounter progressively more adjacent utilities as more of these routes are located on residential streets. Options 2 and 3 would be installed entirely along residential streets adjacent to some closely aligned utilities which would result in the highest relative risk to longevity and safety of the pipeline from adjacent utilities.

- Option 1: low impact, better route choice (4)
- Option 1a: low impact, better route choice (4)
- Option 1b: moderate impact, good route choice (3)
- Option 2: high impact, poor route choice (2)
- Option 3: high impact, poor route choice (2)

2.7.3.6 *Natural Hazards*

The presence of mature trees, especially on the route options aligned on narrower residential streets, could present potential hazards to the pipeline integrity. Option 1 would be located in the west bound lane on East 1st Avenue beside the existing median. This alignment would maximize proximity to the established trees in the median and between the road curb and the pavement and thus mitigate any potential impact from tree root encroachment. The other options would potentially involve installation of the pipeline in proximity to established trees along the more residential East 2nd Avenue, East 3rd Avenue and Graveley Street.

Option 1 would be a low impact route choice compared to the other options in terms of potential pipeline hazards. Option 1b would install the replacement NPS 30 IP pipeline along the same running line as the existing NPS 20 IP pipeline between Slocan Street and Woodland Drive; the existing NPS 20 IP pipeline alignment might not be optimized in terms of natural hazards considerations therefore this option is a relatively high impact route choice. Options 1a, 2 and 3 would present some risk which could be mitigated through detailed route selection and would, therefore, be moderate impact route choices.

- Option 1: low impact, better route choice (4)
- Option 1a: moderate impact, good route choice (3)
- Option 1b: high impact, poor route choice (2)
- Option 2: moderate impact, good route choice (3)
- Option 3: moderate impact, good route choice (3)

2.7.4 Cost

Option 1 would involve pipeline construction on East 1st Avenue. Option 1a would also involve pipeline construction on East 1st Avenue to Kamloops Street and East 3rd Avenue from Kamloops Street to Woodland Drive. Option 1b would involve pipeline construction on East 1st Avenue from Slocan Street to Woodland Drive. The construction would become more challenging along these options between Nanaimo Street, Kamloops Street and Slocan Street respectively and Woodland Drive due to more constrained working width and proximity to trees and traffic. Option 1 would deliver the highest overall construction productivity and therefore the lowest cost. Option 1a and Option 2 would involve greater lengths of route along residential streets with a smaller area in which to construct, more adjacent underground utilities and trees and power poles between the curb and footpath. These options have similar pipeline construction costs. Option 3 is the most constrained route in terms of adjacent buried utilities. The pipeline route would also have to navigate Clinton Park. These requirements make Option 3 the most expensive route along with Option 1b which would require a significant portion of the existing NPS 20 IP pipeline to be isolated and removed from service prior to installation of the NPS 30 IP pipeline.

2.7.5 Route Options Scoring and Selection

The relative impact scoring of these options in Table 6 reflects the impacts and considerations outlined in the previous sections. Option 1 is the least cost preferred option.

Table 6: Boundary Rd. to Woodland Dr. Route Options Screening Matrix

Metro IP Route Selection: Boundary to East 2nd and Woodland Drive (Vancouver)

	Option	1		1a		1b		2		3	
	Length (m)	3990		4155		3890		4390		4340	
Impact and Vulnerability Considerations	**Weight**	**E 1st (Boundary to E 2nd and Woodland)**		**E 1st (Boundary to Kamloops) + E 3rd (Kamloops to E 3rd and Woodland)**		**E 1st (Boundary to Slocan) + E 2nd (Slocan to Woodland)**		**E 1st (Boundary to Windermere) + E 3rd (Windermere to E 2nd and Woodland)**		**E 1st (Boundary to Windermere) + Graveley (Windermeere to E 2nd and Woodland)**	
		Score	Weighted Score	Score	Weighted Score	Score	Weighted Score	Score	Weighted Score	Score	Weighted Score
Community/Stakeholder											
Health and Safety	15	3	45	3	45	2	30	3	45	3	45
Socio-Economic	15	2	30	3	45	3	45	4	60	4	60
Land Ownership and Use	5	4	20	4	20	3	15	3	15	3	15
Environmental											
Ecology	5	3	15	2	10	2	10	2	10	2	10
Cultural Heritage	5	4	20	4	20	4	20	4	20	4	20
Human Environment	15	4	60	3	45	2	30	2	30	2	30
Engineering/Technical											
Engineering/Design	5	3	15	3	15	2	10	3	15	3	15
Construction	10	4	40	3	30	2	20	3	30	2	20
Operation	10	3	30	3	30	3	30	3	30	3	30
System interface	5	3	15	3	15	4	20	4	20	3	15
Adjacent Infrastructure	5	4	20	4	20	3	15	2	10	2	10
Natural Hazards	5	4	20	3	15	2	10	3	15	3	15
Totals	**100**		**330**		**310**		**255**		**300**		**285**
Ranking		**1**		**2**		**5**		**3**		**4**	
Relative Cost		**100%**		**122%**		**131%**		**118%**		**130%**	
Cost Ranking		**1**		**3**		**5**		**2**		**4**	

3. CONCLUSION - PREFERRED COQUITLAM IP ROUTE OPTION.

The routing process identified a route corridor between Coquitlam Gate station and East 2nd Avenue and Woodland station. The corridor was sectionalized into seven sections based on the locations of lateral offtakes from the existing NPS 20 IP pipeline. Twenty four route options (ranging from two to five for each section) within the corridor were evaluated. This approach helped to identify feasible options while ensuring routing efficiency in interfacing with the existing IP network. The selected preferred route aligns closely with the existing NPS 20 IP pipeline. The relative position of the selected route to the existing IP pipeline is detailed in the Table 7.

For detailed route maps of the preferred route see attachments "Coquitlam Gate IP Detailed Routing Part 1 and Part 2" in section 5.

Table 7: Selected Pipeline Route Details

Section	Existing NPS 20 Coquitlam IP route	Proposed NPS 30 Coquitlam IP route	Relative Position
1	Como Lake Avenue	Como Lake Avenue	Parallel in same road
2	Como Lake Avenue	Como Lake Avenue	Parallel in same road
3	Como Lake Avenue and Broadway	Como Lake Avenue and Broadway	Parallel in same road
4	Broadway	Broadway	Parallel in same road
5	Broadway	Broadway	Parallel in same road
6	Springer Avenue, Halifax Street, Brentlawn Drive, Lane adjacent to Brentwood Town Centre, Halifax Street, 2nd Avenue	Springer Avenue, Halifax Street, Highlawn Drive, Graveley Street	Parallel Street (offset one to two streets north)
7	East 2nd Avenue	East 1st Avenue	Parallel Street (offset one street north)

The routing analysis determined that for the initial 70% of the route corridor (between Como Lake Avenue & Mariner Way in Coquitlam and Broadway & Springer Avenue in Burnaby) the optimum alignment for the replacement NPS 30 IP pipeline is parallel to the existing NPS 20 IP pipeline and within the same roadway. However, due to various constraints none of the options assessed between Broadway & Springer Avenue in Burnaby and East 2nd & Woodland Drive in Vancouver were viable to form an efficient pipeline route parallel to the existing NPS 20 IP pipeline and within the same roadway.

3.1 *FURTHER ANALYSIS OF LOUGHEED HIGHWAY*

Lougheed Highway, a major thoroughfare through the City of Burnaby, was identified and evaluated as a route option in corridor Sections 4 and 5. Due to traffic concerns, construction

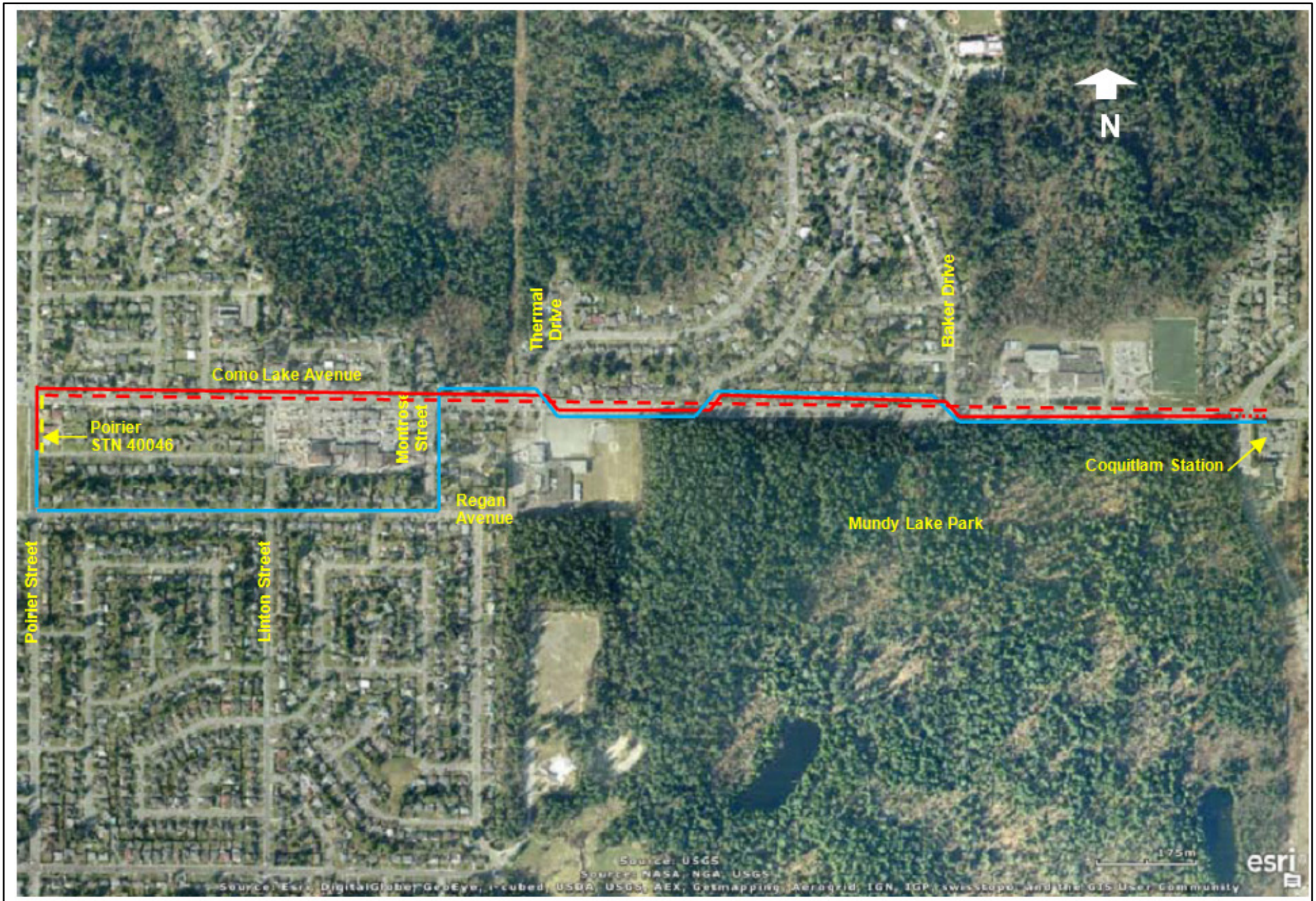
constraints and utility congestion, a route option through Section 6 was ruled out during the preliminary screening and not evaluated using the FEI's Pipeline Route Evaluation Criteria.

The Lougheed Highway option in Section 4 was determined as not being viable due to excessive cost. The option on Lougheed Highway through Section 5 was less expensive and scored favourably against the preferred option on Broadway in most criteria except socio-economic. However, due to traffic disruption from multiple lane closure during construction, the Lougheed Highway option scored lower. This resulted in the Lougheed Highway option in Section 5 ranking second to the preferred Broadway option. As noted above, in Section 6 through the Brentwood area of Burnaby, Lougheed Highway was not considered as a route option due to significant anticipated traffic disruption, construction constraints and utility congestion.

As part of the ongoing consultation with the City of Burnaby, at a meeting between FEI and the City on November 27th 2014, the City suggested that FEI reconsider routing the NPS 30 Coquitlam Gate IP pipeline in the Brentwood area of Burnaby along Lougheed Highway.

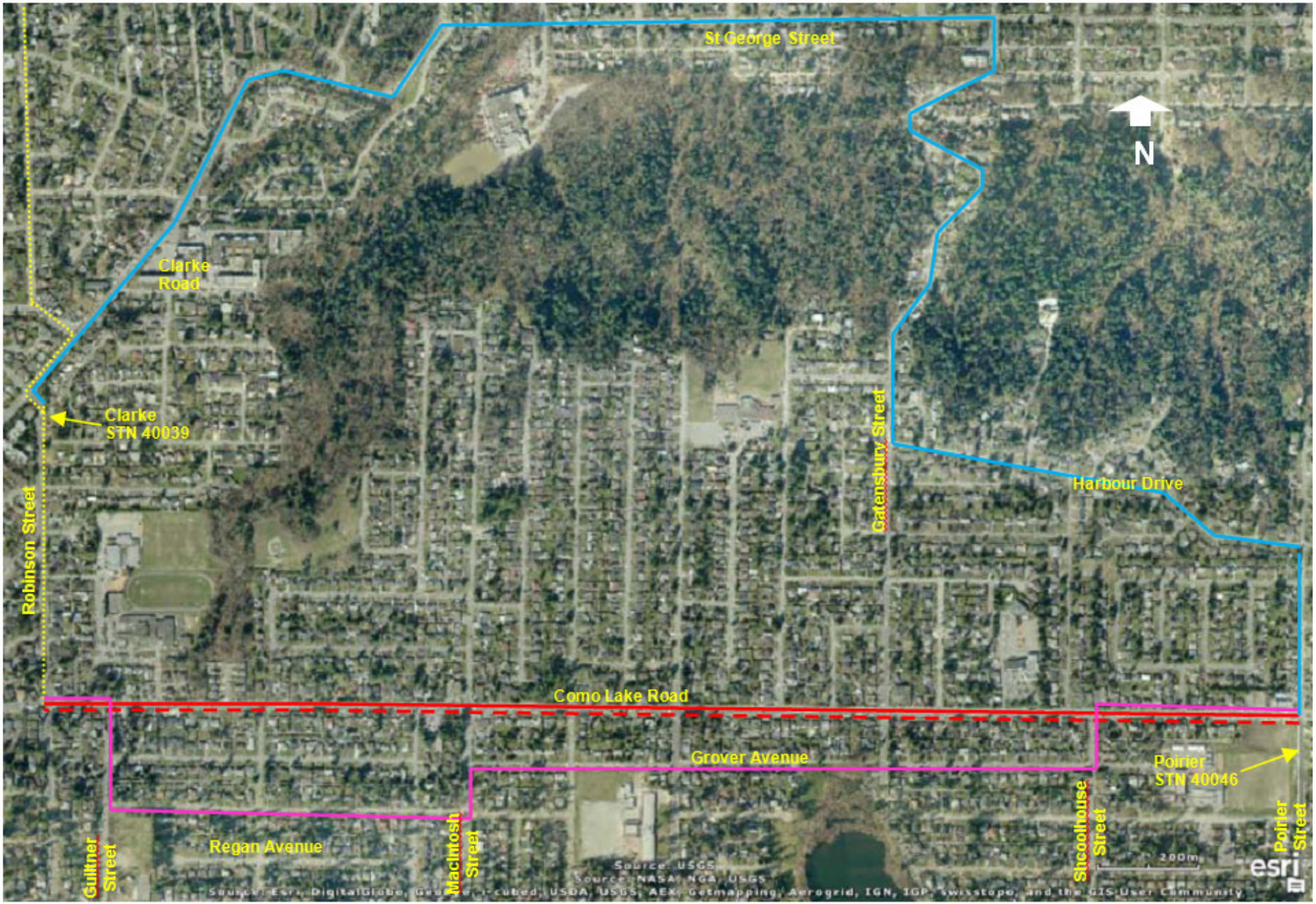
The City of Burnaby indicated that traffic impacts along Lougheed Highway should not be considered as a major issue when assessing route feasibility. The City stated that if a mutually agreeable route alignment can be determined along Lougheed Highway in Section 5 and Section 6, between approximately Bainbridge Avenue and Boundary Road, the City will support the route.

As a result of the feedback from the City, FEI, in conjunction with the City of Burnaby and in consultation with other stakeholders such as Translink, B.C. Hydro and MoTI, will conduct further analysis to determine if a route option along Lougheed Highway in Section 5 and 6 is feasible. It is anticipated that this analysis will be completed early 2015. If the analysis shows that a route option along Lougheed Highway is technically feasible, constructible, that traffic issues can be managed with reasonable efforts and that the route option scoring and cost is comparable to the current preferred route alignment options, FEI will submit a revised route evaluation for the sections of route corridor through Burnaby to the BCUC for consideration.



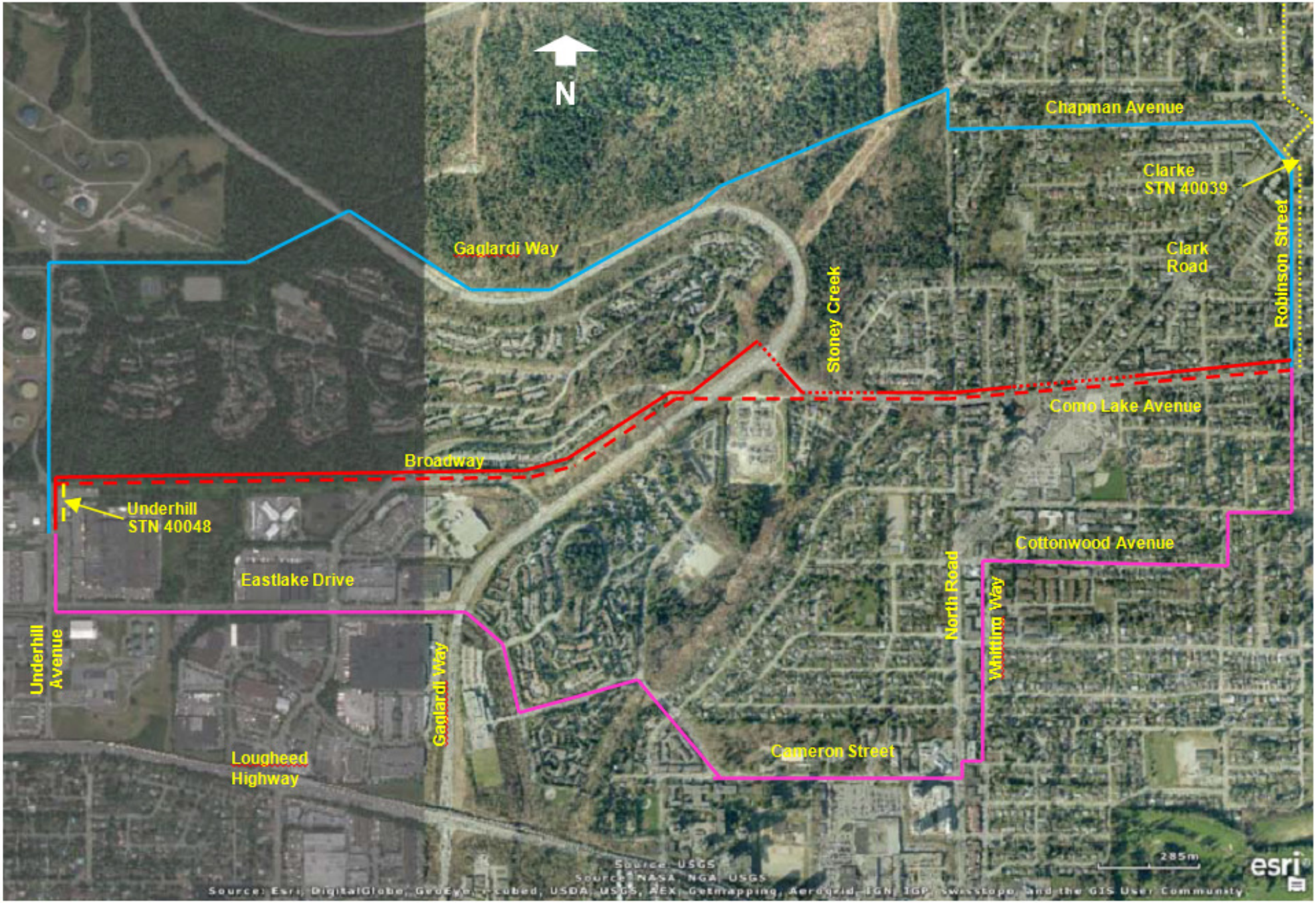
LMSU - Coquitlam IP Route Options Section 1
Coquitlam Station to Poirier Street

Existing NPS 20 Pipeline
Option 1 NPS 30 Pipeline Route
Trenchless Section
Option 2 NPS 30 Pipeline Route
Existing Pipeline Lateral



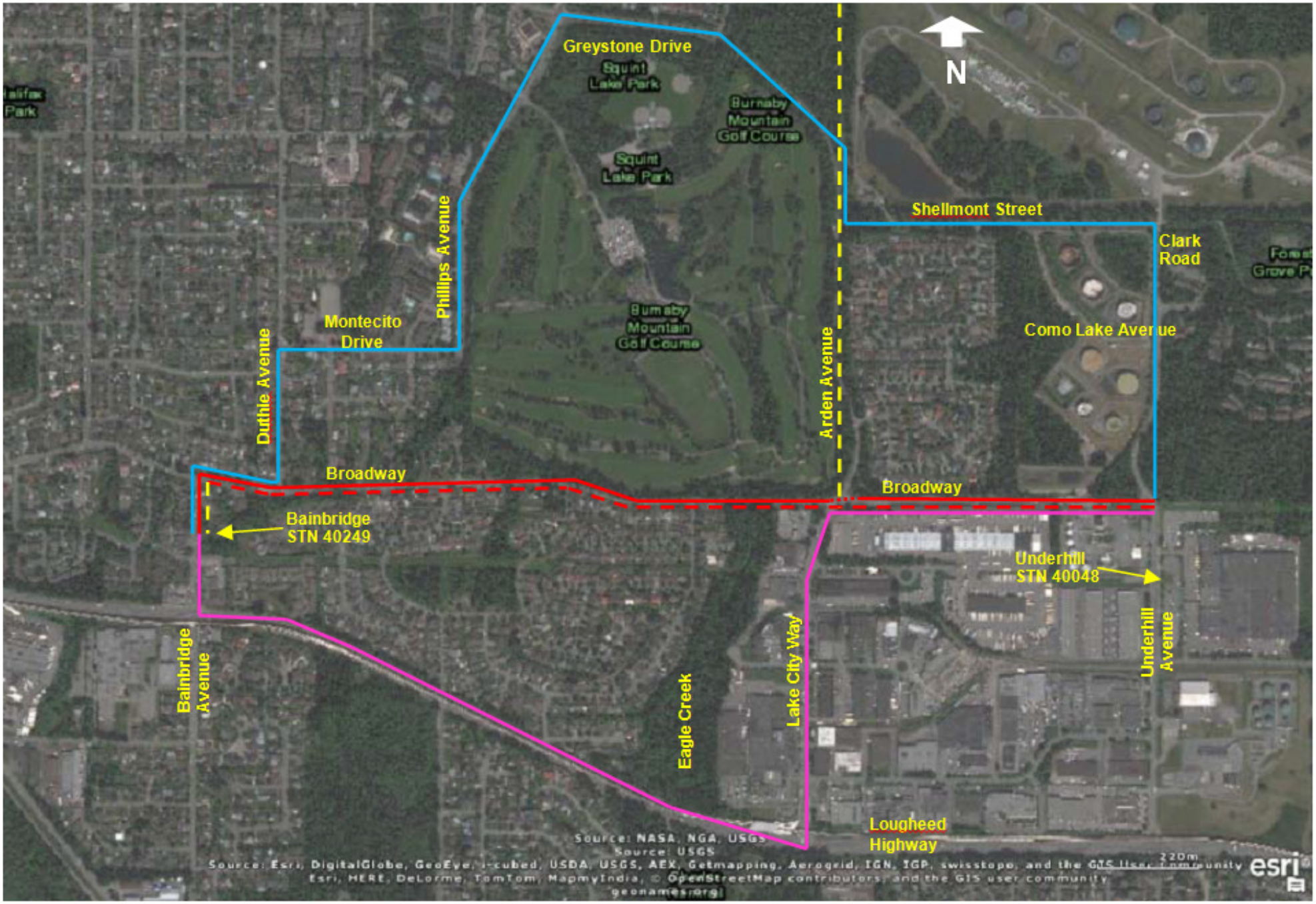
LMSU - Coquitlam IP Route Options Section 2
Poirier Street to Clarke and Robinson

Existing NPS 20 Pipeline
Option 1 NPS 30 Pipeline Route
Option 2 NPS 30 Pipeline Route
Option 3 NPS 30 Pipeline Route
Existing Pipeline Lateral



LMSU - Coquitlam IP Route Options Section 3
Clarke and Robinson to Underhill

Existing NPS 20 Pipeline
Option 1 NPS 30 Pipeline Route
Trenchless Section
Option 2 NPS 30 Pipeline Route
Option 3 NPS 30 Pipeline Route
Existing Pipeline Lateral

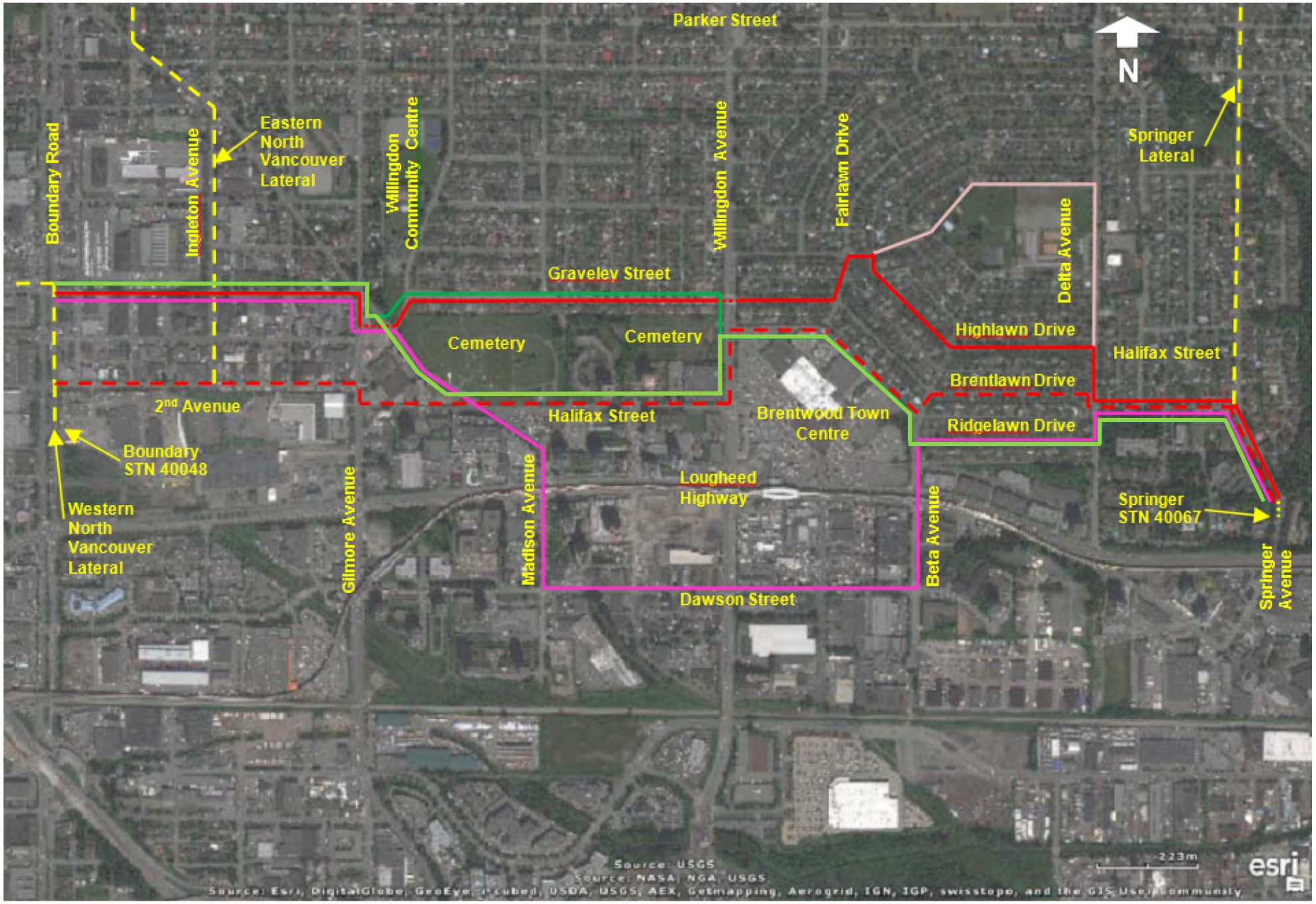


LMSU - Coquitlam IP Route Options Section 4
Underhill to Bainbridge

Existing NPS 20 Pipeline
Option 1 NPS 30 Pipeline Route
Trenchless Section
Option 2 NPS 30 Pipeline Route
Option 3 NPS 30 Pipeline Route
Existing Pipeline Lateral

LMSU - Coquitlam IP Route Options Section 5
Bainbridge to Springer

Existing NPS 20 Pipeline
Option 1 NPS 30 Pipeline Route
Trenchless Section
Option 2 NPS 30 Pipeline Route
Option 3 NPS 30 Pipeline Route
Existing Pipeline Lateral

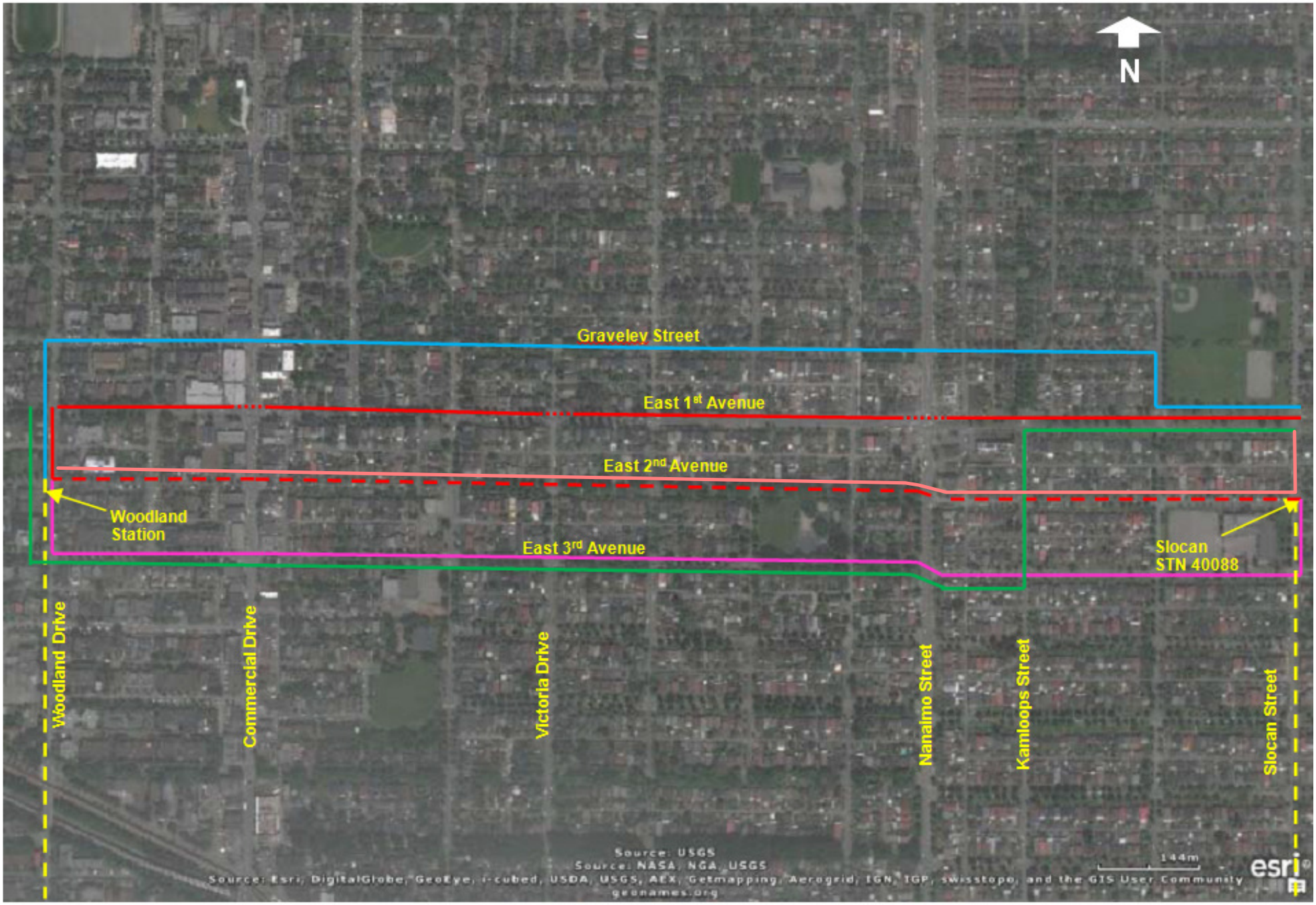


LMSU- Coquitlam IP Route Options Section 6
Springer to Boundary

Existing NPS 20 Pipeline
Option 1 NPS 30 Pipeline Route
Option 2 NPS 30 Pipeline Route
Option 3 NPS 30 Pipeline Route
Existing Pipeline Lateral
Trenchless Section
Option 3A NPS 30 Pipeline Route
Option 1A NPS 30 Pipeline Route

LMSU - Coquitlam IP Route Options Section 7 Boundary to Slocan

Existing NPS 20 Pipeline
Option 2 NPS 30 Pipeline Route
Existing Pipeline Lateral
Option 1 NPS 30 Pipeline Route
Option 3 NPS 30 Pipeline Route
Trenchless Section



LMSU - Coquitlam IP Route Options Section 8
Slocan to Woodland

Existing NPS 20 Pipeline
Option 2 NPS 30 Pipeline Route
Option 1A NPS 30 Pipeline Route
Option 1NPS 30 Pipeline Route
Option 3 NPS 30 Pipeline Route
Existing Pipeline Lateral
Trenchless Section
Option 1B NPS 30 Pipeline Route

Legend

- Proposed Metro IP Route Replacement Kilometre Post Rev. C
- Kilometre Post 100m Submarker Rev. C
- Tee Junction
- Gas Valve
- BCHYDRO Manhole
- BCHYDRO Power Pole
- BCHYDRO Pull Box
- BCHYDRO Service Box
- BCHYDRO Transmission Tower
- BCHYDRO Switching Kiosk
- BCHYDRO U.G. Transformer
- TELUS Telecoms. Facility
- TELUS Telecoms. Structure
- SHAW Manhole
- SHAW Pole
- SHAW Telecoms. Facility
- Traffic Signal
- Communications Box
- Street Light
- Street Lighting Junction Boxe
- Combined Manhole
- Sanitary Capped End
- Sanitary Cleanout
- Sanitary Pump Station
- Sanitary Valve
- Sanitary Manhole
- Storm Manhole
- Storm Intake
- Storm Catch Basin
- Storm Cleanout
- Water Hydrant
- Water Control Valve
- Proposed Metro IP Route Replacement Rev. C
- Existing Metro IP Line and Offtakes
- Gas Distribution Pipe
- Communications Duct
- Combined Main
- Combined Service Connection
- Sanitary Main
- Sanitary Service Connection
- Storm Main
- Storm Service Connection
- Water Main
- Water Service Connection
- Water Abandoned Main
- Water Hydrant Feed
- BCHYDRO Duct Bank
- BCHYDRO U.G. Primary
- BCHYDRO U.G. Secondary
- BCHYDRO O/H Wire
- SHAW Telecoms. U.G. Line
- TELUS Cable (Wire) Line
- Land Parcel
- Water Chamber

PRELIMINARY - SUBJECT TO REVISION

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DESIGN: VI
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FORTIS BC LOWER MAINLAND NATURAL GAS SYSTEM UPGRADE (LMSU) PROJECT
PROPOSED METRO IP GAS LINE REPLACEMENT
ROUTE MAP LEGEND

PROJECTION	DATUM	CONTRACTOR NAME	MAP NUMBER	REV.
UTM 10N	NAD83	WORLEYPARSONS CANADA	03-003-000a	1

SCALE	DATE	PROJECT NUMBER	ORIG.PAGE SIZE
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DESIGN: VI
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FORTIS BC LOWER MAINLAND NATURAL GAS SYSTEM UPGRADE (LMSU) PROJECT
PROPOSED METRO IP GAS LINE REPLACEMENT
ROUTE MAP

PROJECTION	DATUM	CONTRACTOR NAME	MAP NUMBER	REV.
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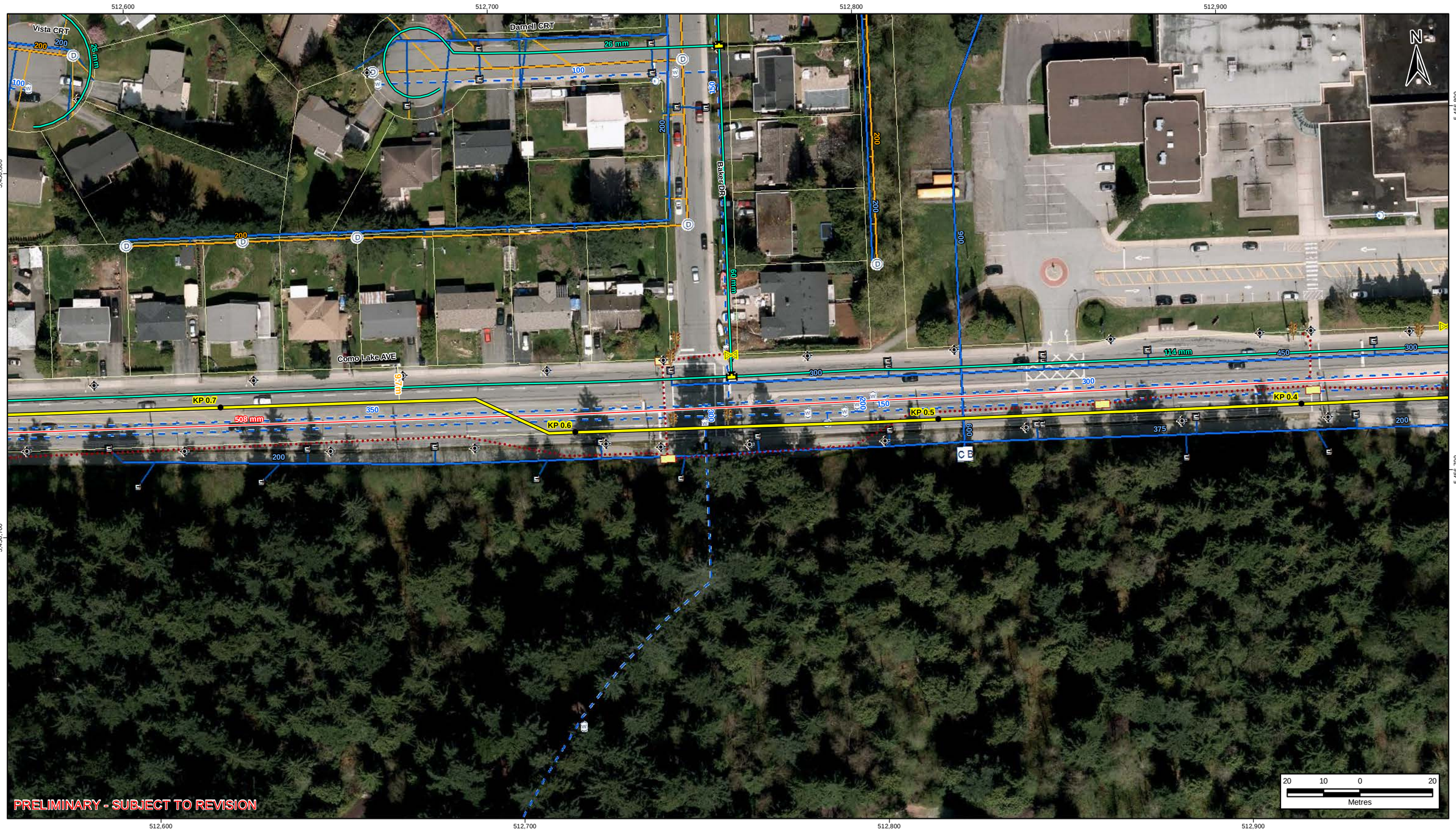

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FORTIS BC LOWER MAINLAND NATURAL GAS SYSTEM UPGRADE (LMSU) PROJECT
PROPOSED METRO IP GAS LINE REPLACEMENT
ROUTE MAP

PROJECTION	DATUM	CONTRACTOR NAME	MAP NUMBER	REV.
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FORTIS BC LOWER MAINLAND NATURAL GAS SYSTEM UPGRADE (LMSU) PROJECT
PROPOSED METRO IP GAS LINE REPLACEMENT
ROUTE MAP

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FORTIS BC LOWER MAINLAND NATURAL GAS SYSTEM UPGRADE (LMSU) PROJECT
PROPOSED METRO IP GAS LINE REPLACEMENT
ROUTE MAP

PROJECTION	DATUM	CONTRACTOR NAME	MAP NUMBER	REV.
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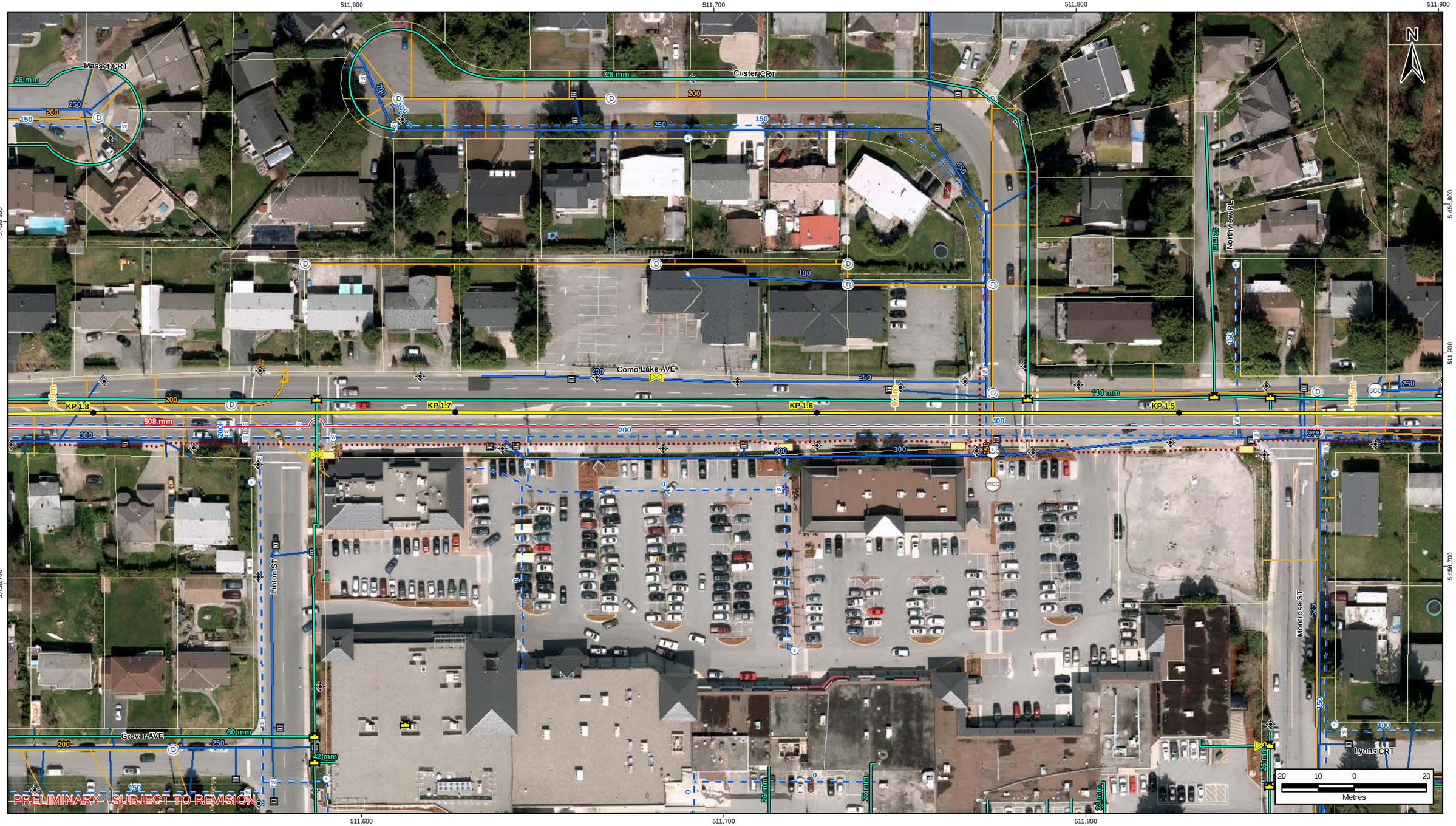

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FORTIS BC LOWER MAINLAND NATURAL GAS SYSTEM UPGRADE (LMSU) PROJECT
PROPOSED METRO IP GAS LINE REPLACEMENT
ROUTE MAP

PROJECTION	DATUM	CONTRACTOR NAME	MAP NUMBER	REV.
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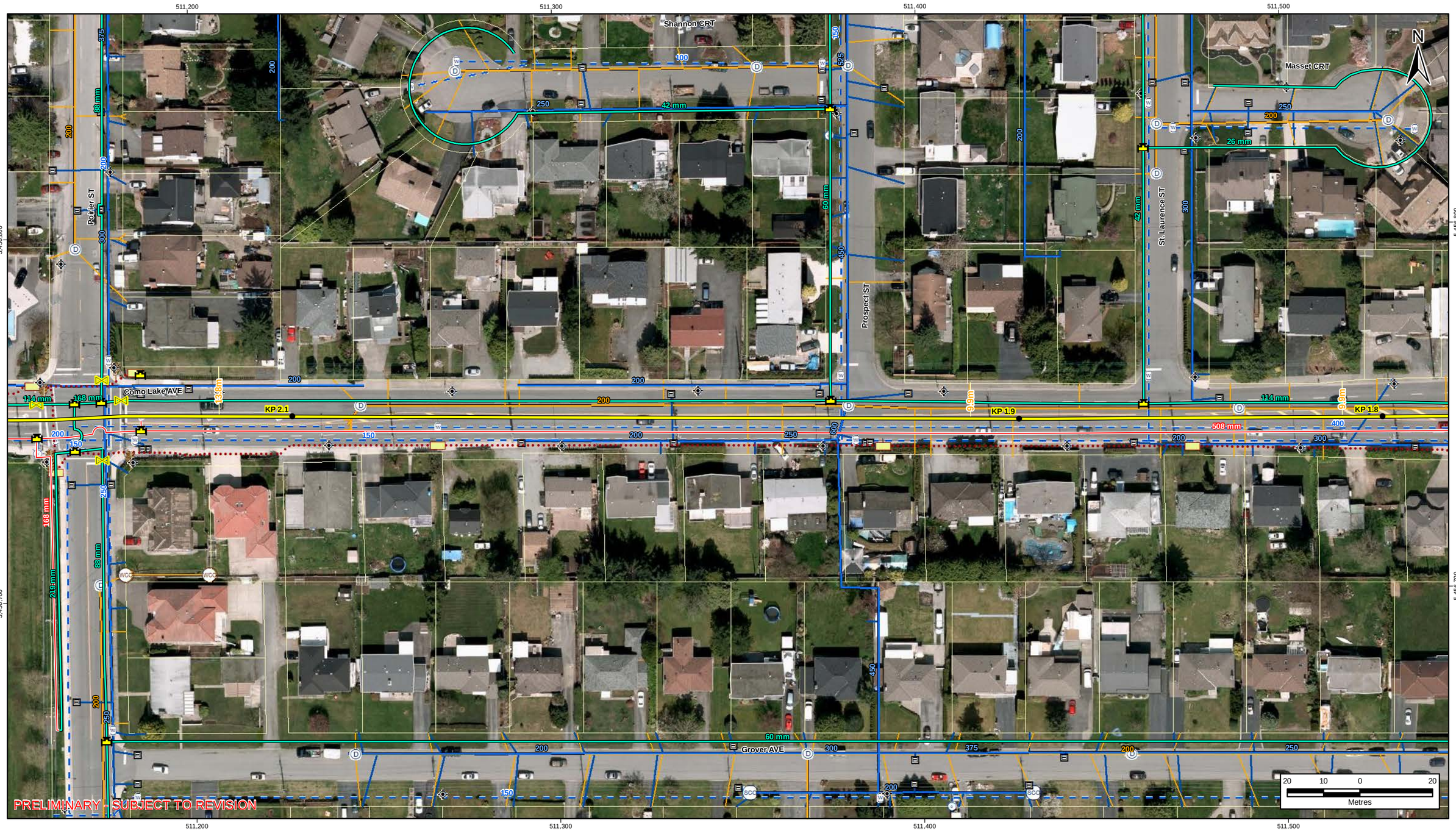

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FORTIS BC LOWER MAINLAND NATURAL GAS SYSTEM UPGRADE (LMSU) PROJECT
PROPOSED METRO IP GAS LINE REPLACEMENT
ROUTE MAP

PROJECTION	DATUM	CONTRACTOR NAME	MAP NUMBER	REV.
UTM 10N	NAD83	WORLEYPARSONS CANADA	03-003-006	2

SCALE	DATE	PROJECT NUMBER	ORIG.PAGE SIZE
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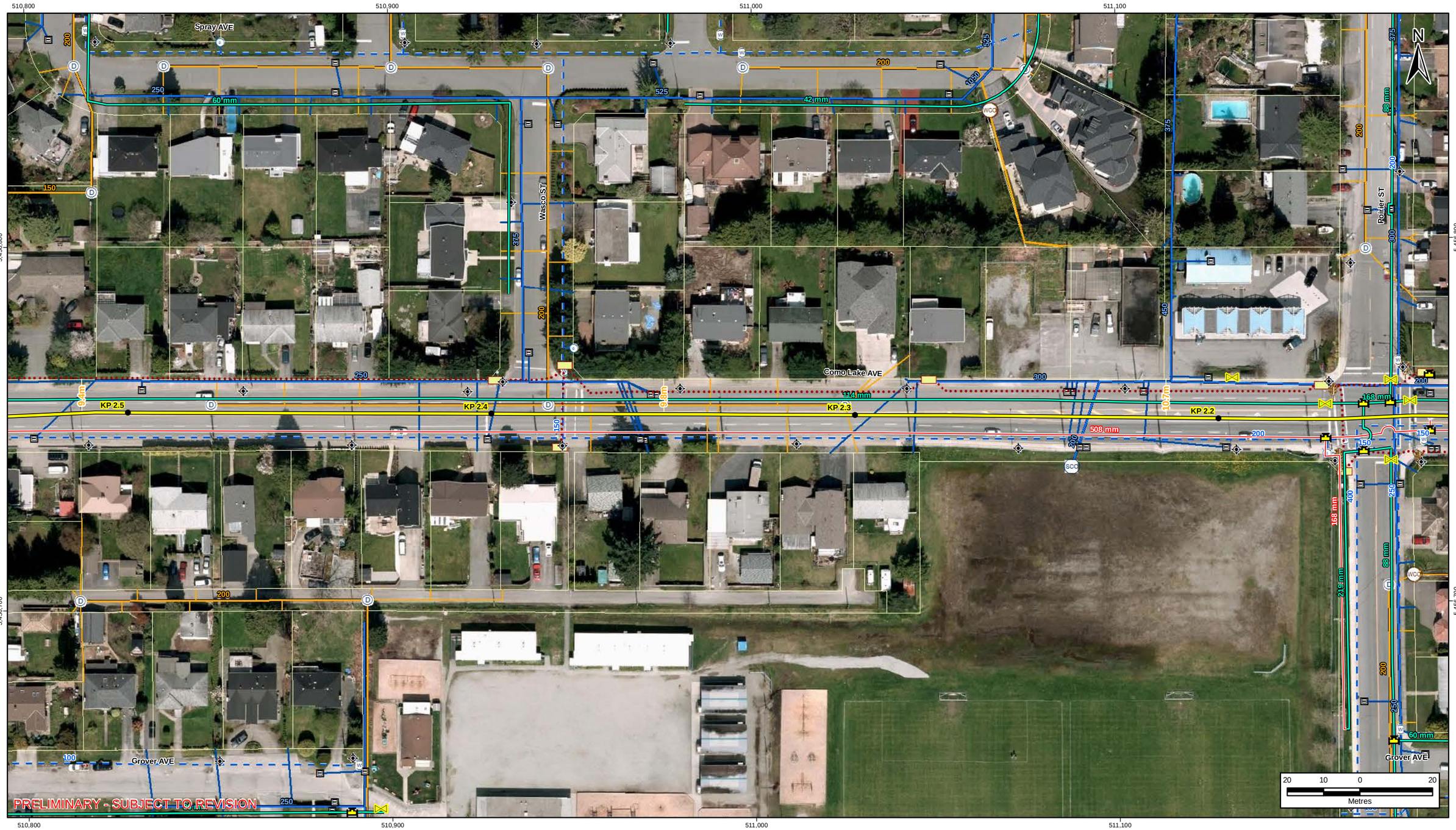

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FORTIS BC LOWER MAINLAND NATURAL GAS SYSTEM UPGRADE (LMSU) PROJECT
PROPOSED METRO IP GAS LINE REPLACEMENT
ROUTE MAP

PROJECTION	DATUM	CONTRACTOR NAME	MAP NUMBER	REV.
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SCALE	DATE	PROJECT NUMBER	ORIG.PAGE SIZE
1:1,000	20 Oct 2014	407071-00064	11X17

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DESIGN: VI
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FORTIS BC LOWER MAINLAND NATURAL GAS SYSTEM UPGRADE (LMSU) PROJECT
PROPOSED METRO IP GAS LINE REPLACEMENT
ROUTE MAP

PROJECTION	DATUM	CONTRACTOR NAME	MAP NUMBER	REV.
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SCALE	DATE	PROJECT NUMBER	ORIG.PAGE SIZE
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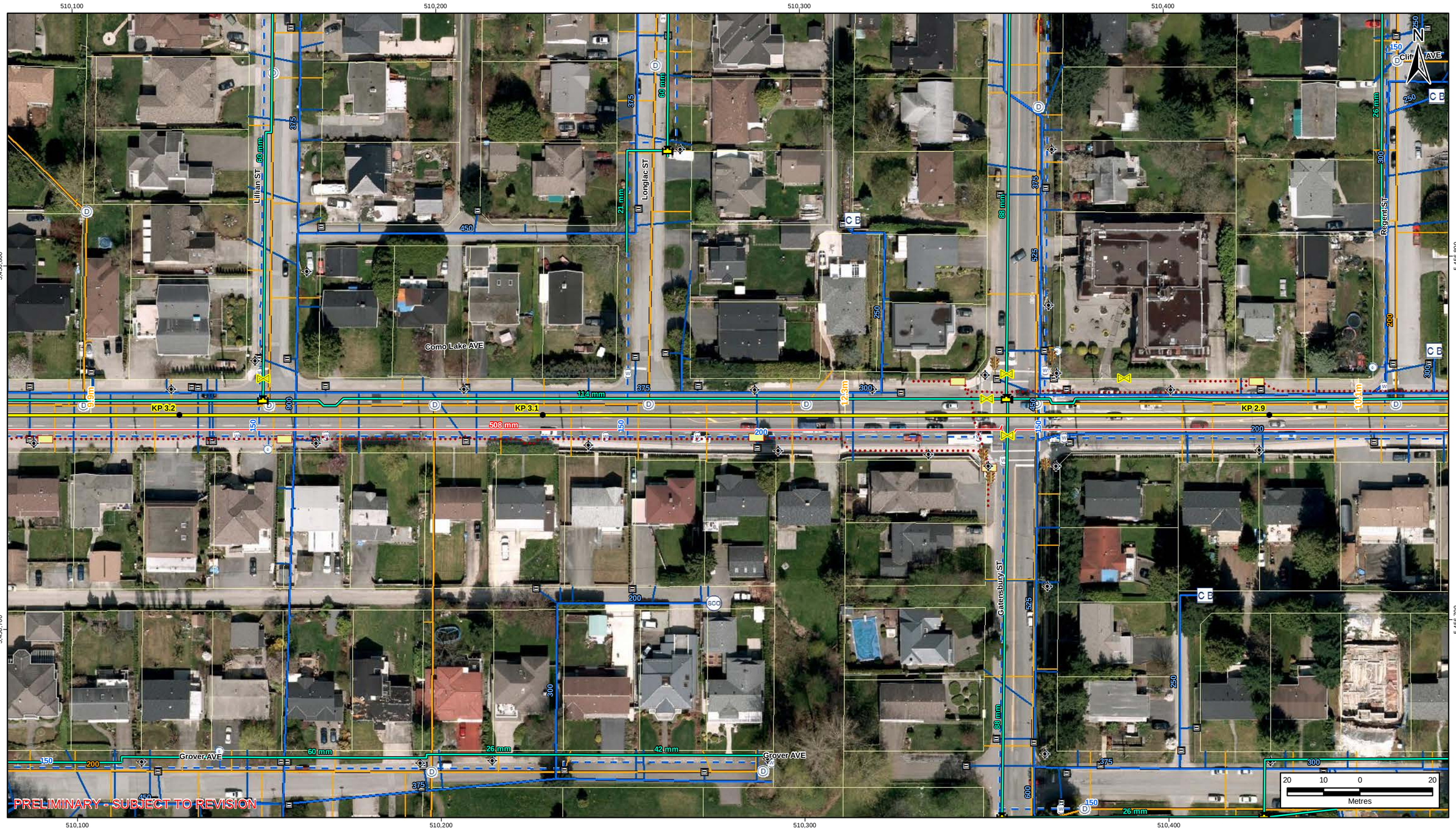

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PROPOSED METRO IP GAS LINE REPLACEMENT
ROUTE MAP

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UTM 10N	NAD83	WORLEYPARSONS CANADA	03-003-009	2

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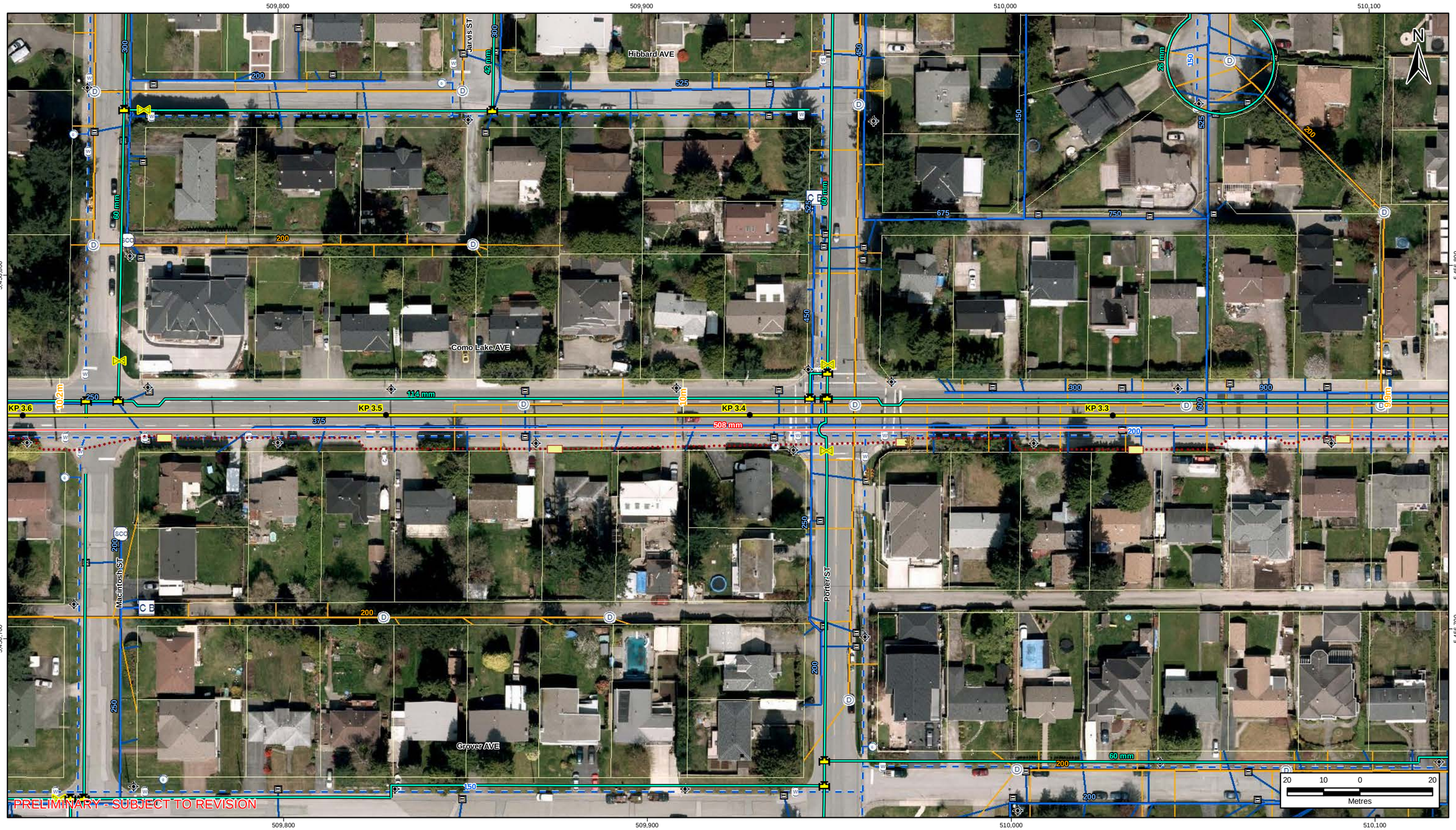

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FORTIS BC LOWER MAINLAND NATURAL GAS SYSTEM UPGRADE (LMSU) PROJECT
PROPOSED METRO IP GAS LINE REPLACEMENT
ROUTE MAP

PROJECTION	DATUM	CONTRACTOR NAME	MAP NUMBER	REV.
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SCALE	DATE	PROJECT NUMBER	ORIG.PAGE SIZE
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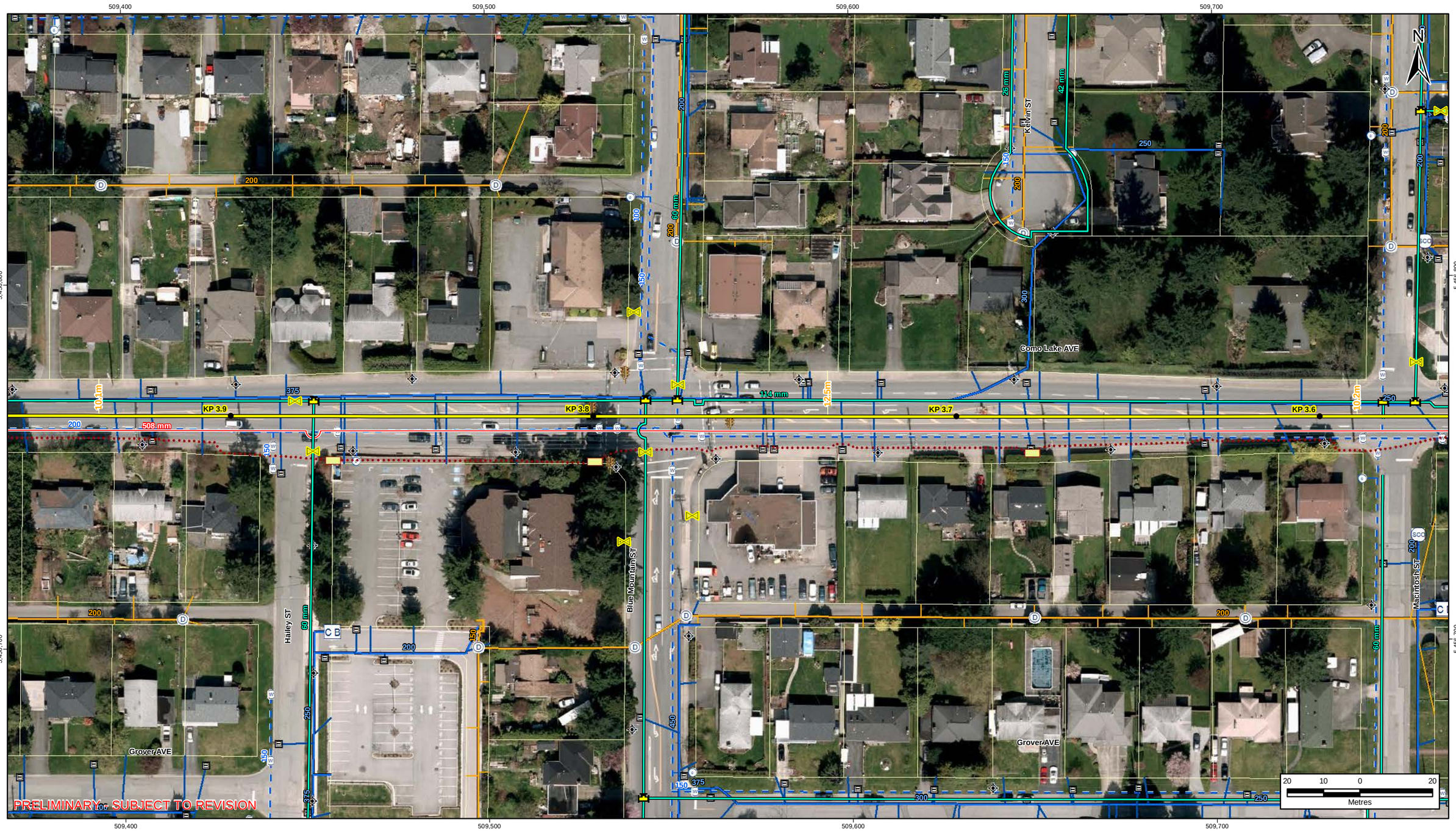

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PROPOSED METRO IP GAS LINE REPLACEMENT
ROUTE MAP

PROJECTION	DATUM	CONTRACTOR NAME	MAP NUMBER	REV.
UTM 10N	NAD83	WORLEYPARSONS CANADA	03-003-011	2

SCALE	DATE	PROJECT NUMBER	ORIG.PAGE SIZE
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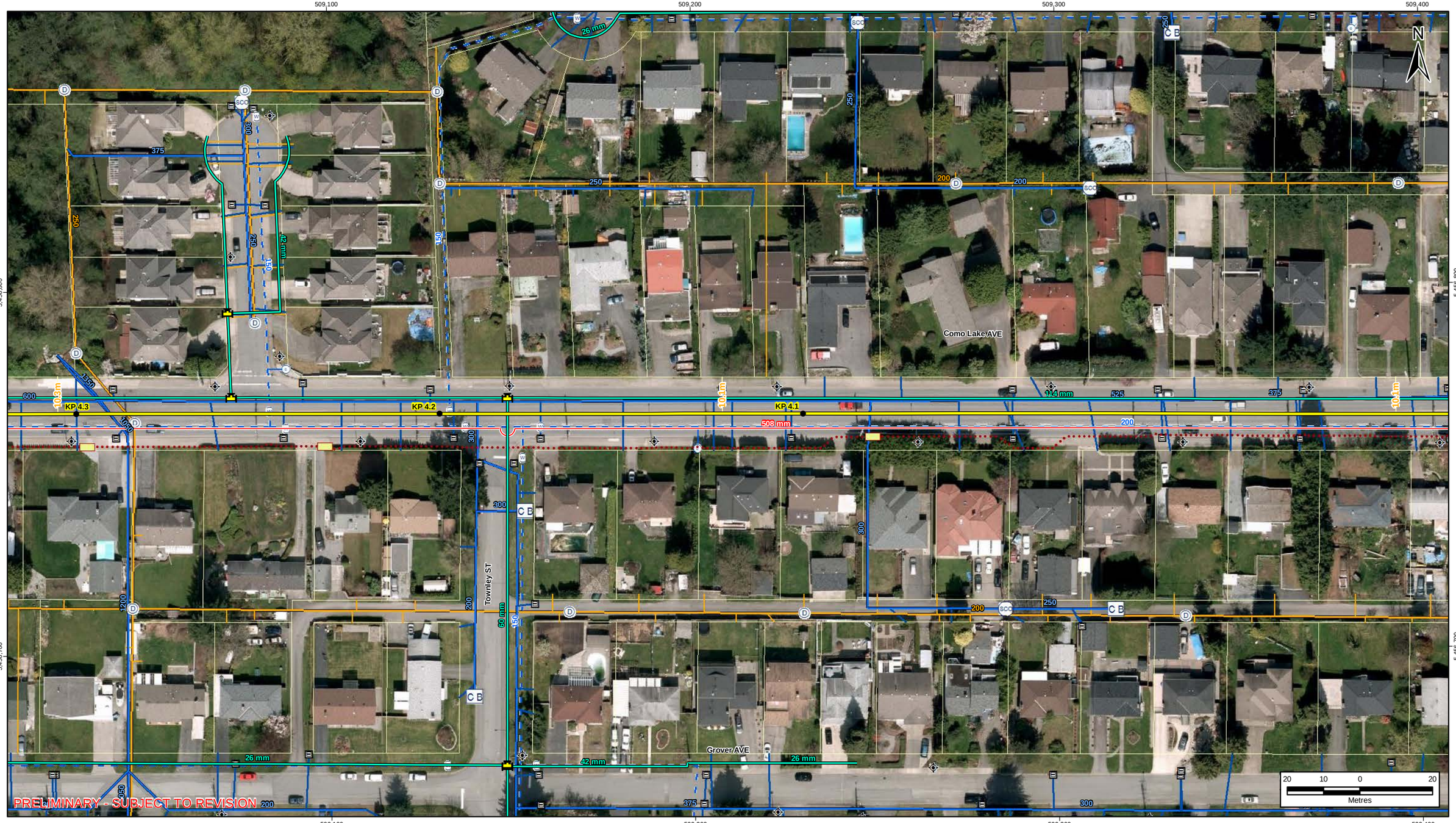

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PROPOSED METRO IP GAS LINE REPLACEMENT
ROUTE MAP

PROJECTION	DATUM	CONTRACTOR NAME	MAP NUMBER	REV.
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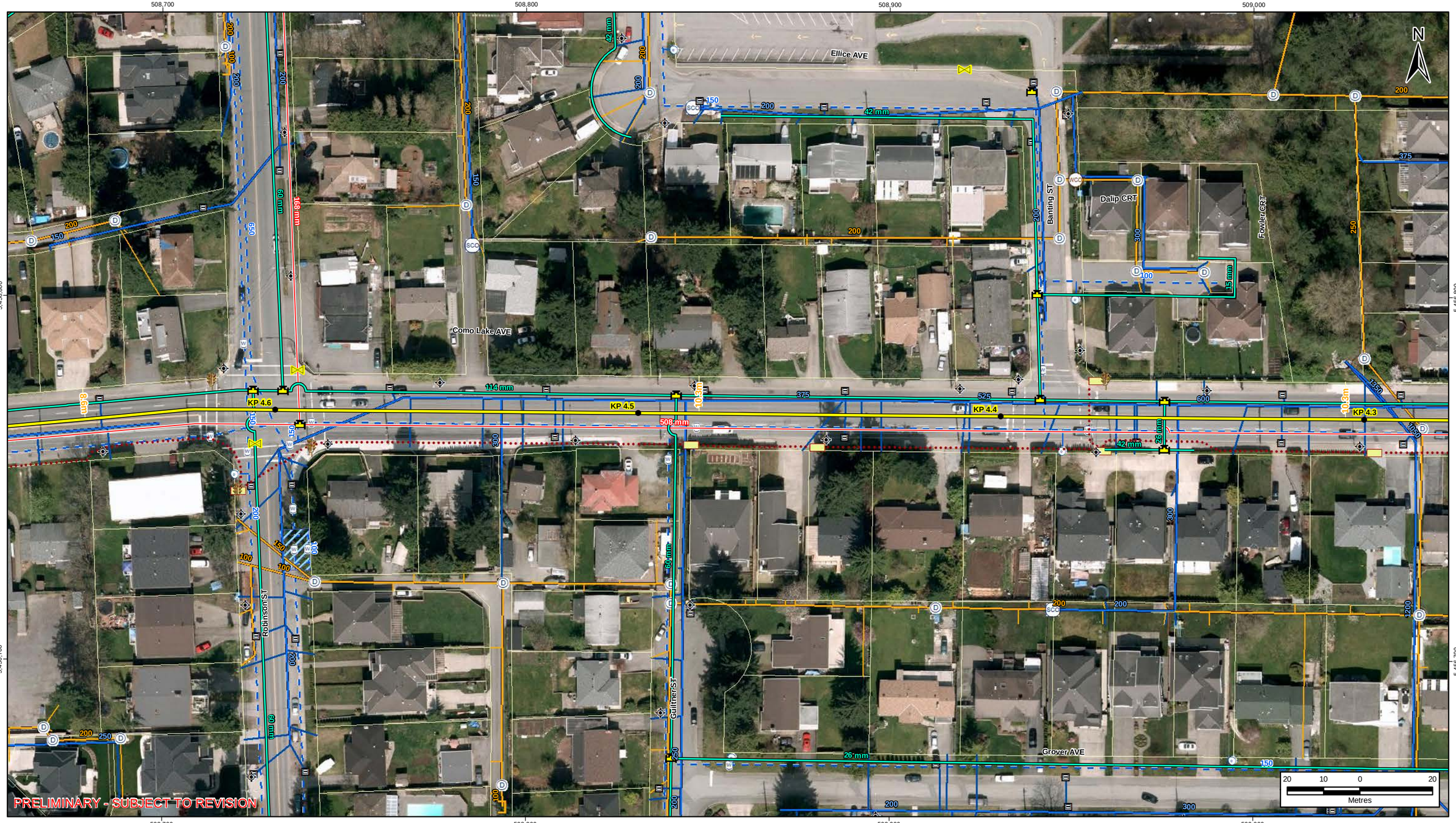

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DRAWN	CHECK	DESIGN	APPR.
KR	JB	VI	

FORTIS BC LOWER MAINLAND NATURAL GAS SYSTEM UPGRADE (LMSU) PROJECT
PROPOSED METRO IP GAS LINE REPLACEMENT
ROUTE MAP

PROJECTION	DATUM	CONTRACTOR NAME	MAP NUMBER	REV.
UTM 10N	NAD83	WORLEYPARSONS CANADA	03-003-013	2

SCALE	DATE	PROJECT NUMBER	ORIG.PAGE SIZE
1:1,000	20 Oct 2014	407071-00064	11X17

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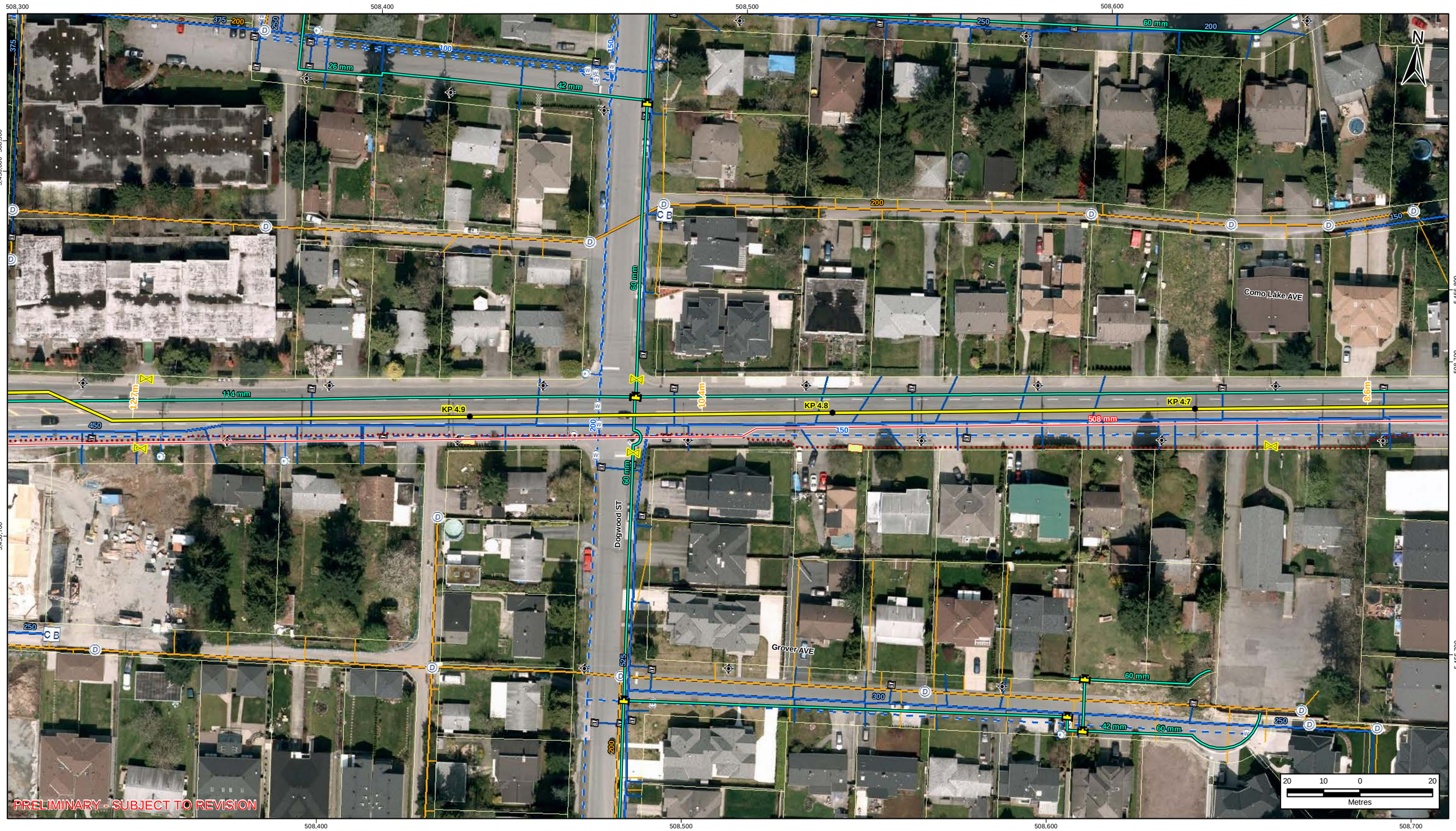

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B-MAP-L Version: A

FORTIS BC

FORTIS BC LMSU

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FORTIS BC LOWER MAINLAND NATURAL GAS SYSTEM UPGRADE (LMSU) PROJECT
PROPOSED METRO IP GAS LINE REPLACEMENT
ROUTE MAP

PROJECTION	DATUM	CONTRACTOR NAME	MAP NUMBER	REV.
UTM 10N	NAD83	WORLEYPARSONS CANADA	03-003-014	2

SCALE	DATE	PROJECT NUMBER	ORIG.PAGE SIZE
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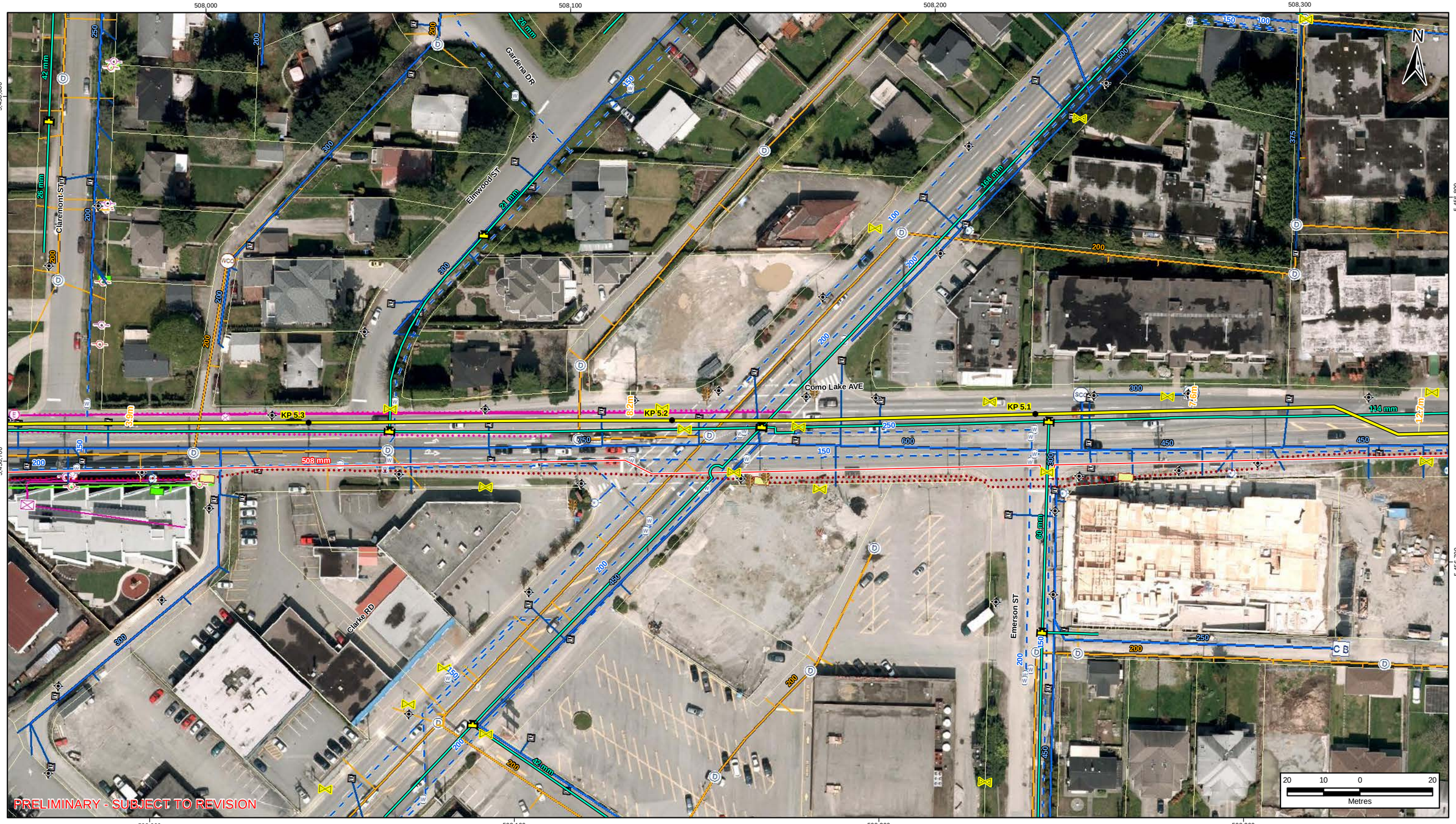

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DRAWN KR
CHECK JB
DESIGN VI
APPR.

FORTIS BC LOWER MAINLAND NATURAL GAS SYSTEM UPGRADE (LMSU) PROJECT
PROPOSED METRO IP GAS LINE REPLACEMENT
ROUTE MAP

PROJECTION	DATUM	CONTRACTOR NAME	MAP NUMBER	REV.
UTM 10N	NAD83	WORLEYPARSONS CANADA	03-003-015	2

SCALE	DATE	PROJECT NUMBER	ORIG.PAGE SIZE
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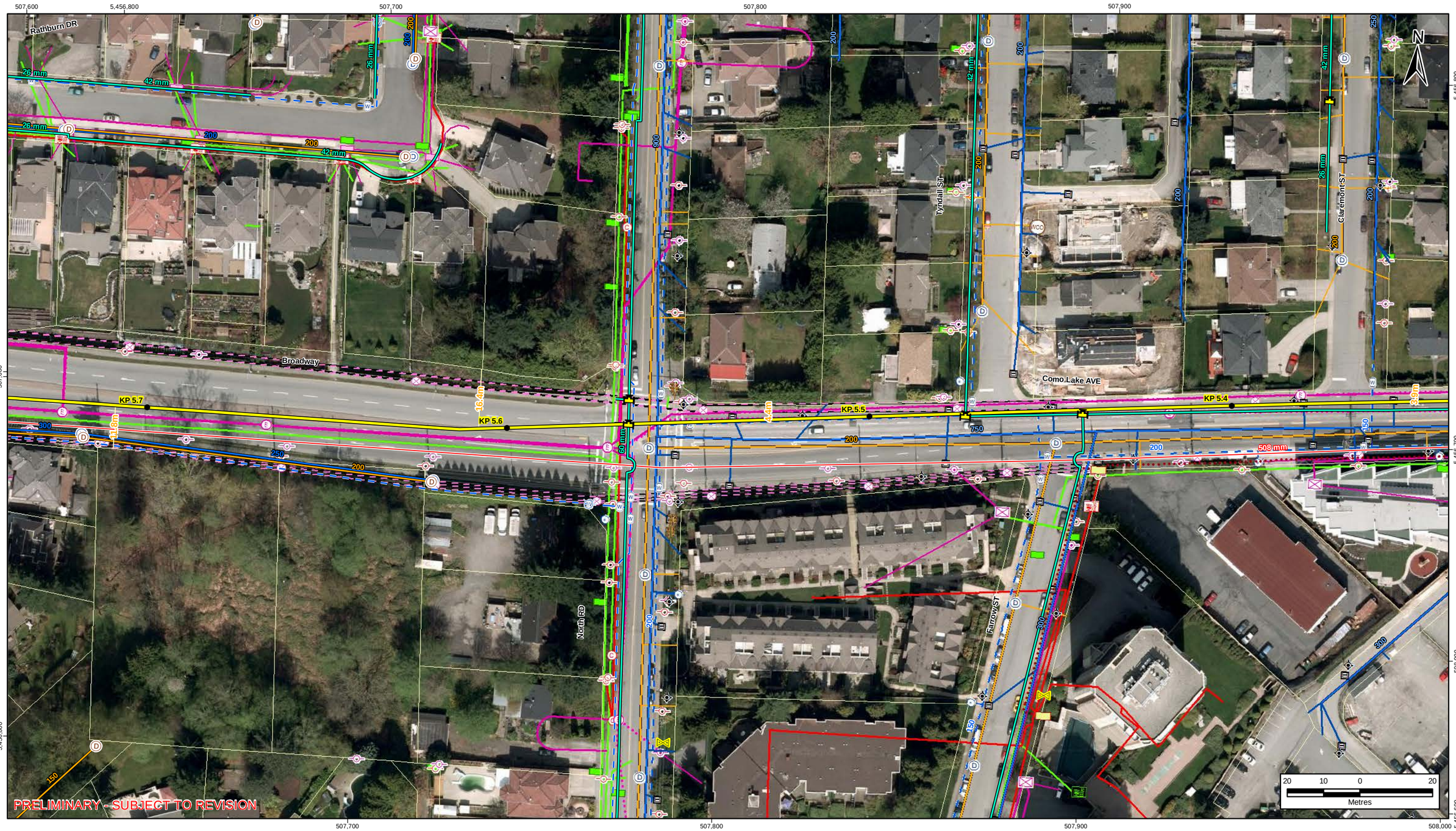

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B-MAP-L Version: A

FORTIS BC

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FORTIS BC LOWER MAINLAND NATURAL GAS SYSTEM UPGRADE (LMSU) PROJECT
PROPOSED METRO IP GAS LINE REPLACEMENT
ROUTE MAP

PROJECTION	DATUM	CONTRACTOR NAME	MAP NUMBER	REV.
UTM 10N	NAD83	WORLEYPARSONS CANADA	03-003-016	2

SCALE	DATE	PROJECT NUMBER	ORIG.PAGE SIZE
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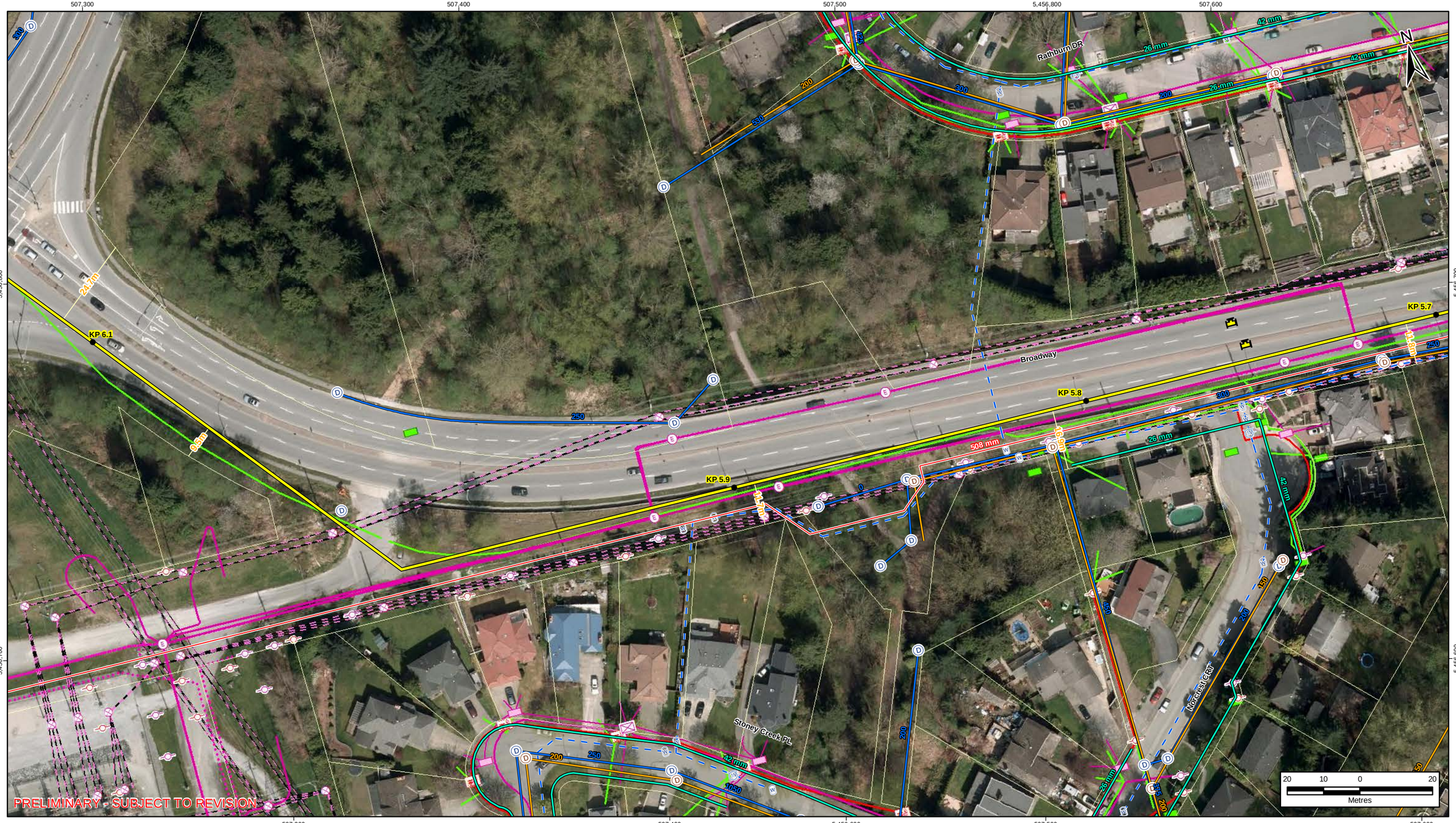

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FORTIS BC LOWER MAINLAND NATURAL GAS SYSTEM UPGRADE (LMSU) PROJECT
PROPOSED METRO IP GAS LINE REPLACEMENT
ROUTE MAP

PROJECTION	DATUM	CONTRACTOR NAME	MAP NUMBER	REV.
UTM 10N	NAD83	WORLEYPARSONS CANADA	03-003-017	2

SCALE	DATE	PROJECT NUMBER	ORIG.PAGE SIZE
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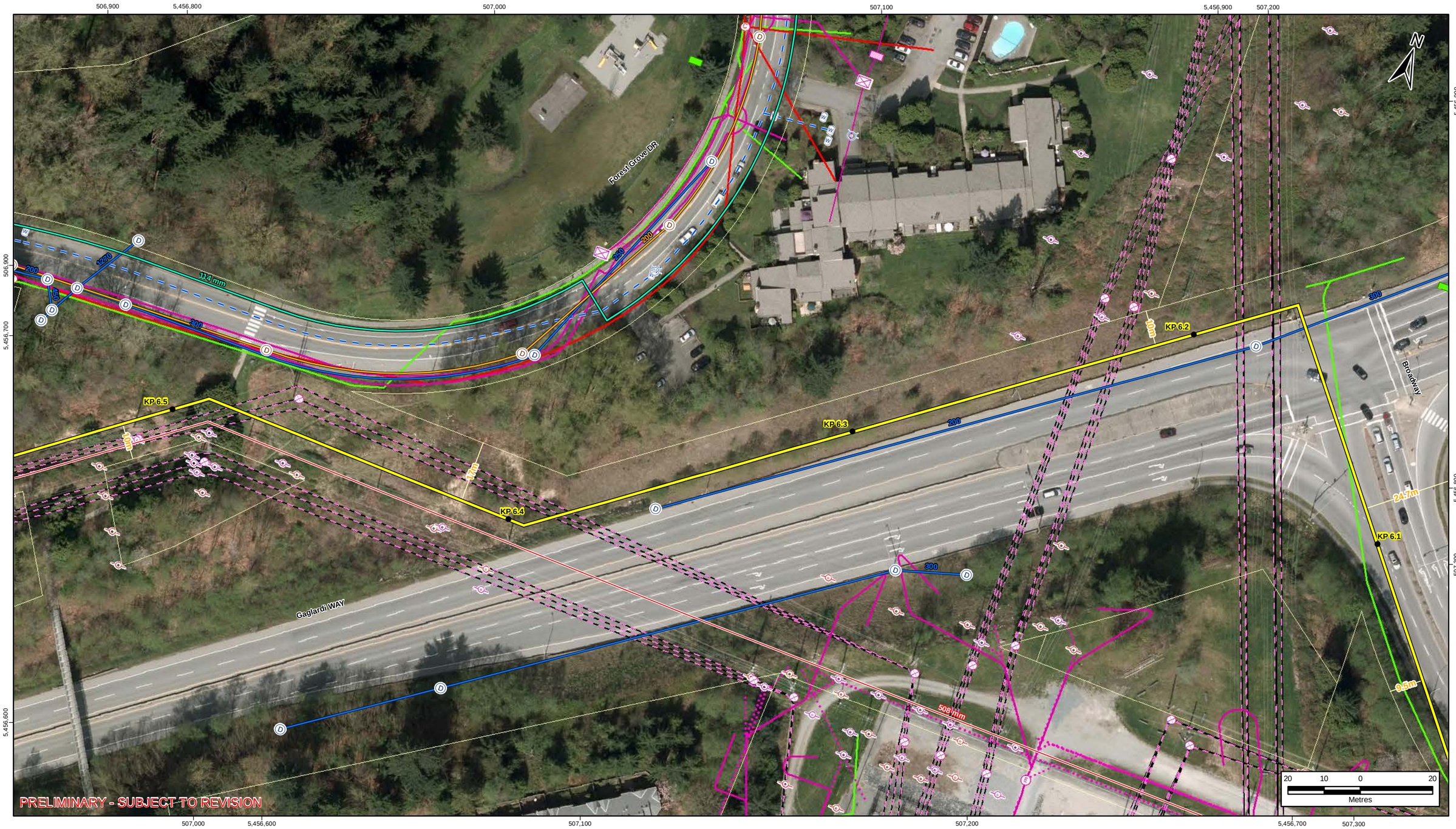

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B-MAP-L Version: A

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FORTIS BC LOWER MAINLAND NATURAL GAS SYSTEM UPGRADE (LMSU) PROJECT
PROPOSED METRO IP GAS LINE REPLACEMENT
ROUTE MAP

PROJECTION	DATUM	CONTRACTOR NAME	MAP NUMBER	REV.
UTM 10N	NAD83	WORLEYPARSONS CANADA	03-003-018	2

SCALE	DATE	PROJECT NUMBER	ORIG.PAGE SIZE
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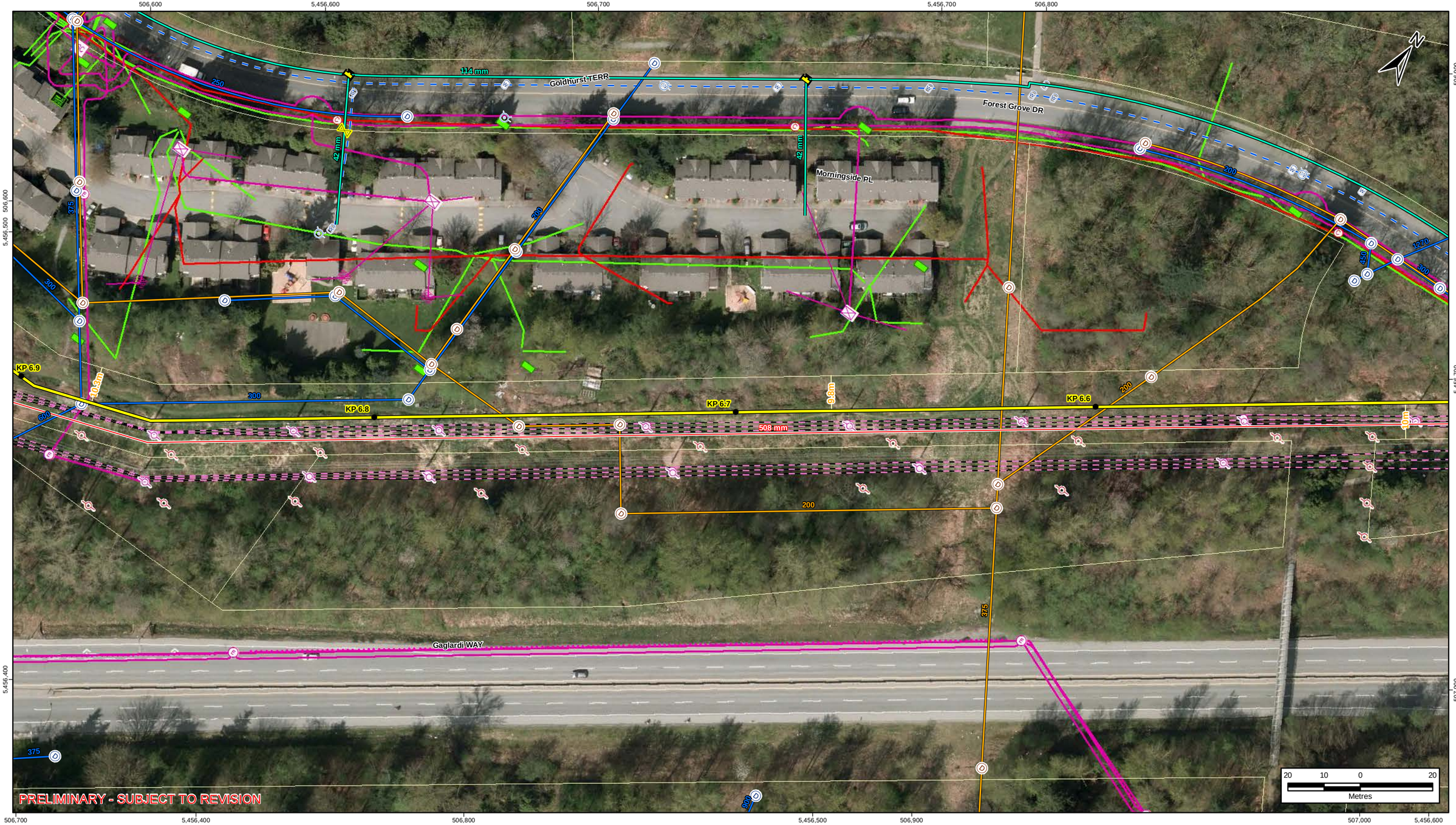

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FORTIS BC

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FORTIS BC LOWER MAINLAND NATURAL GAS SYSTEM UPGRADE (LMSU) PROJECT
PROPOSED METRO IP GAS LINE REPLACEMENT
ROUTE MAP

PROJECTION	DATUM	CONTRACTOR NAME	MAP NUMBER	REV.
UTM 10N	NAD83	WORLEYPARSONS CANADA	03-003-019	2

SCALE	DATE	PROJECT NUMBER	ORIG.PAGE SIZE
1:1,000	20 Oct 2014	407071-00064	11X17

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B-MAP-L Version: A

FORTIS BC

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DRAWN: KR
CHECK: JB
DESIGN: VI
APPR.:

FORTIS BC LOWER MAINLAND NATURAL GAS SYSTEM UPGRADE (LMSU) PROJECT
PROPOSED METRO IP GAS LINE REPLACEMENT
ROUTE MAP

PROJECTION	DATUM	CONTRACTOR NAME	MAP NUMBER	REV.
UTM 10N	NAD83	WORLEYPARSONS CANADA	03-003-020	2

SCALE	DATE	PROJECT NUMBER	ORIG.PAGE SIZE
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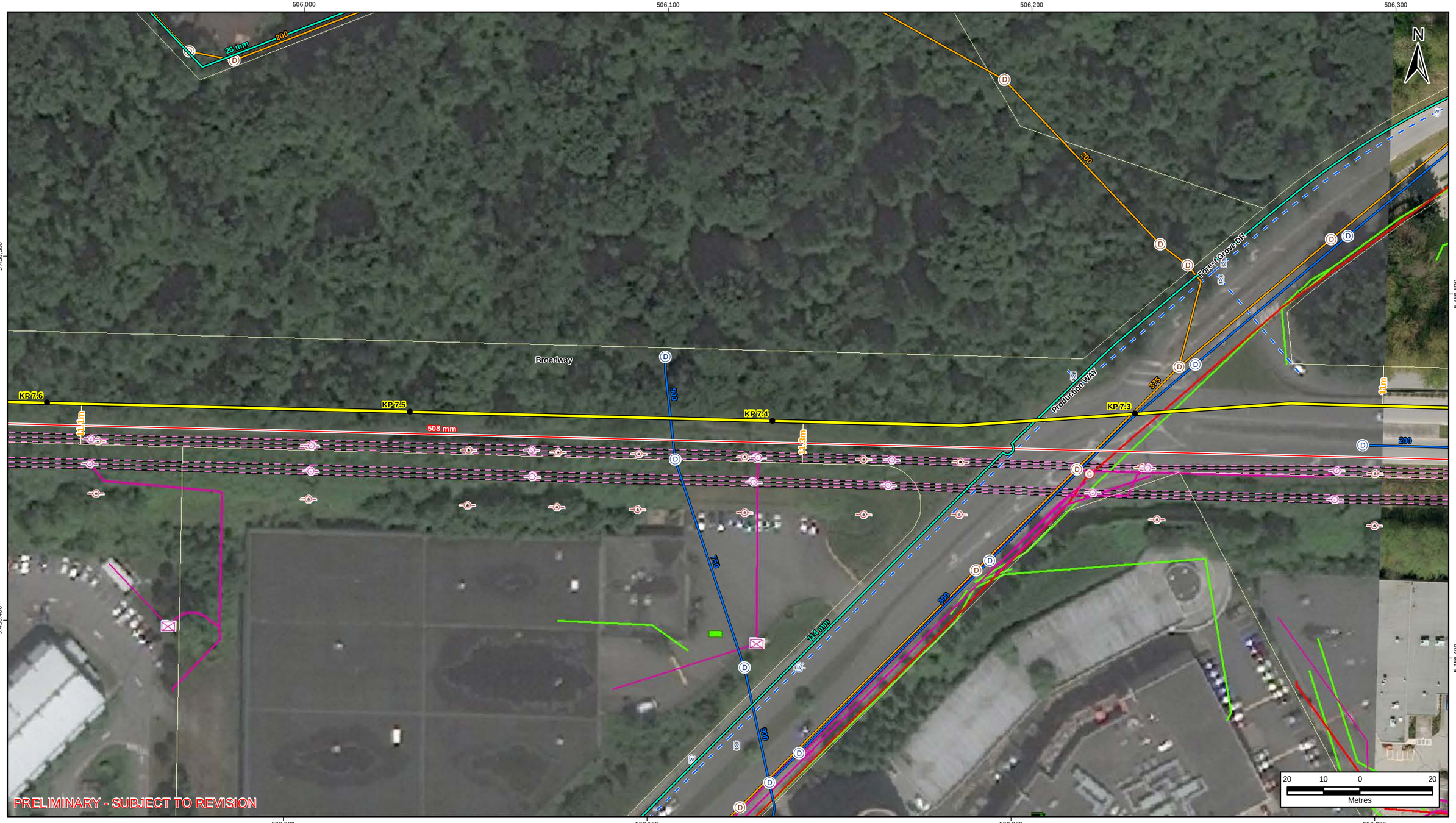

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B-MAP-L Version: A

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DRAWN KR
CHECK JB
DESIGN VI
APPR.

FORTIS BC LOWER MAINLAND NATURAL GAS SYSTEM UPGRADE (LMSU) PROJECT
PROPOSED METRO IP GAS LINE REPLACEMENT
ROUTE MAP

PROJECTION	DATUM	CONTRACTOR NAME	MAP NUMBER	REV.
UTM 10N	NAD83	WORLEYPARSONS CANADA	03-003-021	2

SCALE	DATE	PROJECT NUMBER	ORIG.PAGE SIZE
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B-MAP-L Version: A

FORTIS BC

FORTIS BC LMSU

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FORTIS BC LOWER MAINLAND NATURAL GAS SYSTEM UPGRADE (LMSU) PROJECT
PROPOSED METRO IP GAS LINE REPLACEMENT
ROUTE MAP

PROJECTION	DATUM	CONTRACTOR NAME	MAP NUMBER	REV.
UTM 10N	NAD83	WORLEYPARSONS CANADA	03-003-022	2

SCALE	DATE	PROJECT NUMBER	ORIG.PAGE SIZE
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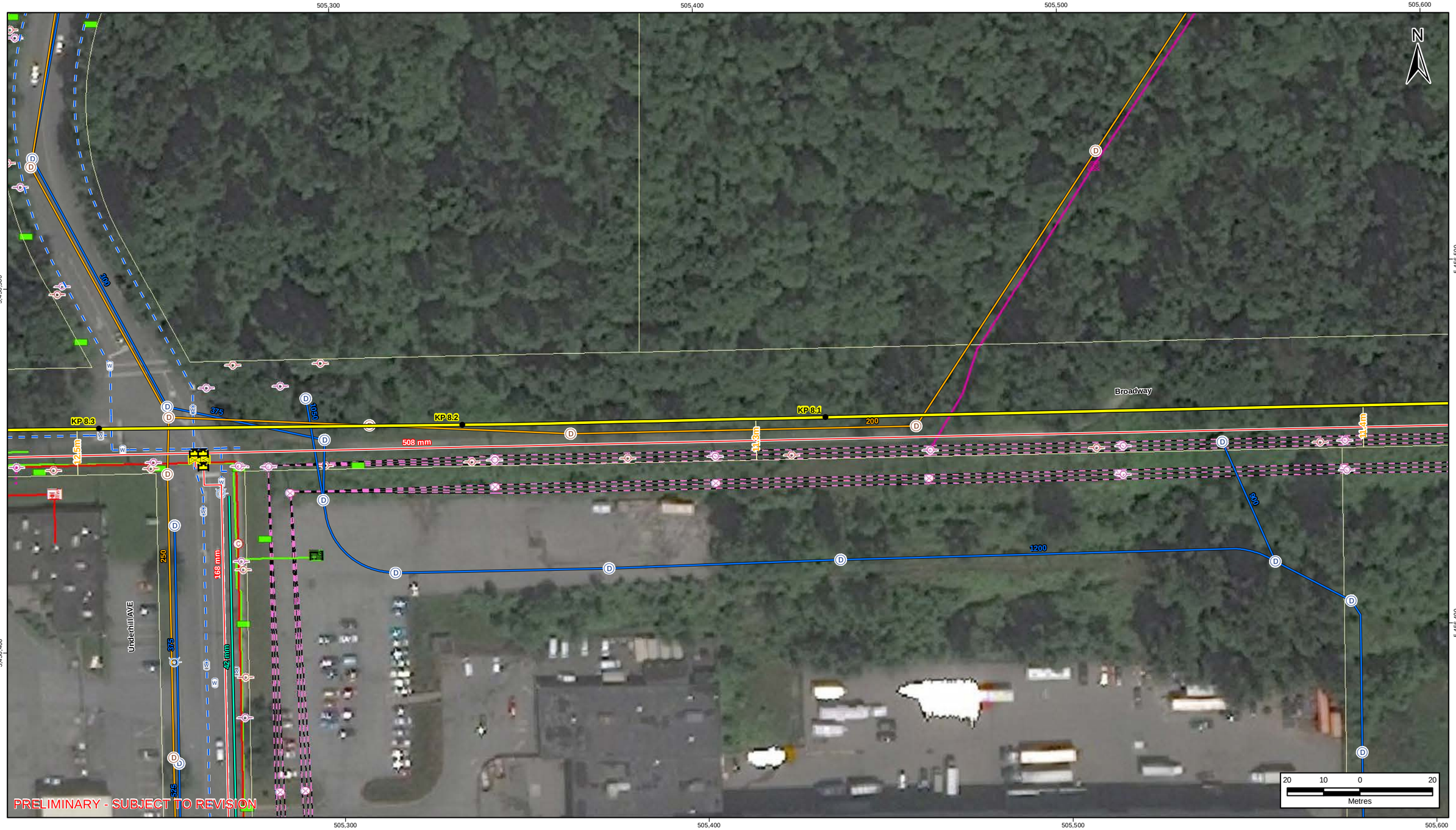

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FORTIS BC LOWER MAINLAND NATURAL GAS SYSTEM UPGRADE (LMSU) PROJECT
PROPOSED METRO IP GAS LINE REPLACEMENT
ROUTE MAP

PROJECTION	DATUM	CONTRACTOR NAME	MAP NUMBER	REV.
UTM 10N	NAD83	WORLEYPARSONS CANADA	03-003-023	2

SCALE	DATE	PROJECT NUMBER	ORIG.PAGE SIZE
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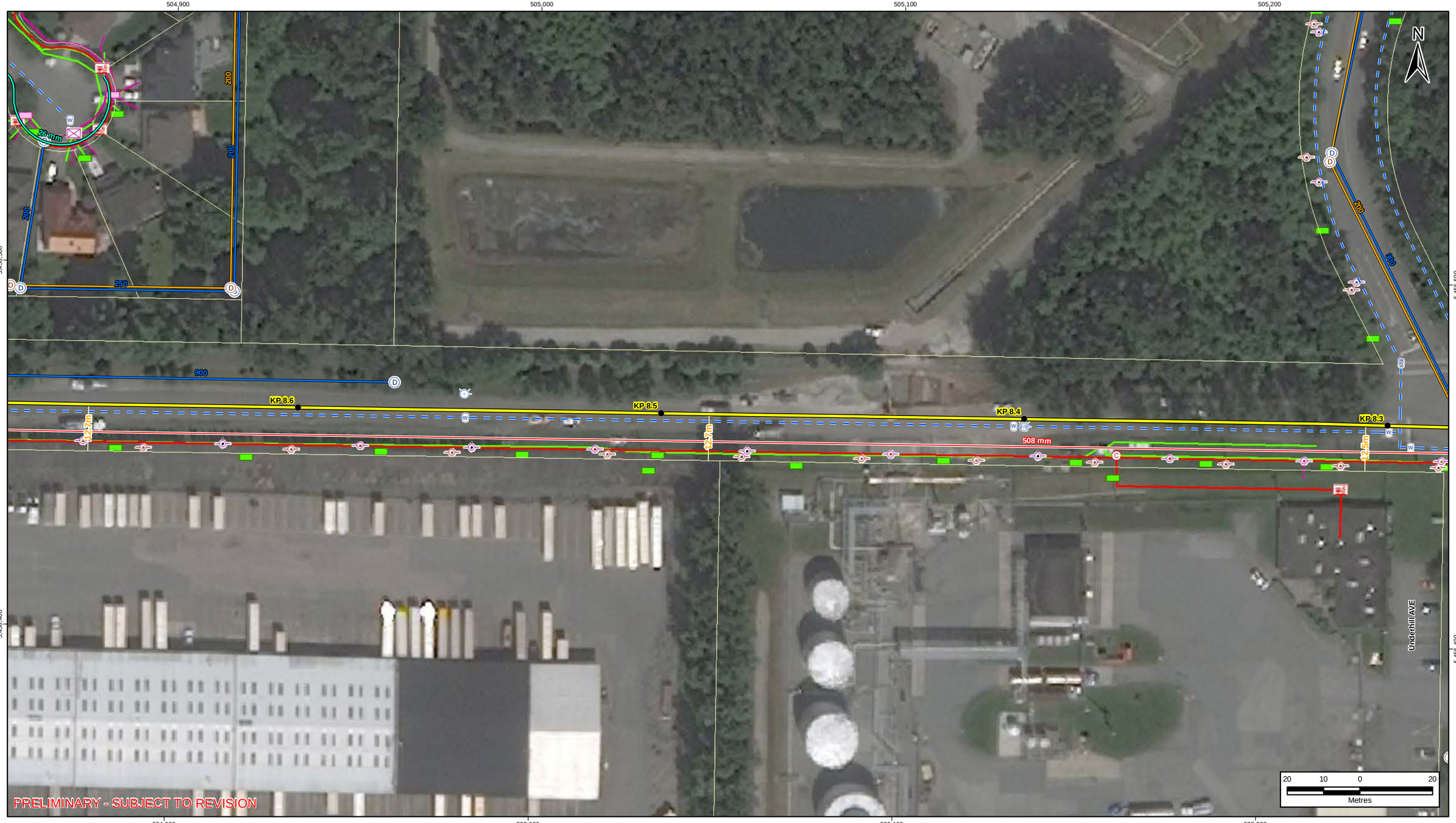

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FORTIS BC LOWER MAINLAND NATURAL GAS SYSTEM UPGRADE (LMSU) PROJECT
PROPOSED METRO IP GAS LINE REPLACEMENT
ROUTE MAP

PROJECTION	DATUM	CONTRACTOR NAME	MAP NUMBER	REV.
UTM 10N	NAD83	WORLEYPARSONS CANADA	03-003-024	2

SCALE	DATE	PROJECT NUMBER	ORIG.PAGE SIZE
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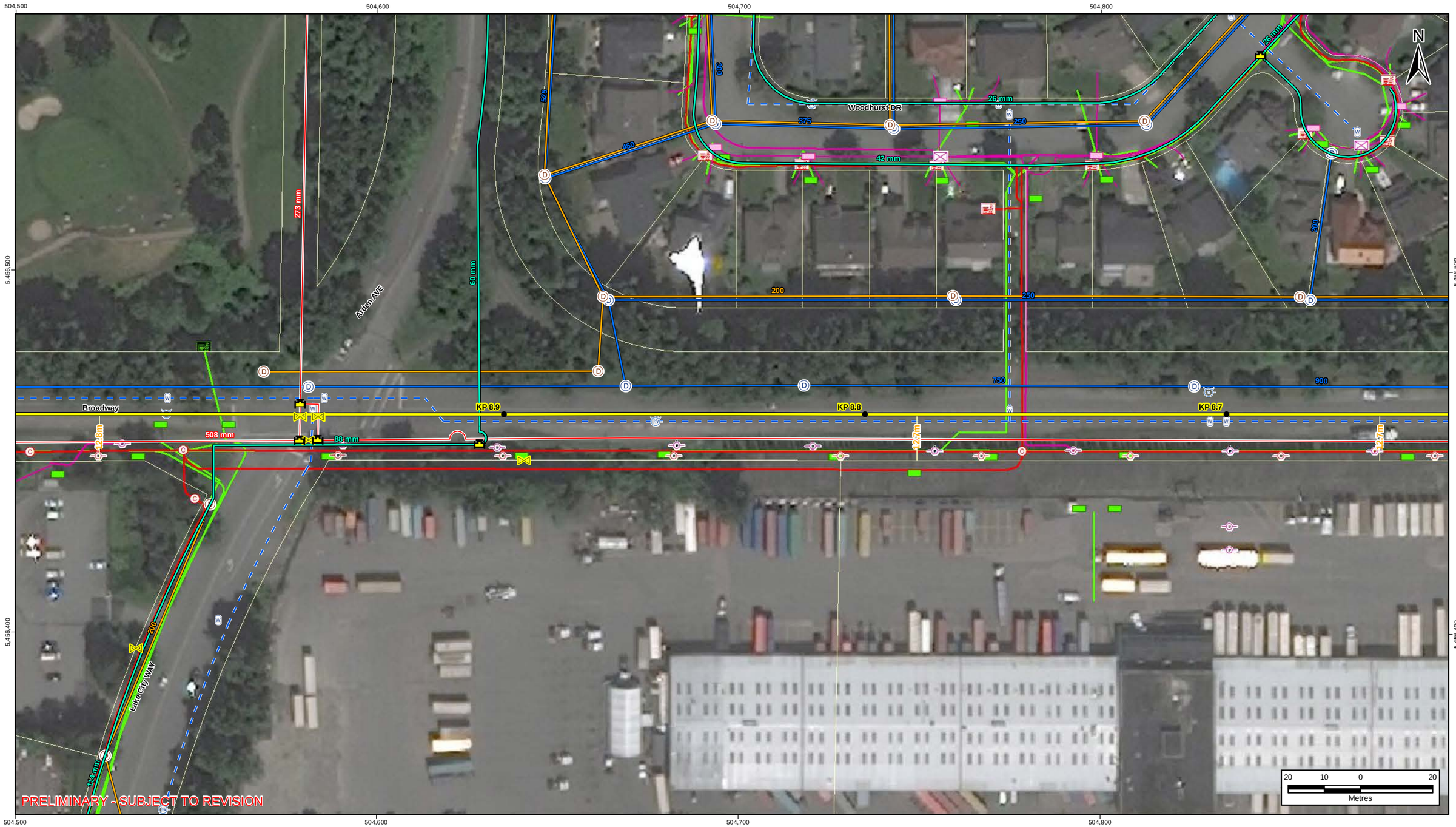

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APPR.

FORTIS BC LOWER MAINLAND NATURAL GAS SYSTEM UPGRADE (LMSU) PROJECT
PROPOSED METRO IP GAS LINE REPLACEMENT
ROUTE MAP

PROJECTION	DATUM	CONTRACTOR NAME	MAP NUMBER	REV.
UTM 10N	NAD83	WORLEYPARSONS CANADA	03-003-025	2

SCALE	DATE	PROJECT NUMBER	ORIG.PAGE SIZE
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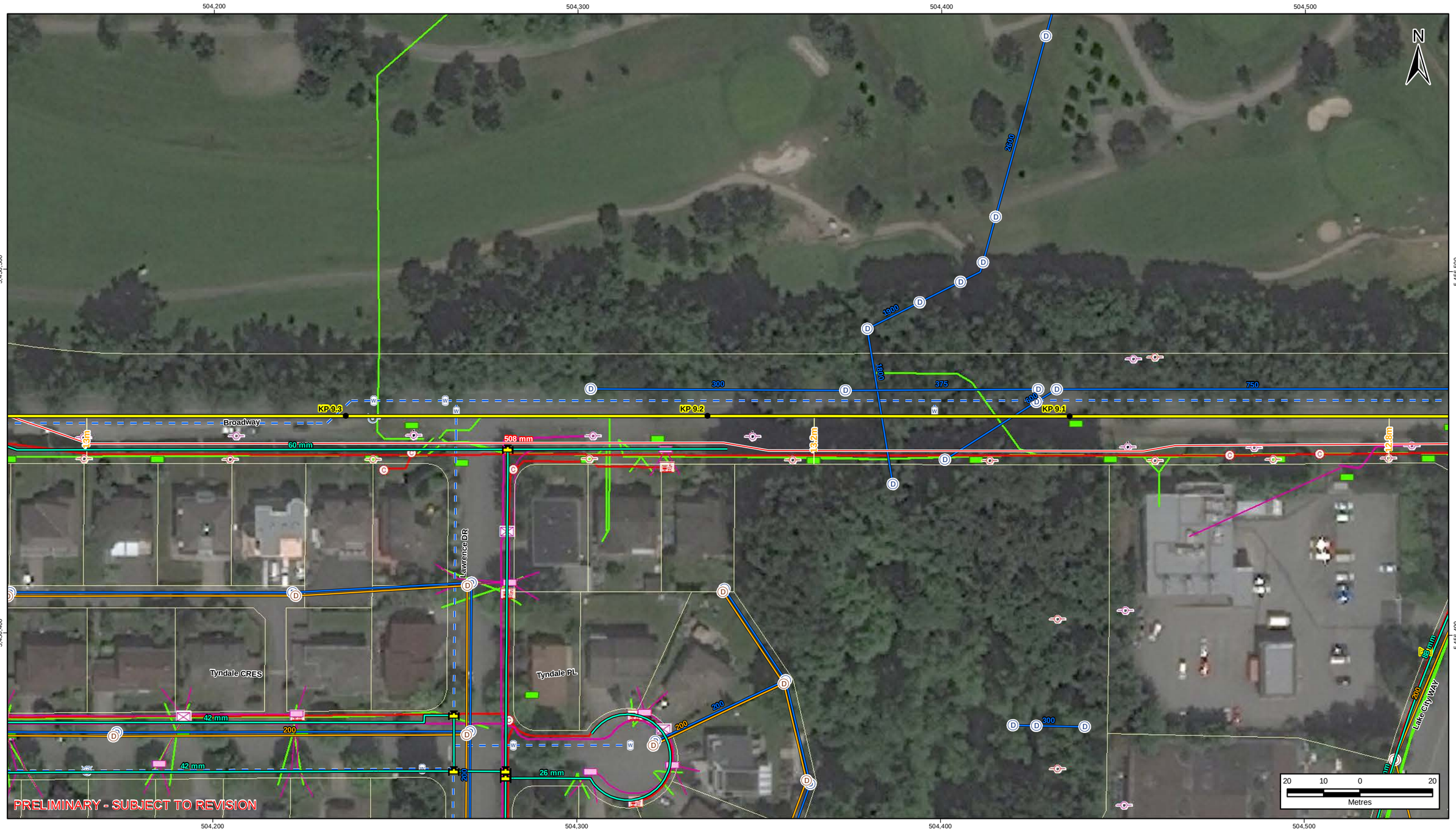

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KR	JB	VI	

FORTIS BC LOWER MAINLAND NATURAL GAS SYSTEM UPGRADE (LMSU) PROJECT
PROPOSED METRO IP GAS LINE REPLACEMENT
ROUTE MAP

PROJECTION	DATUM	CONTRACTOR NAME	MAP NUMBER	REV.
UTM 10N	NAD83	WORLEYPARSONS CANADA	03-003-026	2

SCALE	DATE	PROJECT NUMBER	ORIG.PAGE SIZE
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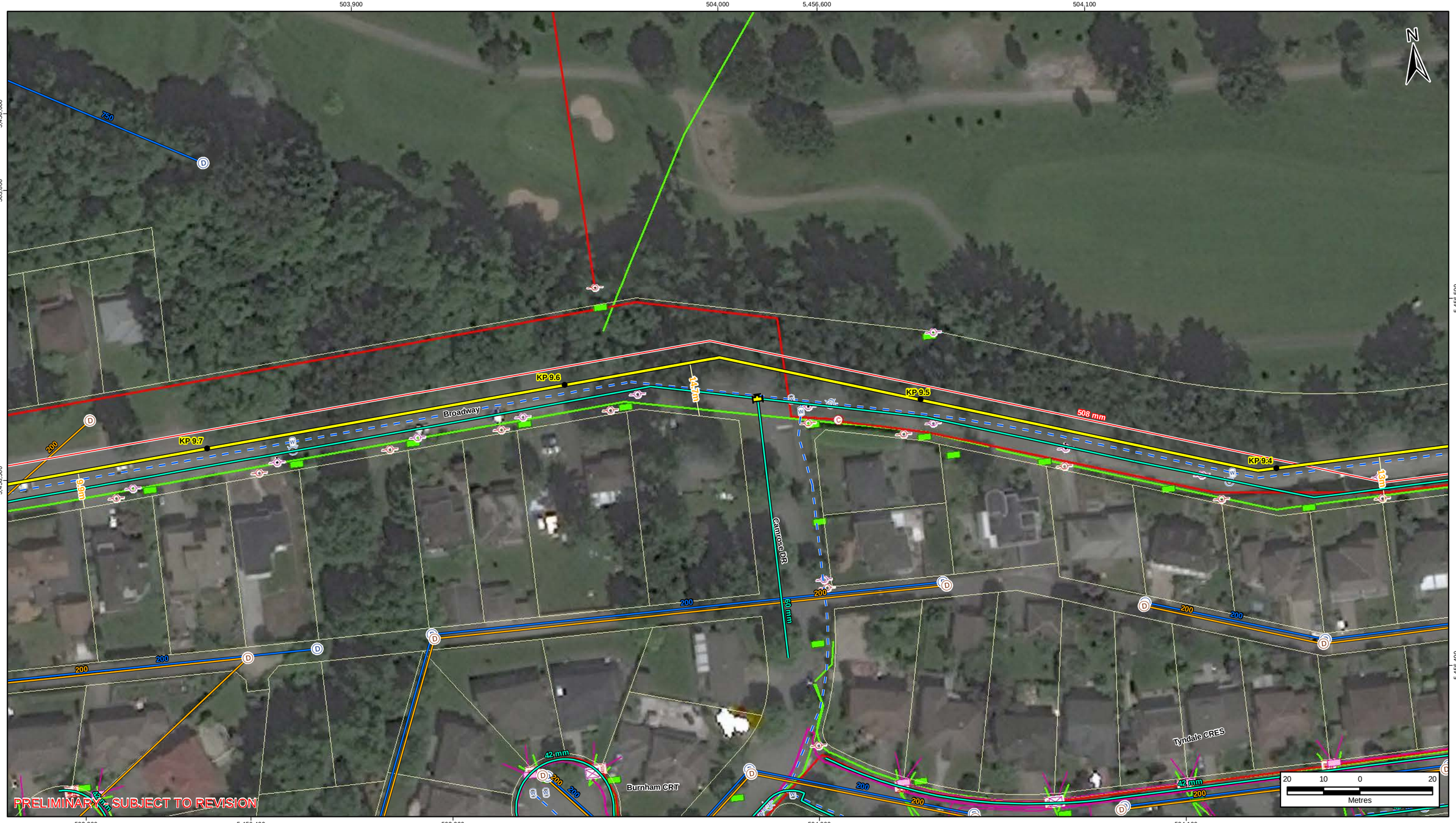

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B-MAP-L Version: A

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FORTIS BC LMSU

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DRAWN	CHECK	DESIGN	APPR.
KR	JB	VI	

FORTIS BC LOWER MAINLAND NATURAL GAS SYSTEM UPGRADE (LMSU) PROJECT
PROPOSED METRO IP GAS LINE REPLACEMENT
ROUTE MAP

PROJECTION	DATUM	CONTRACTOR NAME	MAP NUMBER	REV.
UTM 10N	NAD83	WORLEYPARSONS CANADA	03-003-027	2

SCALE	DATE	PROJECT NUMBER	ORIG.PAGE SIZE
1:1,000	20 Oct 2014	407071-00064	11X17

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B-MAP-L Version: A

FORTIS BC LMSU

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DRAWN: KR
CHECK: JB
DESIGN: VI
APPR.:

FORTIS BC LOWER MAINLAND NATURAL GAS SYSTEM UPGRADE (LMSU) PROJECT
PROPOSED METRO IP GAS LINE REPLACEMENT
ROUTE MAP

PROJECTION	DATUM	CONTRACTOR NAME	MAP NUMBER	REV.
UTM 10N	NAD83	WORLEYPARSONS CANADA	03-003-028	2

SCALE	DATE	PROJECT NUMBER	ORIG.PAGE SIZE
1:1,000	20 Oct 2014	407071-00064	11X17

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B-MAP-L Version: A

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FORTIS BC LMSU

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DRAWN	CHECK	DESIGN	APPR.
KR	JB	VI	

FORTIS BC LOWER MAINLAND NATURAL GAS SYSTEM UPGRADE (LMSU) PROJECT
PROPOSED METRO IP GAS LINE REPLACEMENT
ROUTE MAP

PROJECTION	DATUM	CONTRACTOR NAME	MAP NUMBER	REV.
UTM 10N	NAD83	WORLEYPARSONS CANADA	03-003-029	2

SCALE	DATE	PROJECT NUMBER	ORIG.PAGE SIZE
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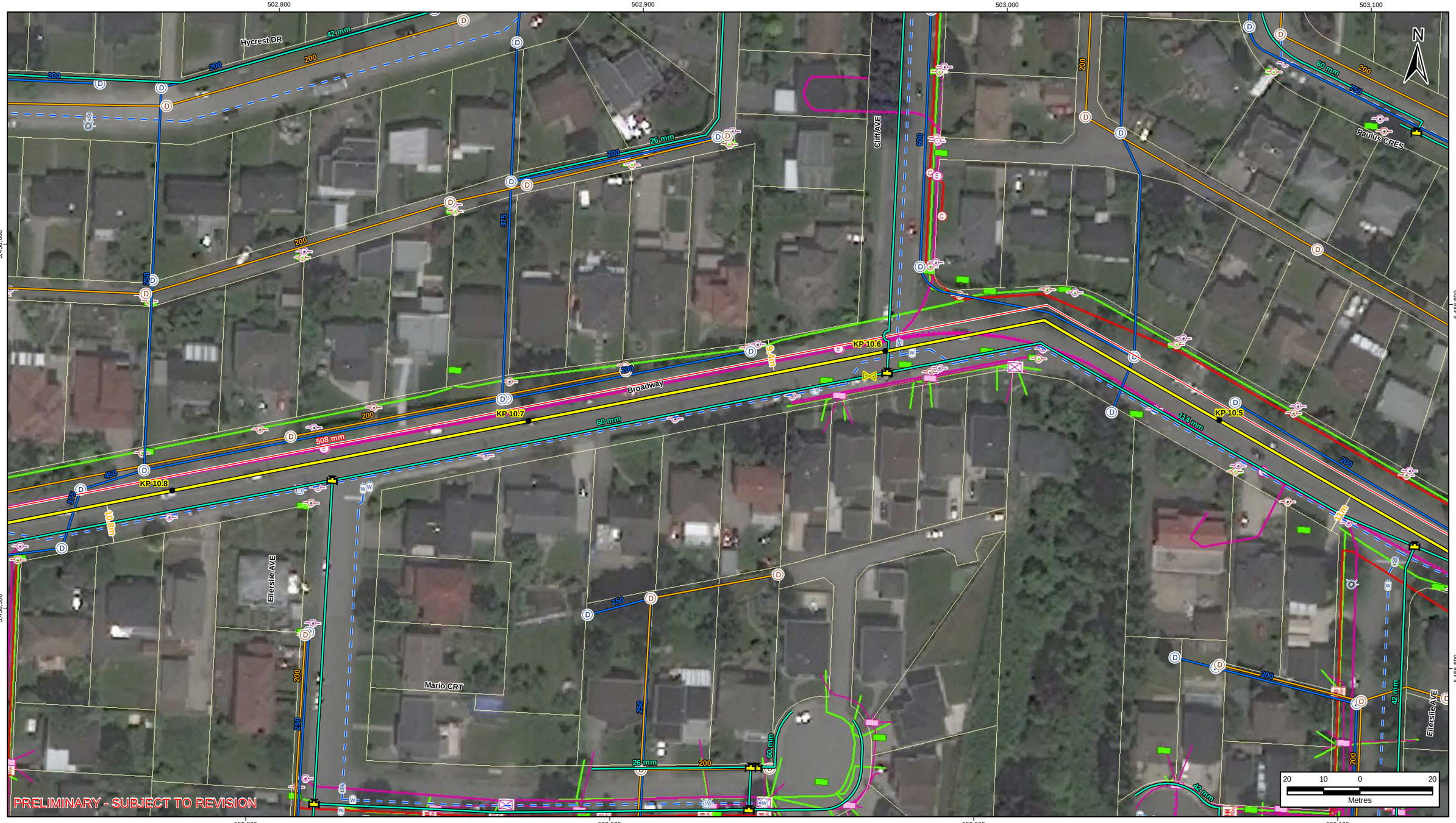

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B-MAP-L Version: A

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FORTIS BC LOWER MAINLAND NATURAL GAS SYSTEM UPGRADE (LMSU) PROJECT
PROPOSED METRO IP GAS LINE REPLACEMENT
ROUTE MAP

PROJECTION	DATUM	CONTRACTOR NAME	MAP NUMBER	REV.
UTM 10N	NAD83	WORLEYPARSONS CANADA	03-003-030	2

SCALE	DATE	PROJECT NUMBER	ORIG.PAGE SIZE
1:1,000	20 Oct 2014	407071-00064	11X17

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B-MAP-L Version: A

FORTIS BC

FORTIS BC LMSU

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FORTIS BC LOWER MAINLAND NATURAL GAS SYSTEM UPGRADE (LMSU) PROJECT
PROPOSED METRO IP GAS LINE REPLACEMENT
ROUTE MAP

PROJECTION	DATUM	CONTRACTOR NAME	MAP NUMBER	REV.
UTM 10N	NAD83	WORLEYPARSONS CANADA	03-003-031	2

SCALE	DATE	PROJECT NUMBER	ORIG.PAGE SIZE
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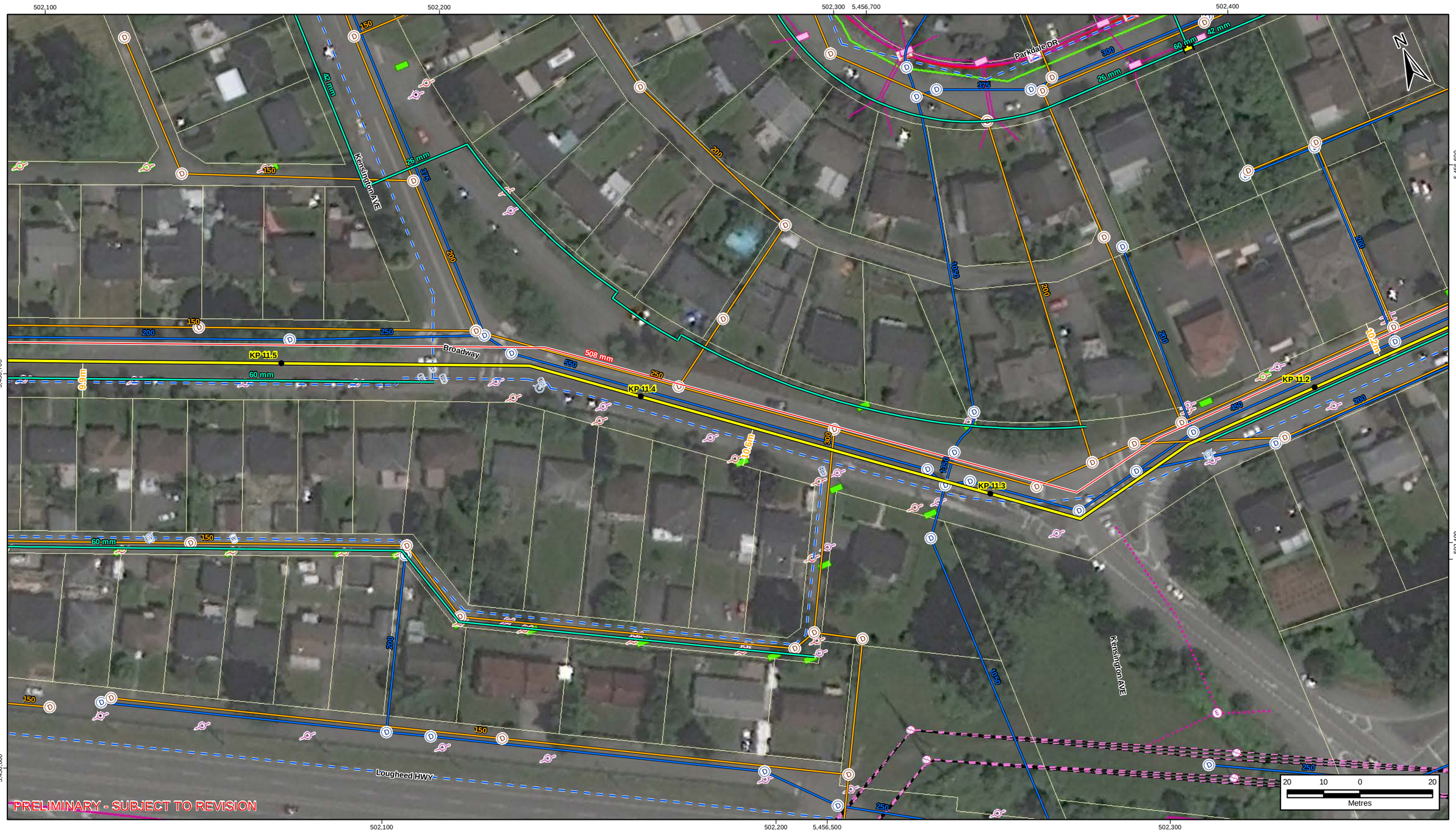

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B-MAP-L Version: A

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FORTIS BC LOWER MAINLAND NATURAL GAS SYSTEM UPGRADE (LMSU) PROJECT
PROPOSED METRO IP GAS LINE REPLACEMENT
ROUTE MAP

PROJECTION	DATUM	CONTRACTOR NAME	MAP NUMBER	REV.
UTM 10N	NAD83	WORLEYPARSONS CANADA	03-003-032	2

SCALE	DATE	PROJECT NUMBER	ORIG.PAGE SIZE
1:1,000	20 Oct 2014	407071-00064	11X17

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FORTIS BC LOWER MAINLAND NATURAL GAS SYSTEM UPGRADE (LMSU) PROJECT
PROPOSED METRO IP GAS LINE REPLACEMENT
ROUTE MAP

PROJECTION	DATUM	CONTRACTOR NAME	MAP NUMBER	REV.
UTM 10N	NAD83	WORLEYPARSONS CANADA	03-003-033	2

SCALE	DATE	PROJECT NUMBER	ORIG.PAGE SIZE
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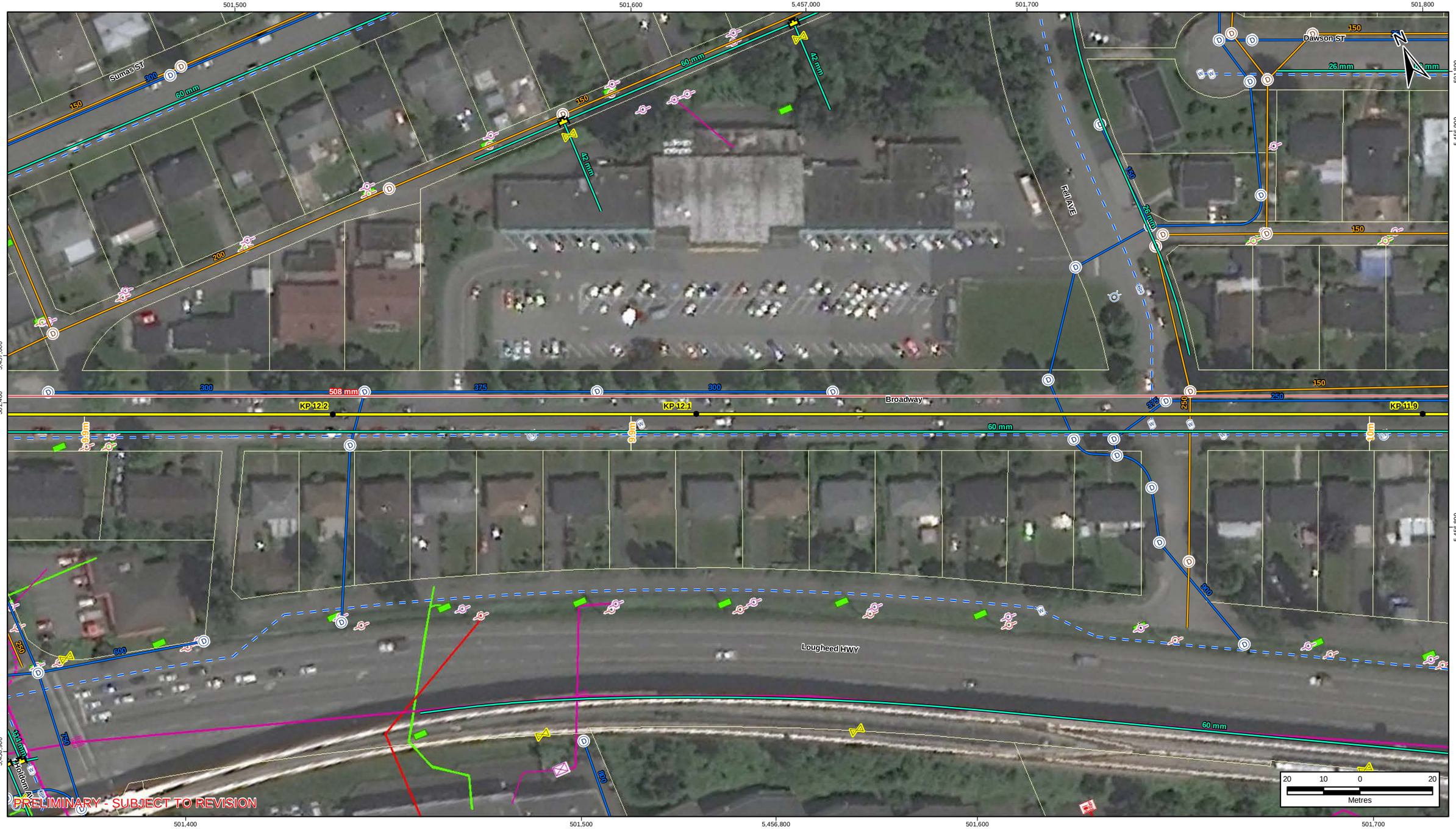

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FORTIS BC LOWER MAINLAND NATURAL GAS SYSTEM UPGRADE (LMSU) PROJECT
PROPOSED METRO IP GAS LINE REPLACEMENT
ROUTE MAP

PROJECTION	DATUM	CONTRACTOR NAME	MAP NUMBER	REV.
UTM 10N	NAD83	WORLEYPARSONS CANADA	03-003-034	2

SCALE	DATE	PROJECT NUMBER	ORIG.PAGE SIZE
1:1,000	20 Oct 2014	407071-00064	11X17

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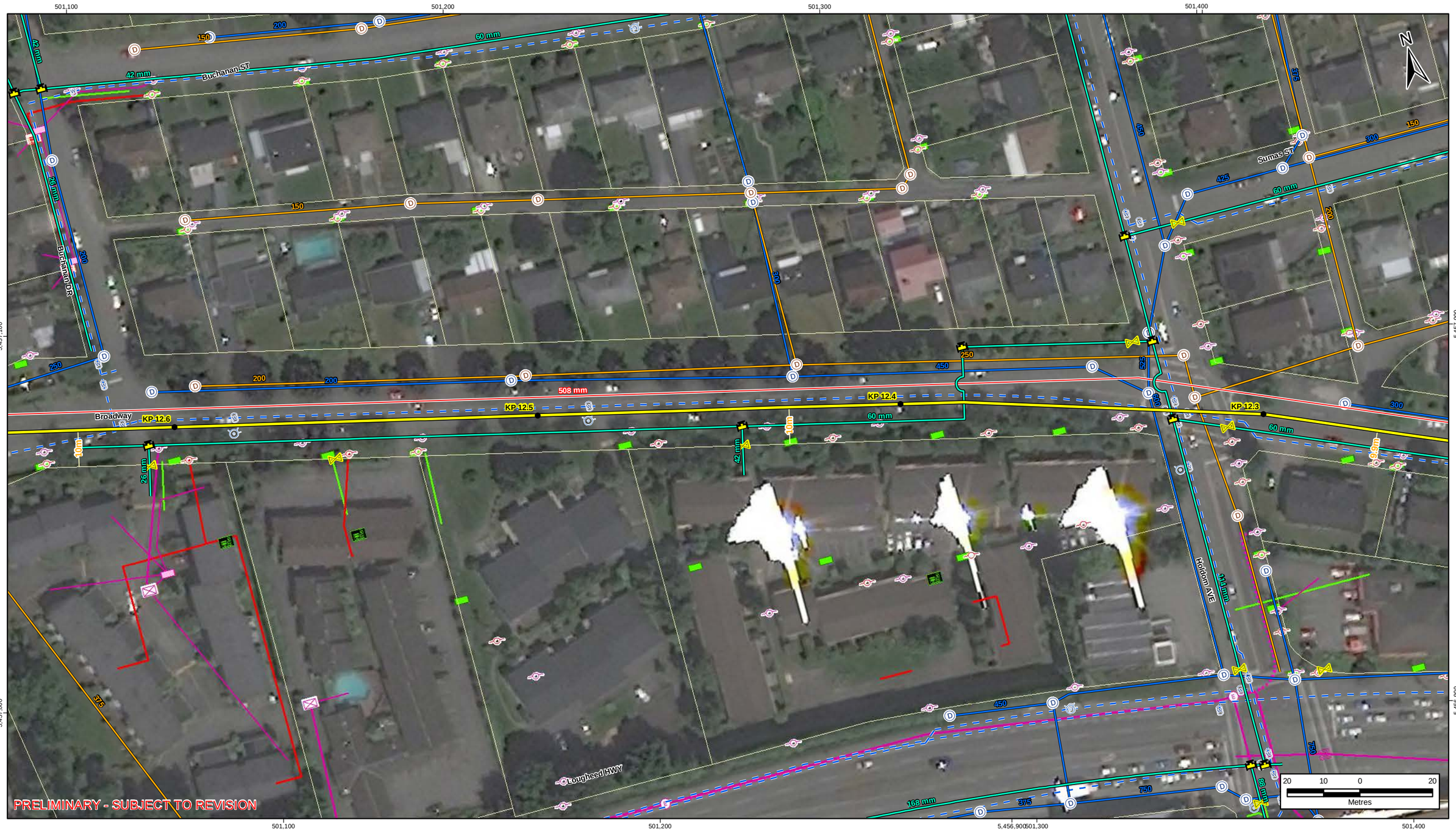

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B-MAP-L Version: A

FORTIS BC

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FORTIS BC LOWER MAINLAND NATURAL GAS SYSTEM UPGRADE (LMSU) PROJECT
PROPOSED METRO IP GAS LINE REPLACEMENT
ROUTE MAP

PROJECTION	DATUM	CONTRACTOR NAME	MAP NUMBER	REV.
UTM 10N	NAD83	WORLEYPARSONS CANADA	03-003-035	2

SCALE	DATE	PROJECT NUMBER	ORIG.PAGE SIZE
1:1,000	20 Oct 2014	407071-00064	11X17

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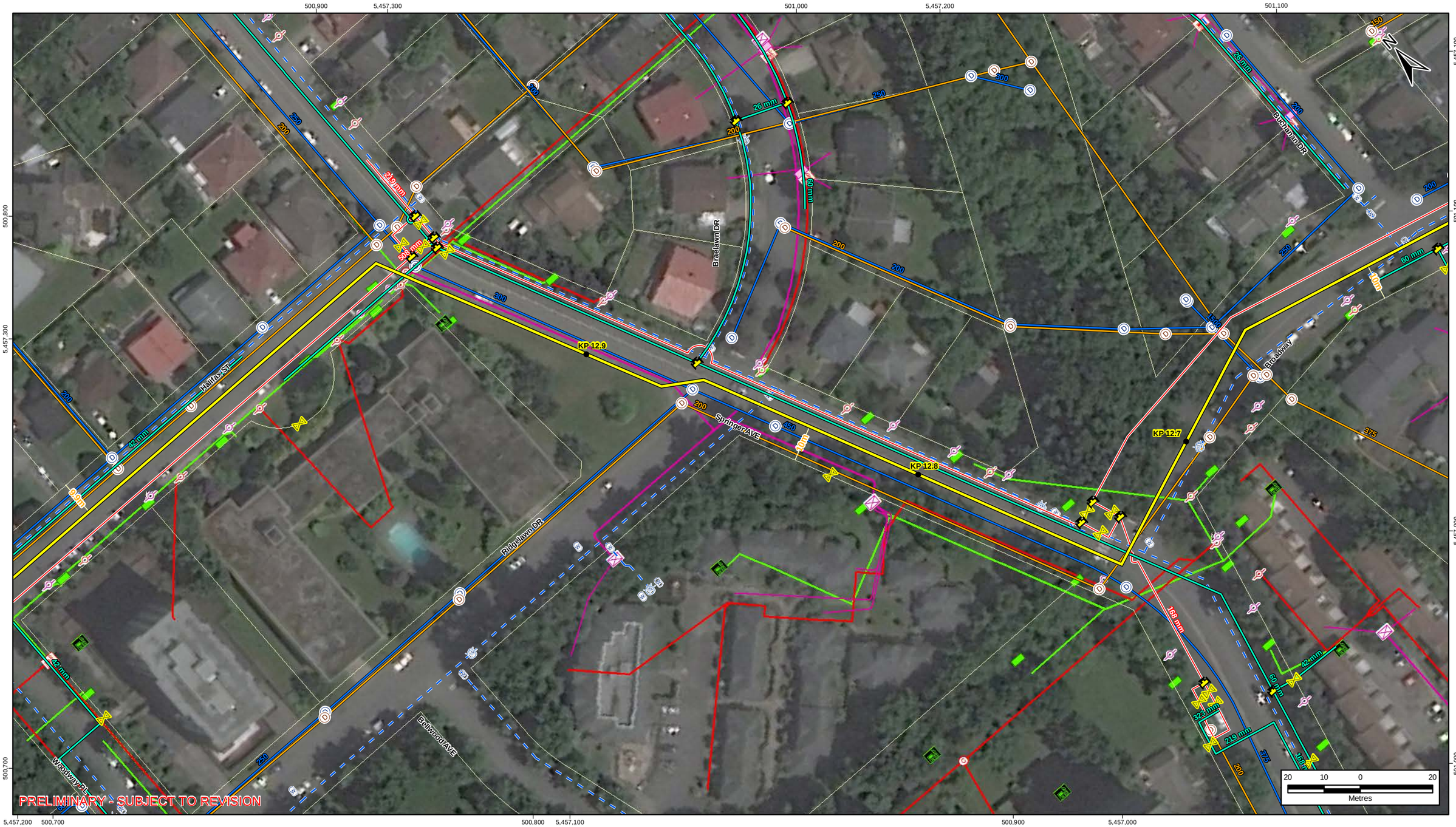

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B-MAP-L Version: A

FORTIS BC

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FORTIS BC LOWER MAINLAND NATURAL GAS SYSTEM UPGRADE (LMSU) PROJECT
PROPOSED METRO IP GAS LINE REPLACEMENT
ROUTE MAP

PROJECTION	DATUM	CONTRACTOR NAME	MAP NUMBER	REV.
UTM 10N	NAD83	WORLEYPARSONS CANADA	03-003-036	2

SCALE	DATE	PROJECT NUMBER	ORIG.PAGE SIZE
1:1,000	20 Oct 2014	407071-00064	11X17

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B-MAP-L Version: A

FORTIS BC™

FORTIS BC LMSU

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DRAWN: KR
CHECK: JB
DESIGN: VI
APPR.:

FORTIS BC LOWER MAINLAND NATURAL GAS SYSTEM UPGRADE (LMSU) PROJECT
PROPOSED METRO IP GAS LINE REPLACEMENT
ROUTE MAP

PROJECTION	DATUM	CONTRACTOR NAME	MAP NUMBER	REV.
UTM 10N	NAD83	WORLEYPARSONS CANADA	03-003-037	2

SCALE	DATE	PROJECT NUMBER	ORIG.PAGE SIZE
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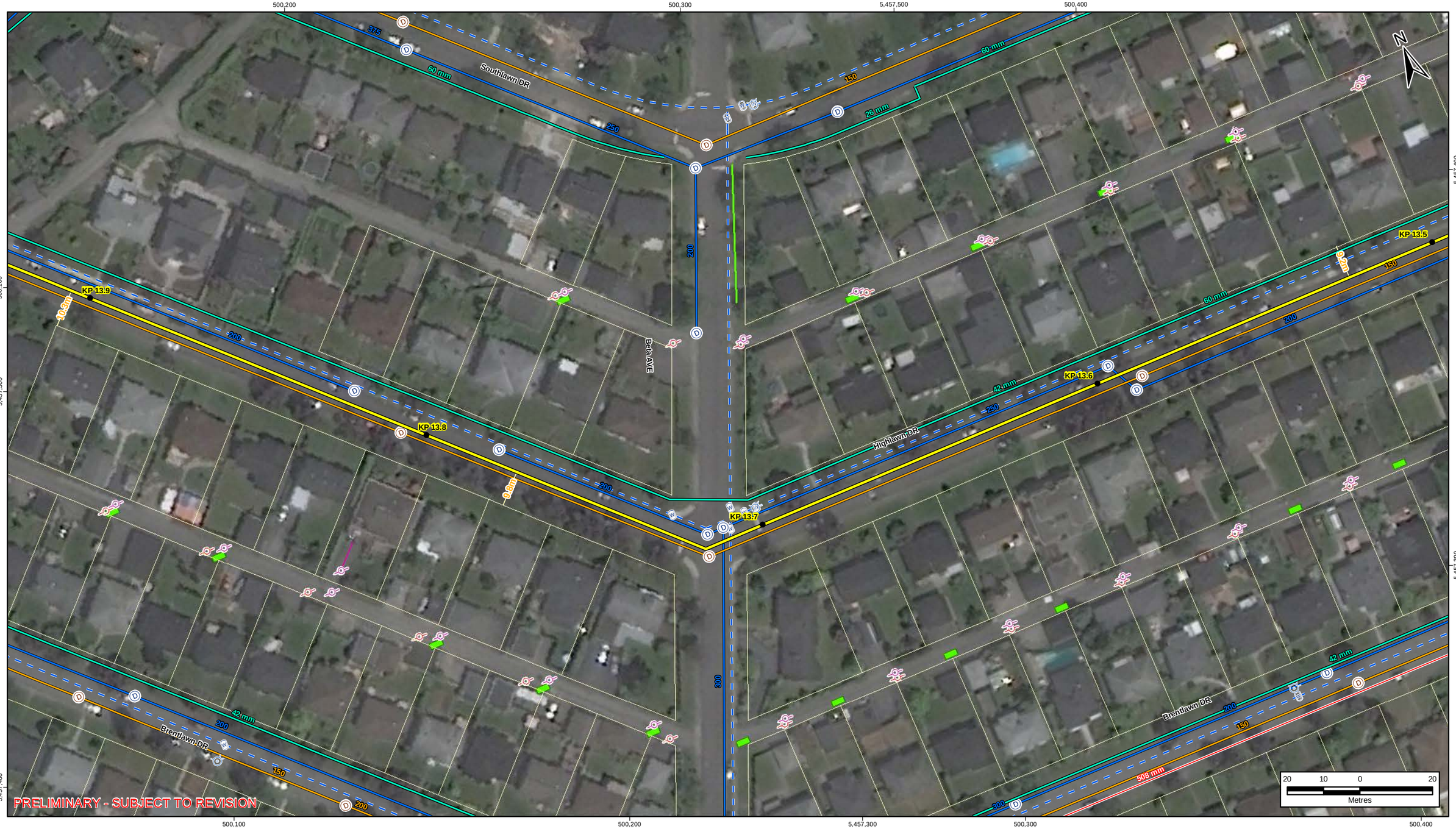

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B-MAP-L Version: A

FORTIS BC

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DRAWN KR
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APPR.

FORTIS BC LOWER MAINLAND NATURAL GAS SYSTEM UPGRADE (LMSU) PROJECT
PROPOSED METRO IP GAS LINE REPLACEMENT
ROUTE MAP

PROJECTION	DATUM	CONTRACTOR NAME	MAP NUMBER	REV.
UTM 10N	NAD83	WORLEYPARSONS CANADA	03-003-038	2

SCALE	DATE	PROJECT NUMBER	ORIG.PAGE SIZE
1:1,000	20 Oct 2014	407071-00064	11X17

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FORTIS BC LOWER MAINLAND NATURAL GAS SYSTEM UPGRADE (LMSU) PROJECT
PROPOSED METRO IP GAS LINE REPLACEMENT
ROUTE MAP

PROJECTION	DATUM	CONTRACTOR NAME	MAP NUMBER	REV.
UTM 10N	NAD83	WORLEYPARSONS CANADA	03-003-039	2

SCALE	DATE	PROJECT NUMBER	ORIG.PAGE SIZE
1:1,000	20 Oct 2014	407071-00064	11X17

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FORTIS BC LOWER MAINLAND NATURAL GAS SYSTEM UPGRADE (LMSU) PROJECT
PROPOSED METRO IP GAS LINE REPLACEMENT
ROUTE MAP

PROJECTION	DATUM	CONTRACTOR NAME	MAP NUMBER	REV.
UTM 10N	NAD83	WORLEYPARSONS CANADA	03-003-040	2

SCALE	DATE	PROJECT NUMBER	ORIG.PAGE SIZE
1:1,000	20 Oct 2014	407071-00064	11X17

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FORTIS BC LOWER MAINLAND NATURAL GAS SYSTEM UPGRADE (LMSU) PROJECT
PROPOSED METRO IP GAS LINE REPLACEMENT
ROUTE MAP

PROJECTION	DATUM	CONTRACTOR NAME	MAP NUMBER	REV.
UTM 10N	NAD83	WORLEYPARSONS CANADA	03-003-041	2

SCALE	DATE	PROJECT NUMBER	ORIG.PAGE SIZE
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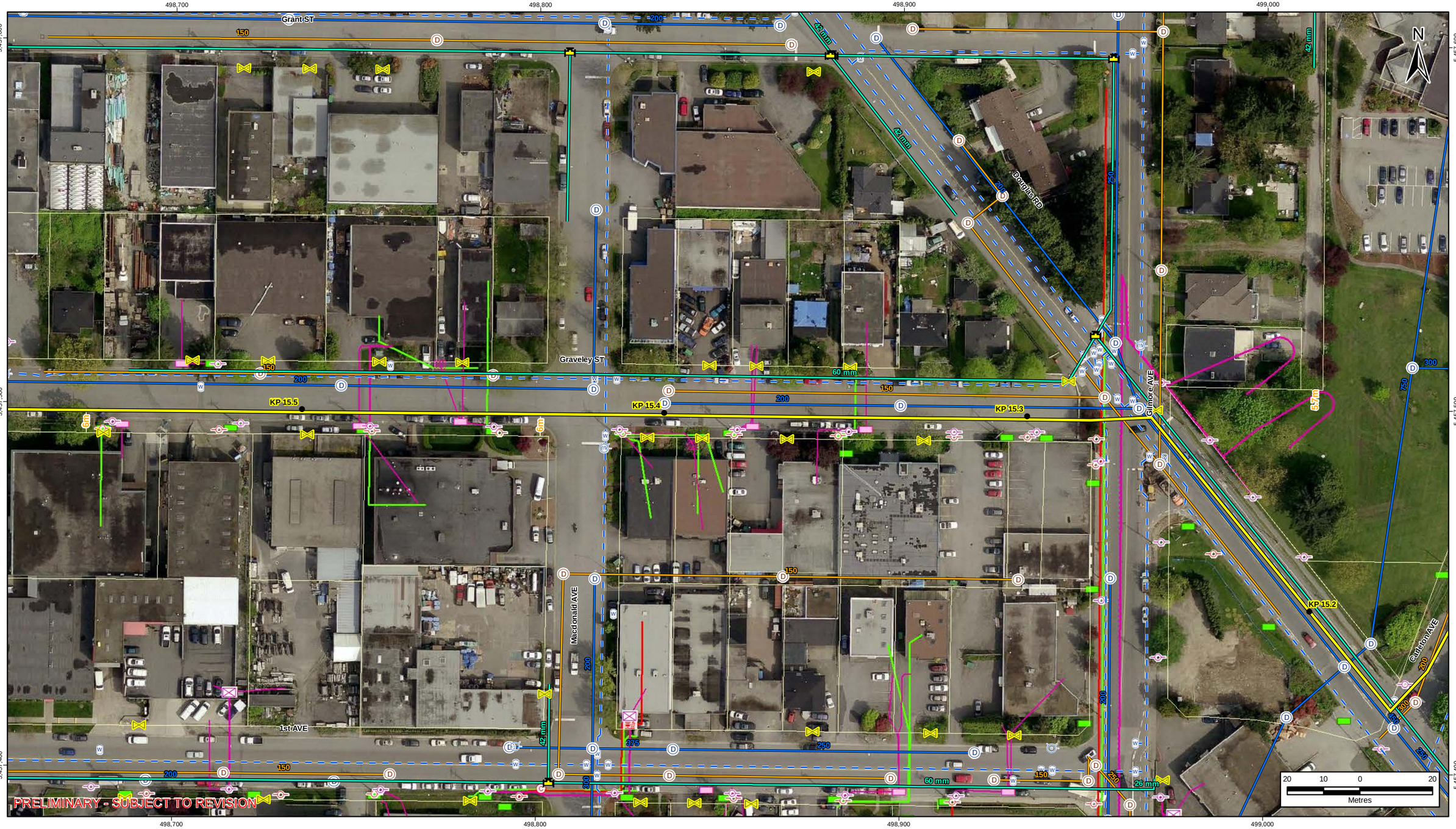

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FORTIS BC LOWER MAINLAND NATURAL GAS SYSTEM UPGRADE (LMSU) PROJECT
PROPOSED METRO IP GAS LINE REPLACEMENT
ROUTE MAP

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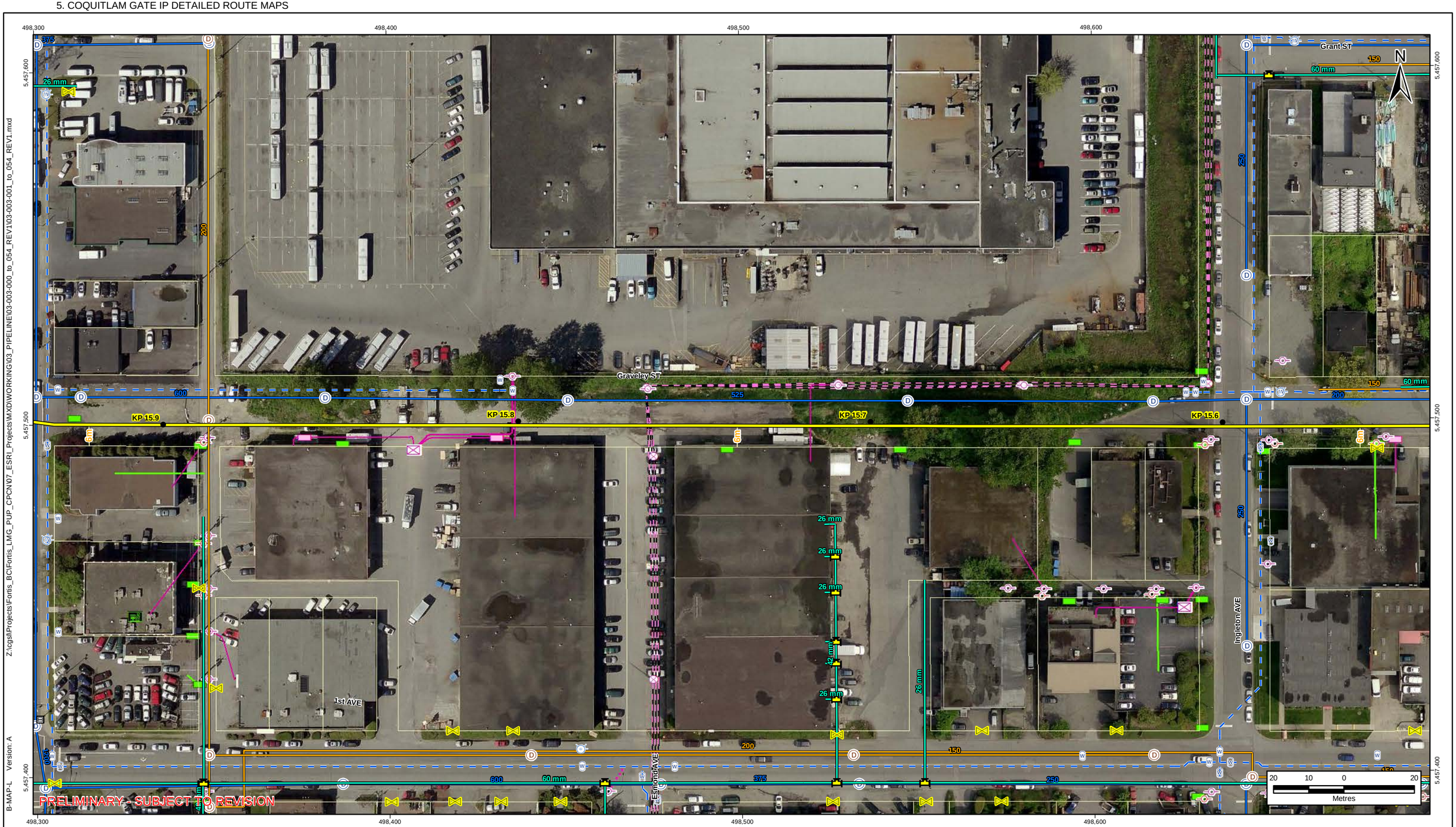

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PROPOSED METRO IP GAS LINE REPLACEMENT
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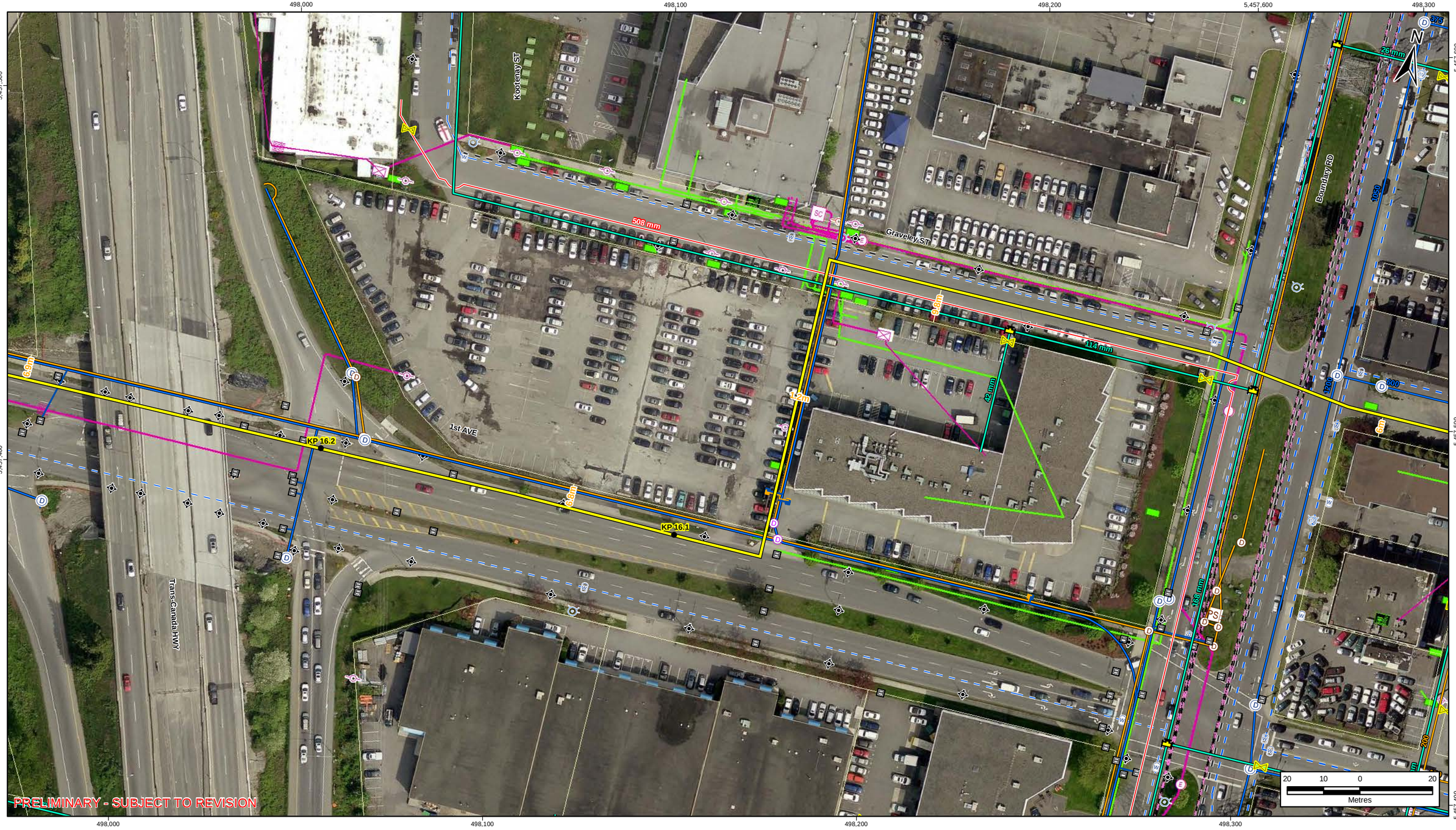

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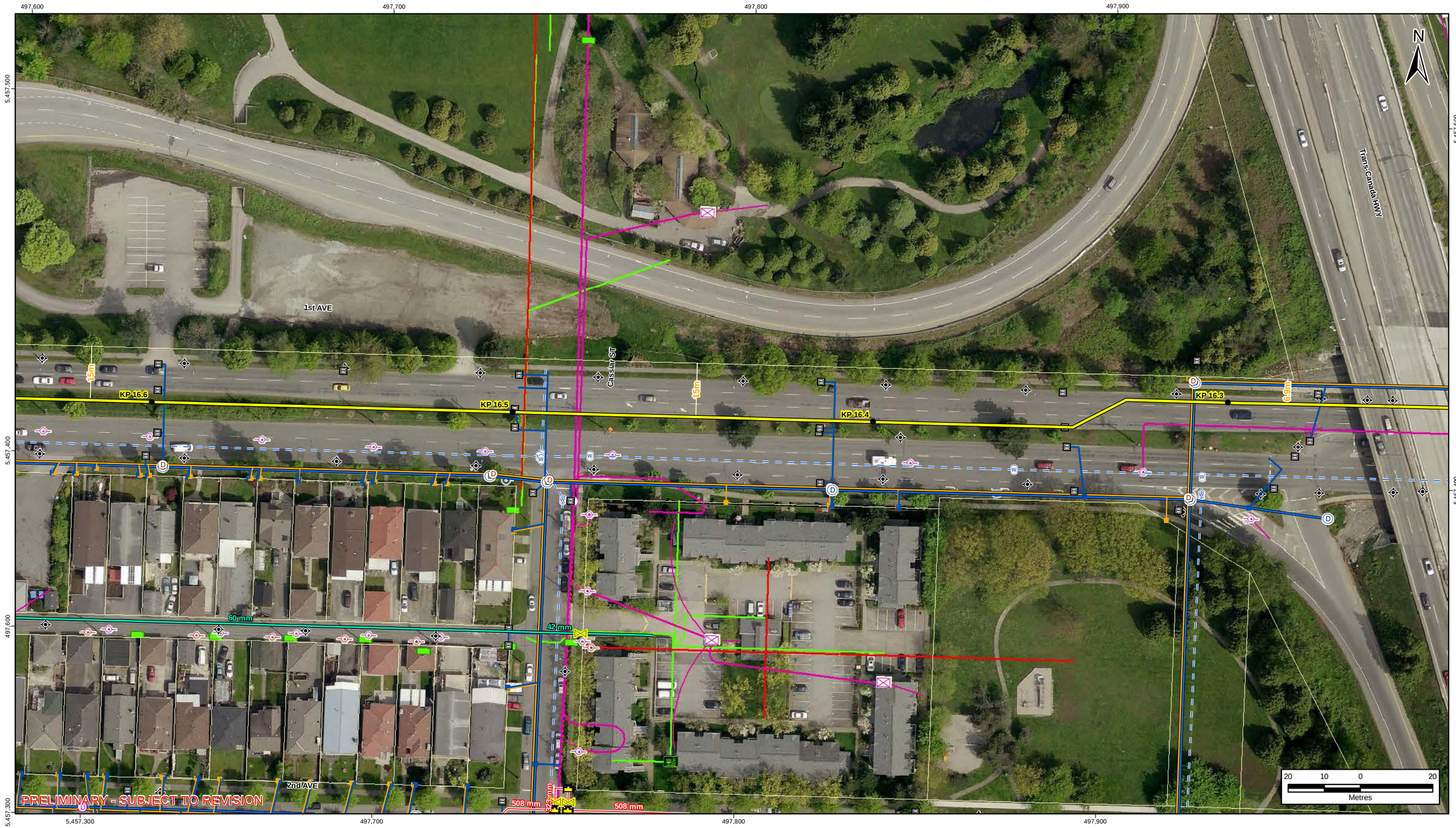

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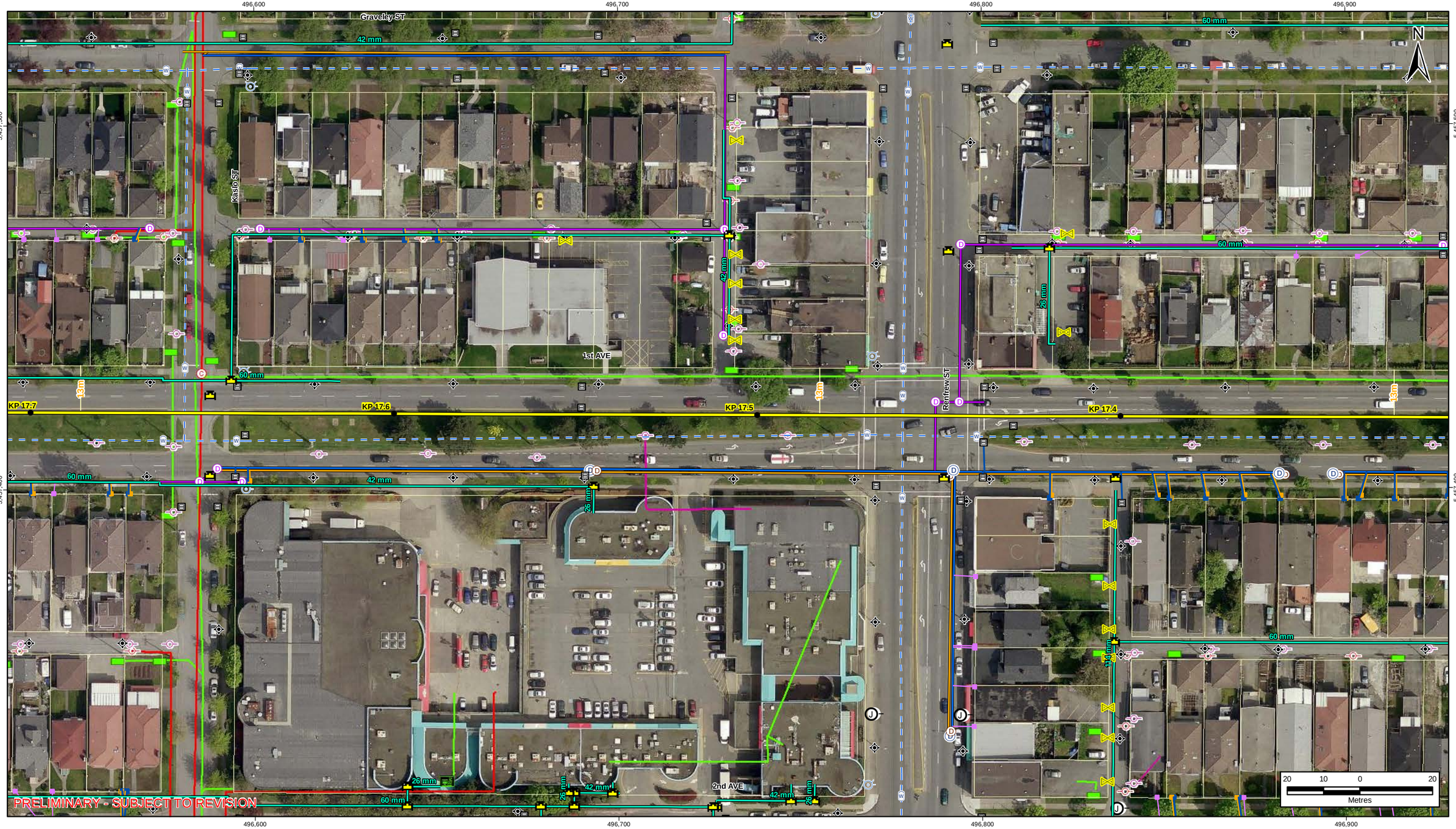

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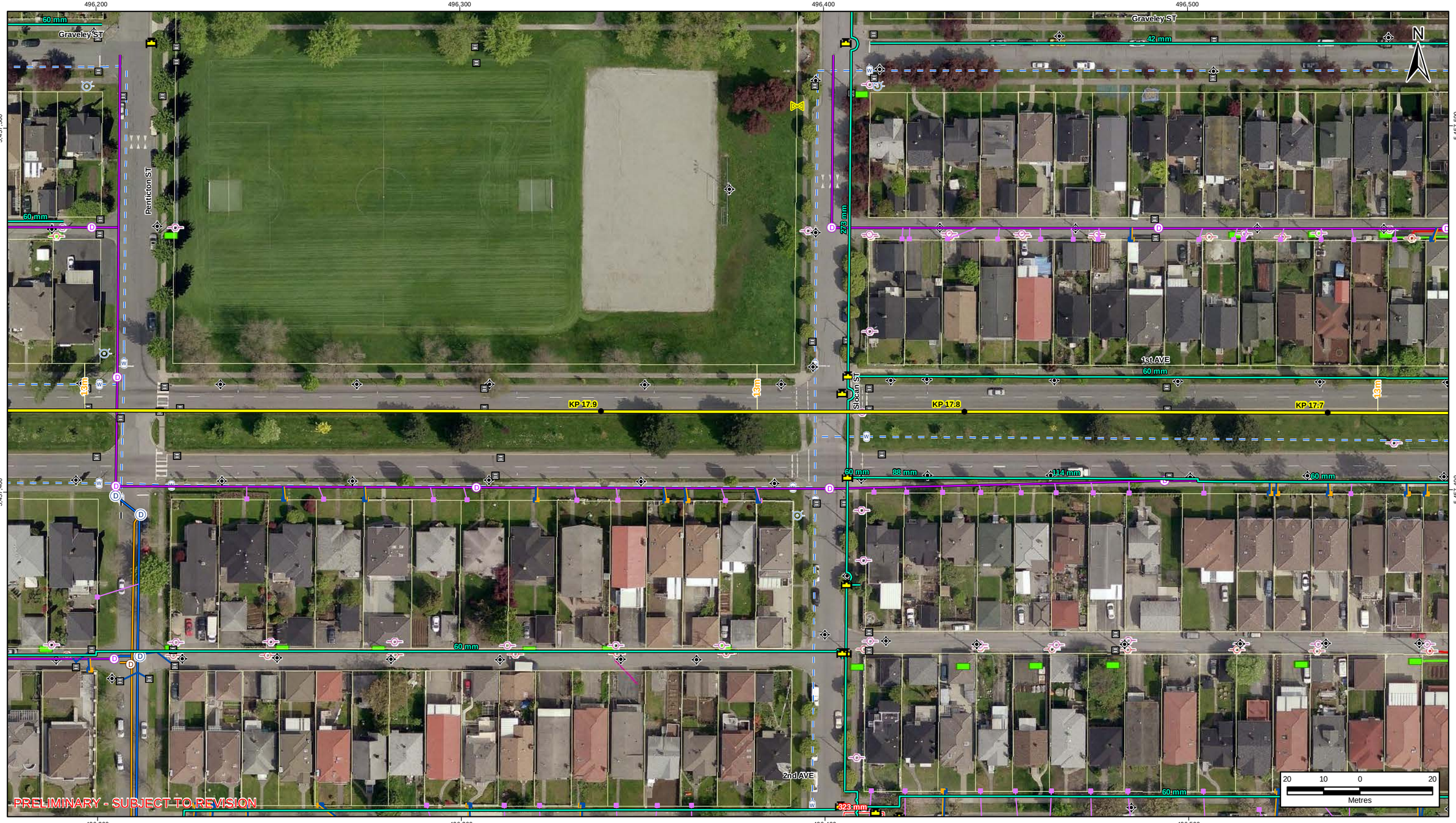

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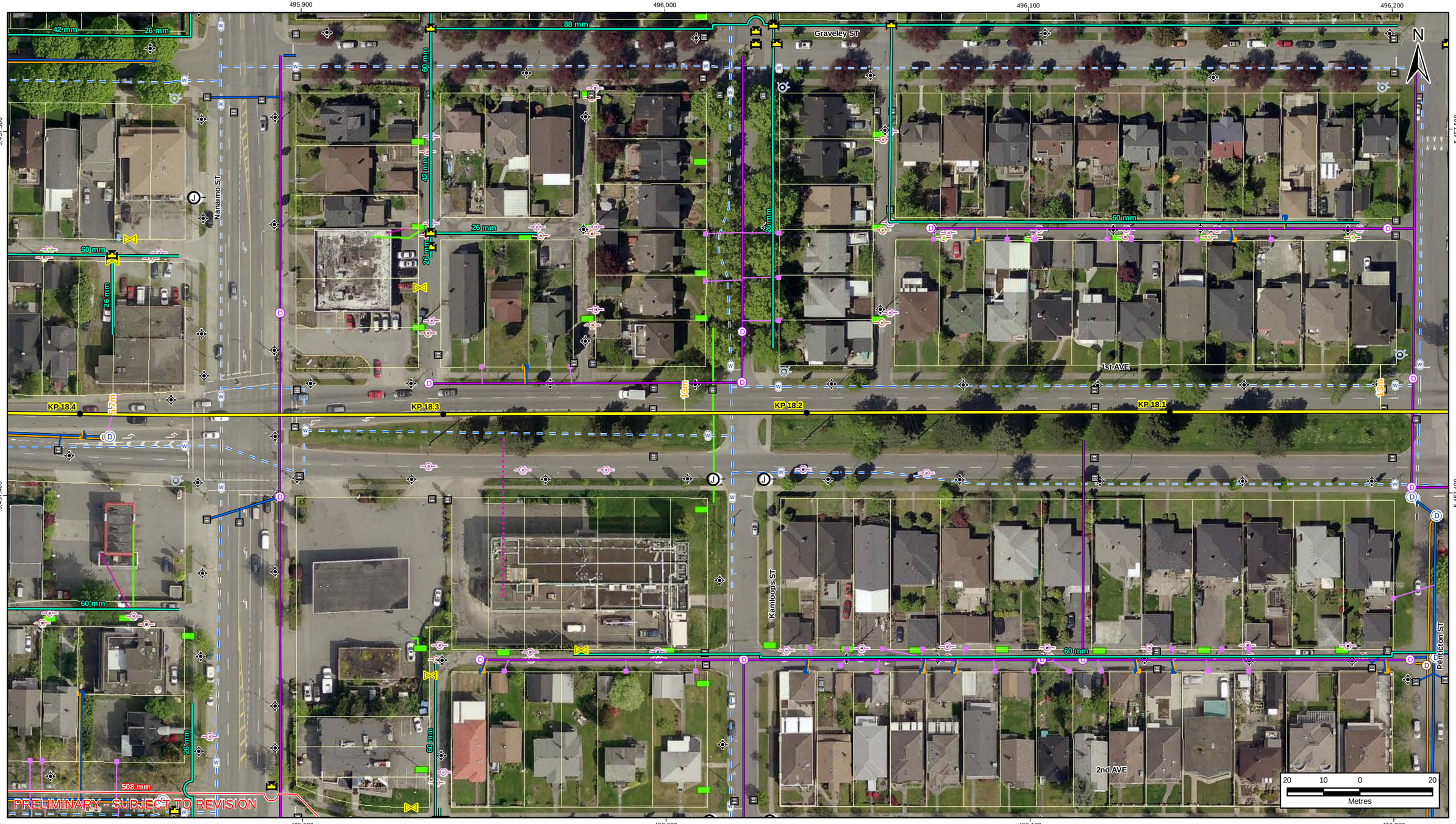

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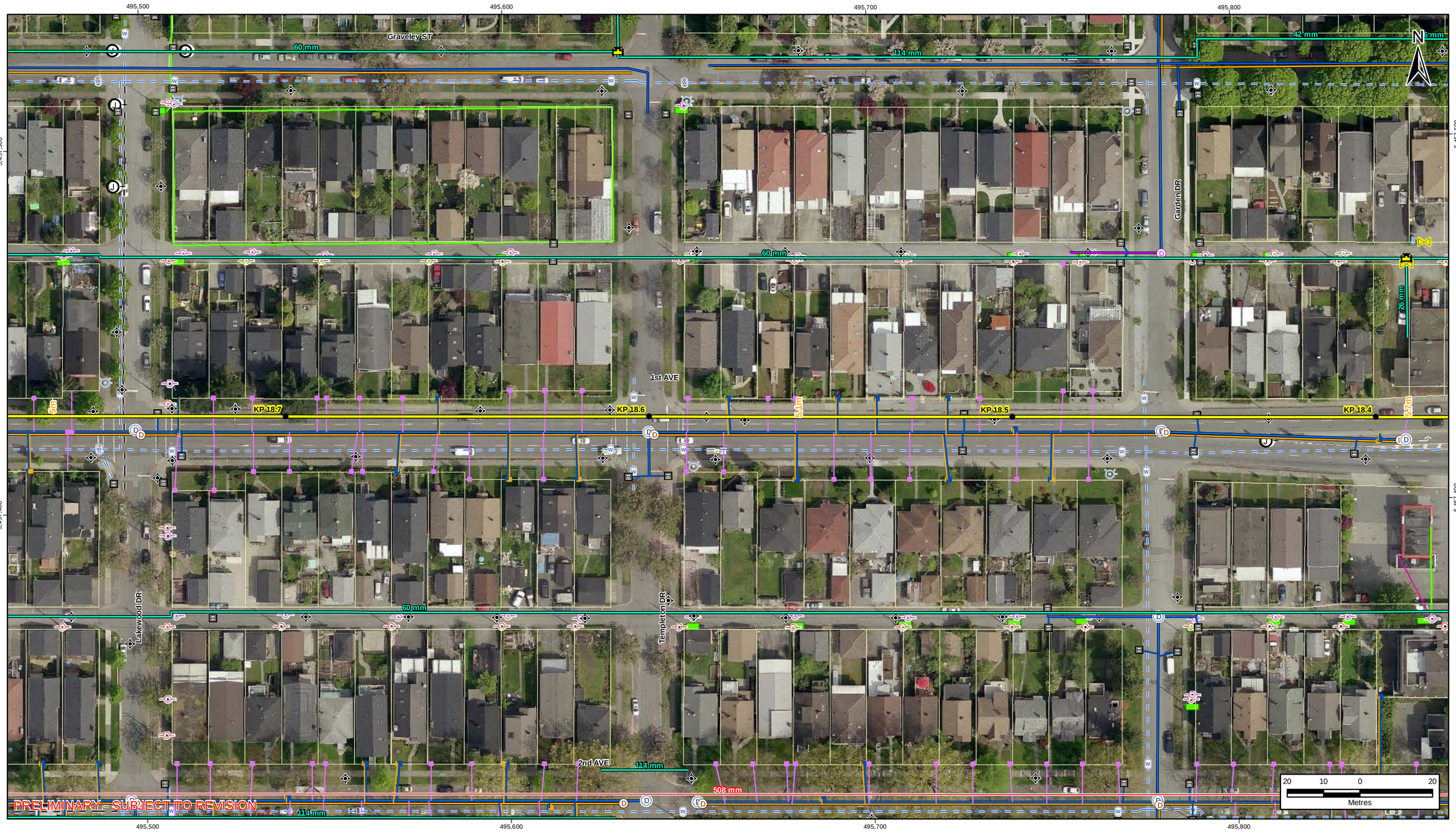

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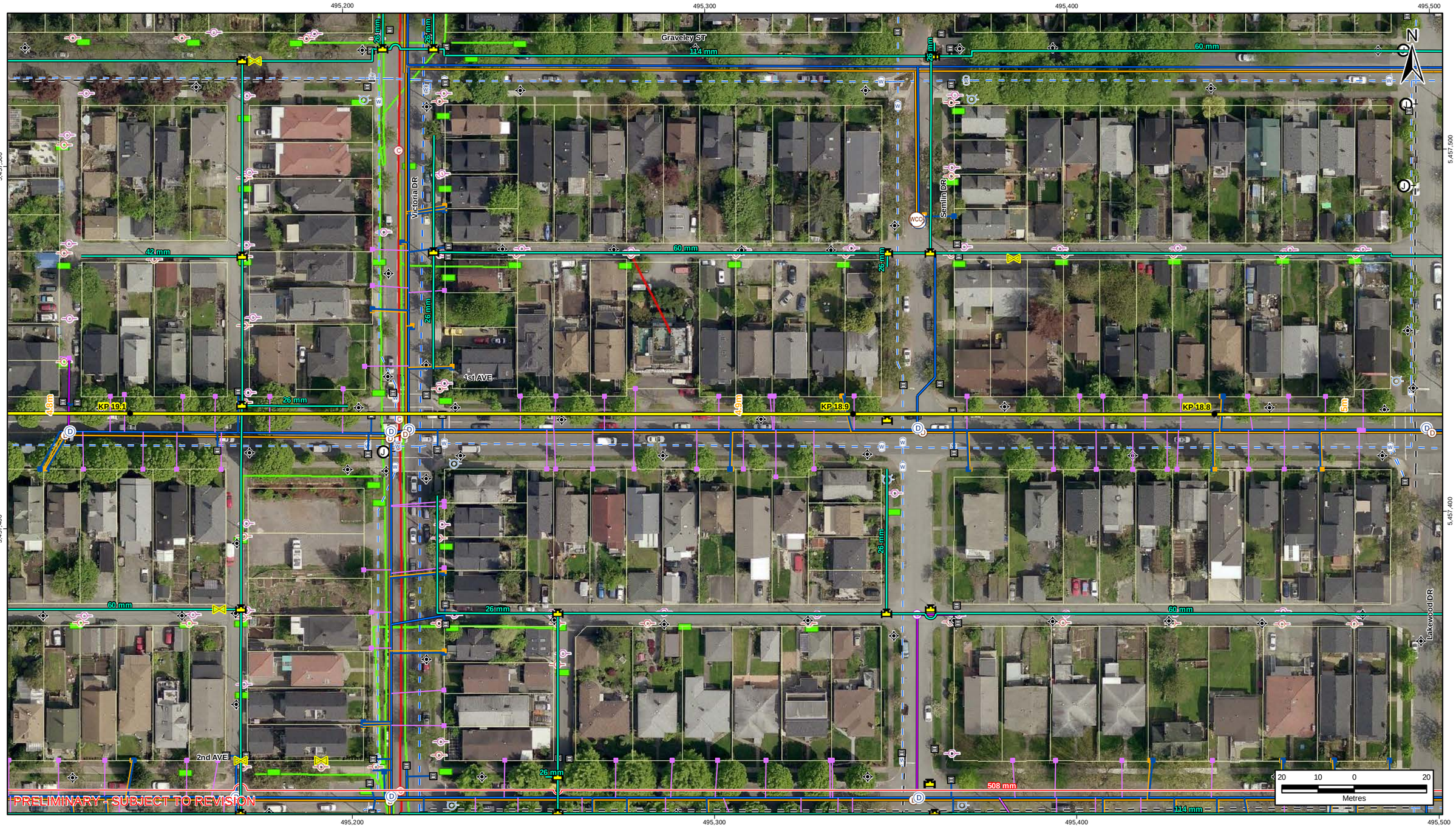

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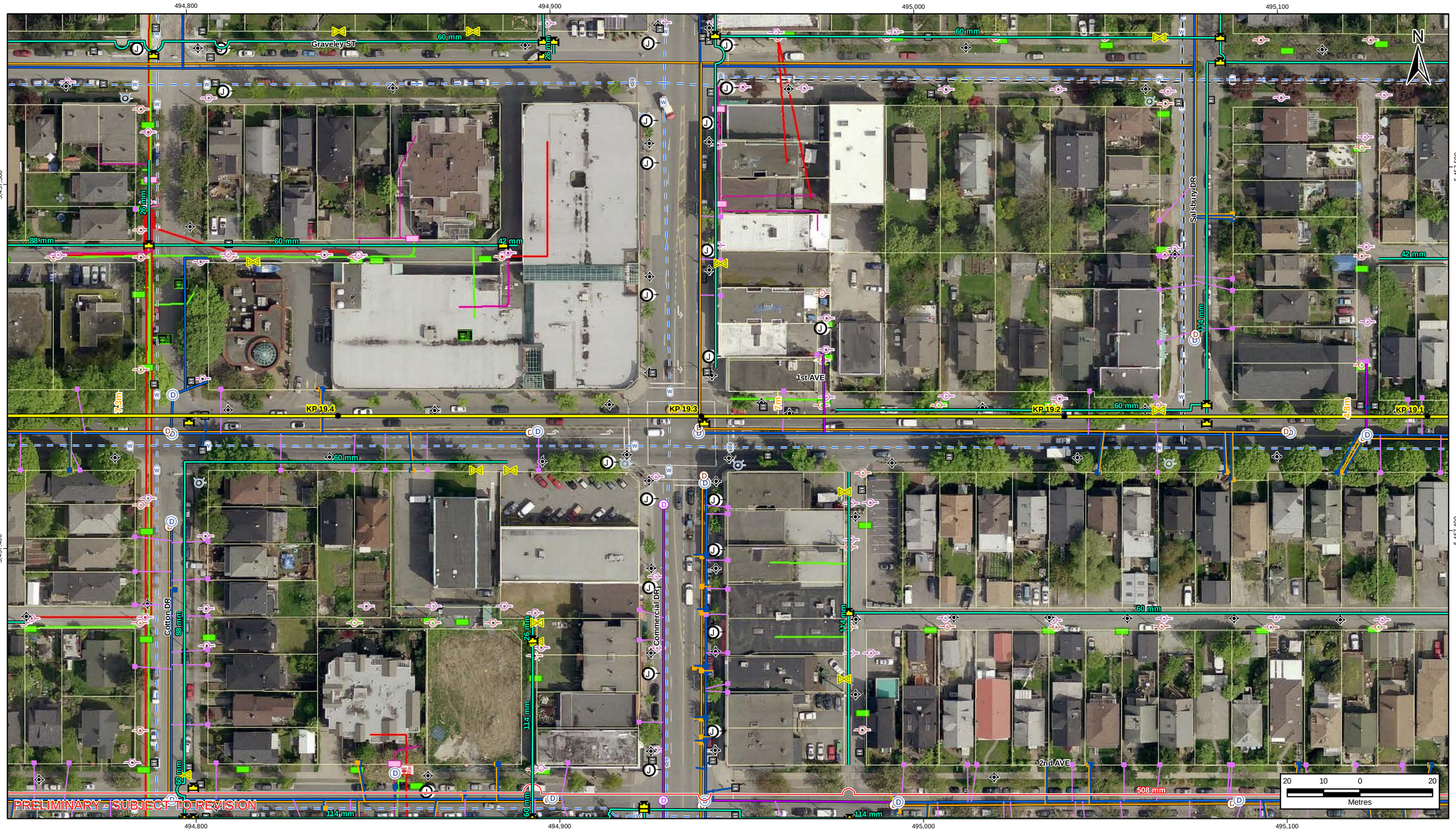

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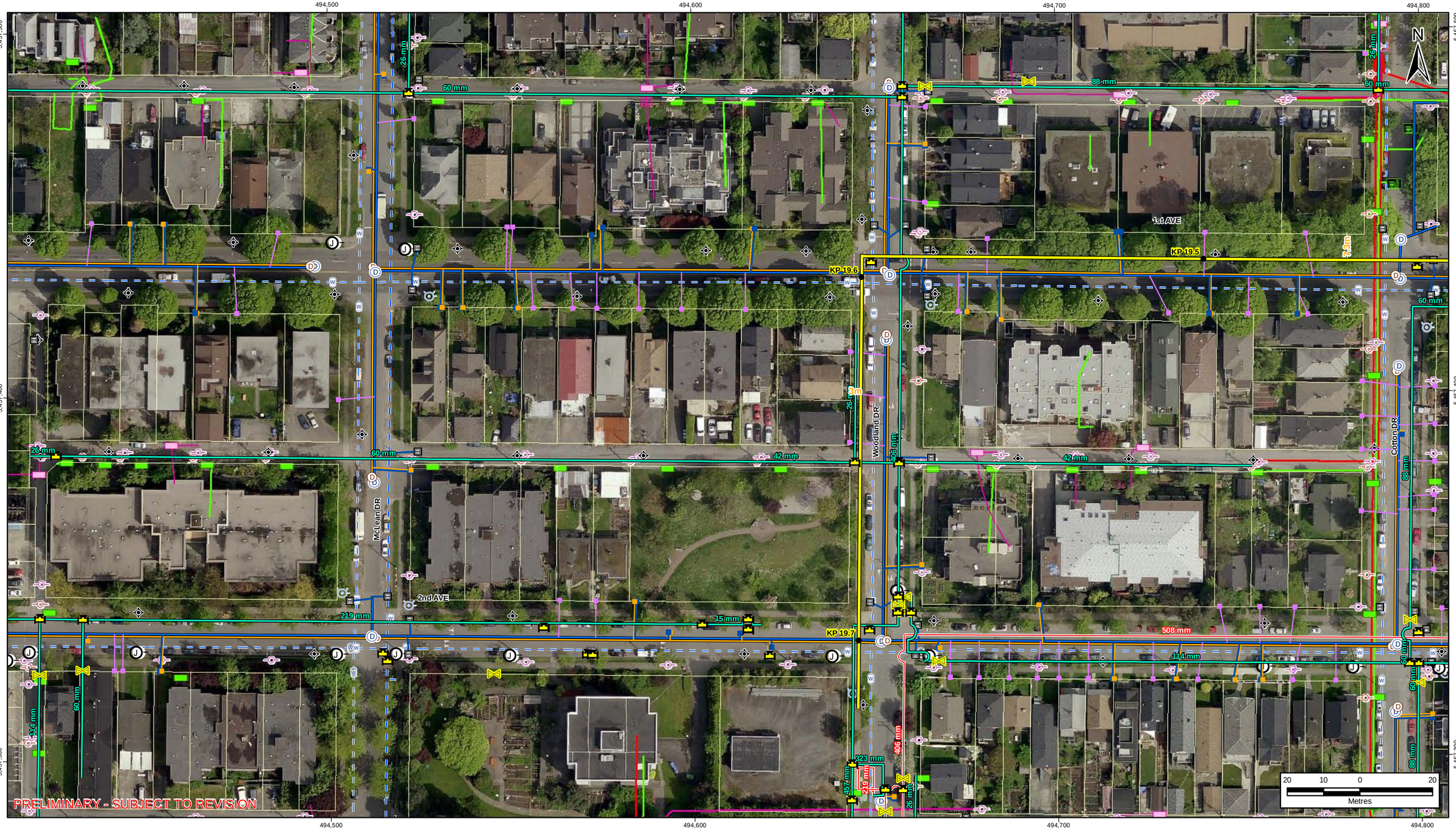

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Appendix A-18

TRAFFIC MANAGEMENT

Appendix A-18-1

PRELIMINARY TRAFFIC MANAGEMENT REVIEW
COQUITLAM SEGMENT

GNEC
GREAT NORTHERN ENGINEERING CONSULTANTS INC.

Coquitlam IP Pipeline Replacement Project Preliminary Traffic Management Review - Coquitlam Segment - Final

August 1, 2014

Submitted to:

FORTIS BC

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Appendix A – Preliminary Gas Line Alignment

Introduction

Fortis BC is proposing to replace the existing 20km long NPS 20 Coquitlam IP Pipeline between Coquitlam (Como Lake Avenue Avenue/Mariner Way intersection) and Vancouver (East 2nd Avenue/Woodland Drive intersection). At present a preliminary design of the gas line has been prepared by Worley Parsons and it is expected that construction will take place during the summer of 2018. For the most part, the replacement gas line will run along existing road rights of way through the Cities of Coquitlam, Burnaby and Vancouver

Fortis BC has retained Great Northern Engineering Consultants (GNEC) to support them and their design team to assist with providing traffic management advice as they proceed forward with community and stakeholder consultation, detailed design and permit approvals. As part of the early work, GNEC was requested to provide a high level review of the traffic management considerations on the affected road corridors. This will be supported with later data collection and traffic modelling that will assist in determining the likely traffic impacts during construction and the development of traffic management strategies to mitigate the impacts as far as possible. This report documents the high level preliminary review of the Coquitlam segment based on information available at the time. Similar reports will be produced for the Vancouver and Burnaby segments.

Proposed Alignment

The proposed preliminary alignment of the gas line within the City of Coquitlam is provided in ***Appendix A***. As can be seen the alignment from east to west is generally:

- West along the south side of Spuraway Avenue;
- West across Mariner Way onto Como Lake Avenue;
- West along Como Lake Avenue where it switches from the north and south side to avoid other major utilities; and
- West along Como Lake Avenue across North Road onto Broadway and into the City of Burnaby.

Como Lake Avenue is a major east/west arterial connecting Coquitlam and Burnaby that also provides access to residential/commercial properties north and south. Between Mariner Way and Baker Drive, there is a raised central median (except for at accesses) with two through lanes in each direction. Between Baxter Drive and Dogwood Street, there are two through lanes in each direction on Como Lake Avenue with painted medians in the vicinity of intersections. Raised median islands have been provided on Como Lake Avenue at the Clarke Road intersection with two through lanes in the east/west directions. (NOTE – this intersection is currently being reconstructed as part of the Evergreen Line project with additional lanes being provided on all approaches).

Left turn lanes have been provided on Como Lake Avenue at the following locations:

- Mariner Way (eastbound and westbound);
- Dr. Charles Best Secondary School (eastbound);
- Baker Drive (eastbound);
- Seymour Drive (eastbound);
- Thermal Drive (eastbound and westbound);

- Como Lake Village (westbound) between Custer Court and Linton Street;
- Linton Street (westbound);
- Blue Mountain Street (eastbound and westbound);
- Clarke Road (eastbound and westbound); and
- North Road (eastbound and westbound).

At intersections and accesses other than those listed above, left turn movements from Como Lake Avenue occur from the inside lane.

The following signalized intersections exist along the alignment and may be directly or indirectly affected by the gas line works:

- Como Lake Avenue/Mariner Way;
- Como Lake Avenue at Dr. Charles Best Secondary School (pedestrian signal);
- Como Lake Avenue/Baker Drive;
- Como Lake Avenue/Seymour Drive (pedestrian signal);
- Como Lake Avenue/Thermal Drive;
- Como Lake Avenue/Custer Court (pedestrian signal);
- Como Lake Avenue/Linton Street;
- Como Lake Avenue/Poirier Street;
- Como Lake Avenue/Wasco Street (pedestrian signal);
- Como Lake Avenue/Schoolhouse Street;
- Como Lake Avenue/Gatensbury Street;
- Como Lake Avenue/Porter Street;
- Como Lake Avenue/Blue Mountain Street;
- Como Lake Avenue/Banting Street (pedestrian signal);
- Como Lake Avenue/Robinson Street;
- Como Lake Avenue/Clarke Road; and
- Como Lake Avenue/North Road/Broadway.

The following unsignalized intersections exist along the alignment and may be directly or indirectly affected by the gas line works:

- Como Lake Avenue/Montrose Street;
- Como Lake Avenue/St Laurence Street;
- Como Lake Avenue/Prospect Street;
- Como Lake Avenue/Crestwood Drive;
- Como Lake Avenue/Regent Street;
- Como Lake Avenue/Longlac Street;
- Como Lake Avenue/Lilian Street;
- Como Lake Avenue/Macintosh Street;
- Como Lake Avenue/Hailey Street;
- Como Lake Avenue/Townley Street;
- Como Lake Avenue/Fowler Court;

- Como Lake Avenue/Dogwood Street;
- Como Lake Avenue/Emerson Street;
- Como Lake Avenue/Westley Avenue;
- Como Lake Avenue/Elmwood Street;
- Como Lake Avenue/Claremont Street;
- Como Lake Avenue/Farrow Street;
- Como Lake Avenue/Tyndall Street; and
- Unnamed lanes intersecting with Como Lake Avenue.

Construction Approach

Based on preliminary advice from Fortis BC, it is intended that the gas line crossing of the following major roads/intersections on Como Lake Avenue will be achieved using trenchless technology:

- Mariner Way;
- Clarke Road; and
- North Road.

The section of gas line on Como Lake Avenue between Emerson Street (east of Clarke Road) and North Road will also be constructed using trenchless technology. Between the intersections listed above and across the minor intersections, the gas line will be constructed using an open cut approach that will require approximately 200-1000m of road space occupation at any one time depending on site conditions. It is anticipated that a single lane will be closed in each direction in the vicinity of the work zone. Due to the nature of construction, it is expected that the road occupation will be on a full time basis limiting the ability to open/close lanes by time of day.

The proposed alignment and construction approach will impact all modes of traffic as discussed in the sections that follow.

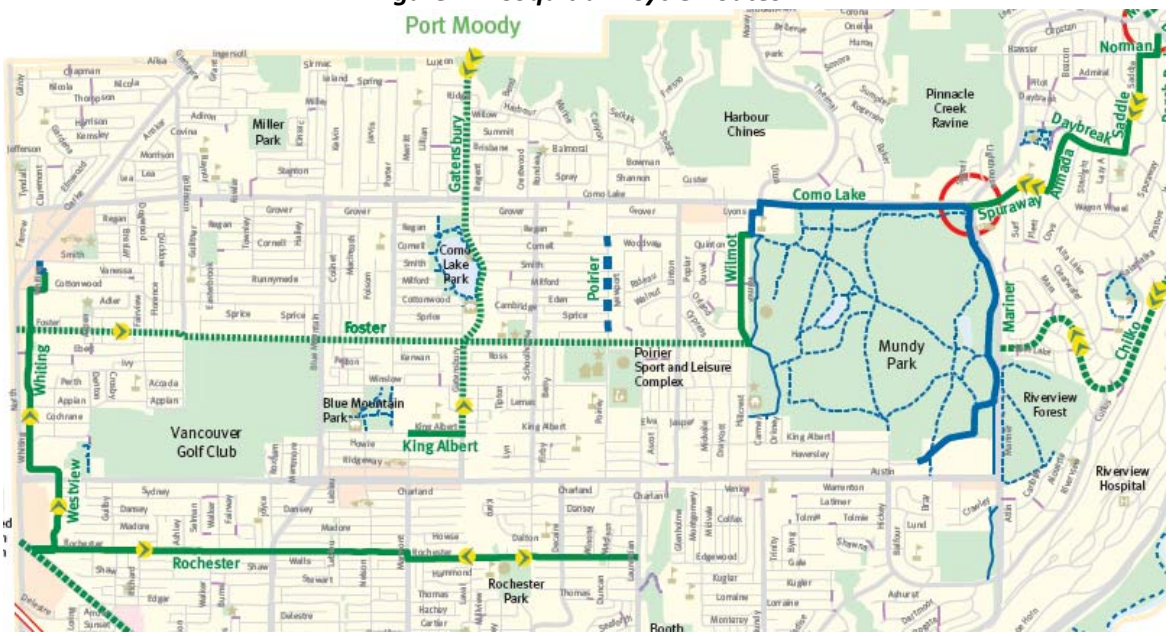
Special Road Users

The Coquitlam segment of the proposed alignment is currently used by a number of special road users as discussed below.

Cycle Routes

The existing designated cycle routes within the City of Coquitlam are illustrated in ***Figure 1***. Paved off street cycle facilities have been provided on the south side of Como Lake Avenue between Thermal Drive and Mariner Way and on the west side of Mariner Way south of Como Lake Avenue. Spuraway Ave is classified as a Neighbourhood Street Bikeway with cyclists sharing the travel lanes. Gatensbury Street is classified as a Major Street Shared Lane with cyclists sharing the travel lanes. Since gas line construction will take place on or in the vicinity of the above routes, cyclists will need to be accommodated on site or alternatively detoured to alternate routes.

Figure 1 – Coquitlam Cycle Routes



Pedestrian Routes

The Mundy Park Community Path is a popular pedestrian route that runs along the south side of Como Lake Avenue between Thermal Drive and Mariner Way and on the west side of Mariner Way south of Como Lake Avenue. On Como Lake Avenue, sidewalks have been provided on both sides of the street between Mariner Way and North Rd. Sidewalks have also been provided on one or both sides of the north/south intersecting streets.

There are a number of major pedestrian generators in the area as follows:

- Dr. Charles Best Secondary School on the north side of Como Lake Avenue between Mariner Way and Baker Street;
- Mundy Park on the south side of Como Lake Avenue;
- Hillcrest Middle School on the south side of Como Lake Avenue at Thermal Drive;
- Como Lake Village on the south side of Como Lake Avenue between Custer Court and Linton Street;
- Parkland Elementary School on the south side of Como Lake Ave at Poirier Street;
- All Saints Parish on the north side of Como Lake Avenue between Schoolhouse Street and Gatensbury Street;
- Porter Street Elementary School to the south of Como Lake Ave at Poirier Street;
- Ecole Banting Middle School and Miller Park Community School to the north of Como Lake Avenue at Banting Street;
- Commercial developments along Clarke Road; and
- The future Evergreen Line Burquitlam Station on Clarke Road

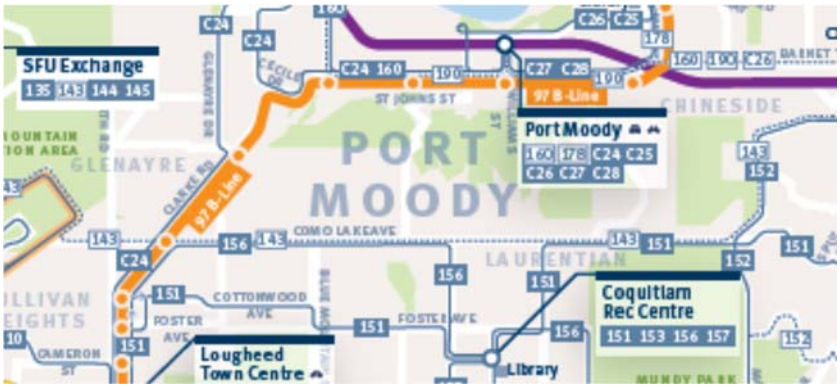
At the intersections that will be crossed using an open cut approach, pedestrians will need to be accommodated at the intersections or alternatively detoured to alternate routes. Where possible the

existing sidewalks on Como Lake Avenue should be retained. If this is not feasible, pedestrians may need to be diverted to the opposite side of the street in the vicinity of the construction zones. Temporary pedestrian crossings may need to be installed to maintain connectivity where required during construction.

Bus Routes

The existing TransLink/Coast Mountain Bus Company bus routes within the project area are illustrated in ***Figure 2***.

Figure 2 – Bus Routes



As can be seen, Spuraway Avenue and Como Lake Avenue are both bus routes (#143, #156, and #151). All of these routes are likely to be impacted by gas line construction and suitable alternative arrangements will need to be made with TransLink/Coast Mountain Bus Company. It is noted that there are bus stops on both sides of Como Lake Avenue at the locations listed in ***Table 1***.

Table 1 – Como Lake Avenue Bus Stops

Direction	Location
Como Lake Avenue Eastbound	Far side of Emerson Street
	Far side of Dogwood Street
	Near side of Robinson Street
	Far side of Banting Street
	Far side of Townley Street
	Far Side of Blue Mountain Street
	Far side of Porter Street
	Far side of Gatensbury Street
	Far side of Schoolhouse Street
	Far side of Wasco Street
	Far side of Poirier Street
	Near side of Linton Street
	Far side of Custer Court
	Far side of Thermal Drive
	Far side of Seymour Drive
	Far side of Baker Drive
	2500 Block (Dr. Charles Best School)
Como Lake Westbound	2500 Block (Dr. Charles Best School)
	Far side of Seymour Drive
	Far side of Thermal Drive
	Near side of Custer Court
	Far side of Linton Street
	Far side of Prospect Street
	Far side of Poirier Street
	Far side of Wasco Street
	Far side of Crestwood Drive
	Far side of Gatensbury Street
	Far side of Porter Street
	Far Side of Blue Mountain Street
	Far side of Townley Street
	Far side of Banting Street
	Far side of Robinson Street
	Far side of Dogwood Street
	Far side of Elmwood Street

At these stops, buses stop in the outside traffic lane. If Como Lake Avenue is reduced to a single lane in each direction during construction as proposed, a stopped bus will delay all through traffic in the only available lane. Special attention will need to be given to accommodating the bus stops possibly by

temporarily relocating the stops outside of the work zone, or alternatively widening the available lane by approximately 3m to provide an out-of-lane stop (bus bay).

In addition to the above considerations on Como Lake Avenue itself, the following bus routes intersect with Como Lake Avenue:

- #97B-Line and #C24 along Clarke Road; and
- #152 along Mariner Way.

The gas line across the above roads is expected to be constructed using trenchless technology, so no direct impacts to these bus routes are expected.

Truck Routes

The City of Coquitlam's official truck routes are presented in ***Figure 3***. In this figure the blue lines indicate a municipal truck route with the grey lines indicating arterial roads

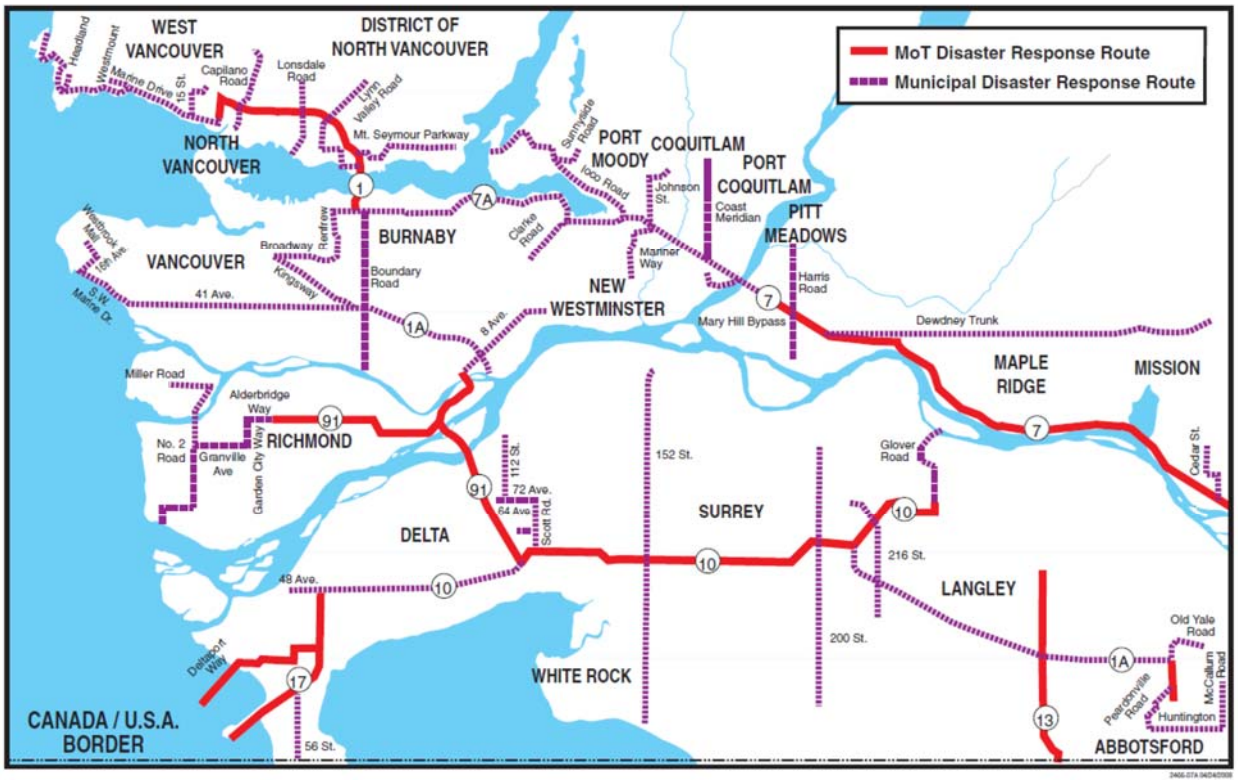
Figure 3 – Designated Truck Routes

As can be seen Como Lake Avenue is a truck route between North Road and Clarke Road. The North Road/Clarke Road corridor crossing Como Lake Avenue is also a truck route. During gas line construction the truck routes should be maintained as far as practically possible as there are limited alternate route available in the immediate proximity.

Disaster Response Routes

The designated Disaster Response Routes in the Lower Mainland are shown in ***Figure 4***. There are two designated Disaster Response Routes within the City of Coquitlam that could be directly affected by the proposed gas line construction. These are the Clarke Road and Mariner Way corridors that cross Como Lake Avenue. Maintenance of these routes will need to be considered during future traffic management planning.

Figure 4 – Disaster Response Routes



On-Street Parking

On-street parking is currently prohibited along the entire proposed alignment within the City of Coquitlam.

Accesses

There are numerous properties that have existing direct access to the roads affected by the proposed gas line alignment. These include the accesses listed in ***Table 2*** based on preliminary observations from Google Earth©.

Table 2 – Property Accesses

Road	From	To	Side of Road	# Residential Accesses	# Commercial/ Industrial/Institutional Accesses
Como Lake Avenue	Mariner Way	Baker Drive	North		3
Como Lake Avenue	Baker Drive	Seymour Drive	North	15	
Como Lake Avenue	Seymour Drive	Thermal Drive	North	9	
Como Lake Avenue	Thermal Drive	Custer Court	North	6	
			South	6	2
Como Lake Avenue	Custer Court	Linton Street	North	3	3
			South		1
Como Lake Avenue	Linton Street	Poirier Street	North	10	
			South	16	
Como Lake Avenue	Poirier Street	Wasco Street	North	3	4
			South	5	
Como Lake Avenue	Wasco Street	Schoolhouse Street	North	5	
			South	4	
Como Lake Avenue	Schoolhouse Street	Gatensbury Street	North	6	3
			South	8	
Como Lake Avenue	Gatensbury Street	Porter Street	North	6	
			South	7	
Como Lake Avenue	Porter Street	Blue Mountain Street	North	6	
			South	13	1
Como Lake Avenue	Blue Mountain Street	Banting Street	North	11	1
			South	13	1
Como Lake Avenue	Banting Street	Robinson Street	North	5	
			South	4	
Como Lake Avenue	Robinson Street	Clarke Road	North	9	1
			South	13	1 (under redevelopment)
Como Lake Avenue/Broadway	Clarke Road	North Road	North	4	
			South		5

The above accesses will need to be maintained or alternative arrangements made with affected property owners during construction.

Existing Traffic Operations

Como Lake Avenue is a major east/west arterial linking the City of Coquitlam with the City of Burnaby. It also provides access to local residential and commercial areas on either side of the road. Como Lake Avenue carries high traffic volumes at times during the week and on weekends. It is particularly heavily trafficked during the weekday AM and PM commuter peak periods during which time recurring congestion is present at the following intersections:

AM Peak Period

- In the vicinity of the Dr. Charles West school due to drop off activities;
- Westbound at Blue Mountain Street; and
- Westbound at Clarke Road.

PM Peak

- Eastbound at North Road and Clarke Road; and
- Eastbound at in the vicinity of the Como Lake Village (Linton Street) and Thermal Drive.

GNEC will be arranging new traffic counts in the summer of 2014 and detailed capacity analysis will then be performed to determine the existing operations of the intersections along Como Lake Avenue. As part of this work traffic models will be created for the Como Lake Avenue corridor and the major intersecting north/south streets. These models will assist in assessing existing traffic operations and the operations associated with any lane reductions on Como Lake Avenue and in turn help define the minimum laning requirements during construction. This later work will be documented in future reports to be produced by GNEC and it is expected that the analysis and findings presented below will be superseded at that time.

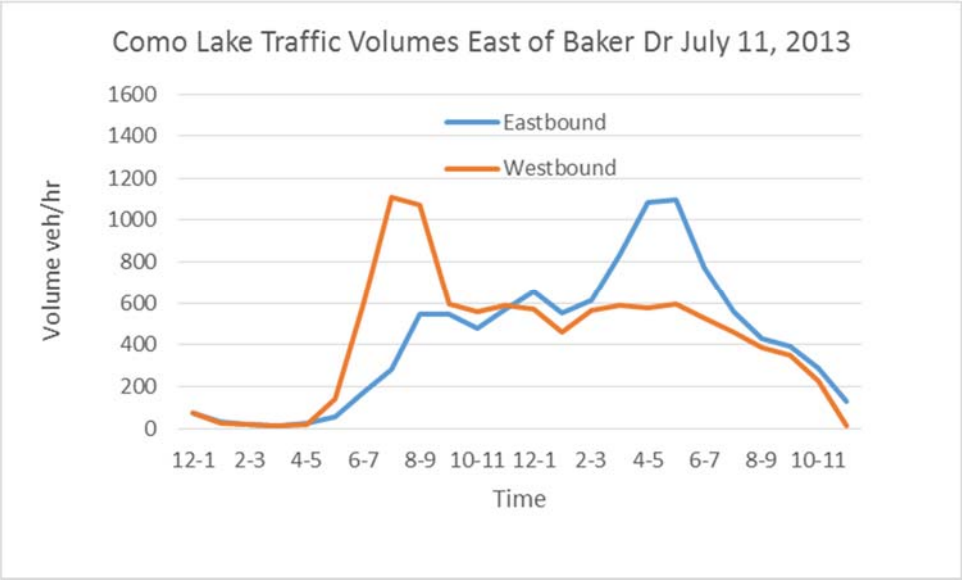
In the interim until such time that the new summer 2014 traffic data becomes available, a preliminary assessment of operations was performed using available traffic data. The City of Coquitlam has current tube counts and turning movement count for the intersections along the Como Lake Avenue corridor. The tube count data at each end of the Como Lake Avenue corridor was reviewed as part of this initial assessment. This included data east of Baker Drive from Wednesday July 11, 2013 and east of Clarke Road from Wednesday December 5, 2013.

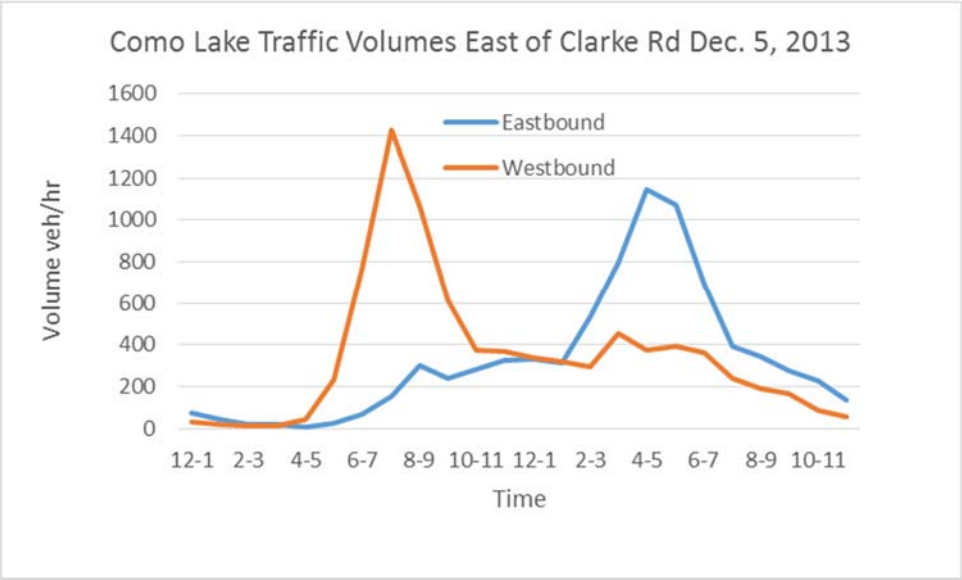
The two way daily traffic volumes at each of the above mentioned locations is summarized in ***Table 3*** below. As can be seen the volumes to the east (Baker Drive) are markedly higher than the volumes to the west (Clarke Road). Eastbound and westbound daily volumes are approximately equal in each direction at each location.

Table 3 – Como Lake Avenue Daily Volumes

Location	Date	Eastbound Daily Volume veh/day	Westbound Daily Volume veh/day	Two Way Daily Volume veh/day
East of Baker Drive	July 11, 2013	10224	10119	20343
East of Clarke Road	December 5, 2013	7806	8237	16043

The hourly traffic volumes per direction for the two locations are illustrated in the charts below.





There are number of items to note in the above charts:

- There is a significant variation in traffic flows by time of day at both locations.
- The maximum westbound volumes occur in the AM peak period and vary between 1100 veh/hr at Baker Drive and 1400 veh/hr at Clarke Road.
- The maximum eastbound volumes occur in the PM peak period with approximately 1100 veh/hr at both Baker Drive and Clarke Road.
- During the midday period the eastbound volumes are between 350 and 650 veh/hr. The westbound volumes are between 350 and 600 veh/hr.
- The data presented in the charts is July and December data and this may not be representative of summer traffic patterns. This will be confirmed with new tube counts scheduled for summer 2014.

With hourly directional traffic volumes in the 1100-1400 veh/hr range it is suspected that the road is currently operating with spare capacity during the peak periods as well as during off peak periods. As a rule of thumb a free flow traffic lane can carry approximately 1800 veh/hr. Since there are two lanes in each direction on Como Lake Avenue, the maximum capacity between intersections is approximately 3600 veh/hr per direction. However, on a corridor like this, it is the signalized intersections that will constrain capacity. Depending on the signal operation (number of phases, timing, coordination, etc.) the lane capacity can be reduced significantly from the 1800 veh/hr/lane. Conservatively, the lane capacity is estimated at 60% of a full lane (1080 veh/hr) so with two lanes in each direction the directional capacity is estimated at 2160 veh/hr.

Using the estimated capacity of 1080 veh/hr/lane, the existing capacity of Como Lake Avenue by time of day was calculated as per ***Table 4***. This table also provides comment on whether there is any spare capacity on Como Lake Avenue.

Table 4 – Como Lake Avenue Capacity (Existing)

Direction	Time Period	# of lanes	Capacity (veh/hr)	Observed Volume (veh/hr)	Spare Capacity?
Eastbound	AM Peak	2	2160	300-550	Appears to be spare capacity
	Midday	2	2160	350-650	Appears to be spare capacity
	PM Peak	2	2160	1100	Appears to be spare capacity
Westbound	AM Peak	2	2160	1100-1400	Appears to be spare capacity
	Midday	2	2160	350-600	Appears to be spare capacity
	PM Peak	2	2160	400-600	Appears to be spare capacity

Currently, it is intended to close a lane in each direction on Como Lake Avenue for gas line construction. ***Table 5*** summarizes the potential impacts on capacity under this scenario.

Table 5 – Como Lake Avenue Capacity (Reduced Laning)

Direction	Time Period	# of lanes	Capacity (veh/hr)	Observed Volume (veh/hr)	Spare Capacity?
Eastbound	AM Peak	1	1080	300-550	Appears to be spare capacity
	Midday	1	1080	350-650	Appears to be spare capacity
	PM Peak	1	1080	1100	Capacity likely to be exceeded
Westbound	AM Peak	1	1080	1100-1400	Capacity likely to be exceeded
	Midday	1	1080	350-600	Appears to be spare capacity
	PM Peak	1	1080	400-600	Appears to be spare capacity

The above very preliminary analysis suggests that with a single lane in each direction the Como Lake Avenue corridor could operate satisfactorily for most of the day. It is however anticipated that during construction, capacity will be exceeded in the westbound direction in the AM peak and in the eastbound direction in the PM peak. It is noted from the charts above that the AM and PM peak flows are of short duration (i.e. not extending over a few hours) and the impacts of the lane closures will only be felt by drivers that actually travel during the peak hours. With minor diversion of some traffic off Como Lake Avenue to alternate routes it is expected that the traffic conditions will be tolerable during construction.

It is reiterated that the above findings are based on information available at the time of this report. New traffic counts and analysis are programmed for summer 2014 and these will assist in confirming the above findings. At that time a detailed assessment of the intersection operations will be performed.

In the interim a number of intersections that are currently proposed to be crossed using open cuts have been identified as potentially being problematic. These include:

- Como Lake Avenue/Thermal Drive – high volumes on Thermal Drive north of Como Lake Avenue turning at the intersection;
- Como Lake Avenue/Linton Street - high volumes on Linton Street south of Como Lake Avenue turning at the intersection;
- Como Lake Avenue/Gatensbury Street - high volumes on Gatensbury Street north and south of Como Lake Avenue turning at the intersection;
- Como Lake Avenue/Blue Mountain Street - high volumes on Blue Mountain Street south of Como Lake Avenue turning at the intersection; and

- Como Lake Avenue/Robinson Street – high volumes on Robinson Street north of Como Lake Avenue turning at the intersection.

If the above intersections are to be crossed using open cuts, traffic entering/exiting Como Lake Avenue will be required to detour to alternate routes (if available). This could create congestion where the alternate routes connect with Como Lake Avenue. This will be assessed later once the new summer 2014 traffic count data is available.

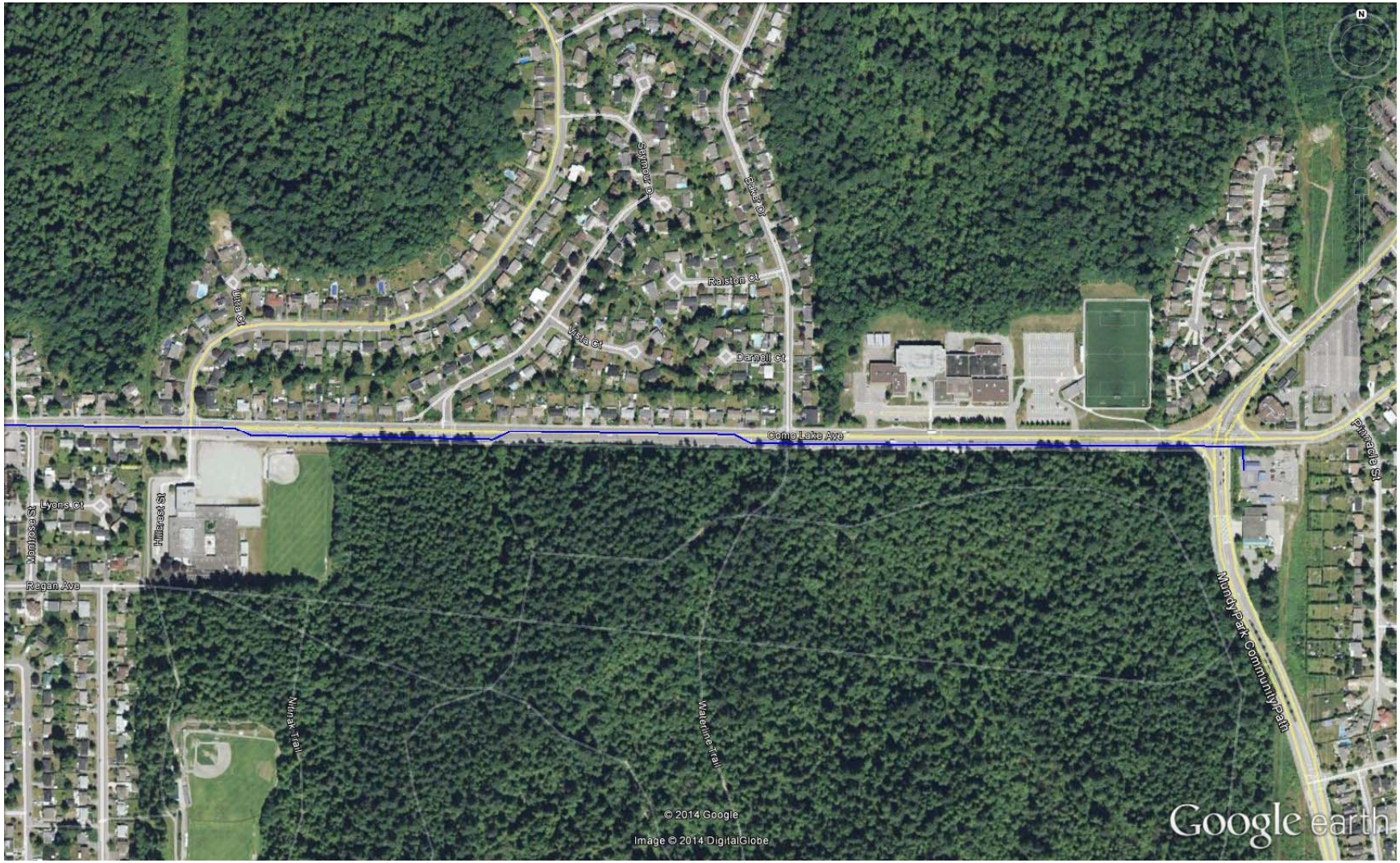
Traffic Management Considerations

Based on the information presented above, there are a number of considerations for traffic management planning associated with the proposed gas line replacement project in the City of Coquitlam. These are summarized below:

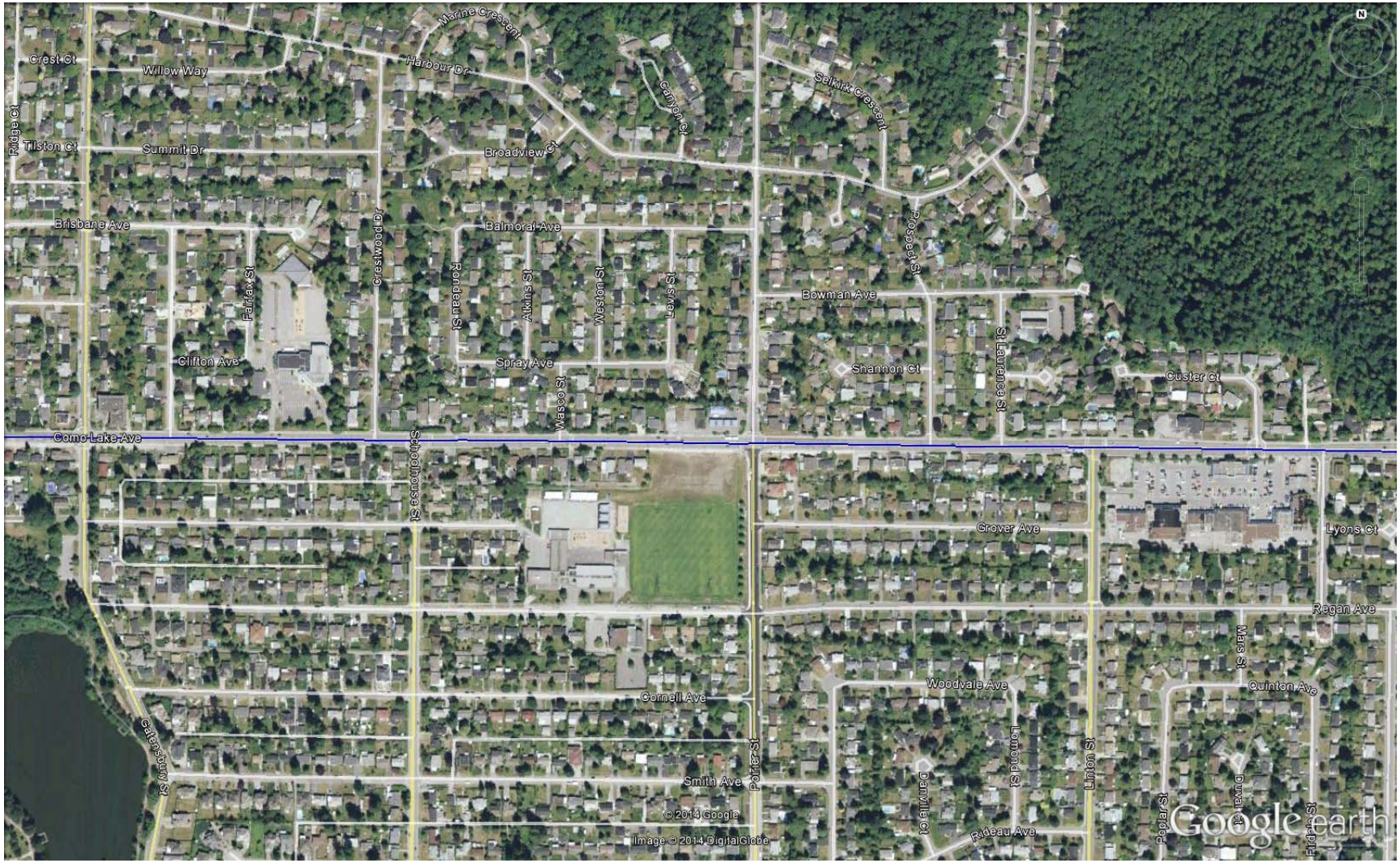
- Special attention will need to be given to accommodating the bus stops on Como Lake Avenue during construction possibly by temporarily relocating the stops outside of the work zone, or alternatively widening the available lane by approximately 3m to provide an out-of-lane stop (bus bay).
- There are numerous properties that have existing direct access to Como Lake Avenue. During construction, these accesses will have to be maintained or alternative arrangements will need to be made with property owners.
- Preliminary analysis suggests that with a single lane in each direction during construction, the Como Lake Avenue corridor could operate satisfactorily for most of the day. It is however anticipated that during construction, capacity will be exceeded in the westbound direction in the AM peak and in the eastbound direction in the PM peak. With minor diversion of some traffic off Como Lake Avenue to alternate routes it is expected that the traffic conditions will be tolerable. This will be assessed in detail later when the summer 2014 data becomes available.
- The impacts of open cut crossings of intersections will need to be assessed in more detail later when new traffic data is available. In the interim however, it is suspected that proposed open cut crossings of the Como Lake Avenue intersections at Thermal Drive, Linton Street, Gatensbury Street, Blue Mountain Street and Robinson Street may be problematic from a traffic management perspective.

Appendix A – Preliminary Gas Line Alignment

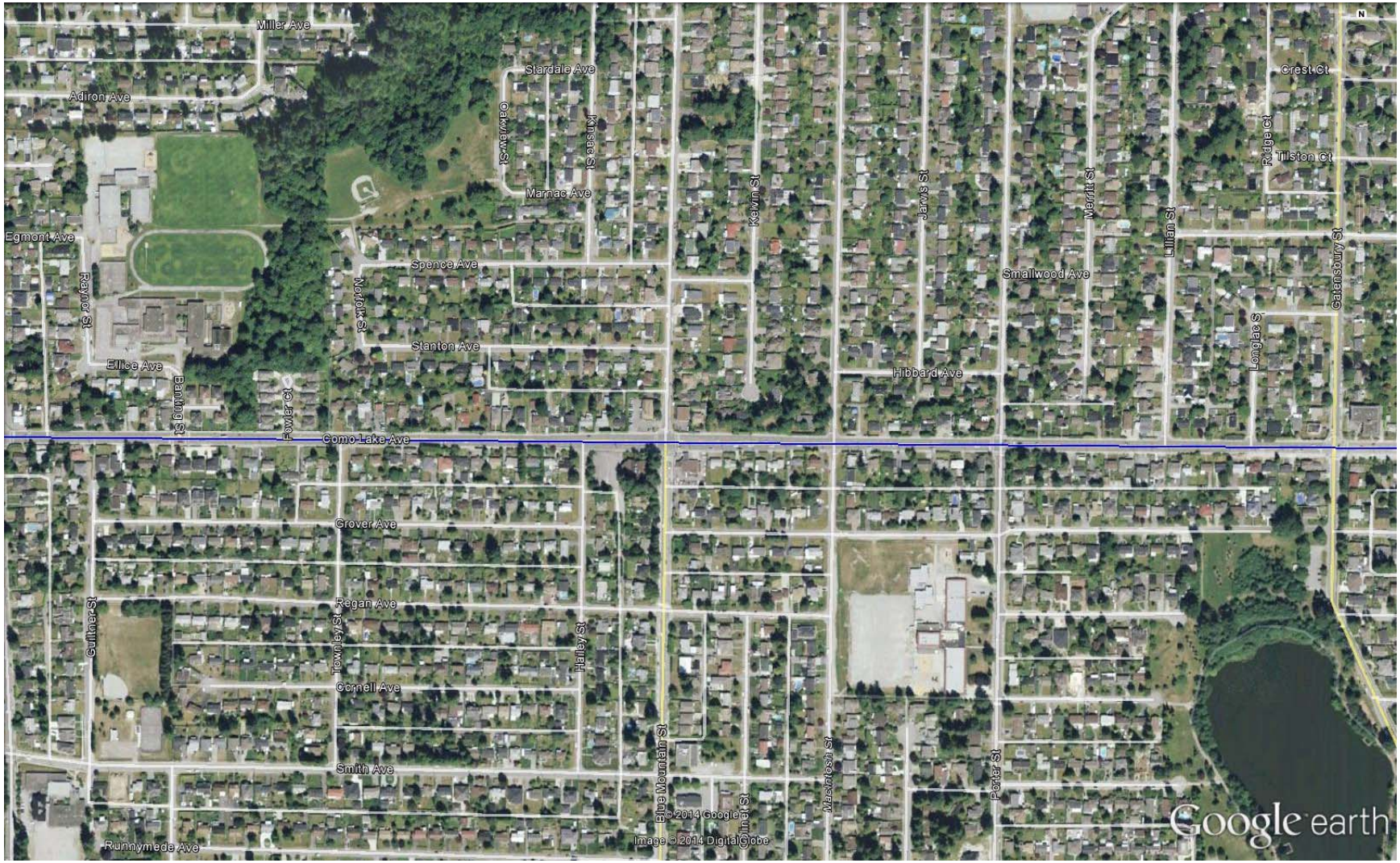
Coquitlam Alignment – Section 1



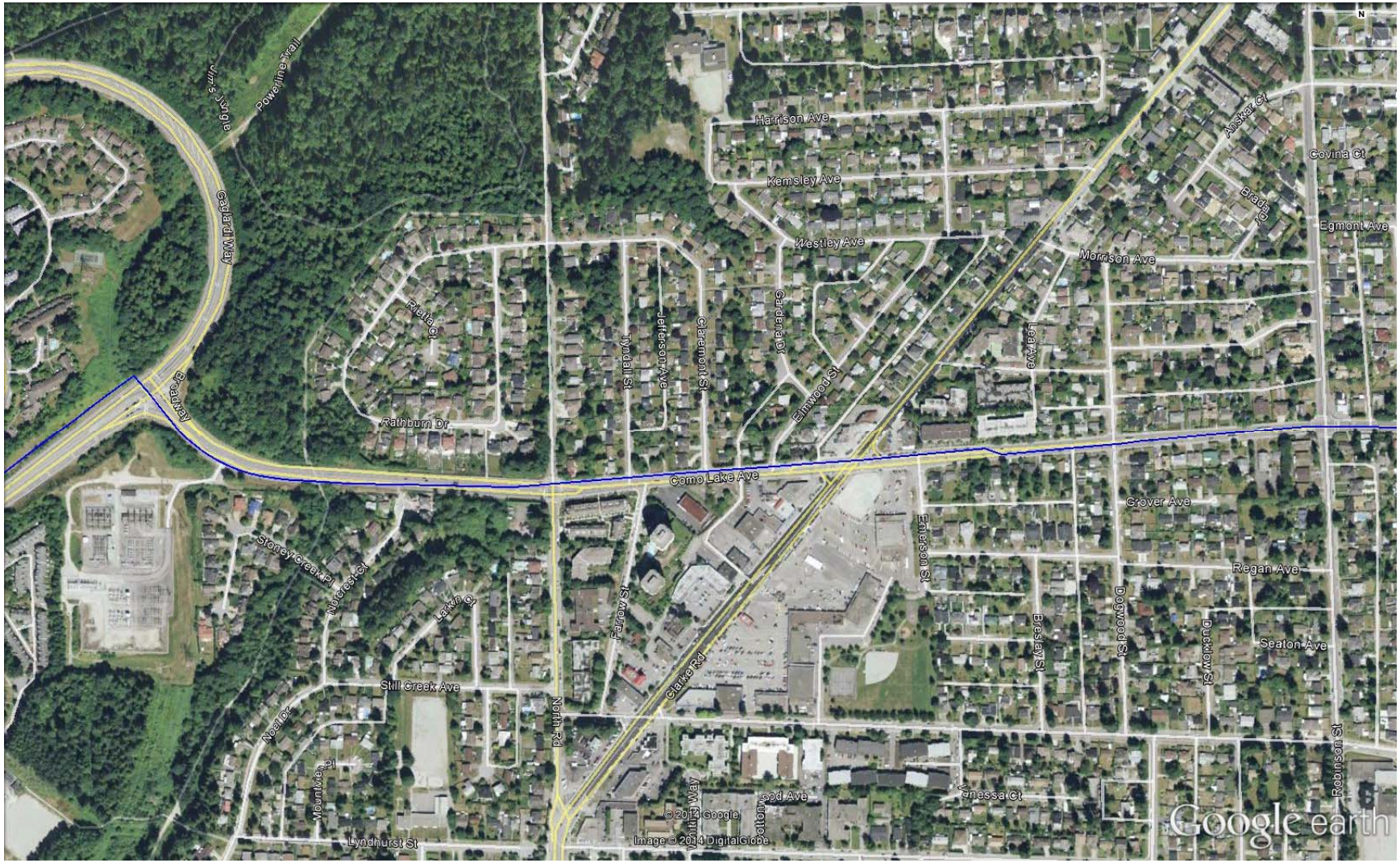
Coquitlam Alignment – Section 2



Coquitlam Alignment – Section 3



Coquitlam Alignment – Section 4



Appendix A-18-2

PRELIMINARY TRAFFIC MANAGEMENT REVIEW
BURNABY SEGMENT

GNEC
GREAT NORTHERN ENGINEERING CONSULTANTS INC.

Coquitlam IP Pipeline Project
Preliminary Traffic Management Review - Burnaby Segment - Final

August 14, 2014

Submitted to: FORTIS BC

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Appendix A – Preliminary Gas Line Alignment

Appendix B – Willingdon Park Alternative

Introduction

Fortis BC is proposing to replace the existing 20km long NPS Coquitlam IP Pipeline between Coquitlam (Como Lake Avenue Avenue/Mariner Way intersection) and Vancouver (East 2nd Avenue/Woodland Drive intersection). At present a preliminary design of the gas line has been prepared by Worley Parsons and it is expected that construction will take place during the summer of 2018. For the most part, the replacement gas line will run along existing road rights of way through the Cities of Coquitlam, Burnaby and Vancouver.

Fortis BC has retained Great Northern Engineering Consultants (GNEC) to support them and their design team to assist with providing traffic management advice as they proceed forward with community and stakeholder consultation, detailed design and permit approvals. As part of the early work, GNEC was requested to provide a high level review of the traffic management considerations on the affected road corridors. This will be supported with later traffic modelling that will assist in determining the likely traffic impacts and the development of traffic management strategies to mitigate the impacts as far as possible. This report documents the high level preliminary review of the Burnaby segment based on information available at the time. Similar reports will be produced for the Vancouver and Coquitlam segments.

Proposed Alignment

The proposed alignment of the gas line within the City of Burnaby is provided in ***Appendix A***. As can be seen the alignment from east to west is generally:

- West along Broadway from North Road;
- West across Gaglardi Way;
- Southwest along the west side of Gaglardi Way to Broadway;
- West along the Broadway alignment through the BC Hydro right of way to Underhill Avenue
- West along Broadway to Springer Avenue;
- North on Springer Avenue to Halifax Street;
- West on Halifax Street to Delta Avenue;
- North on Delta Avenue to Highlawn Drive;
- West on Highlawn Drive to Midlawn Drive;
- West on Midlawn Drive to Fairlawn Drive;
- South on Fairlawn Drive to Brentlawn Drive;
- West on Brentlawn Drive across Willingdon Avenue to Graveley Street;
- West on Graveley Street to Carleton Avenue;
- Either:
    - West across the park across Gilmore Avenue/Douglas Road to Graveley Street; or
    - South on Carlton Avenue, west across vacant lot, north on Gilmore Avenue, and west on Graveley Street(See ***Appendix B***); and
- West on Graveley Street across Boundary Road into the City of Vancouver.

Broadway is a major east/west arterial connecting Coquitlam and Burnaby that also provides access to residential/commercial/institutional properties north and south. Between North Road and Gaglardi Way

there is a raised central median on Broadway with two through lanes in each direction. Between Gaglardi Way and Production Way/Forest Grove Drive, Broadway has single lanes in each direction with a raised median separation.

On Broadway between Underhill Avenue and Springer Avenue, there are single lanes in each direction with no median islands. Springer Avenue, Halifax Street, Delta Avenue, Highlawn Drive, Midlawn Drive and Brentlawn Drive all have single lanes in each direction. West of Willingdon Avenue, Graveley Street, and Carleton Avenue also all have single lanes in each direction.

The following signalized intersections exist along the alignment and may be directly or indirectly affected by the gas line works:

- Como Lake Avenue/North Road/Broadway;
- Broadway/Gaglardi Way (E);
- Broadway/Gaglardi Way (W);
- Broadway/Underhill Avenue;
- Broadway/Lake City Way;
- Broadway/Sperling Avenue;
- Broadway/Kensington Avenue (E);
- Broadway/Kensington (W);
- Broadway/Holdom Avenue; and
- Graveley Street/Brentlawn Drive/Willingdon Avenue.

The following unsignalized intersections exist along the alignment and may be directly or indirectly affected by the gas line works:

- Broadway/Production Way/Forest Grove Drive;
- Broadway/Lawrence Drive;
- Broadway/Camrose Drive;
- Broadway/Phillips Avenue;
- Broadway/Duthie Avenue;
- Broadway/Bainbridge Avenue;
- Broadway/Ellerslie Avenue (E);
- Broadway/Cliff Avenue;
- Broadway/Ellerslie Avenue (W);
- Broadway/Kingsford Avenue;
- Broadway/Woolwich Avenue;
- Broadway/Fell Avenue;
- Broadway/Buchanan Drive;
- Broadway/Springer Avenue;
- Springer Avenue/Ridgelawn Drive;
- Springer/Halifax Street;
- Halifax Street/Woodway Place;
- Halifax Street/Taralawn Court;

- Halifax Street/Delta Avenue;
- Delta Avenue/Brentlawn Drive;
- Delta Avenue/Highlawn Drive;
- Highlawn Drive/Beta Avenue;
- Highlawn Drive/Midlawn Drive;
- Midlawn Drive/Fairlawn Drive;
- Fairlawn Drive/Brentlawn Drive;
- Graveley Street/Whitsell Avenue;
- Graveley Street/Rosser Avenue;
- Graveley Street/Dent Avenue;
- Graveley Street/Madison Avenue;
- Graveley Street/Carleton Avenue;
- Graveley Street/Douglas Road/Gilmore Avenue;
- Graveley Street/MacDonald Avenue;
- Graveley Street/Ingleton Avenue; and
- Graveley Street/Boundary Road.

Construction Approach

Based on preliminary advice from Fortis BC, it is intended that the gas line crossing of the following major roads/intersections in Burnaby will be achieved using trenchless technology:

- Broadway/North Road;
- Broadway/Gaglardi Way (E);
- Broadway/Production Way/Forest Grove Drive;
- Broadway/Underhill Avenue;
- Broadway/Lake City Way;
- Broadway/Holdom Avenue;
- Graveley Street/Brentlawn Drive/Willingdon Avenue;
- Graveley Street/Douglas Road/Gilmore Avenue; and
- Graveley Street/Boundary Road.

Between the intersections listed above and across the minor intersections, the gas line will be constructed using an open cut approach that will require approximately 200-1000m of road space occupation at any one time depending on site conditions. It is currently anticipated that full road closures will be required on Broadway west of Gaglardi Way and around Brentwood Mall in the vicinity of the work zones, requiring traffic to detour to alternate routes. On Broadway between Gaglardi Way and North Road, it is currently proposed to close two of the existing four lanes for construction. Due to the nature of construction, it is expected that the road occupation will be on a full time basis possibly limiting the ability to open/close lanes by time of day.

The proposed alignment and construction approach will impact all modes of traffic as discussed in the sections that follow.

Special Road Users

The Burnaby segment of the proposed alignment is currently used by a number of special road users as discussed below.

Cycle Routes

The existing designated cycle routes within the City of Burnaby are illustrated in ***Figure 1***. The following routes are in proximity to or on the proposed gas line alignment:

- Forest Grove Drive;
- Underhill Avenue;
- Broadway;
- Sperling Avenue;
- Holdom Avenue;
- Springer Avenue;
- Halifax Street;
- Brentlawn Drive;
- Graveley Street;
- Gilmore Avenue; and
- Carlton Drive.

Since gas line construction will take place on or in the vicinity of the above routes, cyclists will need to be accommodated on site or alternatively detoured to alternate routes.

Figure 1 – Burnaby Cycle Routes

Pedestrian Routes

The only section of Urban Trail potentially affected by the gas line construction is the section of Broadway between Underhill Avenue and Lake City Way where there is a separated shared use pathway on the north side. For the remainder of the corridor, sidewalks have been provided on one or both sides of the streets.

There are a number of major pedestrian generators in the area as follows:

- Commercial/industrial/office developments south of Broadway between Lake City Way and Gaglardi Way;
- SkyTrain stations along the Lougheed Highway corridor;
- Brentwood Mall east of Willingdon Avenue;
- Commercial/residential developments west of Willingdon Avenue; and
- Commercial/industrial/office developments near Graveley Street east of Boundary Road.

Pedestrian access to/from the above generators will need to be maintained.

At the intersections that will be crossed using an open cut approach, pedestrians will need to be accommodated at the intersections or alternatively detoured to alternate routes. Where possible the existing sidewalks should be retained along the corridor. If this is not feasible, pedestrians may need to be diverted to alternate facilities in close proximity.

Bus Routes

The existing TransLink/Coast Mountain Bus Company bus routes within the project area are illustrated in ***Figure 2***.

Figure 2 – Bus Routes

As can be seen, the following bus routes may be affected by the gas line construction:

- Broadway east of Gaglardi Way (#143)
- Production Way/Forest Grove Drive (#145, #136)
- Broadway (#134, # 136, #144)
- Underhill Avenue (#134)
- Lake City Way/Arden Avenue (#134)
- Duthie Avenue (#144)

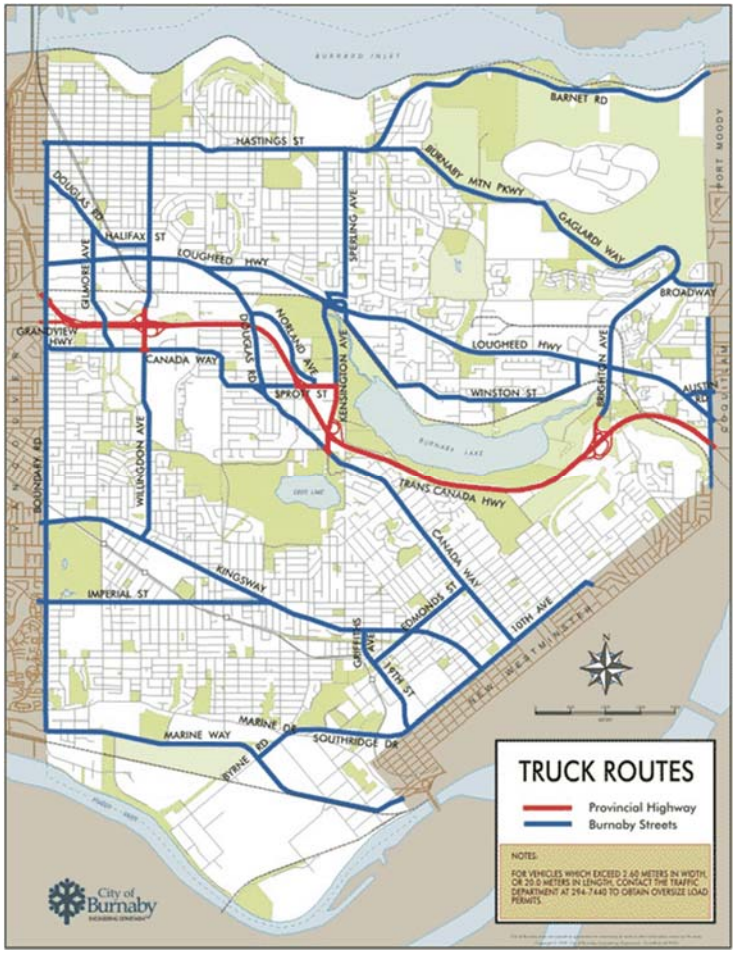
- Sperling Avenue (#134)
- Fell Avenue (#136)
- Holdom Avenue (#129, #136)
- Delta Avenue (#134)
- Brentlawn Drive (#134)
- Fairlawn Drive (#134)
- Midlawn Drive (#134)
- Willingdon Avenue (#130, #134)
- Gilmore Avenue (#129)
- Boundary Road (#28)

Where bus routes or stops will be affected by the gas line construction, suitable alternative arrangements will need to be made with TransLink/Coast Mountain Bus Company.

Truck Routes

The City of Burnaby's official truck routes are presented in ***Figure 3***.

Figure 3 – Designated Truck Routes



As can be seen, the following routes on or crossing the proposed gas line are truck routes:

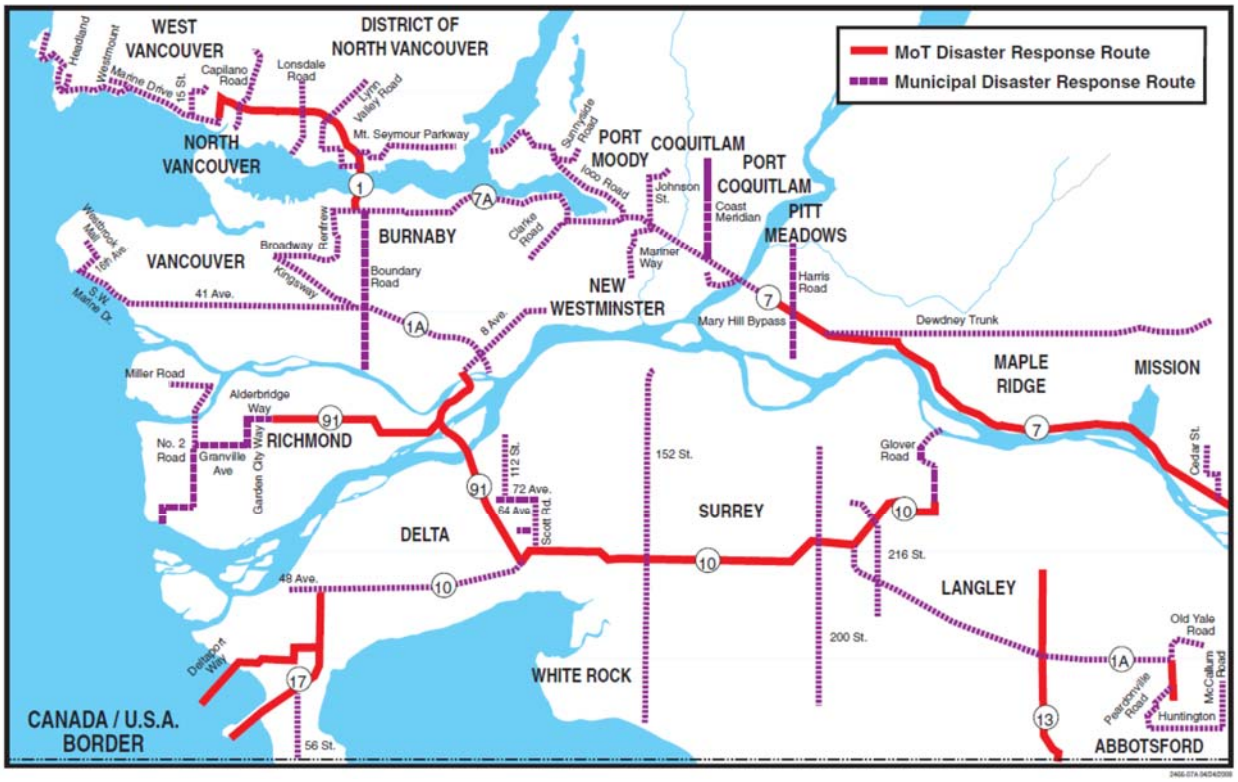
- Broadway east of Gaglardi Way;
- Sperling Avenue;
- Willingdon Avenue;
- Halifax Street;
- Gilmore Avenue;
- Douglas Road; and
- Boundary Road.

During gas line construction the truck routes should be maintained as far as practically possible as there are limited alternate routes available in the immediate proximity.

Disaster Response Routes

The designated Disaster Response Routes in the Lower Mainland are shown in ***Figure 4***. There are no designated Disaster Response Routes within the City of Burnaby that could be directly affected by the proposed gas line construction.

Figure 4 – Disaster Response Routes



On-Street Parking

On-street parking is currently permitted along the following portions of the gas line alignment:

- Broadway from Bainbridge Ave to Springer Avenue;
- Springer Ave from Broadway to Halifax Street;
- Halifax Street from Springer Ave to Delta Avenue;
- Delta Avenue from Halifax Street to Highlawn Drive;
- Highlawn Drive from Delta Avenue to Midlawn Drive;
- Midlawn Drive from Highlawn Drive to Fairlawn Drive;
- Fairlawn Drive from Midlawn Drive to Brentlawn Drive;
- Brentlawn Drive from Fairlawn Drive to Willingdon Avenue; and
- Graveley Street from Willingdon Avenue to Ingleton Avenue.

The on-street parking above will likely be affected by the proposed gas line construction and alternative arrangements will need to be made with affected residents.

Accesses

There are numerous properties that have existing direct access to the roads affected by the proposed gas line alignment. These include the accesses listed in ***Table 1*** based on preliminary observations from Google Earth©.

Table 1 – Property Accesses

Road	From	To	Side of Road	# Residential Accesses	# Commercial/ Industrial/Institutional Accesses
Broadway Avenue	Lake City Way	Duthie Avenue	North	11	
			South	14	
Broadway Avenue	Duthie Avenue	Sperling Avenue	North	17	
			South	20	
Broadway Avenue	Sperling Avenue	Kensington Avenue (E)	North	10	
			South	11	
Broadway Avenue	Kensington Avenue (E)	Kensington Avenue (W)	North	1	
Broadway Avenue	Fell Avenue	Holdom Avenue	North	2	
			South	4	
Broadway Avenue	Holdom Avenue	Springer Avenue	North	6	
			South	3	
Halifax Street	Springer Avenue	Delta Avenue	North	8	
Delta Avenue	Halifax Street	Highlawn Drive	East	1	
Graveley Street	Willingdon Avenue	Carlton Avenue	North	2	
			South	50	
Graveley Street	Gilmore Avenue	Ingleton Avenue	North		9
			South		8

The above accesses will need to be maintained or alternative arrangements made with the affected property owners during construction. It is observed that in many cases, the affected properties have rear access (not facing the gas line corridor). The major exception is Graveley Street between Willingdon Avenue and Carlton Avenue where the properties to the south have no alternative access. This area will require special attention in order to maintain access for the residents and business owners.

Existing Traffic Operations

GNEC will be arranging new traffic counts in the summer of 2014 and detailed capacity analysis will then be performed to determine the existing operations of the intersections within Burnaby that may be affected by gas line construction. As part of this work traffic models will be created for the Broadway and Lougheed Highway corridors and the major intersecting north/south streets. These models will assist in assessing existing traffic operations and the operations associated with any lane reductions during construction and in turn help define the minimum laning requirements during construction. This later work will be documented in future reports to be produced by GNEC and it is expected that the analysis and findings presented below will be superseded at that time.

Broadway is a secondary major east/west arterial linking the City of Coquitlam with the City of Burnaby. It also provides access to local residential and commercial areas on either side of the road. Broadway carries relatively high traffic volumes at times during the week. From the limited traffic data currently available from the City of Burnaby, the weekday peak hour traffic volumes on Broadway were estimated as per ***Table 2***.

Table 2 – Broadway Peak Hour Volumes

Road	Location	Eastbound Volume (veh/hr)	Westbound Volume (veh/hr)	Eastbound Volume (veh/hr)	Westbound Volume (veh/hr)
		AM Peak		PM Peak	
Broadway	East of Gaglardi Way	448	2409	1897	670
Broadway	West of Fell Avenue	165	552	563	269
	East of Fell Avenue	178	553	546	270
	West of Duthie Avenue	260	909	729	419
	East of Duthie Avenue	204	724	557	343

It is observed that In the AM peak period westbound volumes are significantly higher than the eastbound volumes, with the reverse occurring in the PM peak period.

East of Gaglardi Way, Broadway carries exceptionally high traffic volumes westbound in the AM peak hour and eastbound in the PM peak hour. With directional volumes in the 1900-2400 veh/hr range and two lanes in each direction, any full time lane closures during gas line construction as currently proposed will likely cause significant congestion. The closest and most logical parallel route to this section of Broadway is Lougheed Highway which is heavily congested during the AM and PM peak periods. It is unlikely that Lougheed Highway will be able to accommodate the diverted volumes from Broadway if lanes are closed without causing significant additional congestion. It thus appears based on the available data that full time closure of two lanes on this section of Broadway between Gaglardi Way and North Road may not be feasible. Alternative construction techniques may therefore need to be explored for this area.

West of Gaglardi Way, directional volumes on Broadway vary between 165 and 909 veh/hr. With the currently proposed full closure of sections of Broadway during construction, these volumes will need to be diverted to alternate parallel routes. Here again, the closest and most logical parallel route is Lougheed Highway which is heavily congested during the AM and PM peak periods. It is unlikely that Lougheed Highway will be able to accommodate the diverted volumes without causing significant additional congestion. As an alternative to full closures of sections of Broadway as proposed, it may be advisable, if feasible, to close a single lane retaining single lane alternating traffic on the other lane controlled by temporary traffic signals. The added advantage of this approach is that bus routes can be retained and access to properties can be better maintained than with a full closure.

There are a number of intersections within Burnaby that are currently proposed to be crossed using open cuts that have been identified as potentially being problematic. These include:

- Broadway/Duthie Avenue – high volumes on Duthie Avenue north of Broadway turning at the unsignalized intersection;
- Broadway/Bainbridge Avenue – high volumes on Bainbridge Avenue south of Broadway turning at the unsignalized intersection;
- Broadway/Sperling Avenue – high volumes on Sperling Avenue north of Broadway turning at the unsignalized intersection;
- Broadway/Kensington (east and west) - high volumes at both intersections; and
- Broadway/Springer Avenue – high volumes on all approaches

If the above intersections are to be crossed using open cuts, traffic entering/exiting Broadway will be required to detour to alternate routes (if available). This could create congestion on the alternate routes as well as where the alternate routes connect with Broadway. This will be assessed later once the new traffic count data is available.

Traffic Management Considerations

Based on the information presented above, there are a number of considerations for traffic management planning associated with the proposed gas line replacement project in the City of Burnaby. These are summarized below:

- Special attention will need to be given to accommodating the bus routes and stops on and crossing Broadway during construction.

- There are numerous properties that have existing direct access to the roads along which the proposed gas line will run. During construction, these accesses will have to be maintained or alternative arrangements will need to be made with property owners. It is observed that in many cases, the affected properties have rear access (not facing the gas line corridor). The major exception is Graveley Street between Willingdon Avenue and Carlton Avenue where the properties to the south have no alternative access. This area will require special attention in order to maintain access for the residents
- On-street parking on all the residential streets will likely be affected by gas line construction. Alternative arrangements will need to be made with affected residents.
- Preliminary analysis suggests that the currently proposed closure of two lanes on Broadway east of Gaglardi Way will cause significant congestion on Broadway as well as on the alternate Lougheed Highway route. Alternative construction techniques may therefore need to be explored for this area.
- On Broadway west of Gaglardi Way, the currently proposed full closures will require traffic diversion to primarily Lougheed Highway. This will cause additional congestion on Lougheed Highway which already experiences congestion during the AM and PM peak periods. As an alternative to full closures of sections of Broadway, it may be advisable, if feasible, to close a single lane retaining single lane alternating traffic on the other lane controlled by temporary traffic signals.
- Consideration may need to be given to trenchless construction at the following intersections originally slated for open cut crossings:
    - Broadway/Duthie Avenue;
    - Broadway/Bainbridge Avenue;
    - Broadway/Sperling Avenue;
    - Broadway/Kensington (east and west); and
    - Broadway/Springer Avenue .

It is stressed that the above findings are based on information available at the time of this report. These findings will be reassessed later once the new summer 2014 traffic counts become available.

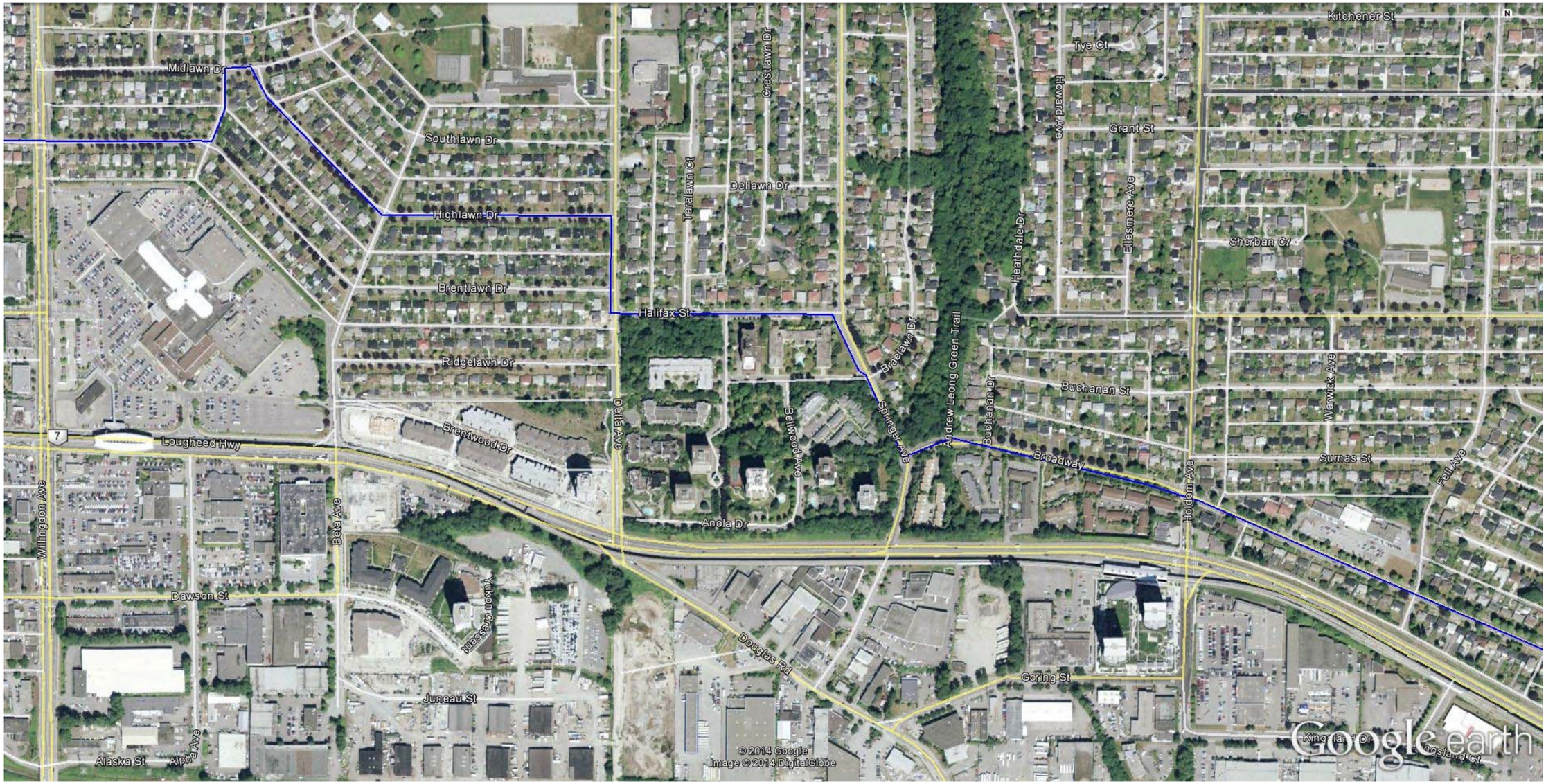
Appendix A – Preliminary Gas Line Alignment

Burnaby Alignment – Section 1

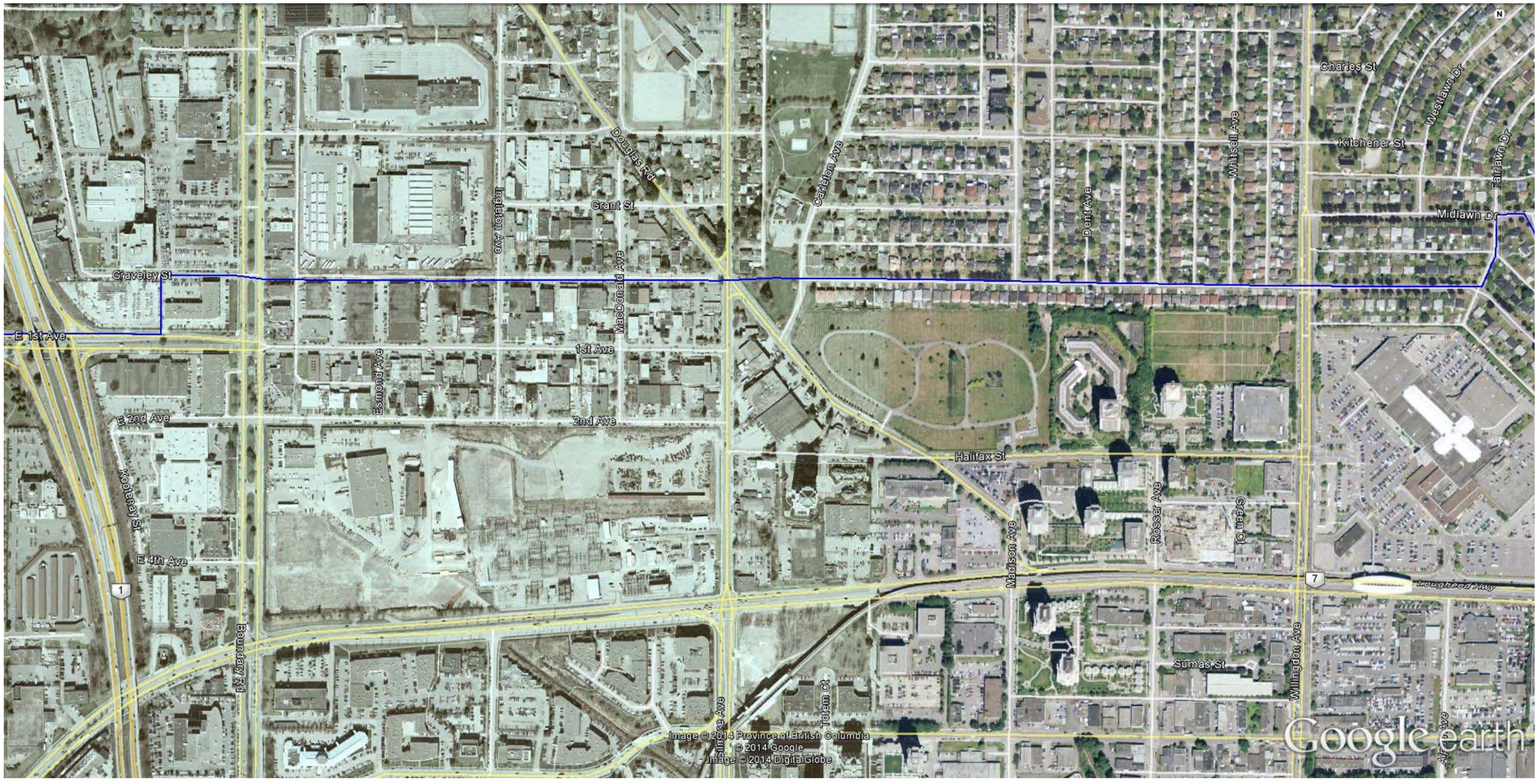
Burnaby Alignment – Section 2

Burnaby Alignment – Section 3

Burnaby Alignment – Section 4

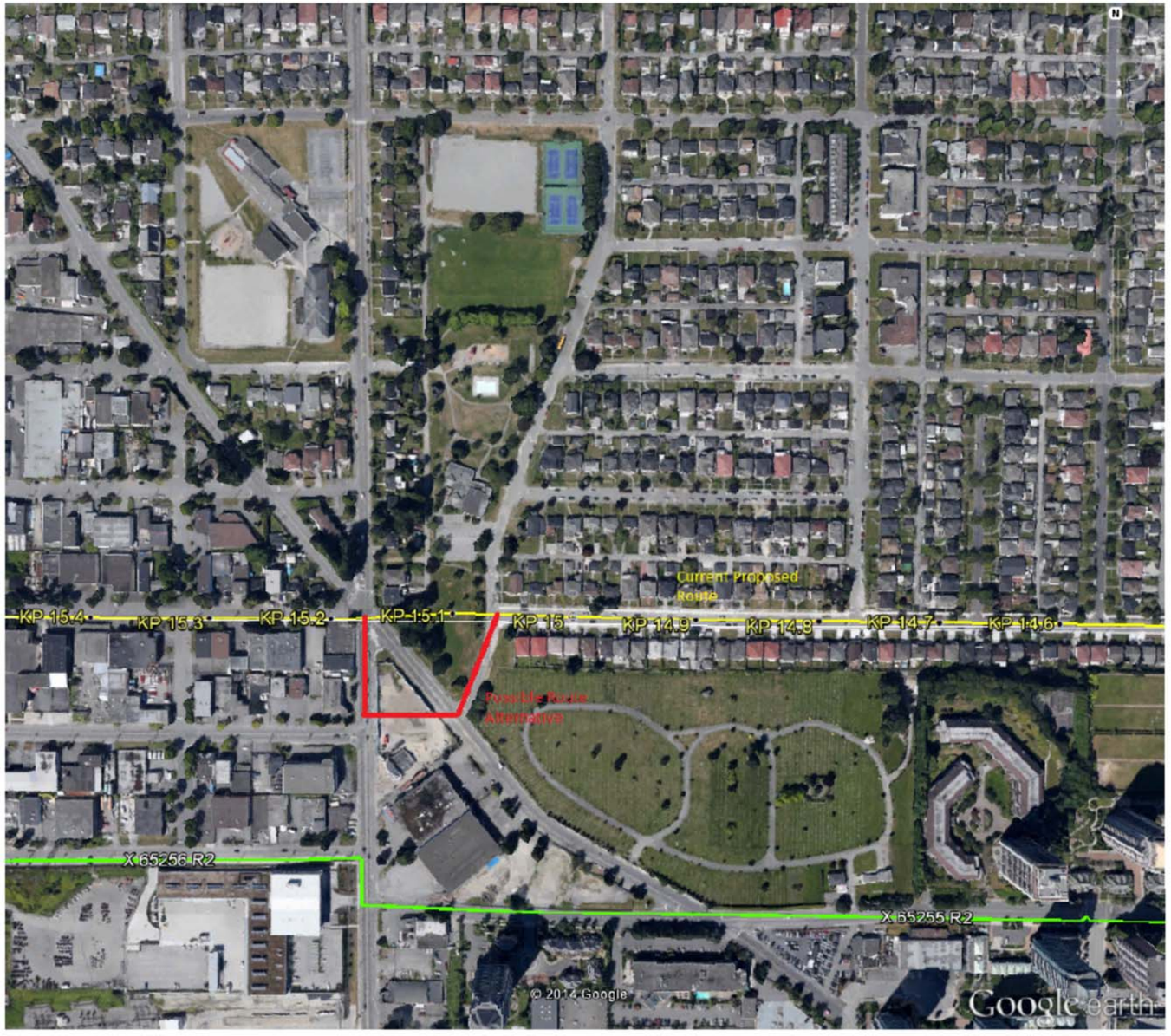


Burnaby Alignment – Section 5



Appendix B – Willingdon Park Alternative

Willingdon Park Alternative



Appendix A-18-3

PRELIMINARY TRAFFIC MANAGEMENT REVIEW
VANCOUVER SEGMENT

GNEC
GREAT NORTHERN ENGINEERING CONSULTANTS INC.

Coquitlam IP Pipeline Replacement Project Preliminary Traffic Management Review - Vancouver Segment - Final

July 29, 2014

Submitted to: FORTIS BC

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Appendix A – Preliminary Gas Line Alignment

Introduction

Fortis BC is proposing to replace the existing 20km long NPS 20 Coquitlam IP Pipeline between Coquitlam (Como Lake Avenue/Mariner Way intersection) and Vancouver (East 2nd Avenue/Woodland Drive intersection). At present a preliminary design of the gas line has been prepared by Worley Parsons and it is expected that construction will take place during the summer of 2018. For the most part, the replacement gas line will run along existing road rights of way through the Cities of Coquitlam, Burnaby and Vancouver

Fortis BC has retained Great Northern Engineering Consultants (GNEC) to support them and their design team to assist with providing traffic management advice as they proceed forward with community and stakeholder consultation, detailed design and permit approvals. As part of the early work, GNEC was requested to provide a high level review of the traffic management considerations on the affected road corridors. This will be supported with later data collection and traffic modelling that will assist in determining the likely traffic impacts and the development of traffic management strategies to mitigate the impacts as far as possible. This report documents the high level preliminary review of the Vancouver segment based on information available at the time. Similar reports have been produced for the Coquitlam and Burnaby segments.

Proposed Alignment

The proposed alignment of the gas line within the City of Vancouver is provided in ***Appendix A***. As can be seen the alignment from east to west is generally:

- West across Boundary Road along Graveley Street;
- South to E 1st Avenue through the Vancouver Police Department parking lot;
- West along E 1st Avenue to Woodland Drive;
- Across Woodland Drive on the north side of E 1st Avenue; and
- South on the west side of Woodland Drive across E 1st Avenue to the end point just south of E 2nd Avenue.

Graveley Street west of Boundary Road is a local two lane access road that connects to Kootenay Street and provides access to the commercial/industrial properties as well as the Vancouver Police Department headquarters. It is a cul-de-sac with the only connection to the local street network being at Boundary Road.

E 1st Avenue is a major east/west arterial connecting Vancouver and Highway 1. On E 1st Avenue between Boundary Road and Nanaimo Street, there is a raised central median (except for at intersections) with two through lanes in each direction. West of Nanaimo Street, there are two through lanes in each direction with no median. Left turn lanes have been provided on E 1st Avenue at the following locations:

- Boundary Road;
- Highway 1;
- Renfrew Street;
- Nanaimo Street; and
- Commercial Drive.

At intersections other than those listed above, left turn movements from E 1st Avenue occur from the inside lane except where left turns are prohibited as follows:

- Victoria Drive – westbound left prohibited 7:00-9:30am and 3:00-6:00pm Monday to Friday, eastbound left prohibited full time.

The following signalized intersections may be directly or indirectly affected by the gas line works:

- Boundary Road/E 1st Avenue;
- E 1st Avenue/Highway 1 Eastbound;
- E 1st Avenue/Highway 1 West bound;
- E 1st Avenue/Rupert Street;
- E 1st Avenue/Lillooet Street (Pedestrian signal);
- E 1st Avenue/Renfrew Street;
- E 1st Avenue/Slocan Street (Pedestrian signal);
- E 1st Avenue/Nanaimo Street;
- E 1st Avenue/Templeton Drive (Pedestrian signal);
- E 1st Avenue/Lakewood Drive (Pedestrian signal);
- E 1st Avenue/Victoria Drive;
- E 1st Avenue/Commercial Drive; and
- E 1st Avenue/Woodland Drive (Pedestrian signal).

Construction Approach

Based on preliminary advice from Fortis BC, the gas line crossing of Boundary Road at Graveley Street will be completed using trenchless technology. West of Boundary Road the line will be constructed using an open cut down the center of Graveley Street.

On the currently proposed E 1st Avenue alignment, it is intended that the gas line crossing of the following major roads/intersections will be achieved using trenchless technology:

- Highway 1;
- Rupert Street;
- Renfrew Street;
- Nanaimo Street; and
- Commercial Drive.

Between the major intersections listed above and across the minor intersections, the gas line will be constructed using an open cut approach that will require approximately 200-1000m of road space occupation at any one time depending on site conditions. Based on preliminary information provided by Fortis BC, it is proposed to construct the gas line along the north side of the center median of E 1st Avenue in the westbound lanes between Highway 1 and Nanaimo Street. The existing westbound lanes in this area would be closed between the major intersections thereby requiring closures up to 1km at a time. West of Nanaimo Street where there is no median, both westbound lanes on E 1st Avenue would also be closed, however, the length of the closures is expected to be less than 1000m. Due to the nature of

construction, it is expected that the road occupation will be on a full time basis limiting the ability to open/close lanes by time of day.

The currently proposed gas line alignment and construction approach will impact all modes of traffic as discussed in the sections that follow.

Special Road Users

The Vancouver segment of the proposed alignment is currently used by a number of special road users as discussed below.

Cycle Routes

The existing designated cycle routes within the City of Vancouver are illustrated in ***Figure 1***. There are no cycle routes that travel along the E 1st Avenue corridor, however, the following routes cross E 1st Avenue:

- Slocan Street;
- Lakewood Drive; and
- Woodland Drive.

Since the above routes will be crossed using an open cut approach, cyclists will need to be accommodated at the intersections or alternatively detoured to alternate routes.

Pedestrian Routes

E 1st Avenue is a popular pedestrian route with sidewalks provided on both sides of the street. Sidewalks have also been provided on one or both sides of the north/south intersecting streets. In addition to the pedestrian signal crossings listed earlier, there is an unsignalized pedestrian crossing of E 1st Avenue at Penticton Street.

There are a number of pedestrian generators in the area as follows:

- Clinton Park located on the north side of E 1st Avenue between Penticton Street and Slocan Street;
- Begbie Elementary School located north of E 1st Avenue at Lilooet Street/Kitchener Avenue;
- Maquinna Elementary School located south of E 1st Avenue at E 2nd Avenue/Slocan Street;
- Nelson Elementary School located north of E 1st Avenue at Templeton Street/Kitchener Avenue;
- Queen Victoria Annex located south of E 1st Avenue at E 3rd Avenue/Victoria Drive; and
- Commercial developments near and along Commercial Drive, Nanaimo Street, and Renfrew Street.

At the intersections that will be crossed using an open cut approach, pedestrians will need to be accommodated at the intersections or alternatively detoured to alternate parallel routes. Where possible the existing sidewalks on E 1st Avenue should be retained. If this is not feasible with the proposed closure of the westbound traffic lanes, pedestrians on the north sidewalk will need to be diverted to the south side of the street in the vicinity of the construction zones. Temporary pedestrian crossings may need to be installed to maintain connectivity where required.

Figure 1 – Vancouver Cycle Routes

Bus Routes

The existing TransLink/Coast Mountain Bus Company bus routes within the project area are illustrated in ***Figure 2***.

Figure 2 – Bus Routes

There are no bus routes that travel along the E 1st Avenue corridor, however, the following routes cross E 1st Avenue:

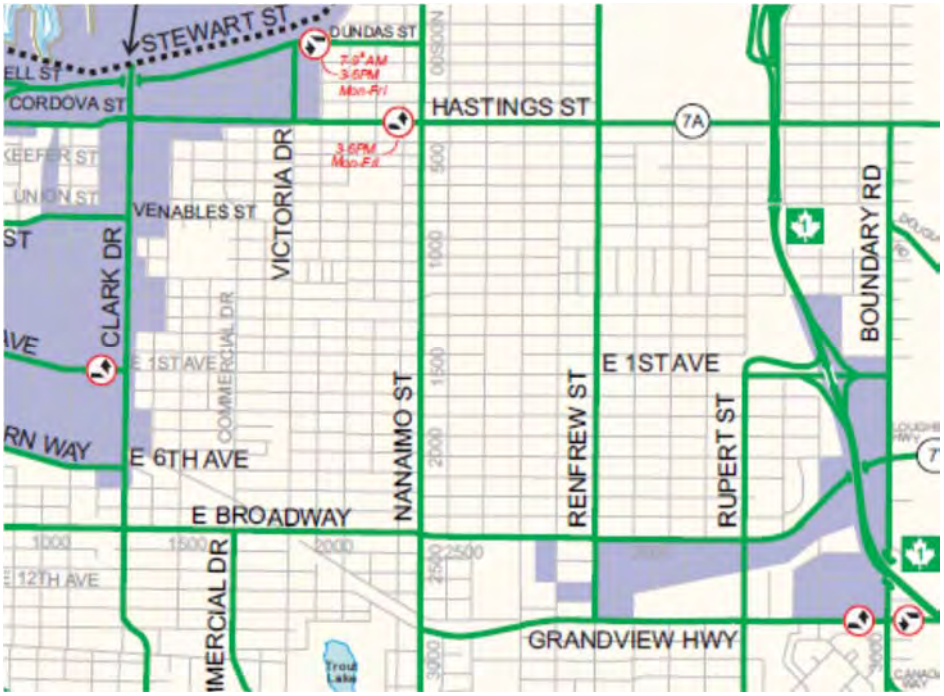
- #28 along Boundary Road;
- #27 along Rupert Street;
- #16 along Renfrew Street;
- #7 along Nanaimo Street; and
- #20 along Commercial Drive.

The gas line across the above roads is expected to be constructed using trenchless technology, so no direct impacts to the bus routes are expected. If there is major traffic diversion off E 1st Avenue during construction onto these roads or the parallel E Hastings Street and E Broadway corridors, buses may incur additional delays due to congestion.

Truck Routes

The City of Vancouver's official truck routes are presented in ***Figure 3***.

Figure 3 – Designated Truck Routes



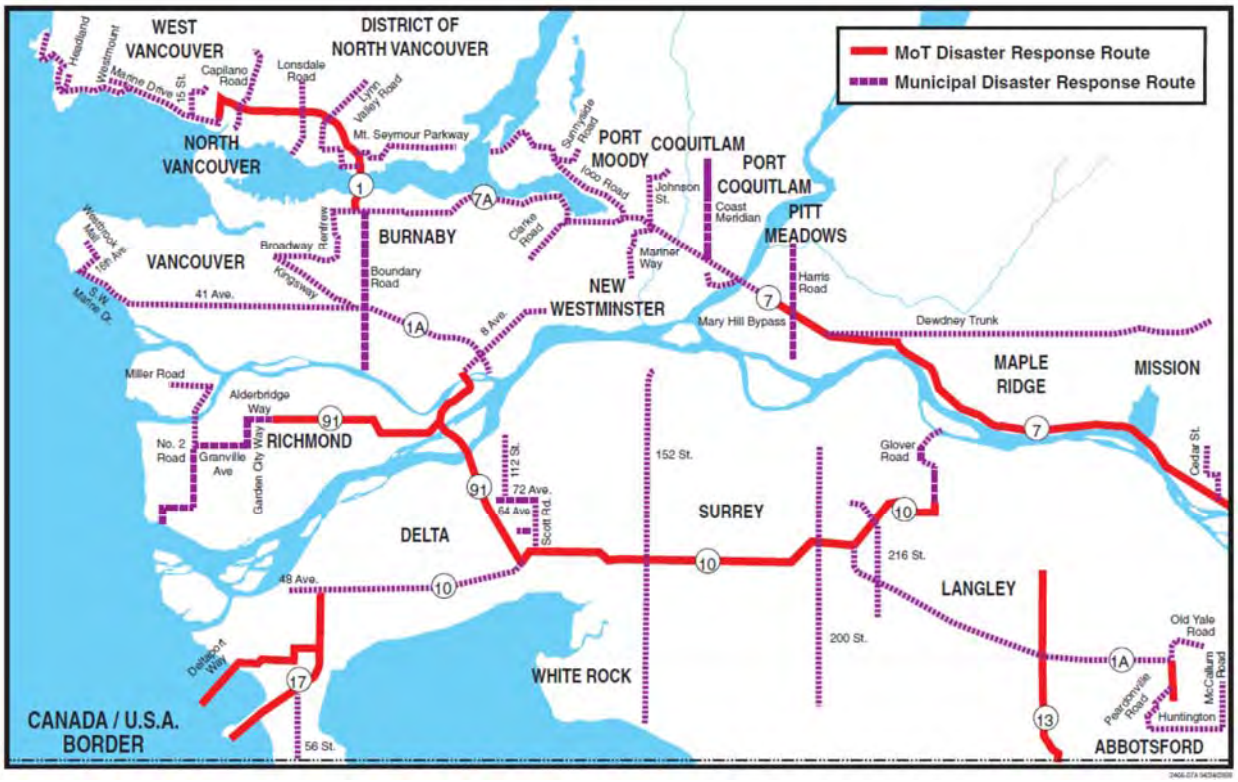
As can be seen, E 1st Avenue is a truck route between Rupert Street and Boundary Road, however, since most of the construction work in this area will be trenchless, impacts to trucks are expected to be minimal. E 1st Avenue is not a truck route west of Rupert Street, however, the following truck routes may be affected by the project works although the routes are expected to be crossed using trenchless technology:

- Boundary Road;
- E 1St Avenue between Boundary Road and Rupert Street;
- Renfrew Street; and
- Nanaimo Street.

Disaster Response Routes

The designated Disaster Response Routes in the Lower Mainland are shown in ***Figure 4***. There are no designated Disaster Response Routes within the City of Vancouver that will be directly affected by the proposed gas line construction. The Highway 1, Highway 7A, and Renfrew Street routes are however located nearby and need to be considered during future traffic management planning.

Figure 4 – Disaster Response Routes



On-Street Parking

There is existing on-street parking that is permitted along the proposed alignment within Vancouver as follows:

- Graveley Street west of Boundary Road – both sides; and
- Woodland Drive north and south of E 1st Avenue – both sides.

This parking may need to be temporarily prohibited adjacent to the gas line work zones during construction if necessary.

Accesses

There are numerous properties that have existing direct access to the roads affected by the proposed gas line alignment. These include the accesses listed in ***Table 1*** based on preliminary observations from Google Earth©.

Table 1 – Property Accesses

Road	From	To	Side of Road	# Residential Accesses	# Commercial/ Industrial/Institutional Accesses
Graveley Street	Boundary Rd	Midblock	South		2
E 1st Avenue	Boundary Rd	Highway 1	North		2
			South		1
E 1st Avenue	Highway 1	Rupert Street	South		2
E 1st Avenue	Rupert Street	Lillooet Street	North		1
			South		1
E 1st Avenue	Lillooet Street	Renfrew Street	North		1
			South		1
E 1st Avenue	Renfrew Street	Slocan Street	North		1
			South		2
E 1st Avenue	Slocan Street	Nanaimo Street	North		1
			South		2
E 1st Avenue	Nanaimo Street	Templeton Drive	South		2
E 1st Avenue	Victoria Drive	Commercial Drive	North	3	2
			South		1
E 1st Avenue	Commercial Drive	Woodland Drive	North		1
			South	1	2

The above accesses will need to be maintained or alternative arrangements made with affected property owners during gas line construction.

Existing Traffic Operations

Graveley Street is a local access road that connects to Kootenay Street. It is a cul-de-sac that carries low traffic volumes, however, volumes are likely to increase in the weekday AM and PM commuter peak periods. It is the only access to the Vancouver Police Department and other commercial properties in the area and, as such, will need to remain open during gas line construction. Single lane alternating traffic should be acceptable as a minimum requirement during construction.

E 1st Avenue is a major east/west arterial linking the City of Vancouver with Highway 1 and Burnaby to the east. It carries high traffic volumes for most of the day Monday to Sunday as well as at night. It is particularly heavily trafficked during the weekday AM and PM commuter peak periods. There is significant recurring congestion that occurs during these times at the following intersections:

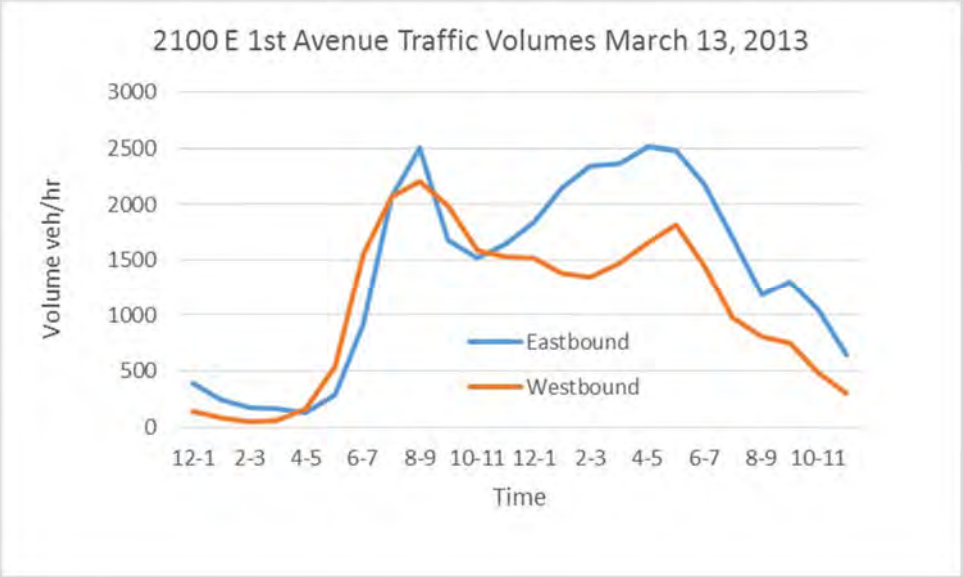
- Boundary Road;
- Highway 1 Interchange;
- Rupert Street;

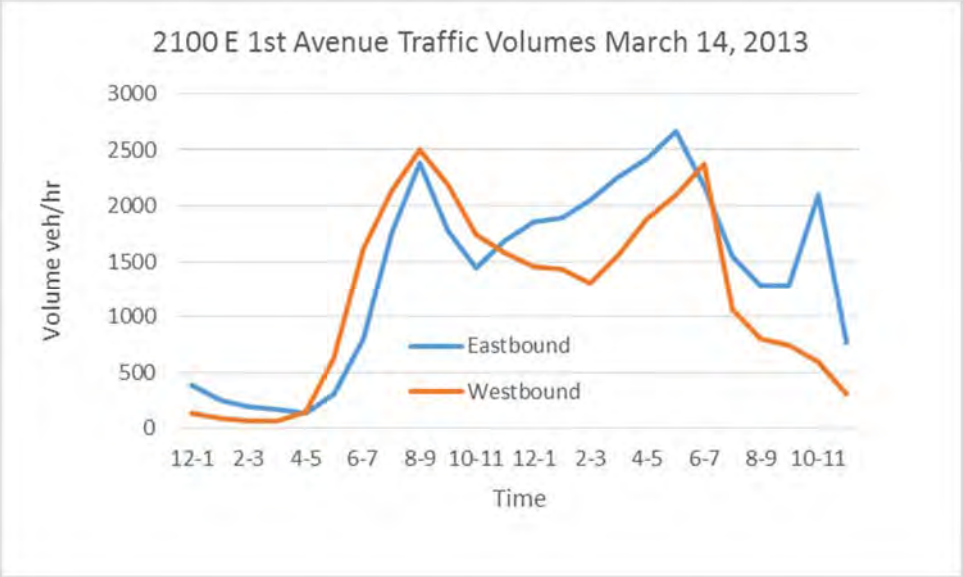
- Renfrew Street;
- Nanaimo Street;
- Victoria Drive;
- Commercial Drive; and
- Clark Drive.

GNEC will be arranging new traffic counts in the summer of 2014 and detailed capacity analysis will then be performed to determine the existing operations of the roads within Vancouver affected by the gas line construction. As part of this work traffic models will be created for the E 1st Avenue, E Hastings Street, and E Broadway corridors and the major intersecting north/south streets between Boundary Road and Clark Drive. These models will assist in assessing existing traffic operations and the operations associated with any lane reductions on E 1st Avenue and in turn help define the minimum laning requirements during construction. This later work will be documented in future reports to be produced by GNEC and it is expected that the analysis and findings presented below will be superseded at that time.

In the interim until such time that the new traffic data becomes available, a preliminary assessment of operations was performed using available traffic data. The City of Vancouver has limited current turning movement count data for the intersections along the E 1st Avenue corridor. The City does however have short count data for various sections along the E 1st Avenue corridor. This data is collected on a 24 hour basis for a few weekdays every couple of years.

The most recent data available on the City website was for the 2100 block between Lakewood Drive and Templeton Drive for March 13 and 14, 2013 (Wednesday and Thursday respectively). Over a 24hr weekday, E 1st Avenue is carrying approximately 33,500 veh/day eastbound and 27,200 veh/day westbound. The hourly traffic volumes per direction for the two days are illustrated in the charts below.





There are number of items to note in the above charts:

- There is a significant variation in traffic flows by day of week. Of interest, there was a Vancouver Canucks home game on March 14 which resulted in a “spike” in westbound traffic between 6 and 7pm, and another spike in eastbound traffic between 10 and 11pm.
- The maximum eastbound volumes are approximately 2500 veh/hr during the AM and PM peak periods.
- The maximum westbound volumes are approximately 2200-2500 veh/hr during the AM peak periods. In the PM peak period, the westbound volumes are between 1800-2300 veh/hr.
- Except for the AM peak period, westbound volumes are generally lower than the eastbound volumes.

- The data presented in the charts is March data and this may not be representative of summer traffic patterns when gas line construction is expected. This will be confirmed when the new short counts scheduled for July/August 2014 are complete.

With hourly directional traffic volumes in the 1800-2500 veh/hr range it is suspected that E 1st Avenue is operating close to its full carrying capacity during peak periods. As a rule of thumb a free flow traffic lane can carry approximately 1800 veh/hr. Since there are two lanes in each direction on E 1st Avenue, the maximum capacity between intersections is approximately 3600 veh/hr per direction. However, on a corridor like this, it is the signalized intersections that will constrain capacity. Depending on the signal operation (number of phases, timing, coordination, etc.) the lane capacity can be reduced significantly from the 1800 veh/hr/lane. Conservatively, the lane capacity is estimated at 60% of a full lane (1080 veh/hr) so with two lanes the existing directional capacity is estimated at 2160 veh/hr.

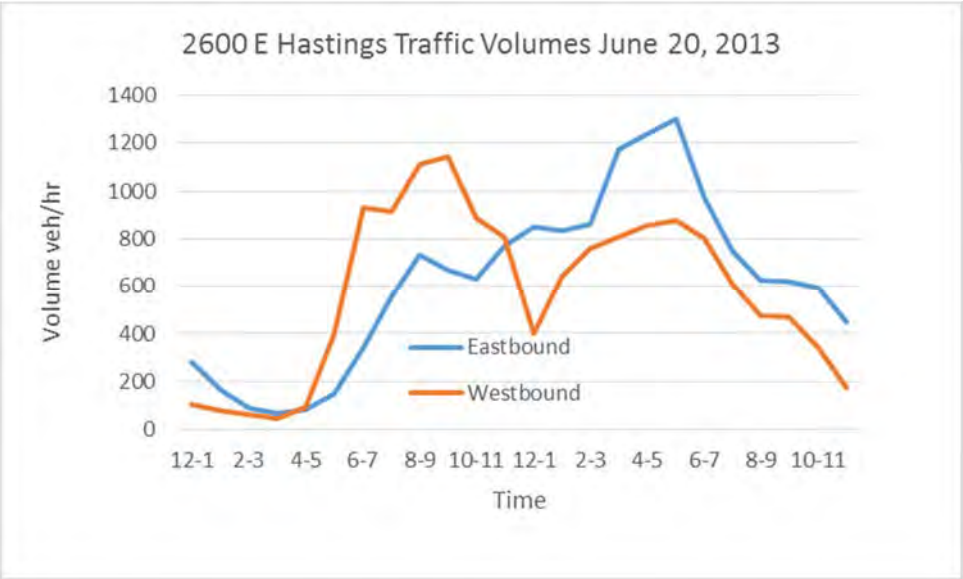
Using the estimated capacity of 1080 veh/hr/lane, the capacity of this section of E 1st Avenue by time of day was calculated as per ***Table 2***. This table also provides comment on whether there is any spare capacity on E 1st Avenue.

Table 2 – E 1st Avenue Capacity

Direction	Time Period	# of lanes	Capacity (veh/hr)	Observed Volume (veh/hr)	Spare Capacity?
Eastbound	AM Peak	2	2160	2300-2500	No
	Midday	2	2160	1500-2300	Possibly at times
	PM Peak	2	2160	2300-2500	No
Westbound	AM Peak	2	2160	2200-2500	No
	Midday	2	2160	1400-1600	Appears to be spare capacity
	PM Peak	2	2160	1800-2300	Possibly at times

Currently, it is intended to close all westbound lanes on E 1st Avenue for gas line construction. This closure would require a reroute of all westbound traffic volumes up to 2500 veh/hr to alternate routes in the peak hours. The nearby continuous east/west routes between Highway 1 and Clarke Drive are E Hastings Street and E Broadway and it is expected that these routes would carry most of the diverted traffic. The volumes and operation of these two alternative corridors was therefore assessed using City short count data.

The volumes on 2600 E Hastings Street (between Slocan and Penticton) for June 20, 2013 are illustrated in the chart below. This section of E Hastings Street has three lanes in each direction however parking in the shoulder lanes is permitted at times. In the AM peak period, there are three westbound lanes and two eastbound lanes, and in the PM peak period, there are two westbound lanes and three eastbound lanes. During the remainder of the day there are two lanes in each direction.



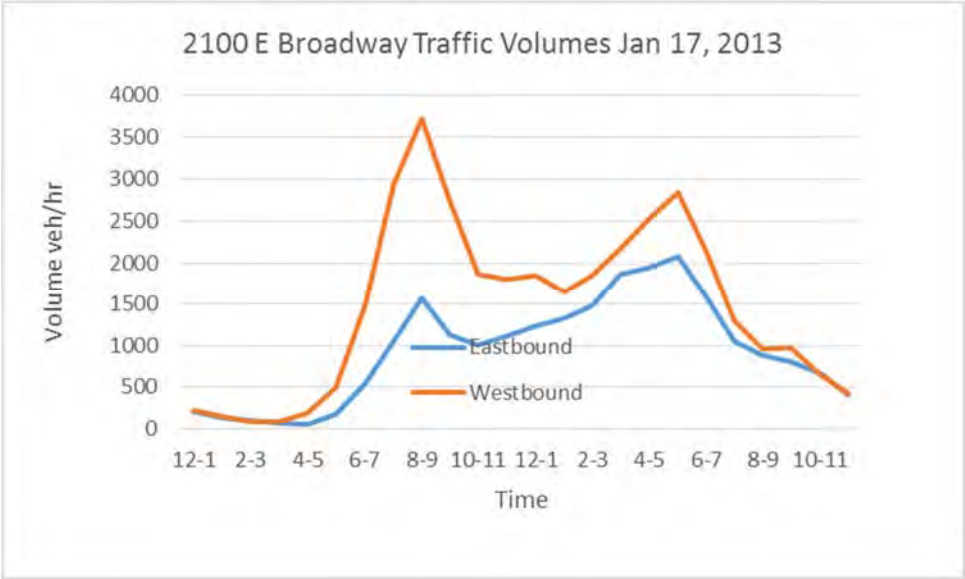
Using the estimated capacity of 1080 veh/hr/lane derived previously, the capacity of this section of E Hastings Street by time of day was calculated as per ***Table 3***.

Table 3 – E Hastings Street Capacity

Direction	Time Period	# of lanes	Capacity (veh/hr)	Observed Volume (veh/hr)	Spare Capacity?
Eastbound	AM Peak	2	2160	700	Appears to be spare capacity
	Midday	2	2160	600-1000	Appears to be spare capacity
	PM Peak	3	3240	1300	Appears to be spare capacity
Westbound	AM Peak	3	3240	1150	Appears to be spare capacity
	Midday	2	2160	400-800	Appears to be spare capacity
	PM Peak	2	2160	900	Appears to be spare capacity

Based on the above analysis, there appears to be spare capacity on E Hastings Street and it may be possible to accommodate some additional traffic volumes diverted off E 1st Avenue during construction. It is noted that the above analysis focused on one specific section of E Hastings Street and more detailed analysis will be required to confirm this finding. In addition, there are locations (e.g. at Nanaimo Street intersection) where the east/west capacity on Hastings Street is likely lower than the estimated 1080 veh/hr/lane.

A similar analysis was performed for the E Broadway corridor. The volumes on 2100 E Broadway (east of Lakewood Drive) for January 17, 2013 are illustrated in the chart below. This section of E Broadway has three lanes in each direction however parking in the shoulder lanes is permitted at times. In the AM peak period, there are three westbound lanes and two eastbound lanes, and in the PM peak period, there are three westbound lanes and two eastbound lanes. During the remainder of the day there are two lanes in each direction.



Using the estimated capacity of 1080 veh/hr/lane derived previously, the capacity of this section of E Broadway by time of day was calculated as per ***Table 4***.

Table 4 – E Broadway Capacity

Direction	Time Period	# of lanes	Capacity (veh/hr)	Observed Volume (veh/hr)	Spare Capacity?
Eastbound	AM Peak	2	2160	1600	Minimal
	Midday	2	2160	1000-1600	Appears to be spare capacity
	PM Peak	3	3240	2000	Appears to be spare capacity
Westbound	AM Peak	3	3240	3600	No
	Midday	2	2160	1800-2000	Minimal
	PM Peak	3	3240	2800	Appears to be spare capacity

Based on the above analysis, there appears to be some spare capacity on E Broadway and it may be possible to accommodate some additional traffic volumes diverted off E 1st Avenue during construction at times. It is noted that the above analysis focused on one specific section of E Broadway and more detailed analysis will be required to confirm this finding. In addition, there are locations (e.g. at Nanaimo

Street intersection) where the east/west capacity on E Broadway is likely lower than the estimated 1080 veh/hr/lane.

Compiling the data from ***Tables 2-4***, ***Table 5*** summarizes the potential of the Hastings Street and Broadway corridors to accommodate westbound traffic diverted off 1st Avenue if both westbound lanes were closed during construction (Scenario 1). This preliminary analysis suggests that the full closure of the westbound lanes of E 1st Avenue should not occur as it will likely cause major queues and congestion on the alternate parallel routes.

As an alternative to fully closing the westbound lanes of E 1st Avenue***,*** another scenario was evaluated. This Scenario 2 assumed that E 1st Avenue would be reduced to a single lane in each direction between the major intersections. ***Table 6*** summarizes the potential of the E Hastings Street and E Broadway corridors to accommodate the volume of eastbound and westbound traffic that exceeds the reduced capacity of 1st Avenue if 1st Avenue was to be restricted to single lanes during construction. This preliminary analysis suggests that the alternate Hastings/Broadway corridors may have sufficient capacity to accommodate the diverted traffic from the E 1st Avenue corridor. This Scenario 2 therefore appears to be a better option from a traffic management perspective than fully closing the westbound lanes as per Scenario 1. Scenario 2 also provides additional benefits to traffic in that it maintains east/west mobility on 1st Avenue albeit with reduced capacity.

Table 5 – Impacts of Full Westbound Lane Closures on E 1st Avenue (Scenario 1)

Direction	Time Period	1st Ave Max Volume	1st Ave Capacity	1st Ave Spare Capacity	Hastings St Max Volume	Hastings St Capacity	Hastings St Spare Capacity	Broadway Max Volume	Broadway Capacity	Broadway Spare Capacity	Total Spare Capacity on Hastings and Broadway	Volume to be diverted off 1st Ave if both WB lanes closed	Can Hastings/Broadway accommodate diversion?
		veh/hr											
Eastbound	AM Peak	2500	2160	0	700	2160	1460	1600	2160	560	2020	0	yes
	Midday	2300	2160	0	1000	2160	1160	1600	2160	560	1720	0	yes
	PM Peak	2500	2160	0	1300	3240	1940	2000	3240	1240	3180	0	yes
Westbound	AM Peak	2500	0	0	1150	3240	2090	3600	3240	0	2090	2500	no
	Midday	1600	0	0	800	2160	1360	1900	2160	260	1620	1600	yes
	PM Peak	2300	0	0	900	2160	1260	2800	3240	440	1700	2300	no

Table 6 – Impacts of Single Lane Eastbound and Westbound Closures on E 1st Avenue (Scenario 2)

Direction	Time Period	1st Ave Max Volume	1st Ave Capacity	1st Ave Spare Capacity	Hastings St Max Volume	Hastings St Capacity	Hastings St Spare Capacity	Broadway Max Volume	Broadway Capacity	Broadway Spare Capacity	Total Spare Capacity on Hastings and Broadway	Volume to be diverted off 1st Ave if 1 lane closed in each direction	Can Hastings/Broadway accommodate diversion?
		veh/hr											
Eastbound	AM Peak	2500	1080	0	700	2160	1460	1600	2160	560	2020	1420	yes
	Midday	2300	1080	0	1000	2160	1160	1600	2160	560	1720	1220	yes
	PM Peak	2500	1080	0	1300	3240	1940	2000	3240	1240	3180	1420	yes
Westbound	AM Peak	2500	1080	0	1150	3240	2090	3600	3240	0	2090	1420	yes
	Midday	1600	1080	0	800	2160	1360	2000	2160	160	1520	520	yes
	PM Peak	2300	1080	0	900	2160	1260	2800	3240	440	1700	1220	yes

Traffic Management Considerations

Based on the information presented above, there are a number of considerations for traffic management planning associated with the proposed gas line replacement project in the City of Vancouver. These are summarized below:

- Graveley Street – This road cannot be fully closed as there is no alternate access to properties on Graveley Street/Kootenay Street. At a minimum single lane alternating flow will need to be maintained west of Boundary Road.
- E 1st Avenue - The full closure of the westbound lanes (Scenario 1) as proposed is likely to cause significant congestion on the alternate Hastings Street and Broadway routes.
- E 1st Avenue – The closure of a single lane in each direction (Scenario 2) and the diversion of some traffic off E 1st Avenue onto Broadway and Hastings Street appears to be a better option than Scenario 1. This Scenario 2 will be assessed in more detail later when the summer 2014 traffic data becomes available.

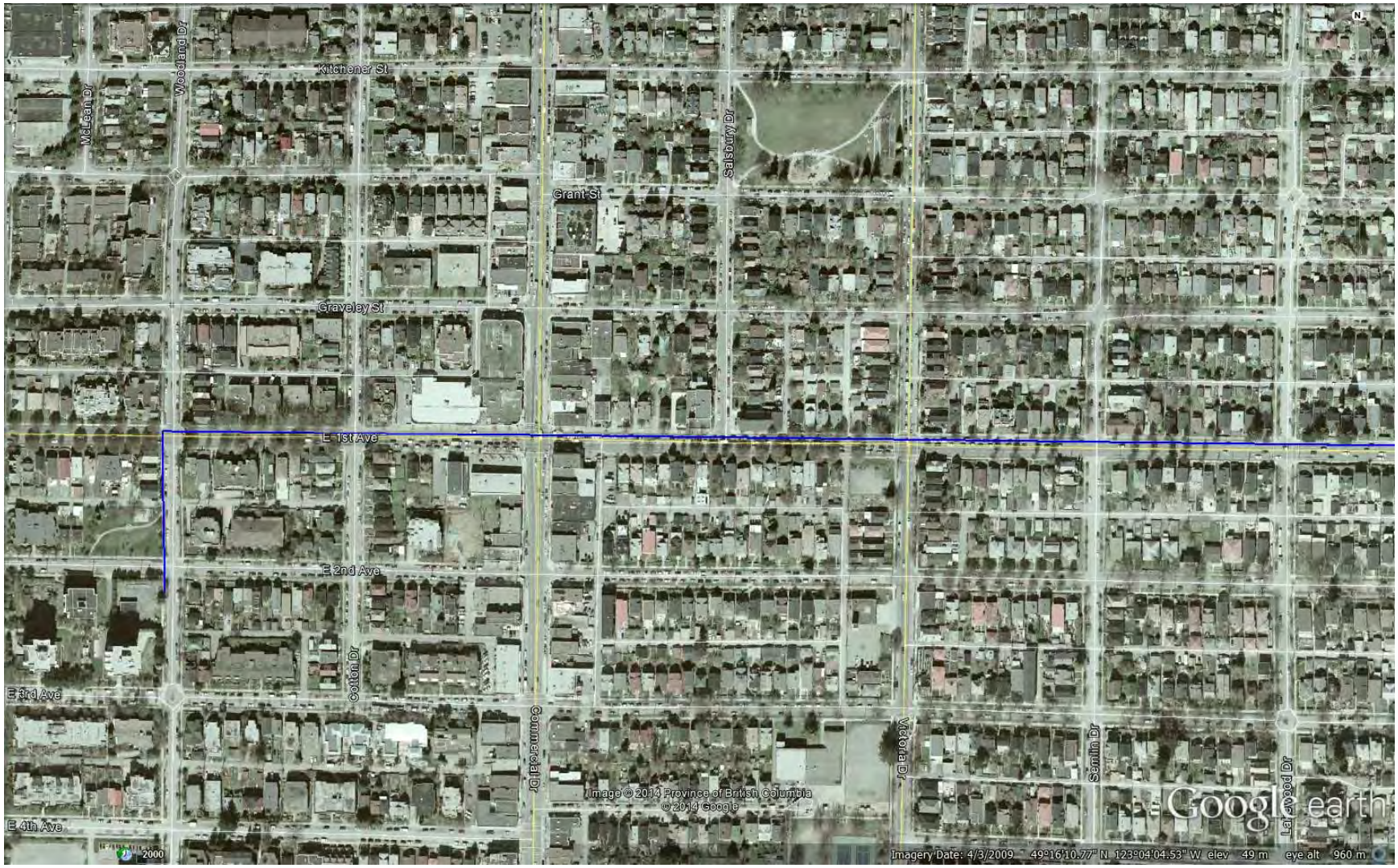
Appendix A – Preliminary Gas Line Alignment

Vancouver Alignment – Section 1

Vancouver Alignment – Section 2

Vancouver Alignment – Section 3

Vancouver Alignment – Section 4



Appendix A-18-4

COQUITLAM BASE TRAFFIC MODELLING

GNEC

GREAT NORTHERN ENGINEERING CONSULTANTS INC.

Coquitlam IP Pipeline Replacement Project
Base Traffic Modelling - Final

October 16, 2014

Submitted to: FORTIS BC

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Exhibit 2.3 - AM Peak Hour Volumes – Kensington Avenue to Lake City Way

Exhibit 2.4 - AM Peak Hour Volumes – Underhill Avenue to North Road

Exhibit 2.5 - AM Peak Hour Volumes – Clarke Road to Schoolhouse Street

Exhibit 2.6 - AM Peak Hour Volumes – Wasco Street to Mariner Way

Exhibit 2.7 – PM Peak Hour Volumes – Clark Drive to Boundary Road

Exhibit 2.8 - PM Peak Hour Volumes – Gilmore Avenue to Holdom Avenue

Exhibit 2.9 - PM Peak Hour Volumes – Kensington Avenue to Lake City Way

Exhibit 2.10 - PM Peak Hour Volumes – Underhill Avenue to North Road

Exhibit 2.11 - PM Peak Hour Volumes – Clarke Road to Schoolhouse Street

Exhibit 2.12 - AM Peak Hour Volumes – Wasco Street to Mariner Way

Introduction

Fortis BC is proposing to replace the existing 20km long NPS 20 Coquitlam IP Pipeline between Coquitlam (Como Lake Avenue/Mariner Way intersection) and Vancouver (East 2nd Avenue/Woodland Drive intersection). At present a preliminary design of the gas line has been prepared by Worley Parsons and it is expected that construction will take place during the summer of 2018. For the most part, the replacement gas line will run along existing road rights of way through the Cities of Coquitlam, Burnaby and Vancouver

Fortis BC has retained Great Northern Engineering Consultants (GNEC) to support them and their design team to assist with providing traffic management advice as they proceed forward with community and stakeholder consultation, detailed design and permit approvals. As part of the early work, GNEC was requested to assess the existing traffic conditions on the proposed alignment by collecting new summer 2014 traffic count data and performing traffic modelling. The traffic modelling would be used later in the project to assess the impacts of any proposed lane/road closures during construction and assist in the development of traffic management strategies to mitigate the impacts as far as possible. This report documents the data collection efforts and the "Base" existing conditions traffic modelling.

GNEC previously prepared three reports titled "Preliminary Traffic Management Review" for each of the three Cities of Coquitlam, Burnaby and Vancouver. These high level reports presented information and findings based on traffic data available at the time. These traffic data were however recognized as possibly not being applicable to summer conditions when the gas line is expected to be constructed. The information contained in these previous three reports pertaining to existing traffic operations is thus superseded by the information and findings in this current "Base Traffic Modelling" report.

Background

In order to define the scope of the traffic engineering work, it was first necessary to understand the proposed alignment and construction approach. These would in turn assist in defining the traffic study area, traffic data collection program and the traffic modelling requirements.

Proposed Alignment

At the commencement of the assignment, a preliminary design and preferred alignment of the LMSU gas line had been prepared by Worley Parsons. This proposed alignment is provided in ***Appendix A*** and as can be seen the alignment from east to west is generally:

- West along the south side of Spuraway Avenue;
- West across Mariner Way onto Como Lake Avenue;
- West along Como Lake Avenue where it switches from the north and south side to avoid other major utilities;
- West along Como Lake Avenue across North Road onto Broadway;

- West along Broadway from North Road;
- West across Gaglardi Way;
- Southwest along the west side of Gaglardi Way to Broadway;
- West along the Broadway alignment through the BC Hydro right of way to Underhill Avenue
- West along Broadway to Springer Avenue;
- North on Springer Avenue to Halifax Street;
- West on Halifax Street to Delta Avenue;
- North on Delta Avenue to Highlawn Drive;
- West on Highlawn Drive to Midlawn Drive;
- West on Midlawn Drive to Fairlawn Drive;
- South on Fairlawn Drive to Brentlawn Drive;
- West on Brentlawn Drive across Willingdon Avenue to Graveley Street;
- West on Graveley Street to Carleton Avenue;
- West across the park across Gilmore Avenue/Douglas Road to Graveley Street;
- West on Graveley Street across Boundary Road
- South to E 1st Avenue through the Vancouver Police Department parking lot;
- West along E 1st Avenue to Woodland Drive;
- Across Woodland Drive on the north side of E 1st Avenue; and
- South on the west side of Woodland Drive across E 1st Avenue to the end point just south of E 2nd Avenue.

Construction Approach

Based on preliminary advice from Fortis BC, it is intended that the gas line will be constructed using a combination of trenchless and open cut methods. The crossing of the following major roads/intersections is expected to be achieved using trenchless technology:

- Como Lake Avenue/Mariner Way;
- Como Lake Avenue/Clarke Rd;
- Broadway/North Road;
- Broadway/Gaglardi Way (E);
- Broadway/Production Way/Forest Grove Drive;
- Broadway/Underhill Avenue;
- Broadway/Lake City Way;
- Broadway/Holdom Avenue;
- Graveley Street/Brentlawn Drive/Willingdon Avenue;
- Graveley Street/Douglas Road/Gilmore Avenue;
- Graveley Street/Boundary Road;
- E 1st Avenue/Highway 1 interchange;
- E 1st Avenue/Rupert Street;
- E 1st Avenue/Renfrew Street;
- E 1st Avenue/Nanaimo Street; and
- E 1st Avenue/Commercial Drive.

Between the intersections listed above and across the remaining intersections, the gas line will be constructed using an open cut approach that will require approximately 200m-1000m of road space occupation at any one time depending on site conditions. Due to the nature of construction, it is expected that the road occupation will be on a full time basis limiting the ability to open/close traffic lanes by time of day to accommodate traffic demands.

Based on preliminary advice from Fortis BC available at the time, the open cut work will require full road closures or lane closures as follows:

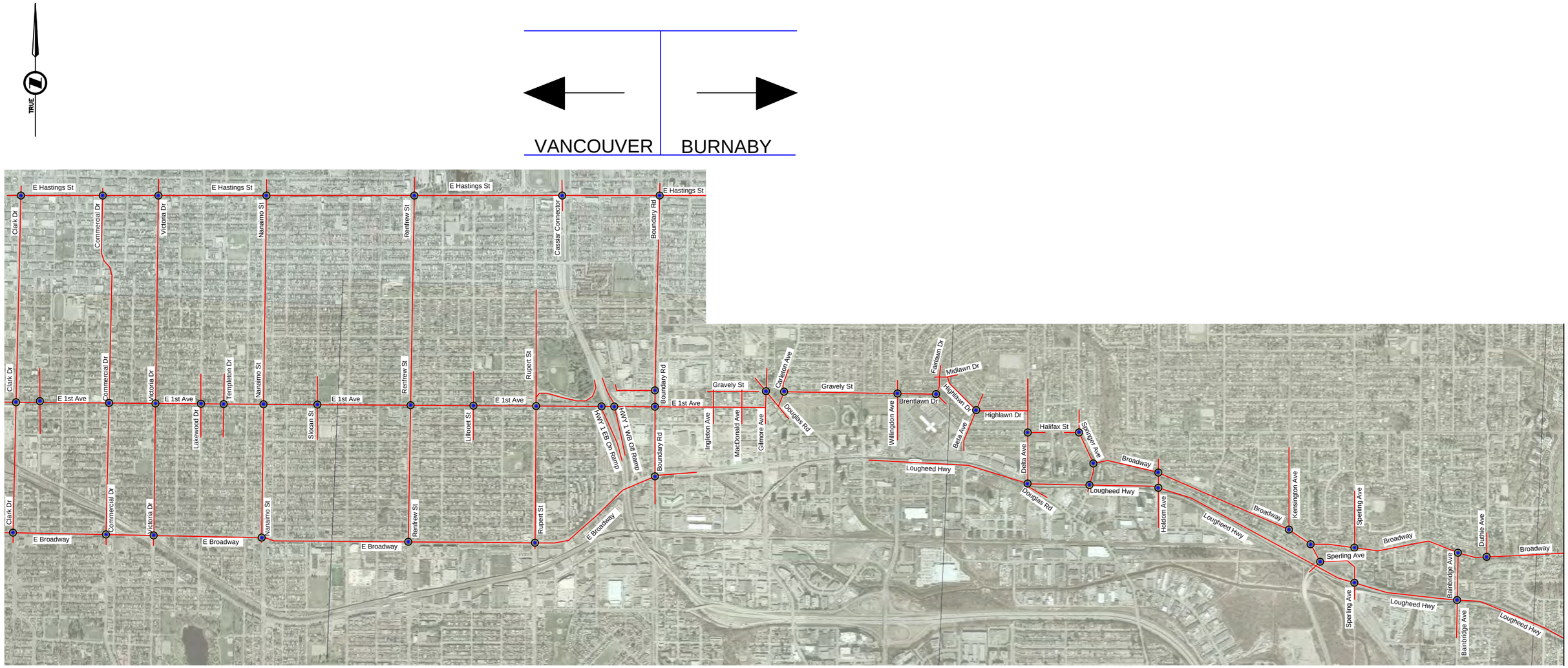
- Como Lake Avenue from Mariner Way to North Road – closure of sections of two lanes and retention of two lanes;
- Broadway between North Road and Gaglardi Way - closure of sections of two lanes and retention of two lanes;
- Broadway between Gaglardi Way and Springer Avenue – full road closures in sections with the possibility of constructing the gas line on the north side of the roadway (utilities permitting) in some sections thus retaining a single lane;
- Springer Avenue - full road closure;
- Halifax Street - full road closure;
- Delta Avenue - full road closure;
- Highlawn Drive - full road closure;
- Midlawn Drive - full road closure;
- Fairlawn Drive - full road closure;
- Brentlawn Drive - full road closure;
- Graveley Street - full road closures in sections;
- E 1st Avenue - closure of two lanes and retention of two lanes between major intersections; and
- Woodland Drive - full road closure at E 1st Avenue.

Study Area

In consideration of the proposed gas line alignment, the construction approach and the likely detour routes that could be used by drivers, a study area for the traffic engineering work was defined. This study area is shown in ***Exhibit 1.1*** and ***1.2***.

The following are noted with respect to the study area:

- In Coquitlam, there are limited east/west alternate routes in proximity to the Como Lake Avenue corridor. As such the study area was limited to the Como Lake Avenue corridor except for in the vicinity of Clarke Road where Robinson Street, Smith Avenue and North Road could be used as detour routes.
- In Burnaby east of Delta Avenue, the closest and most direct continuous east/west alternate route to the Broadway corridor is Lougheed Highway. Lougheed Highway is however congested and any detouring from Broadway during construction would exacerbate existing conditions. The section of Lougheed Highway between Delta Avenue and Gaglardi Way was therefore included in the study area.



CONTINUATION ON EXHIBIT 1.2

FORTIS BC™

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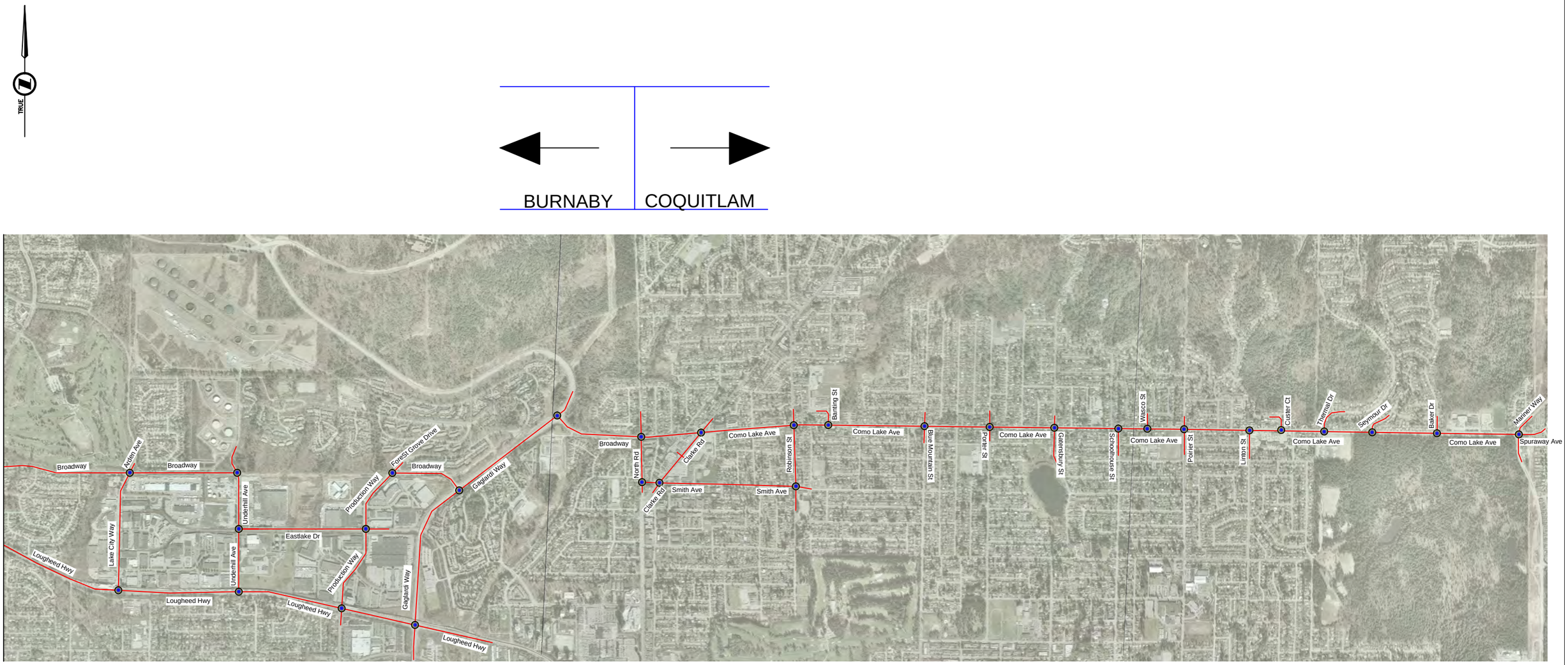
www.gnec.ca

TRAFFIC STUDY AREA
(CLARK DRIVE TO DUTHIE AVENUE)

(NOT TO SCALE)

EXHIBIT 1.1



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Burnaby, BC V5A 4V7
Tel: 1.855.463.2266
www.gnec.ca

TRAFFIC STUDY AREA
(LAKE CITY WAY TO MARINER WAY)
(NOT TO SCALE)

EXHIBIT 1.2

- In Burnaby west of Delta Avenue, the proposed gas line runs along residential streets and there are multiple opportunities for traffic to detour to alternate routes. Since the traffic volumes that would be affected by the construction work would be low, and the impacts of the increase of detour traffic on the multiple alternative routes would also be low, no parallel alternate routes were included in the study area.
- In Vancouver, any construction work on the heavily congested E 1st Avenue route would likely result in traffic detouring primarily to the parallel E Hastings Avenue and E Broadway routes. All three of these east/west routes were therefore included in the study area along with the major north/south routes between Boundary Road and Clark Drive (excluding Highway 1). On E 1st Avenue all signalized intersections were included in the study area. On E Hastings Avenue and E Broadway only the signalized intersections with the major north/south roads were included. On the major north/south roads only the intersections at E 1st Avenue, E Broadway and E Hastings Street were included.
- The study area focused on the major roads and signalized intersections as these would typically have the biggest impact on roadway capacity during construction. Minor intersections and accesses within the study area were generally not included except for in the area around Brentwood Mall where the alignment follows a circuitous alignment along residential streets and the impacts to residents may need to be quantified.

Traffic Data Collection

The Cities of Coquitlam, Burnaby and Vancouver were contacted to enquire about the availability of traffic count data. It became apparent that there was not sufficient count data for the summer months when it is expected that the gas line will be constructed in 2018. The data that was available was mostly for the non-summer months when traffic patterns are quite different to the summer months when many people are on vacations and school trip generation is down.

It was therefore decided to undertake a comprehensive project specific traffic data collection program during the summer of 2014. This involved two types of data collection as discussed in the following sub-sections.

Tube Counts

Tube counts involve placing pneumatic tubes across the road that are connected to a counter device on the side of the road. They enable the collection of directional traffic volumes by time of day and over multiple days. For the purposes of this project the tube counts were undertaken for a full week at the following locations between Friday July 25 and Thursday July 31 2014:

- Como Lake Avenue west of Gatensbury Street;
- Broadway west of North Road (east of Gaglardi Way);
- Broadway west of Lake City Way;
- Broadway east of Holdom Avenue; and
- E 1st Avenue west of Rupert Street.

In ***Appendix B***, a sample has been provided of the processed data from a tube count. Data for all five locations surveyed is available in digital format if required.

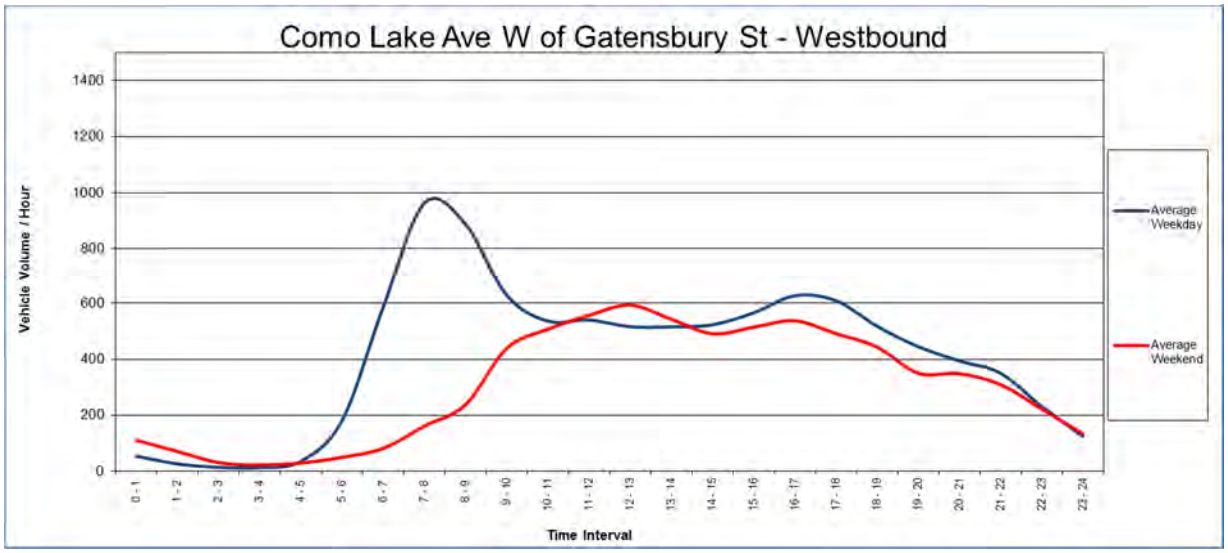
In ***Table 1*** below, the average weekday (Monday to Friday) and average weekend (Saturday and Sunday) daily volumes are presented for each location by direction.

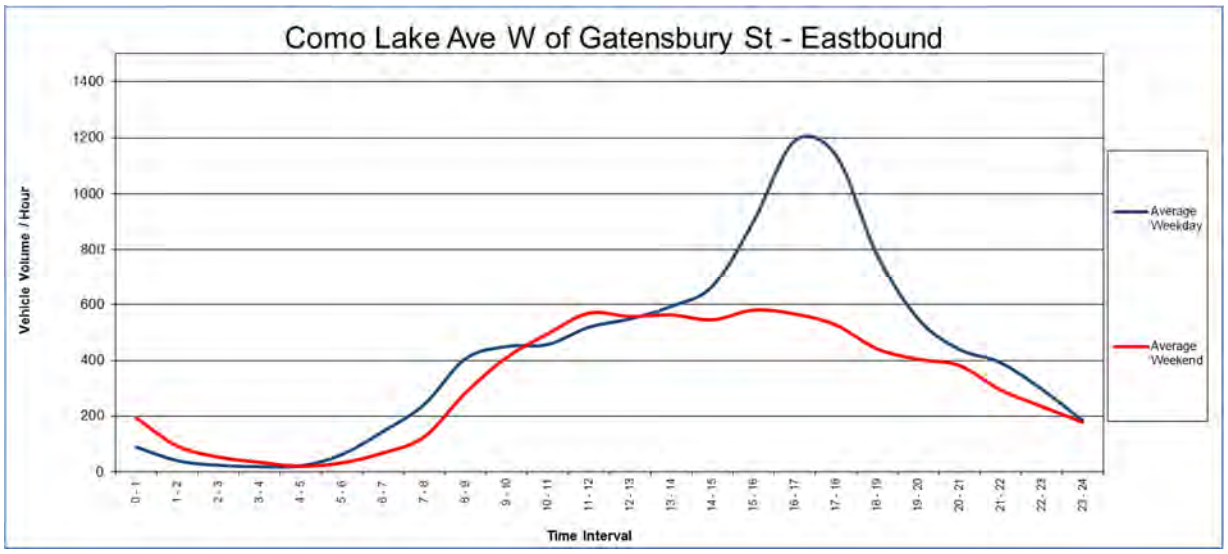
Table 1 – Average Weekday/Weekend Daily Volumes (veh/day)

Tube Count Location	Day	Westbound	Eastbound	Two Way
Como Lake Avenue west of Gatensbury Street	Weekday	9888	10158	20046
	Weekend	7275	7655	14930
Broadway west of North Road	Weekday	12292	12351	24643
	Weekend	8225	8629	16854
Broadway west of Lake City Way	Weekday	2895	2911	5806
	Weekend	1919	2125	4044
Broadway east of Holdom Avenue	Weekday	4633	4108	8741
	Weekend	3751	3173	6924
E 1st Avenue west of Rupert Street	Weekday	25819	29976	55795
	Weekend	22642	26877	49519

With the exception of on Broadway east of Holdom Avenue, the eastbound daily volumes at all locations exceed the westbound daily volumes. The above summary also shows that weekend daily volumes are lower than weekday volumes, but not by a significant margin.

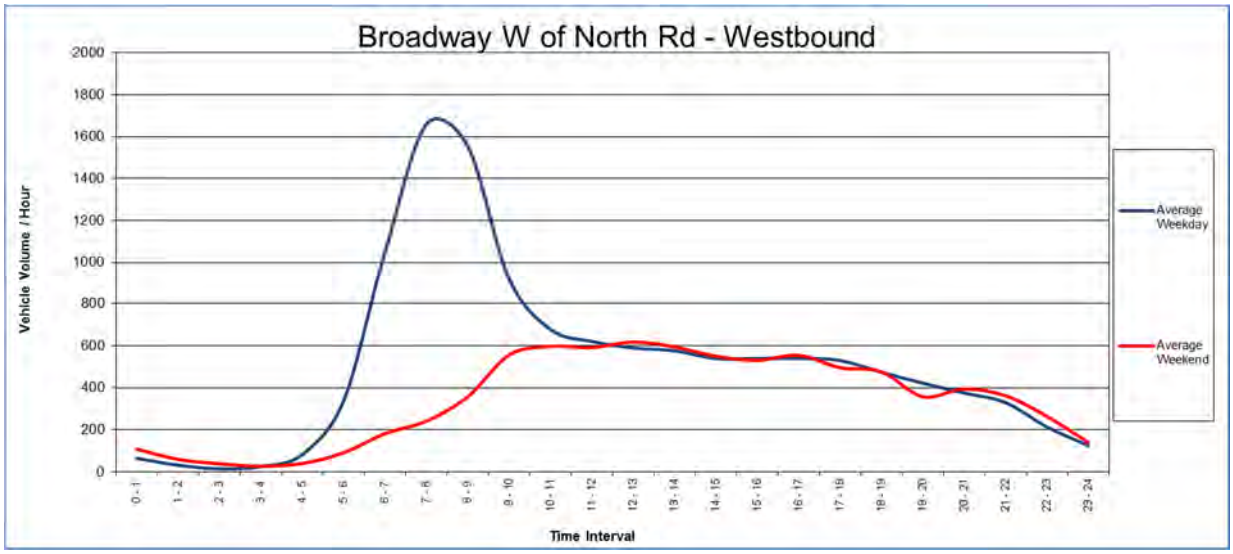
In the charts below, the average weekday and average weekend day hourly volumes are presented for each location by direction. Comments on observations have also been provided where applicable. The daily and hourly traffic volume information contained below will assist later in determining when the gas line constructor may be permitted to impact traffic.

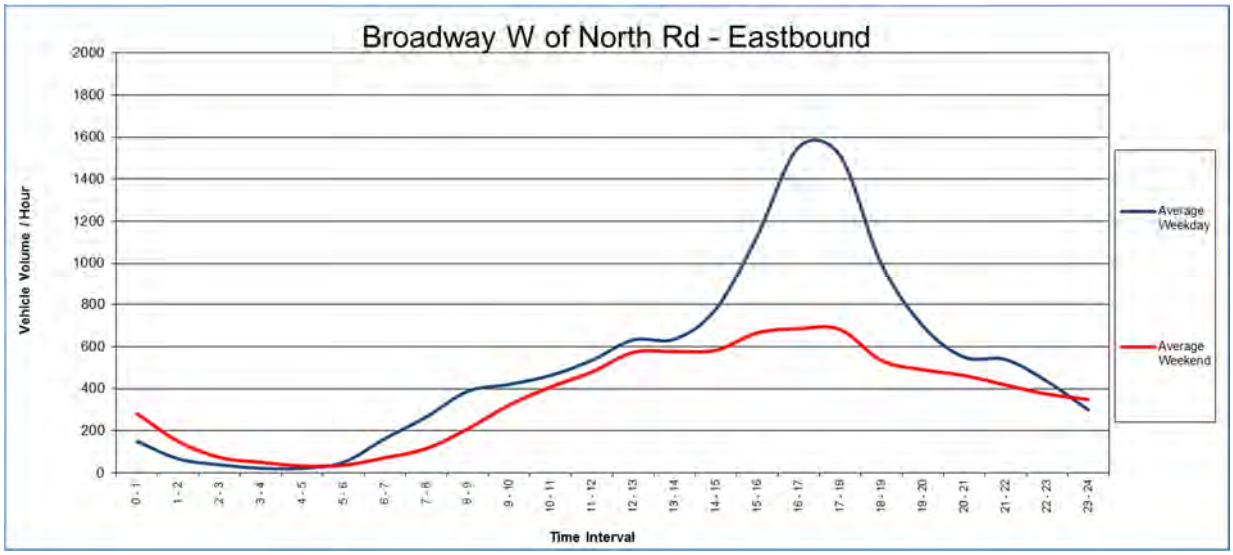




Notes:

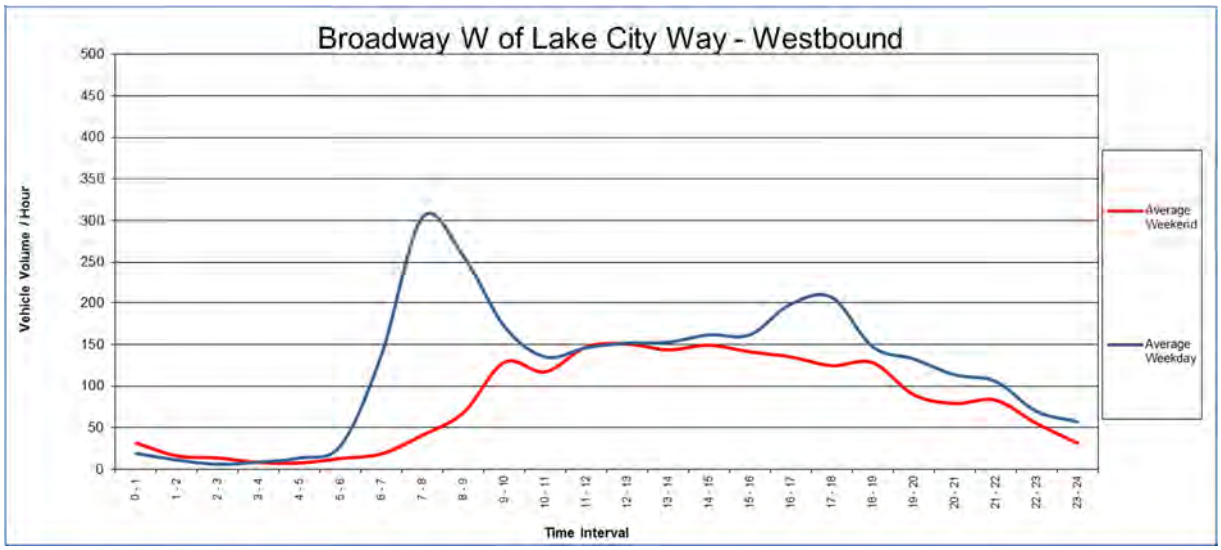
(a) Predominant direction of travel is westbound on the AM peak period and eastbound in the PM peak period
(b) Westbound weekday volumes peak at 1000 veh/hr in the AM peak period
(c) Eastbound weekday volumes peak at 1200 veh/hr in the PM peak period
(d) Weekday midday peak volumes are <600 veh/hr per direction
(e) Weekend peak volumes are < 600 veh/hr per direction

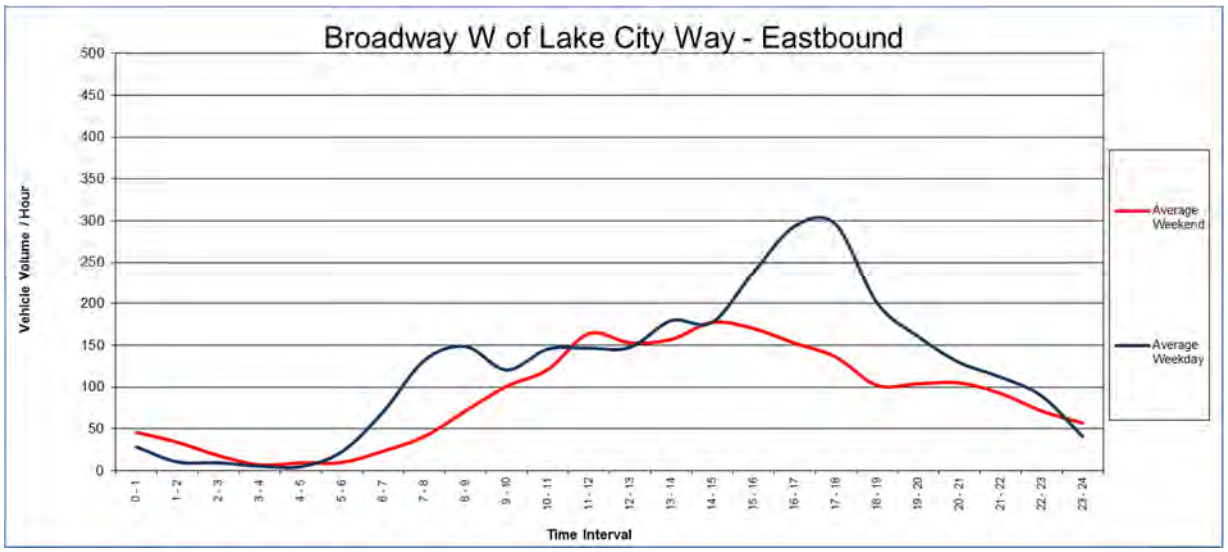




Notes:

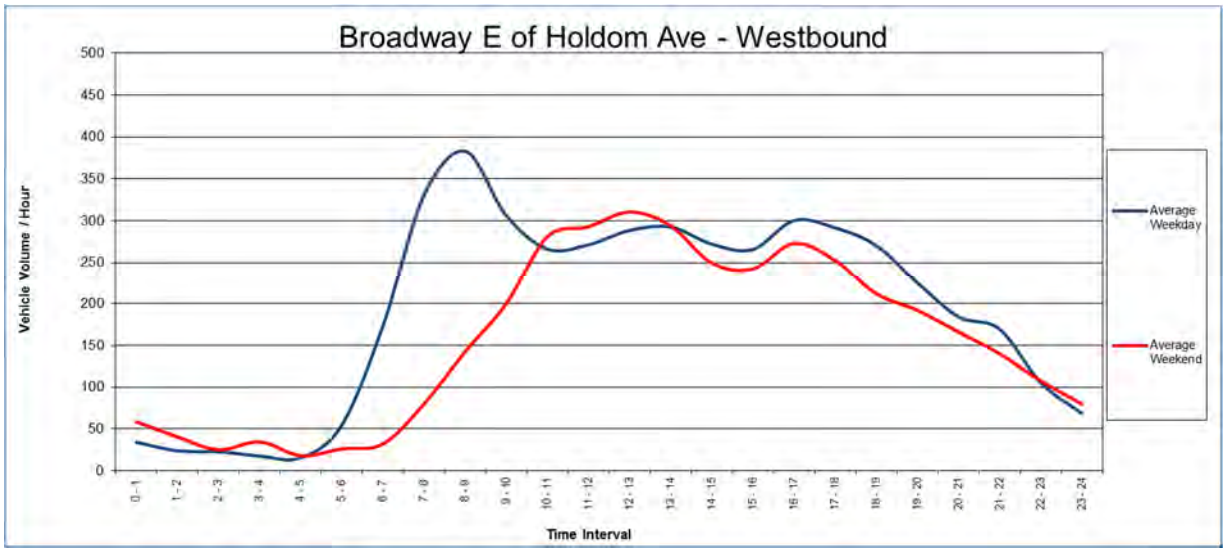
(a) Predominant direction of travel is westbound on the AM peak period and eastbound in the PM peak period
(b) Westbound weekday volumes peak at 1650 veh/hr in the AM peak period
(c) Eastbound weekday volumes peak at 1600 veh/hr in the PM peak period
(d) Weekday midday peak volumes are approximately 600 veh/hr per direction
(e) Weekend peak volumes are < 700 veh/hr per direction

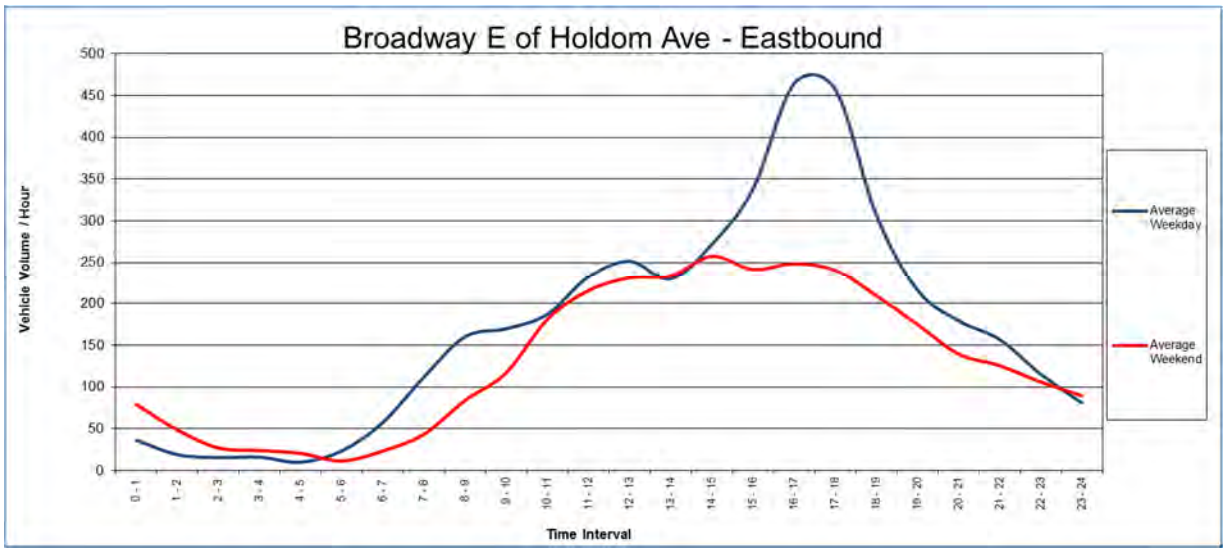




Notes:

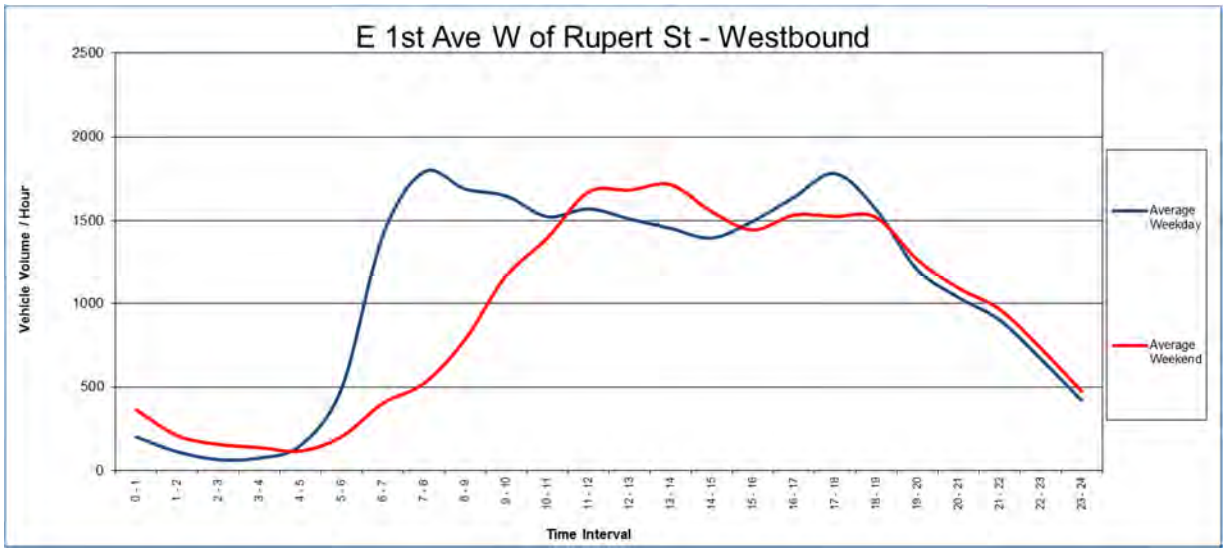
(a) Predominant direction of travel is westbound on the AM peak period and eastbound in the PM peak period
(b) Westbound weekday volumes peak at 310 veh/hr in the AM peak period
(c) Eastbound weekday volumes peak at 310 veh/hr in the PM peak period
(d) Weekday midday peak volumes are 150 veh/hr per direction
(e) Weekend peak volumes are < 175 veh/hr per direction

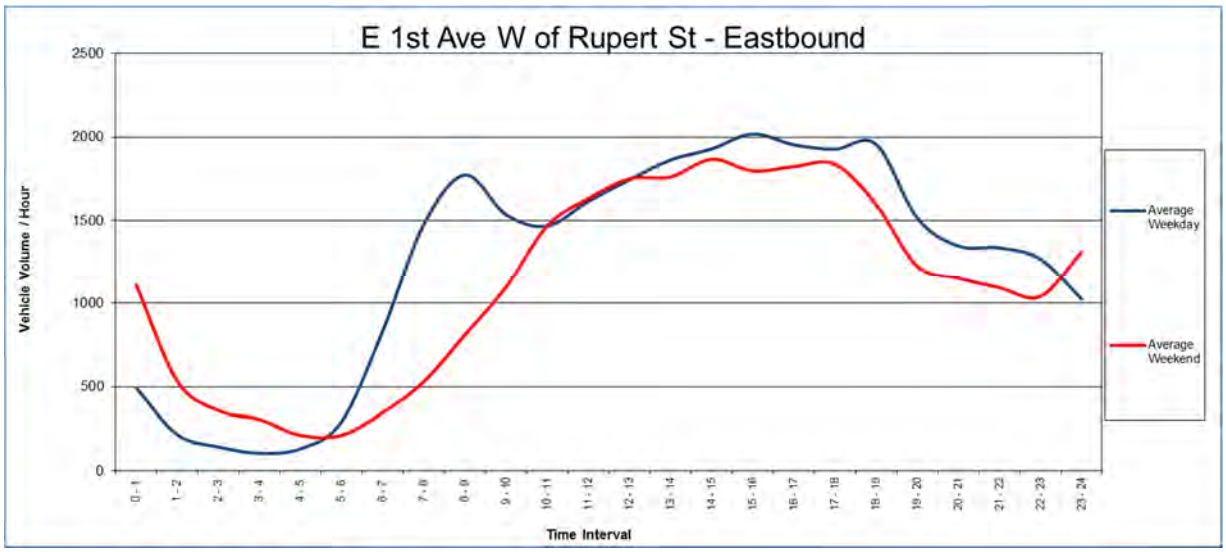




Notes:

(a) Predominant direction of travel is westbound on the AM peak period and eastbound in the PM peak period
(b) Westbound weekday volumes peak at 375 veh/hr in the AM peak period
(c) Eastbound weekday volumes peak at 475 veh/hr in the PM peak period
(d) Weekday midday peak volumes are <300 veh/hr per direction
(e) Weekend peak volumes are < 310 veh/hr per direction





Notes:

(a) There is no predominant direction of travel in the AM peak period
(b) The predominant direction of travel is eastbound in the PM peak period
(c) Westbound weekday volumes peak at 1800 veh/hr in the AM peak period
(d) Eastbound weekday volumes peak at 2000 veh/hr in the PM peak period
(e) Weekday midday peak volumes are 1500-1750 veh/hr per direction
(f) Weekend peak volumes are 1700 veh/hr westbound and 1800 veh/hr eastbound

Turning Movement Counts

Turning movement counts were undertaken at the intersections shown in ***Exhibit 2.1 to 2.12*** between July 29, 2014 and August 28, 2014. These exhibits have been numbered as follows:

Exhibit 2.1 – AM Peak Hour Volumes – Clark Drive to Boundary Road

Exhibit 2.2 - AM Peak Hour Volumes – Gilmore Avenue to Holdom Avenue

Exhibit 2.3 - AM Peak Hour Volumes – Kensington Avenue to Lake City Way

Exhibit 2.4 - AM Peak Hour Volumes – Underhill Avenue to North Road

Exhibit 2.5 - AM Peak Hour Volumes – Clark Road to Schoolhouse Street

Exhibit 2.6 - AM Peak Hour Volumes – Wasco Street to Mariner Way

Exhibit 2.7 – PM Peak Hour Volumes – Clark Drive to Boundary Road

Exhibit 2.8 - PM Peak Hour Volumes – Gilmore Avenue to Holdom Avenue

Exhibit 2.9 - PM Peak Hour Volumes – Kensington Avenue to Lake City Way

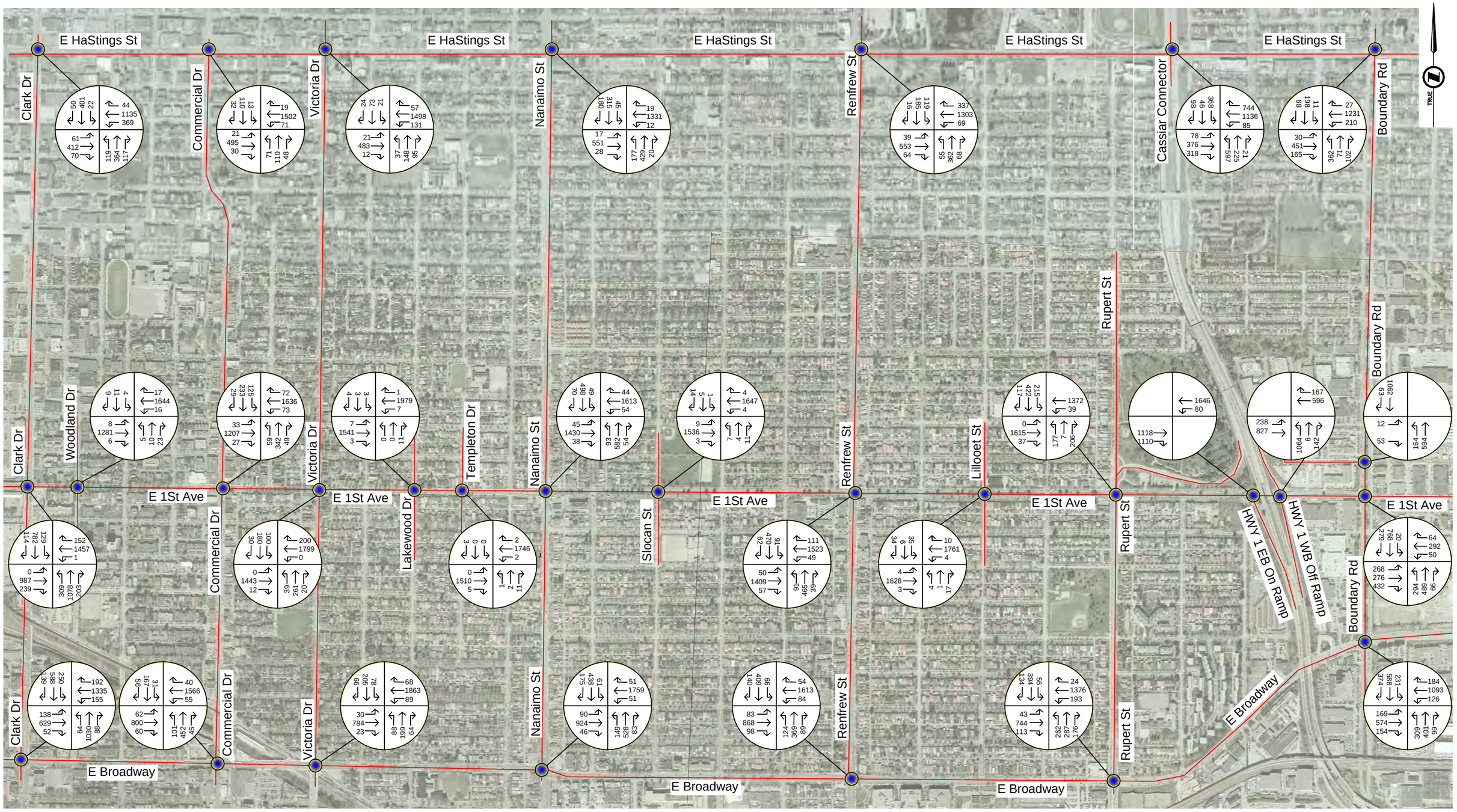
Exhibit 2.10 - PM Peak Hour Volumes – Underhill Avenue to North Road

Exhibit 2.11 - PM Peak Hour Volumes – Clark Road to Schoolhouse Street

Exhibit 2.12 - AM Peak Hour Volumes – Wasco Street to Mariner Way

The turning movement counts were performed on either a Tuesday, Wednesday or Thursday between the hours of 7:00 – 9:00am (AM Peak Period), 11:00am – 1:00pm (Midday Peak Period), and 3:00pm – 6:00pm (PM Peak Period). Data was collected for passenger cars, heavy vehicles, TransLink buses and pedestrians. An example of the processed data for one intersection has been included in ***Appendix C*** for information. Data for all the intersections surveyed is available in digital format if required. It is noted that although data was collected for the AM, Midday, and PM peak periods, only the AM and PM peak period data has been analyzed to date for the purposes of this assignment. The reasoning behind this was that any capacity constraints imposed by gas line construction would really become apparent during the more critical AM and PM peak periods.

The time of the peak hour within each two or three hour peak period varied by intersection so the data was analyzed to determine the "average" peak hour within each peak period as per ***Table 2*** below. It is noted that the peak hours for the three east/west Vancouver corridors were determined separately. Hastings Street and Broadway could be used as alternate routes during construction on 1st Avenue, and since the study area did not include all the east/west intersecting streets between Broadway and Hastings Street, it was considered best to consider the peak hours on each corridor separately as opposed to having global peak hours covering the whole of Vancouver within the study area.



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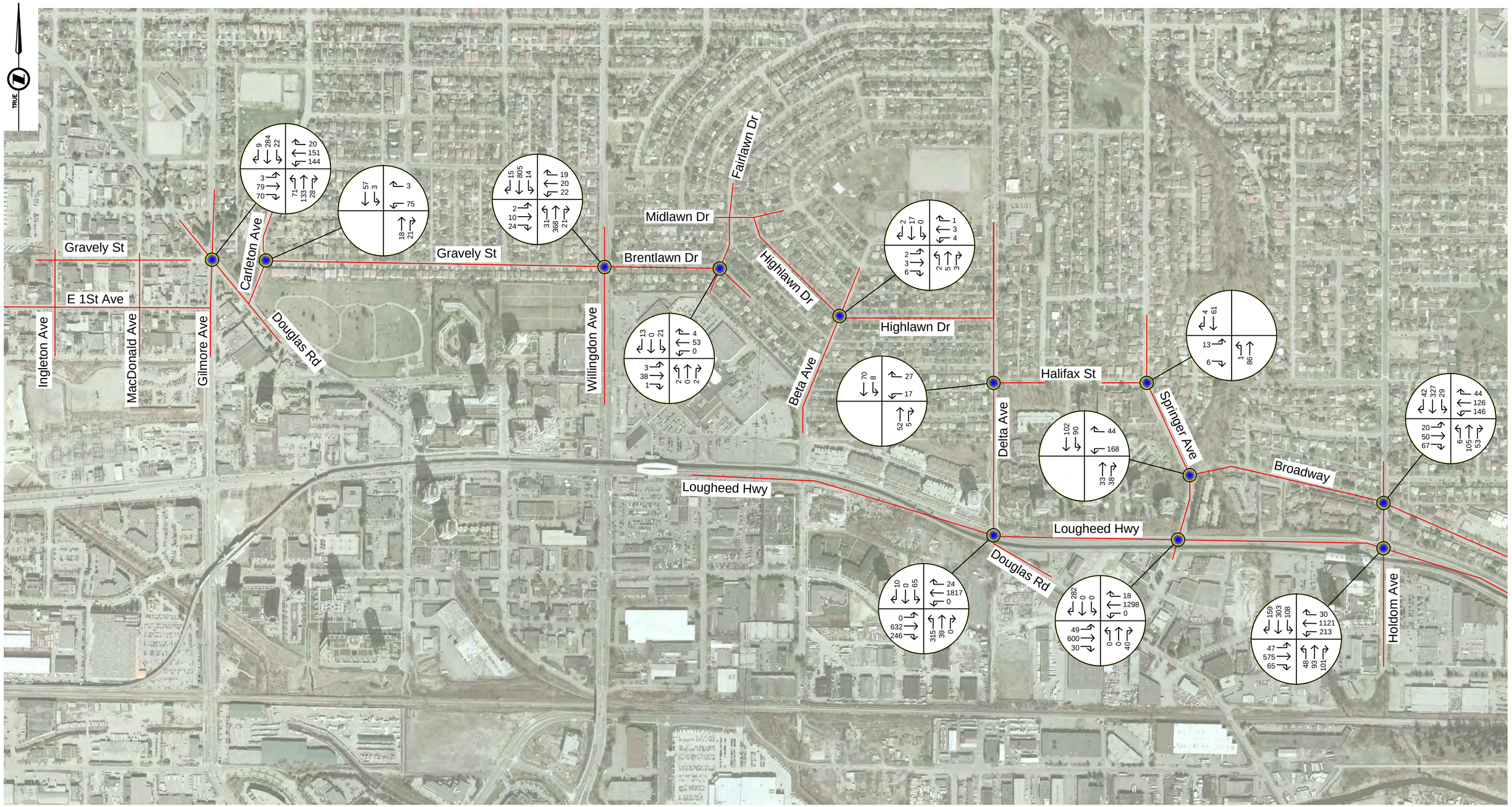
AM PEAK HOUR VOLUMES
(CLARK DRIVE TO BOUNDARY ROAD)
(NOT TO SCALE)

EXHIBIT 2.1



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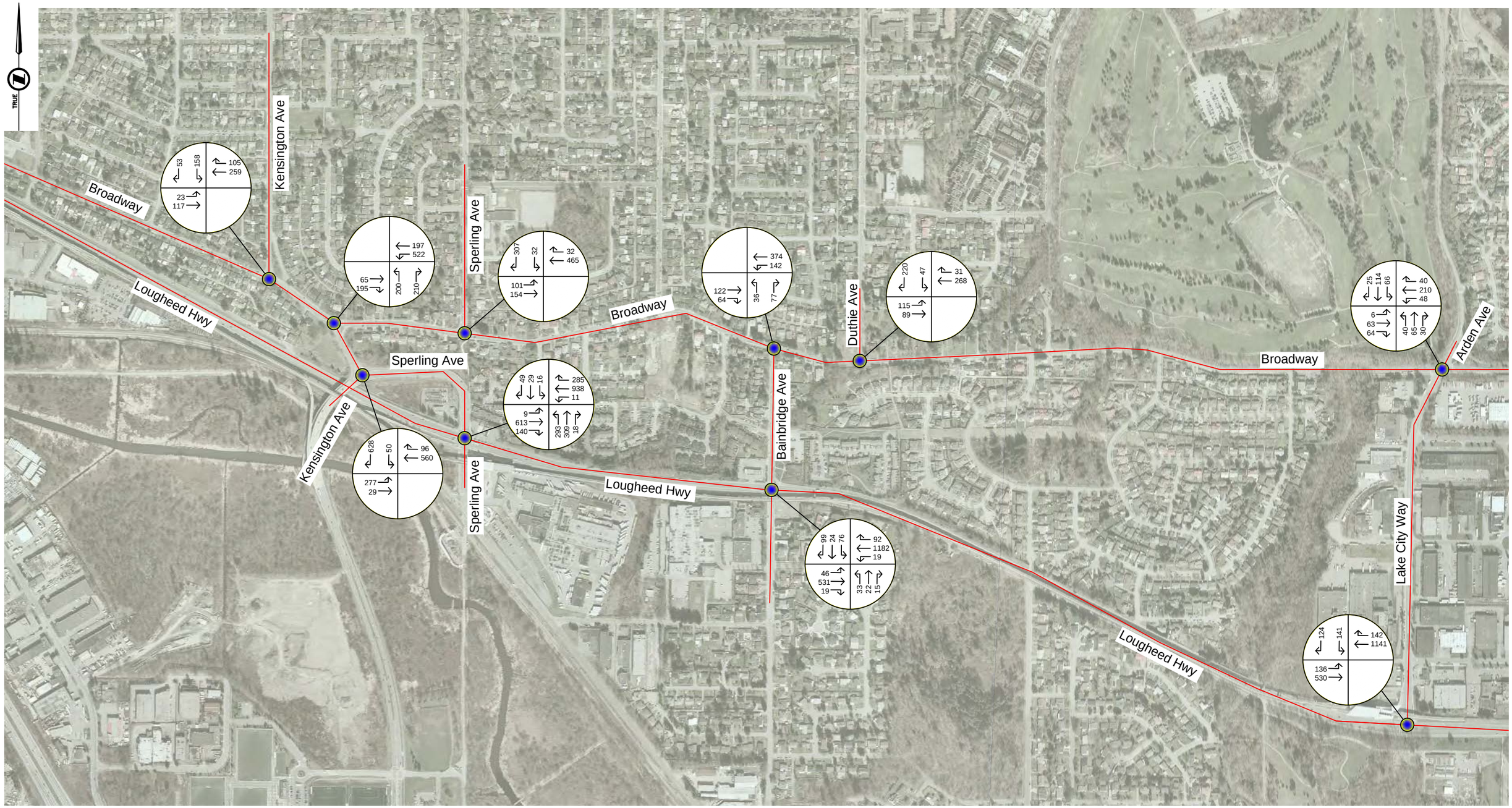
AM PEAK HOUR VOLUMES
(GILMORE AVENUE TO HOLDOM AVENUE)

(NOT TO SCALE)

EXHIBIT 2.2



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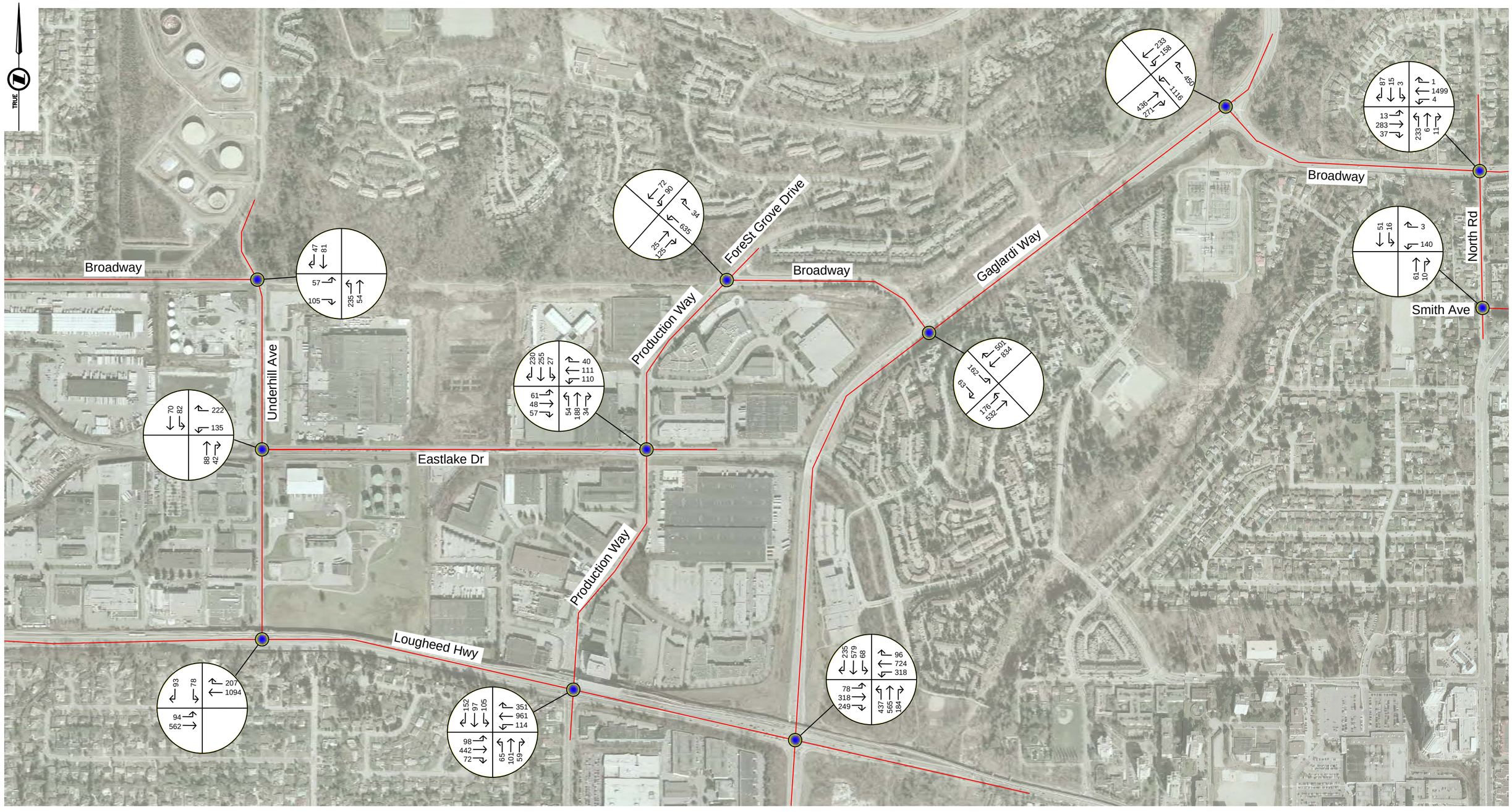
AM PEAK HOUR VOLUMES
(KENSINGTON AVENUE TO LAKE CITY WAY)

(NOT TO SCALE)

EXHIBIT 2.3



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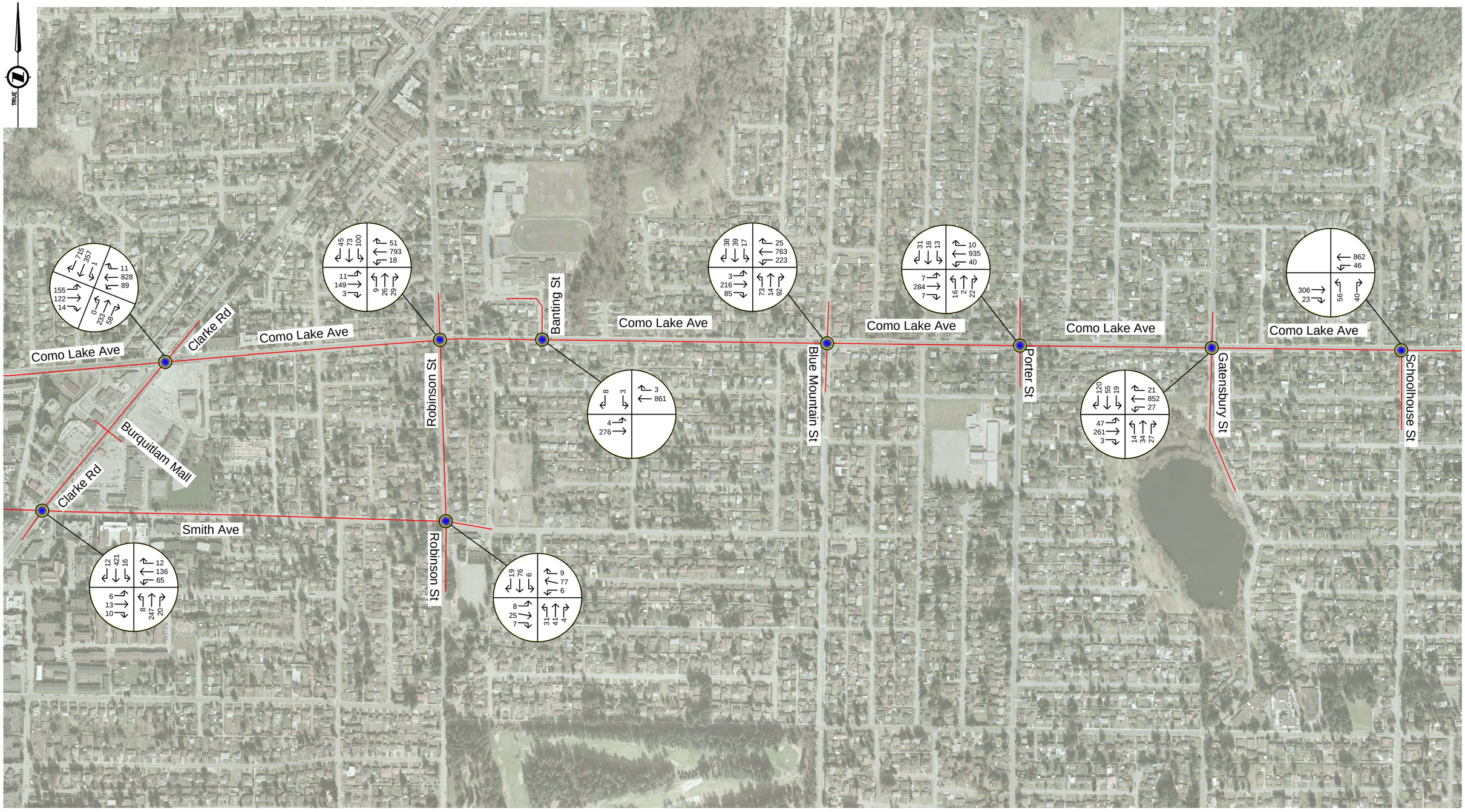
AM PEAK HOUR VOLUMES
(UNDERHILL AVENUE TO NORTH ROAD)
(NOT TO SCALE)

EXHIBIT 2.4



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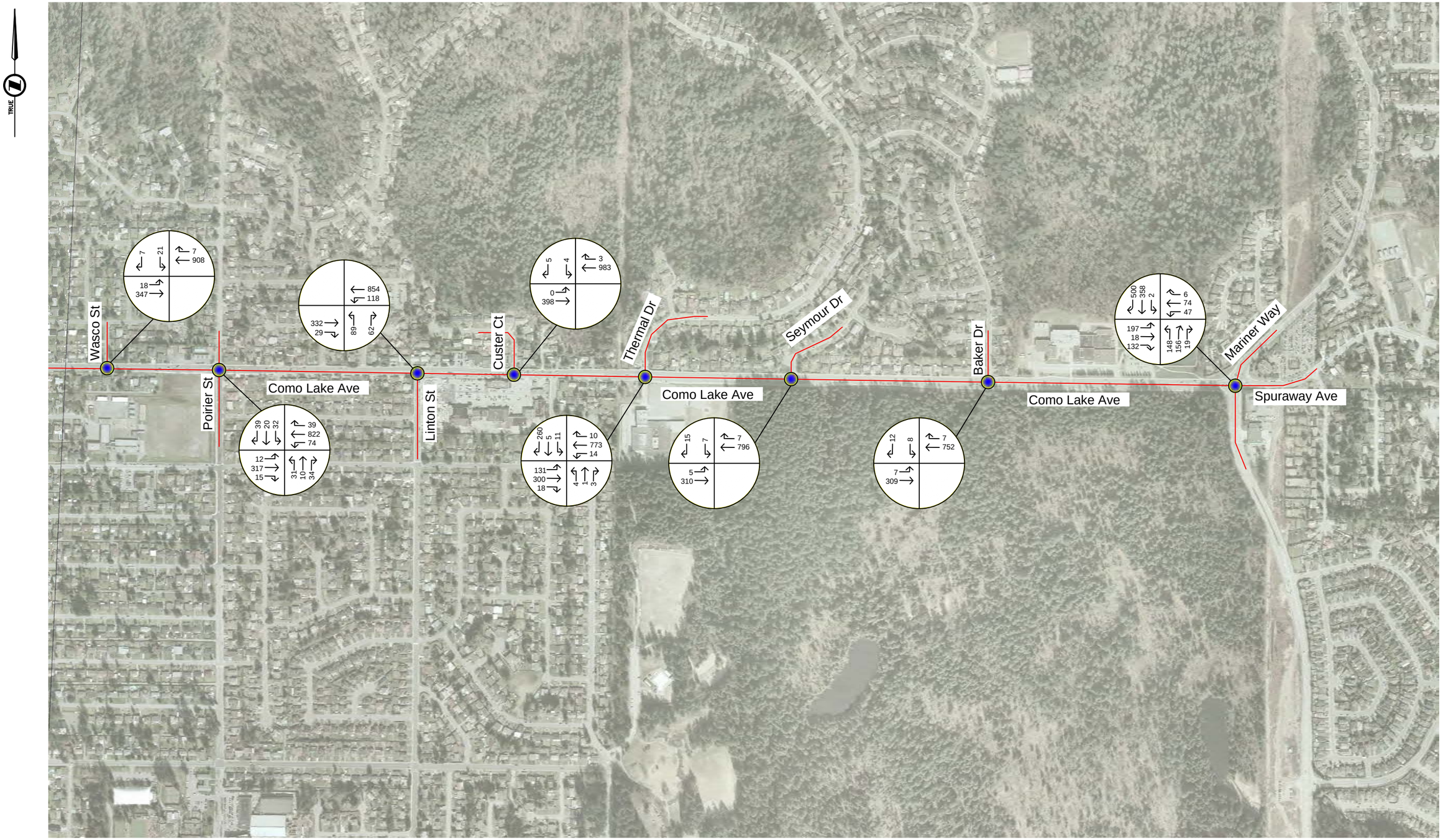
AM PEAK HOUR VOLUMES
(CLARKE ROAD TO SCHOOLHOUSE STREET)

(NOT TO SCALE)

EXHIBIT 2.5



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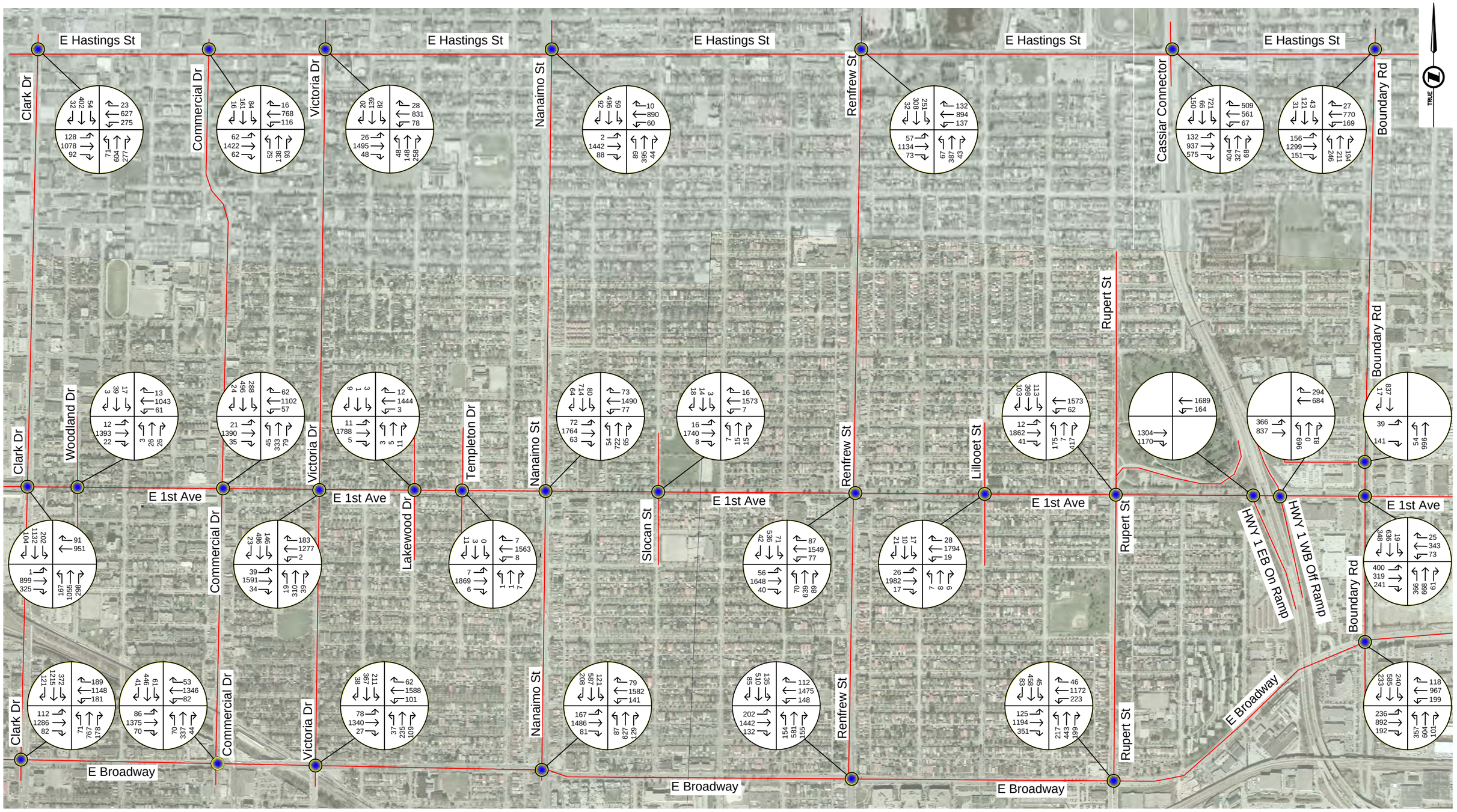
AM PEAK HOUR VOLUMES
(WASCO STREET TO MARINER WAY)
(NOT TO SCALE)

EXHIBIT 2.6



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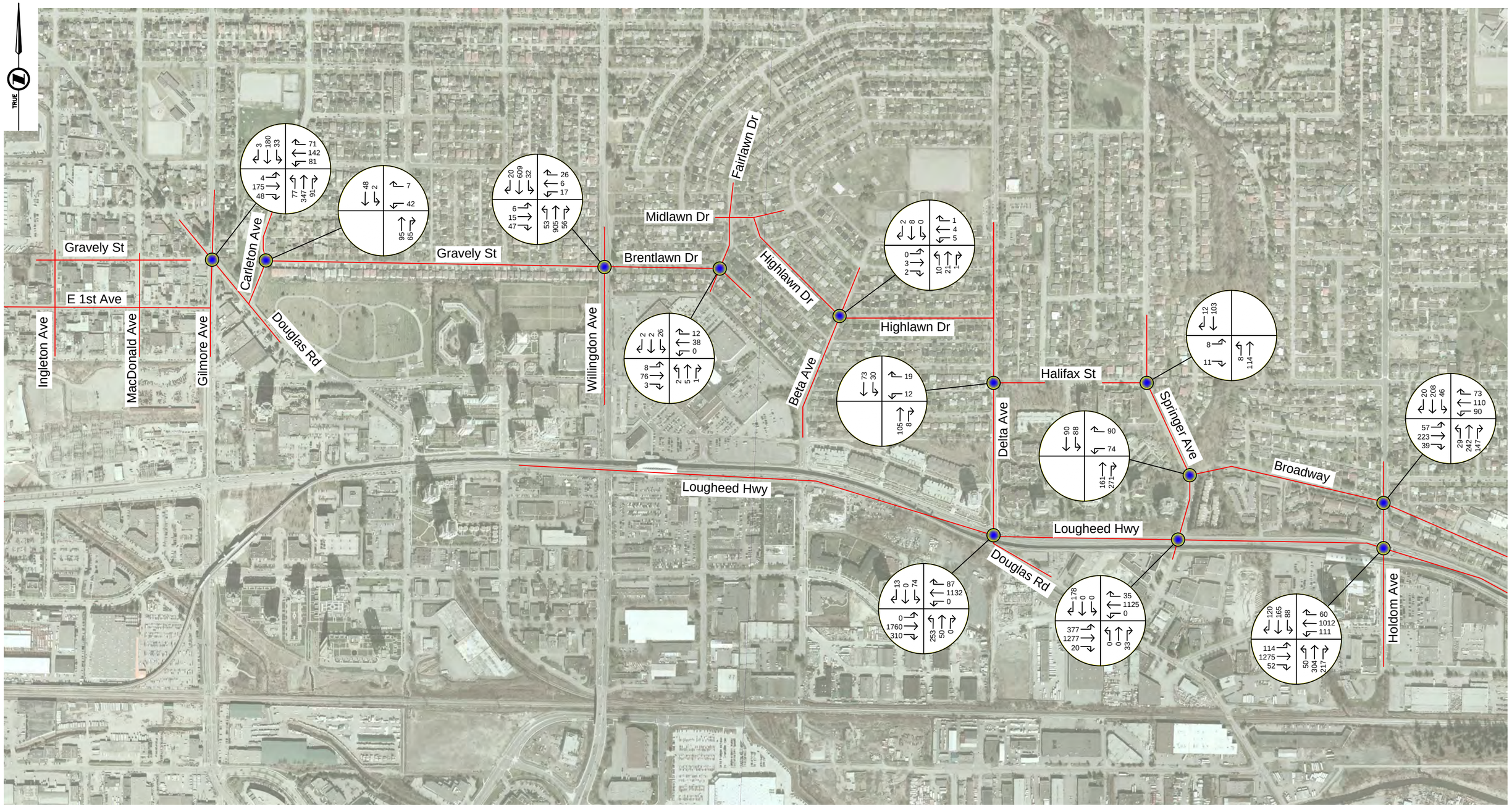
PM PEAK HOUR VOLUMES
(CLARK DRIVE TO BOUNDARY ROAD)
(NOT TO SCALE)

EXHIBIT 2.7



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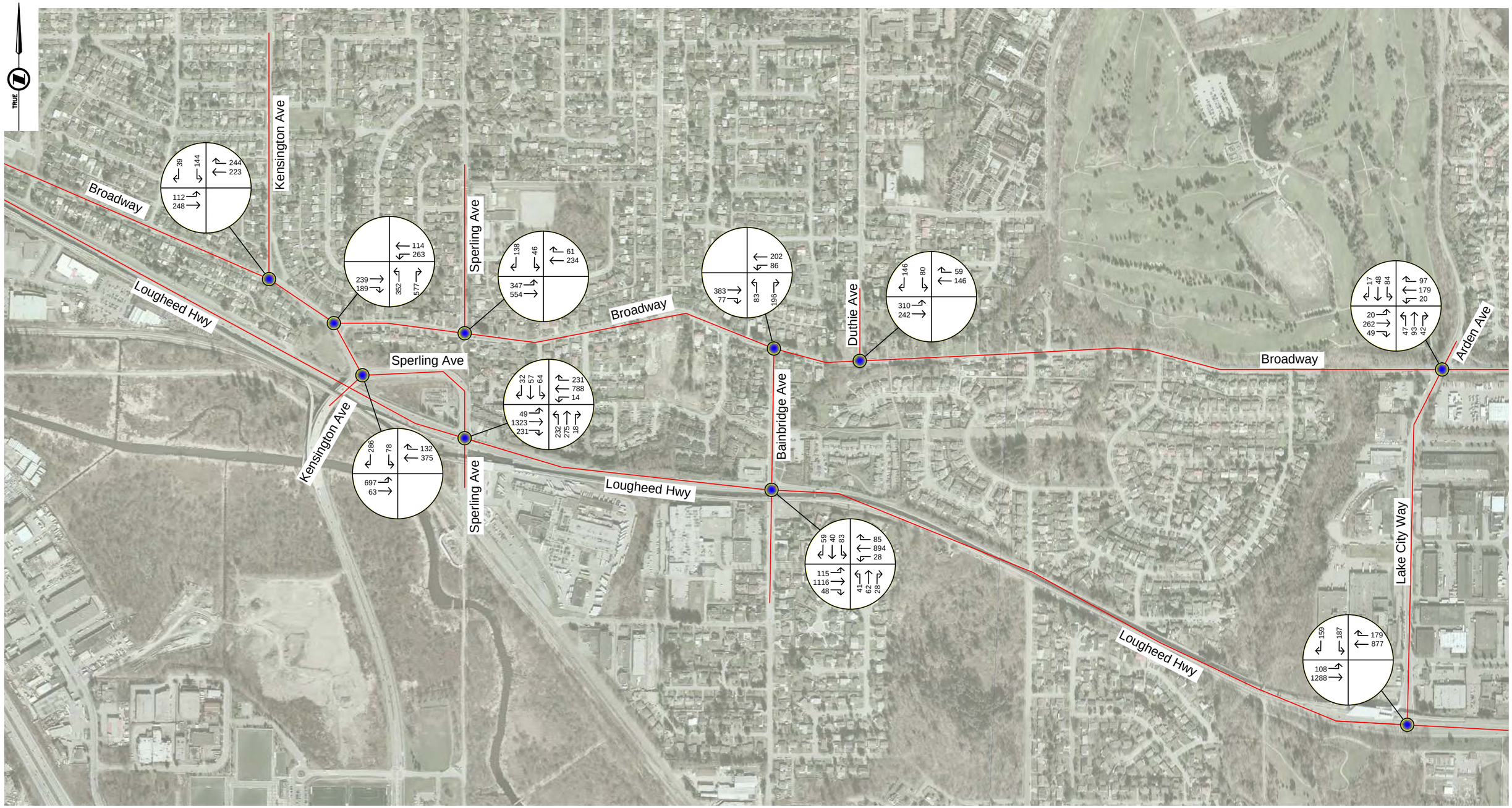
PM PEAK HOUR VOLUMES
(GILMORE AVENUE TO HOLDOM AVENUE)

(NOT TO SCALE)

EXHIBIT 2.8



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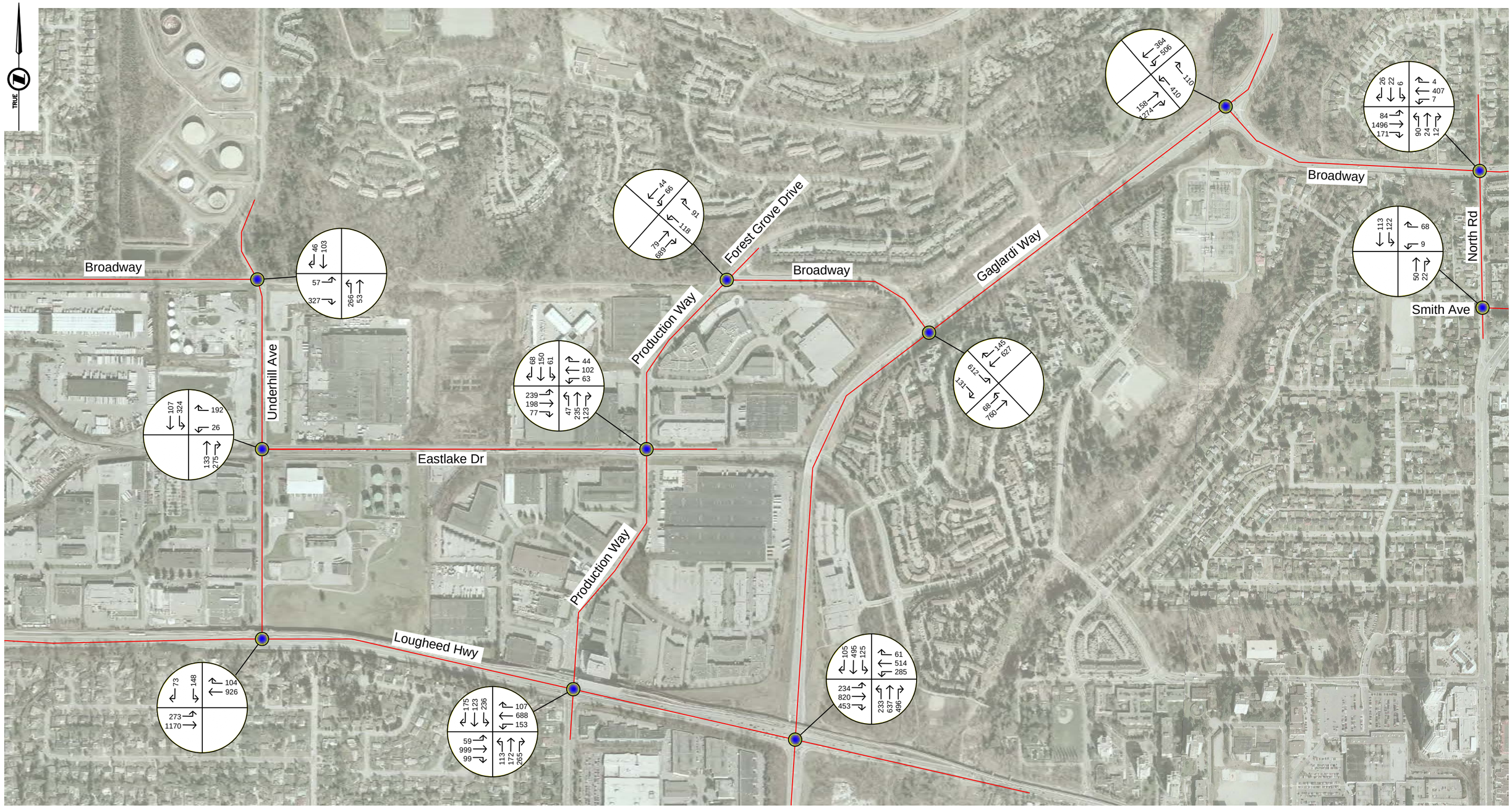
PM PEAK HOUR VOLUMES
(KENSINGTON AVENUE TO LAKE CITY WAY)

(NOT TO SCALE)

EXHIBIT 2.9



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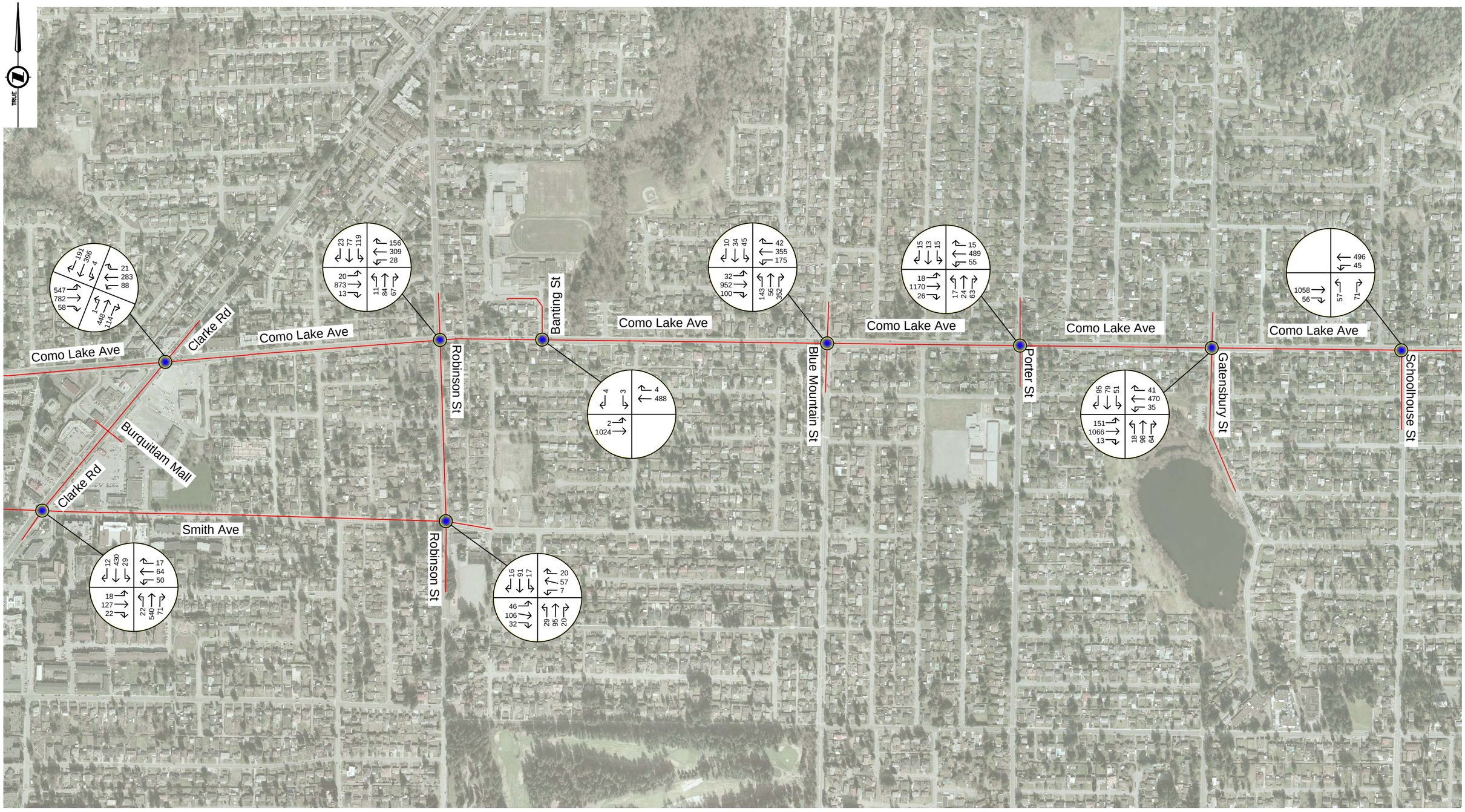
PM PEAK HOUR VOLUMES
(UNDERHILL AVENUE TO NORTH ROAD)
(NOT TO SCALE)

EXHIBIT 2.10



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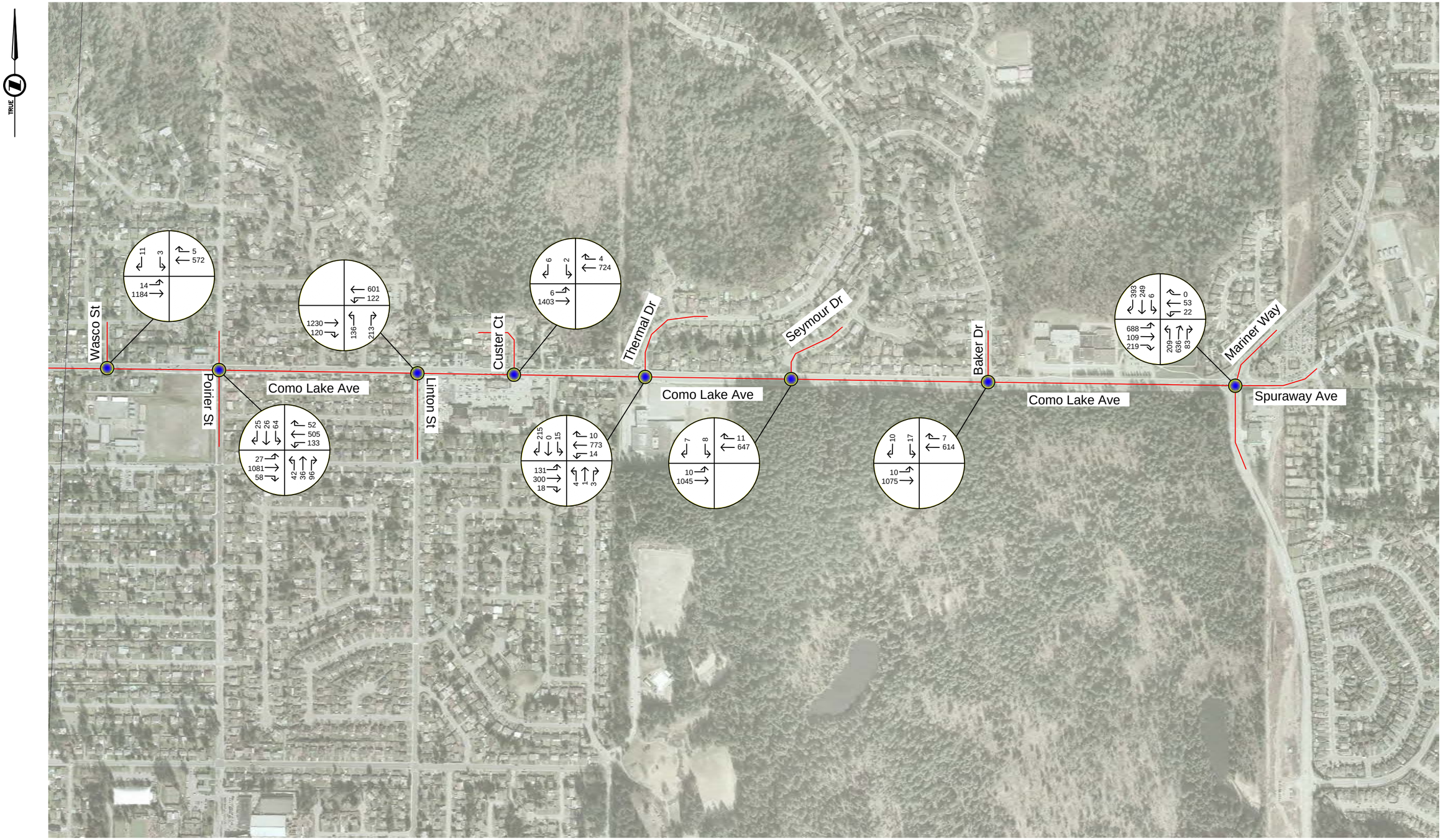
PM PEAK HOUR VOLUMES
(CLARKE ROAD TO SCHOOLHOUSE STREET)

(NOT TO SCALE)

EXHIBIT 2.11



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PM PEAK HOUR VOLUMES
(WASCO STREET TO MARINER WAY)
(NOT TO SCALE)

EXHIBIT 2.12

Table 2 – Average Peak Hours

Area/Corridor	AM Peak Hour	PM Peak Hour
Vancouver E Hastings Street - Boundary Road to Clarke Drive	07:45-08:45	16:45-17:45
Vancouver E 1st Avenue - Boundary Road to Clarke Drive	07:45-08:45	16:30-17:30
Vancouver E Broadway - Boundary Road to Clarke Drive	07:45-08:45	16:45-17:45
Burnaby - Boundary Road to North Road	08:00-09:00	16:30-17:30
Coquitlam - North Road to Mariner Way	07:30-08:30	16:30-17:30

All the turning movement count data was then processed to determine the turning movement volumes at each intersection for the AM and PM peak hours as per ***Table 2***. The resultant AM and PM peak hour volumes are illustrated in ***Exhibit 2*** for all vehicle types combined.

Base Synchro Model Development

For traffic modelling purposes, the study area was divided into three sub areas covering the Cities of Coquitlam, Burnaby and Vancouver respectively. "Base" traffic models were then developed for the AM and PM peak hours for each subarea using the Synchro software. The models were coded over scaled aerial photographs to ensure correct distances between intersections. These six Base models (three subareas times two peak periods) reflected existing traffic conditions and as such, incorporated the following data:

- Existing laning geometry at all the major intersections and between intersections (excluding minor intersections and accesses);
- Existing traffic signal timings at all signalized intersections (as provided by the relevant road agencies);
- Existing stop controls at unsignalized intersections;
- Peak hour turning movement volumes from ***Exhibit 2.1*** to ***2.12***;
- Pedestrians volumes at the intersections that have high pedestrian activity; and
- Existing time of day parking and HOV lane restrictions where applicable.

Typically the performance of roadways in an urban environment is evaluated in terms of intersection performance as intersections are usually the capacity constraints. This performance is commonly evaluated in terms of Level of Service and volume/capacity ratios as discussed below:

- Level of Service (LOS) - the Level of Service for a movement or an overall intersection is an indication of the delays due to the intersection controls. LOS is derived by calculating the intersection or approach control delay and converting it to a letter between A and F. LOS A represents minimal delays and LOS F represents lengthy delays. The LOS categories for signalized intersections are presented in ***Table 3***. As a general rule, LOS of D or better is considered desirable in an urban environment.

Table 3 – LOS Categories

LOS	Delay (sec/veh)
A	<10
B	>10 and <20
C	>20 and <35
D	>35 and <55
E	>55 and <80
F	>80

- Volume/capacity ratio (v/c) - The v/c ratio indicates the amount of congestion for each lane group. Any v/c ratio greater than 1.0 indicates that the demand exceeds the capacity. As a general rule, v/c ratios less than 0.85 are considered desirable in an urban environment.

The existing performance data for the signalized intersections was then extracted from the Base models in terms of overall intersection LOS and average delay, and turning movement LOS and v/c ratios. The Synchro model output is provided in ***Appendix D*** with a summary in ***Table 4***. In this table abbreviations such as EBL (eastbound left), SBT (southbound through), WBR (westbound right), etc. have been used to describe the individual turning movements. If a movement occurs from a shared lane (e.g. a right turn movement from a shared through/right lane), the performance is recorded for the through lane. Only in cases where there are dedicated left or right turn lanes, is the performance of the applicable movement recorded under the relevant left or right turn columns. In this table the highlighted cells indicate where the LOS is D or worse or where the v/c ratio exceeds 0.85 thus indicating existing operational issues in terms of delay/congestion.

Next Steps

With an understanding of the existing or Base traffic patterns and roadway performance, the next steps will be to ascertain the impacts of gas line construction and develop strategies to mitigate these impacts as far as is practically possible. This work will be undertaken on an as needed basis as directed by Fortis BC and will be documented in subsequent reports and memoranda as applicable.

Table 4 – Base Intersection Performance

				Turning Movements																							
				EBL		EBT		EBR		WBL		WBT		WBR		NBL		NBT		NBR		SBL		SBT		SBR	
Intersection	Time Period	Int. LOS	Int. Avg. Delay (sec/veh)	LOS	v/c	LOS	v/c	LOS	v/c	LOS	v/c	LOS	v/c	LOS	v/c	LOS	v/c	LOS	v/c	LOS	v/c	LOS	v/c	LOS	v/c	LOS	v/c
	Vancouver - E Hastings Street																										
Hastings/Boundary	AM	C	26	B	0.18	C	0.62	-	-	B	0.54	C	0.64	-	-	D	0.61	C	0.57	-	-	D	0.04	C	0.51	-	-
	PM	C	30	B	0.53	C	0.76	-	-	D	0.70	C	0.57	-	-	D	0.70	C	0.70	-	-	D	0.23	D	0.41	-	-
Hastings/Cassiar Connector/Hwy 1 ramps	AM	C	28	D	0.37	C	0.32	A	0.43	D	0.39	C	0.66	B	0.05	C	0.69	D	0.41	B	0.08	D	0.55	D	0.14	B	0.41
	PM	C	34	E	0.59	C	0.62	C	0.80	E	0.41	D	0.66	A	0.69	D	0.69	D	0.63	B	0.23	D	0.80	D	0.08	A	0.31
Hastings/Renfrew	AM	B	15	D	0.42	C	0.33	-	-	A	0.19	B	0.61	-	-	-	-	B	0.39	-	-	-	-	C	0.51	-	-
	PM	C	27	D	0.51	C	0.56	-	-	F	1.28	B	0.69	-	-	-	-	B	0.47	-	-	-	-	B	0.62	-	-
Hastings/Nanaimo	AM	B	13	-	-	A	0.46	-	-	-	-	A	0.69	-	-	B	0.51	B	0.27	-	-	B	0.13	B	0.37	-	-
	PM	B	20	-	-	B	0.73	-	-	-	-	C	0.91	-	-	B	0.33	C	0.31	-	-	B	0.19	C	0.42	-	-
Hastings/Victoria	AM	A	10	C	0.21	C	0.25	-	-	A	0.29	A	0.56	-	-	-	-	C	0.40	A	0.19	-	-	B	0.14	-	-
	PM	A	9	A	0.11	A	0.58	-	-	D	0.84	A	0.46	-	-	-	-	C	0.40	C	0.53	-	-	C	0.30	-	-
Hastings/Commercial	AM	B	13	A	0.22	A	0.37	-	-	B	0.18	B	0.6	-	-	B	0.20	B	0.27	-	-	B	0.04	B	0.25	-	-
	PM	B	15	B	0.23	B	0.67	-	-	C	0.56	B	0.42	-	-	B	0.18	B	0.43	-	-	C	0.31	C	0.32	-	-
Hastings/Clark	AM	B	15	B	0.24	C	0.44	-	-	B	0.75	A	0.57	-	-	-	-	C	0.65	A	0.14	-	-	C	0.43	B	0.07
	PM	C	25	B	0.48	C	0.74	-	-	A	0.62	B	0.44	-	-	-	-	D	0.83	C	0.34	-	-	C	0.64	A	0.05
	Vancouver - E 1st Avenue																										
E 1st/Boundary	AM	C	28	D	0.78	B	0.34	B	0.50	C	0.18	D	0.77	-	-	-	-	C	1.45	-	-	-	-	D	0.82	A	0.33
	PM	C	34	E	1.01	B	0.37	B	0.27	D	0.28	D	0.80	-	-	-	-	C	1.71	-	-	-	-	D	0.73	A	0.39
Highway 1/E 1St (east)	AM	C	32	D	0.49	B	0.50	-	-	-	-	D	0.73	A	0.11	C	0.79	-	-	C	0.48	-	-	-	-	-	-
	PM	C	35	E	0.75	B	0.51	-	-	-	-	E	0.83	A	0.20	C	0.72	-	-	C	0.29	-	-	-	-	-	-
Highway 1/E 1St (west)	AM	A	6	-	-	A	0.30	B	0.89	D	0.37	A	0.35	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	PM	B	12	-	-	A	0.35	C	0.98	E	0.75	A	0.36	-	-	-	-	-	-	-	-	-	-	-	-	-	-
E 1st/Rupert	AM	C	25	-	-	C	0.6	-	-	-	-	C	0.94	-	-	E	0.83	B	0.25	B	0.23	C	0.60	C	0.42	B	0.24
	PM	E	61	-	-	A	0.78	-	-	-	-	F	1.28	-	-	D	0.78	C	0.48	C	0.48	C	0.43	C	0.39	B	0.22
E 1st/Lillooet	AM	C	21	-	-	C	0.86	-	-	-	-	B	0.94	-	-	-	-	B	0.05	-	-	-	-	B	0.18	-	-
	PM	F	174	-	-	F	1.37	-	-	-	-	F	1.32	-	-	-	-	B	0.05	-	-	-	-	B	0.11	-	-
E 1st/Renfrew	AM	B	18	D	0.58	C	0.80	-	-	B	0.57	A	0.90	-	-	C	0.49	C	0.46	-	-	C	0.45	C	0.49	-	-
	PM	B	20	C	0.66	A	0.92	-	-	D	0.90	C	0.90	-	-	C	0.41	C	0.67	-	-	D	0.63	C	0.53	-	-
E 1st/Slocan	AM	A	9	-	-	B	0.83	-	-	-	-	A	0.87	-	-	-	-	B	0.05	-	-	-	-	B	0.04	-	-
	PM	B	20	-	-	B	0.97	-	-	-	-	C	0.88	-	-	-	-	B	0.08	-	-	-	-	B	0.07	-	-
E 1st/Nanaimo	AM	B	17	D	0.53	C	0.75	-	-	C	0.63	A	0.85	-	-	D	0.53	C	0.66	-	-	C	0.42	C	0.41	-	-
	PM	B	18	D	0.84	B	0.94	-	-	E	0.90	A	0.80	-	-	D	0.48	C	0.81	-	-	F	0.94	C	0.56	-	-
E 1st/Templeton	AM	A	3	-	-	A	0.62	-	-	-	-	A	0.75	-	-	-	-	B	0.06	-	-	-	-	A	0.01	-	-

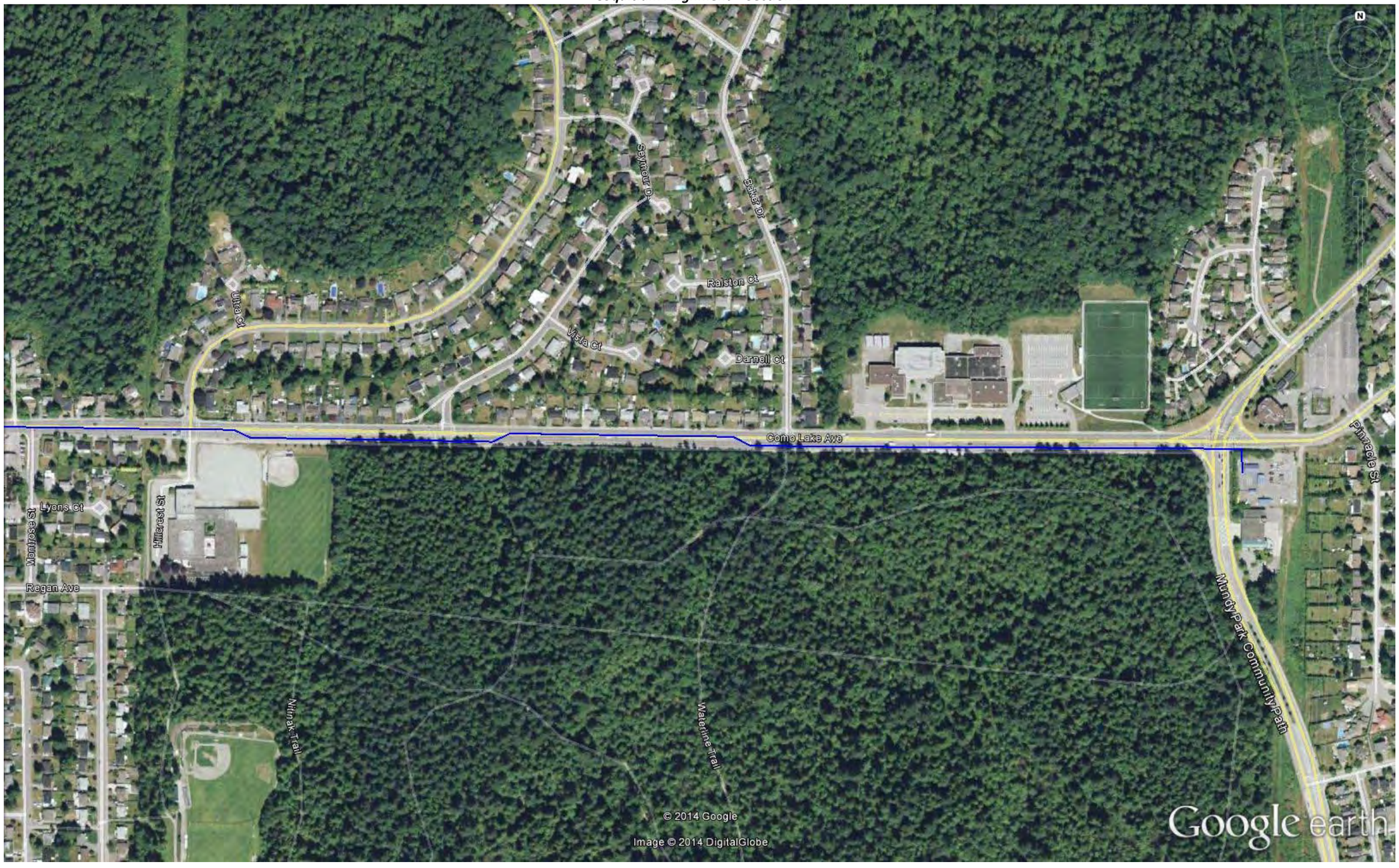
				Turning Movements																							
				EBL		EBT		EBR		WBL		WBT		WBR		NBL		NBT		NBR		SBL		SBT		SBR	
Intersection	Time Period	Int. LOS	Int. Avg. Delay (sec/veh)	LOS	v/c	LOS	v/c	LOS	v/c	LOS	v/c	LOS	v/c	LOS	v/c	LOS	v/c	LOS	v/c	LOS	v/c	LOS	v/c	LOS	v/c	LOS	v/c
	PM	A	7	-	-	A	0.82	-	-	-	-	B	0.69	-	-	-	-	B	0.04	-	-	-	-	B	0.06	-	-
E 1st/Lakewood	AM	A	7	-	-	A	0.68	-	-	-	-	A	0.86	-	-	-	-	A	0.04	-	-	-	-	C	0.04	-	-
	PM	A	5	-	-	A	0.79	-	-	-	-	A	0.63	-	-	-	-	C	0.08	-	-	-	-	B	0.06	-	-
E 1st/Victoria	AM	B	18	-	-	B	0.72	-	-	-	-	B	0.99	-	-	-	-	C	0.41	-	-	-	-	C	0.50	-	-
	PM	D	44	-	-	E	1.10	-	-	-	-	C	0.81	-	-	-	-	B	0.40	-	-	-	-	D	0.90	-	-
E 1st/Commercial	AM	B	18	C	0.35	C	0.65	-	-	C	0.70	B	0.91	-	-	C	0.34	C	0.63	-	-	C	0.50	B	0.26	-	-
	PM	C	24	B	0.23	B	0.88	-	-	D	0.61	C	0.73	-	-	C	0.35	C	0.64	-	-	D	0.84	B	0.41	-	-
E 1st/Woodland	AM	A	7	-	-	B	0.6	-	-	-	-	A	0.77	-	-	-	-	B	0.12	-	-	-	-	C	0.08	-	-
	PM	B	10	-	-	A	0.65	-	-	-	-	B	0.64	-	-	-	-	B	0.17	-	-	-	-	C	0.19	-	-
E 1st/Clark	AM	D	50	-	-	C	0.78	-	-	-	-	D	1.07	-	-	F	1.05	F	1.08	-	-	C	0.48	C	0.81	-	-
	PM	C	30	-	-	C	0.90	-	-	-	-	C	0.73	-	-	D	0.81	C	0.87	-	-	E	0.98	C	0.79	-	-
	Vancouver - E Broadway																										
Boundary/Lougheed/ Broadway	AM	D	38	C	0.66	C	0.49	A	0.25	B	0.40	D	0.97	A	0.30	D	0.68	D	0.62	A	0.27	E	0.78	D	0.76	B	0.69
	PM	D	42	D	0.84	D	0.82	A	0.31	D	0.76	D	0.91	A	0.21	D	0.77	E	0.91	B	0.27	E	0.81	D	0.75	A	0.44
Broadway/Rupert	AM	C	27	B	0.30	C	0.40	-	-	B	0.55	C	0.57	-	-	D	0.81	D	0.35	A	0.35	C	0.23	D	0.68	A	0.36
	PM	C	34	C	0.59	C	0.76	-	-	E	0.89	C	0.54	-	-	D	0.73	D	0.51	A	0.37	C	0.23	D	0.72	B	0.24
Broadway/Renfrew	AM	C	30	C	0.45	C	0.46	-	-	B	0.33	C	0.79	-	-	C	0.48	D	0.51	-	-	C	0.27	D	0.66	-	-
	PM	D	43	E	0.86	D	0.80	-	-	D	0.72	D	0.84	-	-	D	0.65	E	0.91	-	-	D	0.65	D	0.74	-	-
Broadway/Nanaimo	AM	C	28	C	0.48	C	0.45	-	-	B	0.41	C	0.78	-	-	C	0.55	D	0.56	-	-	C	0.29	D	0.68	-	-
	PM	C	34	D	0.77	C	0.74	-	-	D	0.69	C	0.80	-	-	C	0.44	D	0.73	-	-	C	0.53	D	0.67	-	-
Broadway/Victoria	AM	B	14	C	0.33	A	0.32	-	-	B	0.33	B	0.76	-	-	C	0.33	B	0.33	A	0.12	B	0.24	C	0.47	-	-
	PM	B	19	F	0.91	A	0.51	-	-	E	0.81	B	0.62	-	-	C	0.27	C	0.42	B	0.22	E	0.78	D	0.73	-	-
Broadway/Commercial	AM	B	15	A	0.22	B	0.33	-	-	A	0.17	B	0.62	-	-	-	-	C	0.62	-	-	-	-	B	0.26	-	-
	PM	C	21	A	0.32	B	0.54	-	-	B	0.28	B	0.51	-	-	-	-	C	0.61	-	-	-	-	D	0.70	-	-
Broadway/Clark	AM	D	45	D	0.72	C	0.39	-	-	C	0.48	D	0.87	-	-	C	0.28	E	0.91	-	-	E	0.86	C	0.43	-	-
	PM	D	51	D	0.64	D	0.80	-	-	E	0.85	D	0.75	-	-	D	0.48	E	0.83	-	-	F	1.12	D	0.77	-	-
	Burnaby																										
Broadway/Gaglardi (N)	AM	B	19	-	-	-	-	-	-	C	0.77	-	-	A	0.49	-	-	C	0.56	A	0.14	C	0.33	B	0.16	-	-
	PM	B	19	-	-	-	-	-	-	C	0.41	-	-	A	0.21	-	-	C	0.16	B	0.75	D	0.65	A	0.19	-	-
Broadway/Gaglardi (S)	AM	A	10	B	0.28	-	-	A	0.11	-	-	-	-	-	-	C	0.75	A	0.34	-	-	-	-	A	0.54	A	0.52
	PM	C	21	B	0.64	-	-	A	0.15	-	-	-	-	-	-	C	0.49	C	0.76	-	-	-	-	C	0.63	A	0.27
Lougheed/Gaglardi	AM	D	40	C	0.25	C	0.55	-	-	D	0.81	C	0.54	B	0.15	F	0.96	D	0.64	A	0.35	D	0.31	D	0.75	B	0.51
	PM	E	60	C	0.58	F	1.11	-	-	D	0.82	C	0.39	B	0.1	E	0.61	E	0.85	C	0.82	E	0.64	D	0.67	A	0.25
Eastlake/Production	AM	A	10	-	-	A	0.16	-	-	-	-	A	0.26	-	-	B	0.27	A	0.32	-	-	A	0.06	B	0.68	-	-
	PM	A	9	-	-	B	0.53	-	-	-	-	A	0.21	-	-	A	0.11	B	0.52	-	-	A	0.20	A	0.32	-	-

				Turning Movements																							
				EBL		EBT		EBR		WBL		WBT		WBR		NBL		NBT		NBR		SBL		SBT		SBR	
Intersection	Time Period	Int. LOS	Int. Avg. Delay (sec/veh)	LOS	v/c	LOS	v/c	LOS	v/c	LOS	v/c	LOS	v/c	LOS	v/c	LOS	v/c	LOS	v/c	LOS	v/c	LOS	v/c	LOS	v/c	LOS	v/c
Lougheed/Production	AM	C	22	D	0.41	B	0.30	A	0.1	D	0.44	C	0.63	A	0.41	C	0.23	D	0.38	B	0.21	C	0.32	B	0.41	-	-
	PM	C	28	D	0.31	C	0.78	B	0.17	D	0.56	B	0.45	A	0.14	C	0.42	D	0.65	B	0.61	D	0.77	B	0.41	-	-
Broadway/Underhill	AM	B	11	B	0.10	-	-	A	0.10	-	-	-	-	-	-	B	0.46	A	0.06	-	-	-	-	C	0.34	A	0.19
	PM	A	10	B	0.17	-	-	A	0.33	-	-	-	-	-	-	B	0.46	A	0.05	-	-	-	-	C	0.41	A	0.18
Broadway/Lake City	AM	A	8	-	-	A	0.20	-	-	-	-	A	0.45	-	-	A	0.11	A	0.18			B	0.18	A	0.29	-	-
	PM	A	8	-	-	A	0.44	-	-	-	-	A	0.36	-	-	A	0.11	A	0.24	-	-	B	0.21	A	0.12	-	-
Lougheed/Lake City	AM	B	15	D	0.48	A	0.21	-	-	-	-	B	0.60	A	0.16	-	-	-	-	-	-	D	0.49	-	-	A	0.35
	PM	B	13	C	0.38	A	0.60	-	-	-	-	B	0.57	A	0.23	-	-	-	-	-	-	C	0.52	-	-	A	0.36
Lougheed/Bainbridge	AM	B	16	D	0.21	A	0.29	-	-	D	0.10	B	0.67	A	0.11	-	-	C	0.22	-	-	-	-	C	0.57	-	-
	PM	B	17	D	0.44	B	0.55	-	-	D	0.15	B	0.51	A	0.10	-	-	C	0.41	-	-	-	-	C	0.61	-	-
Broadway/Sperling	AM	B	12	A	0.24	A	0.14	-	-	-	-	B	0.64	A	0.05	-	-	-	-	-	-	B	0.10	-	-	A	0.58
	PM	A	8	A	0.46	A	0.44	-	-	-	-	B	0.44	A	0.12	-	-	-	-	-	-	B	0.15	-	-	A	0.36
Lougheed/Sperling/ Kensington	AM	B	15	D	0.04	B	0.29	A	0.19	D	0.05	B	0.63	A	0.38	C	0.68	C	0.50	A	0.03	B	0.08	A	0.07	-	-
	PM	B	16	C	0.19	B	0.54	A	0.28	D	0.06	B	0.55	A	0.32	C	0.66	C	0.54	B	0.04	C	0.33	B	0.09	-	-
Broadway/Kensington E	AM	B	11	-	-	C	0.21	A	0.45	B	0.68	A	0.21	-	-	C	0.51	-	-	A	0.41	-	-	-	-	-	-
	PM	B	13	-	-	C	0.58	A	0.37	B	0.51	A	0.14	-	-	C	0.68	-	-	A	0.67	-	-	-	-	-	-
Kensington/Kensington	AM	B	12	A	0.27	A	0.03	-	-	-	-	B	0.57	A	0.18	-	-	-	-	-	-	B	0.13	-	-	B	0.80
	PM	B	12	A	0.61	A	0.07	-	-	-	-	C	0.50	A	0.29	-	-	-	-	-	-	C	0.26	-	-	A	0.57
Lougheed/Delta	AM	C	24	-	-	A	0.28	A	0.23	-	-	C	0.82	-	-	E	0.74	E	0.77	-	-	E	0.45	-	-	C	0.07
	PM	C	20	-	-	B	0.77	A	0.28	-	-	B	0.54	-	-	E	0.72	E	0.74	-	-	E	0.56	-	-	C	0.10
Graveley/Willingdon	AM	A	9	-	-	B	0.07	-	-	-	-	B	0.13	-	-	-	-	A	0.26	-	-	-	-	A	0.47	-	-
	PM	B	11	-	-	A	0.13	-	-	-	-	B	0.10	-	-	-	-	B	0.62	-	-	-	-	A	0.41	-	-
Broadway/Holdom	AM	A	9	-	-	A	0.29	-	-	B	0.46	B	0.36	-	-	-	-	A	0.12	A	0.06	-	-	A	0.43	-	-
	PM	B	10	-	-	B	0.54	-	-	B	0.28	A	0.29	-	-	-	-	B	0.42	A	0.22	-	-	B	0.44	-	-
Lougheed/Holdom	AM	C	24	D	0.22	C	0.52	A	0.12	D	0.65	C	0.72	-	-	-	-	C	0.23	A	0.20	-	-	C	0.71	-	-
	PM	C	25	D	0.41	C	0.81	A	0.07	D	0.42	C	0.70	-	-	-	-	C	0.55	A	0.42	-	-	C	0.64	-	-
	Coquitlam																										
Mariner/Como Lake	AM	B	16	C	0.32	C	0.33	A	0.32	C	0.16	C	0.27	-	-	C	0.46	A	0.12	-	-	C	0.01	C	0.46	A	0.34
	PM	C	24	C	0.72	D	0.74	A	0.34	D	0.11	D	0.25	-	-	D	0.65	B	0.55	-	-	C	0.07	D	0.49	A	0.27
Baker/Como Lake	AM	A	2	A	0.01	A	0.1	-	-	-	-	A	0.26	-	-	-	-	-	-	-	-	-	-	C	0.14	-	-
	PM	A	2	A	0.02	A	0.35	-	-	-	-	A	0.21	-	-	-	-	-	-	-	-	-	-	C	0.18	-	-
Seymour/Como Lake	AM	B	10	A	0.02	A	0.22	-	-	-	-	B	0.57	-	-	-	-	-	-	-	-	-	-	A	0.04	-	-
	PM	A	10	A	0.03	B	0.62	-	-	-	-	A	0.39	-	-	-	-	-	-	-	-	-	-	B	0.03	-	-
Thermal/Como Lake	AM	B	19	A	0.34	A	0.14	-	-	B	0.03	B	0.45	-	-	-	-	C	0.02	-	-	-	-	C	0.04	D	0.75
	PM	B	18	B	0.66	A	0.44	-	-	-	-	C	0.56	-	-	-	-	C	0.01	-	-	-	-	C	0.06	D	0.72

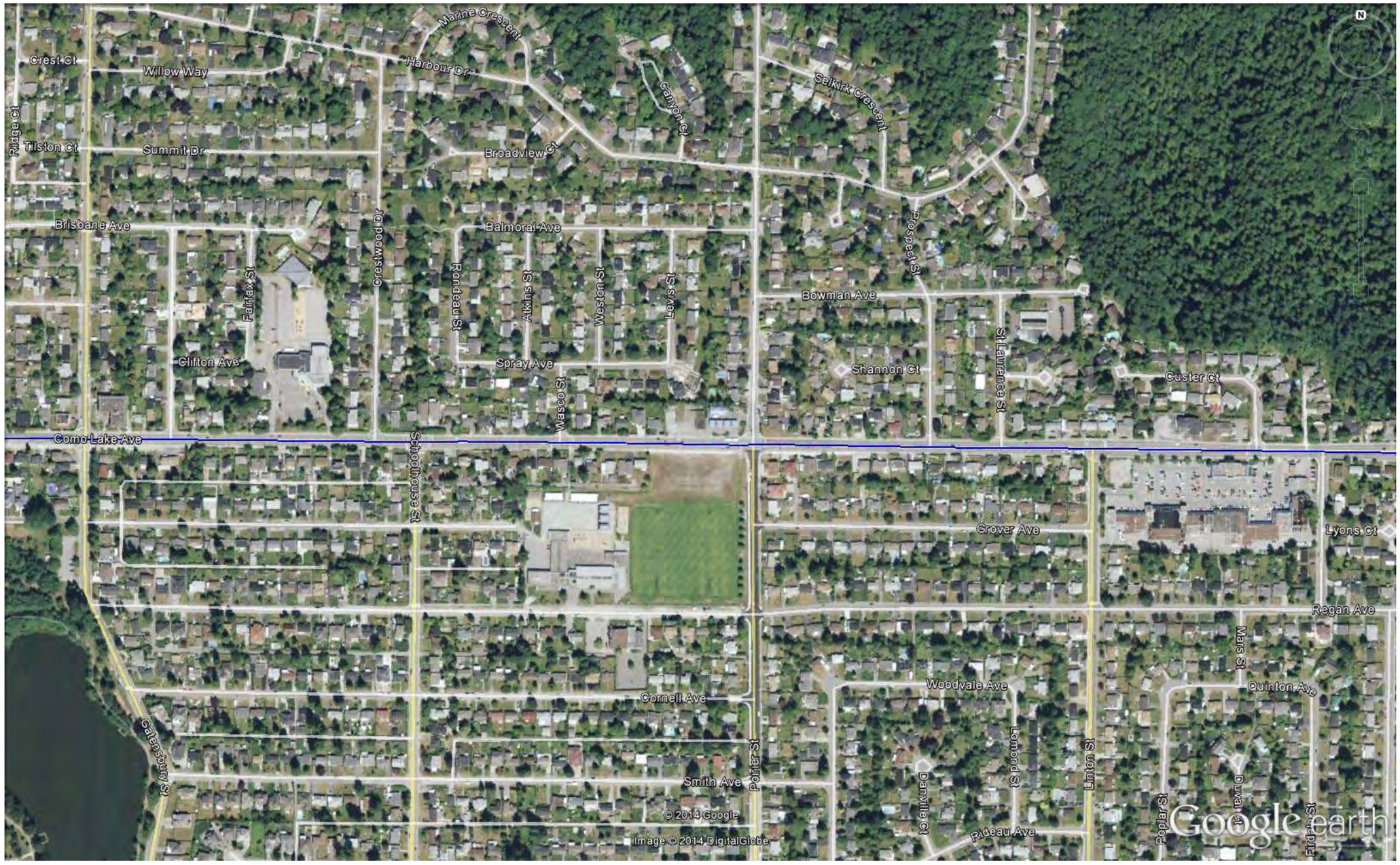
				Turning Movements																							
				EBL		EBT		EBR		WBL		WBT		WBR		NBL		NBT		NBR		SBL		SBT		SBR	
Intersection	Time Period	Int. LOS	Int. Avg. Delay (sec/veh)	LOS	v/c	LOS	v/c	LOS	v/c	LOS	v/c	LOS	v/c	LOS	v/c	LOS	v/c	LOS	v/c	LOS	v/c	LOS	v/c	LOS	v/c	LOS	v/c
Custer/Como Lake	AM	A	10	-	-	A	0.25	-	-	-	-	B	0.61	-	-	-	-	-	-	-	-	-	-	B	0.02	-	-
	PM	B	11	-	-	B	0.76	-	-	-	-	A	0.37	-	-	-	-	-	-	-	-	-	-	B	0.02	-	-
Linton/Como Lake	AM	A	9	-	-	A	0.18	-	-	A	0.18	A	0.35	-	-	-	-	D	0.53	-	-	-	-	-	-	-	-
	PM	C	23	-	-	C	0.77	-	-	C	0.55	A	0.27	-	-	-	-	D	0.81	-	-	-	-	-	-	-	-
Poirier & Como Lake	AM	A	7	A	0.03	A	0.14	-	-	A	0.10	A	0.32	-	-	-	-	C	0.40	-	-	-	-	D	0.48	-	-
	PM	B	12	A	0.05	A	0.46	-	-	C	0.51	A	0.25	-	-	-	-	D	0.65	-	-	-	-	D	0.63	-	-
Wasco/Como Lake	AM	A	9	-	-	A	0.26	-	-	-	-	B	0.59	-	-	-	-	-	-	-	-	-	-	A	0.05	-	-
	PM	A	9	-	-	B	0.68	-	-	-	-	A	0.31	-	-	-	-	-	-	-	-	-	-	B	0.03	-	-
Schoolhouse/Como Lake	AM	A	5	-	-	A	0.12	-	-	-	-	A	0.36	-	-	-	-	D	0.47	-	-	-	-	-	-	-	-
	PM	A	5	-	-	A	0.43	-	-	-	-	A	0.27	-	-	-	-	C	0.55	-	-	-	-	-	-	-	-
Gatensbury/Como Lake	AM	B	13	A	0.13	A	0.12	-	-	A	0.04	A	0.35	-	-	-	-	C	0.30	-	-	-	-	C	0.67	-	-
	PM	B	14	A	0.27	A	0.46	-	-	B	0.14	B	0.27	-	-	-	-	D	0.57	-	-	-	-	D	0.79	-	-
Porter/Como Lake	AM	A	5	-	-	A	0.12	-	-	-	-	A	0.38	-	-	-	-	C	0.25	-	-	-	-	C	0.34	-	-
	PM	A	4	-	-	A	0.49	-	-	-	-	A	0.29	-	-	-	-	C	0.48	-	-	-	-	C	0.25	-	-
Blue Mountain/Como Lake	AM	B	14	D	0.02	B	0.17	-	-	D	0.70	A	0.32	-	-	-	-	D	0.50	B	0.33	-	-	C	0.39	-	-
	PM	C	25	D	0.21	C	0.66	-	-	E	0.66	A	0.20	-	-	-	-	D	0.72	B	0.7	-	-	C	0.32	-	-
Banting/Como Lake	AM	B	13	-	-	A	0.21	-	-	-	-	B	0.62	-	-	-	-	-	-	-	-	-	-	A	0.02	-	-
	PM	B	12	-	-	B	0.67	-	-	-	-	A	0.3	-	-	-	-	-	-	-	-	-	-	B	0.01	-	-
Robinson/Como Lake	AM	A	9	-	-	A	0.10	-	-	-	-	A	0.48	-	-	-	-	A	0.14	-	-	-	-	B	0.53	-	-
	PM	B	16	-	-	B	0.53	-	-	-	-	A	0.31	-	-	-	-	B	0.28	-	-	-	-	C	0.60	-	-
Clarke/Como Lake	AM	C	27	D	0.44	D	0.23	-	-	C	0.21	D	0.83	-	-	-	-	B	0.21	-	-	B	0.01	B	0.24	B	0.81
	PM	D	36	D	0.76	D	0.83	-	-	D	0.43	D	0.44	-	-	-	-	C	0.40	-	-	C	0.01	C	0.28	A	0.26
North Road/Broadway	AM	B	16	B	0.13	A	0.17	-	-	A	0.01	B	0.79	-	-	-	-	C	0.74	-	-	-	-	B	0.23	-	-
	PM	A	9	A	0.14	A	0.71	-	-	A	0.06	A	0.17	-	-	-	-	C	0.50	-	-	-	-	B	0.17	-	-
Clarke/Burquitlam Mall	AM	A	7	-	-	-	-	-	-	-	-	D	0.37	B	0.23	A	0.01	A	0.12	-	-	A	0.09	A	0.15	-	-
	PM	A	6	-	-	-	-	-	-	-	-	E	0.43	B	0.40	A	0.01	A	0.24	-	-	A	0.10	A	0.18	-	-
Clarke/Smith	AM	B	14	C	0.04	C	0.09	-	-	D	0.32	D	0.54	-	-	A	0.01	A	0.12	-	-	A	0.02	A	0.18	-	-
	PM	B	18	D	0.11	D	0.60	-	-	D	0.39	D	0.33	-	-	A	0.03	A	0.26	-	-	A	0.05	B	0.19	-	-

Appendix A – Preliminary Gas Line Alignment

Coquitlam Alignment – Section 1

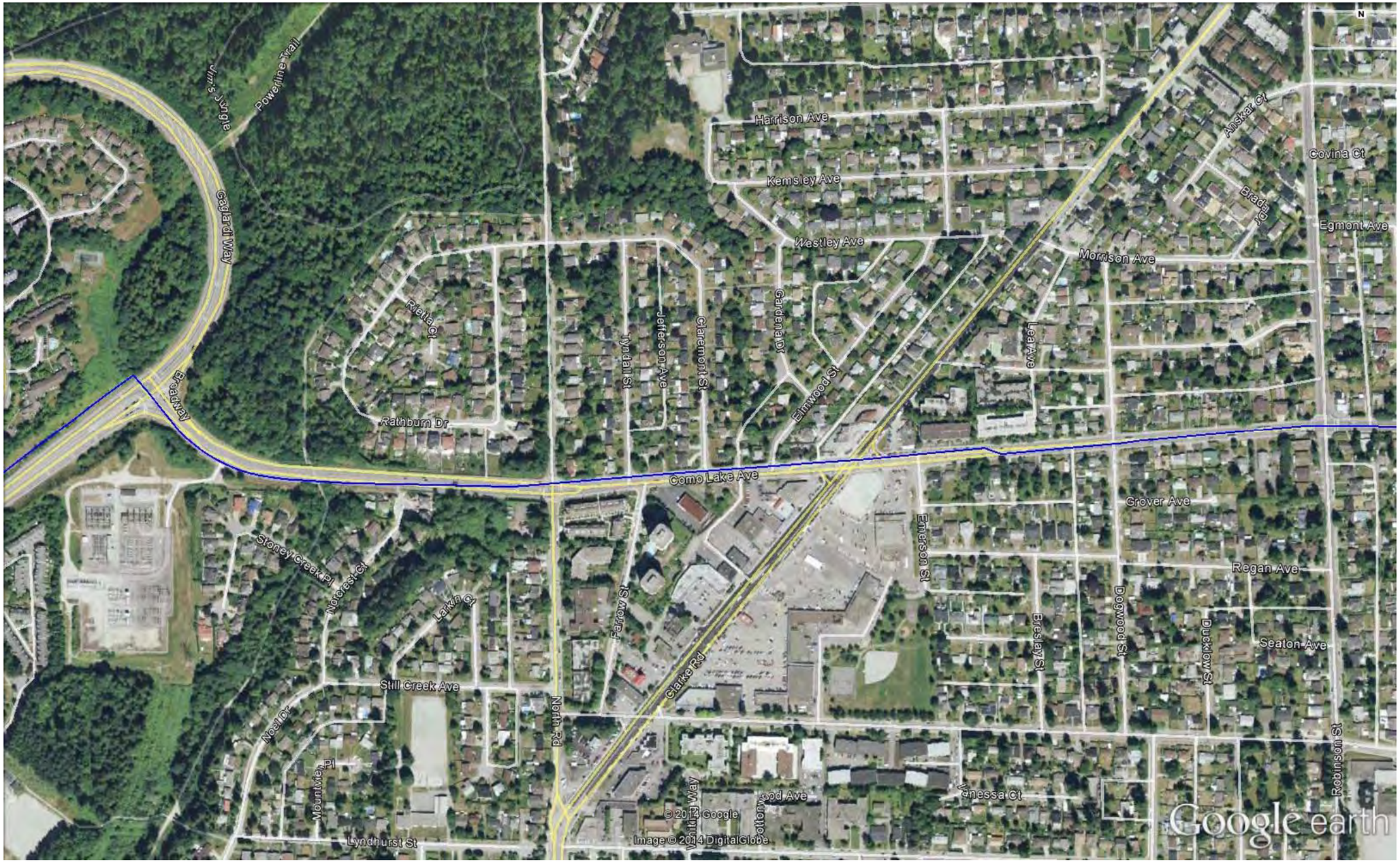


Coquitlam Alignment – Section 2



Coquitlam Alignment – Section 3

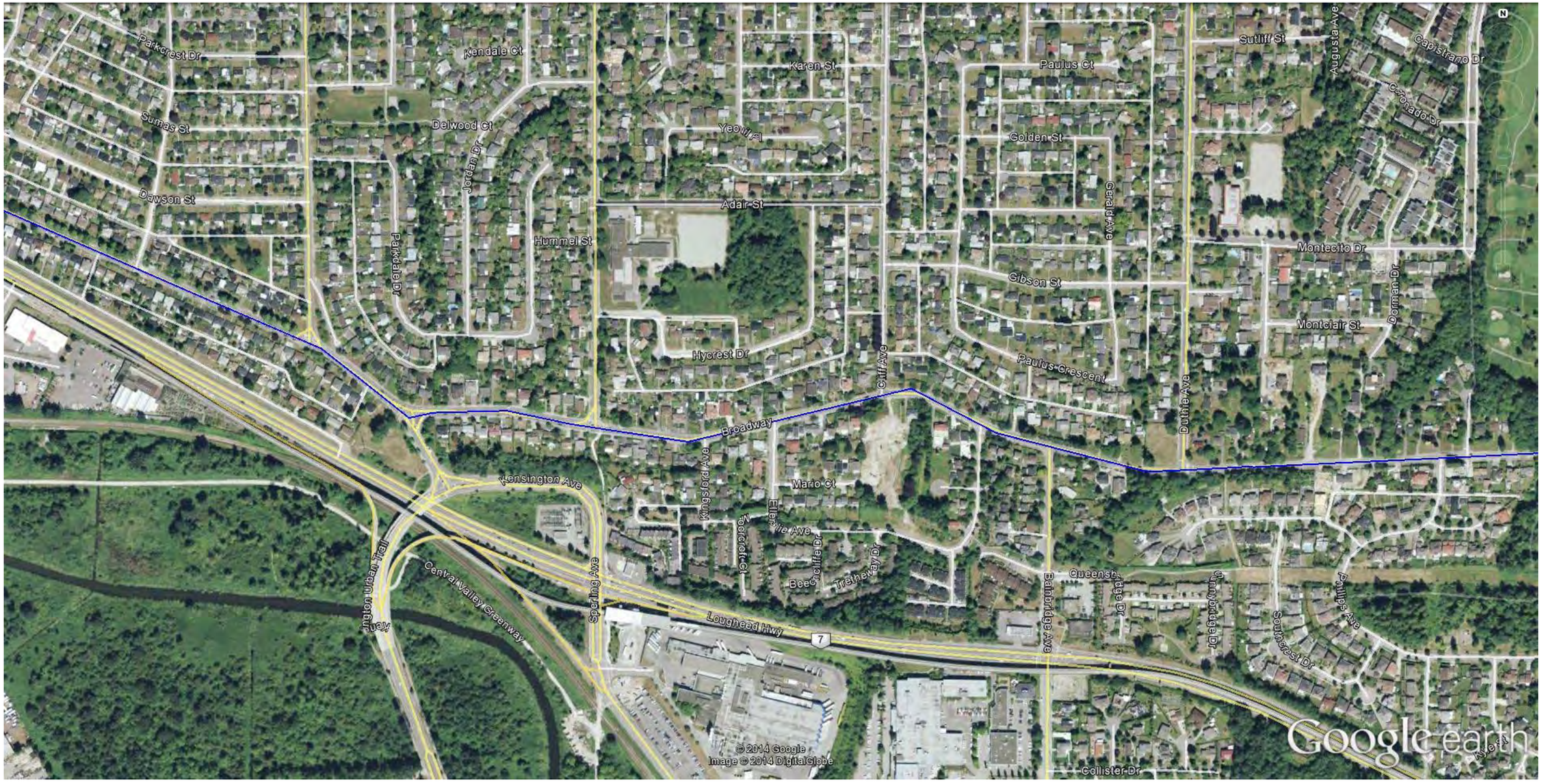
Coquitlam Alignment – Section 4



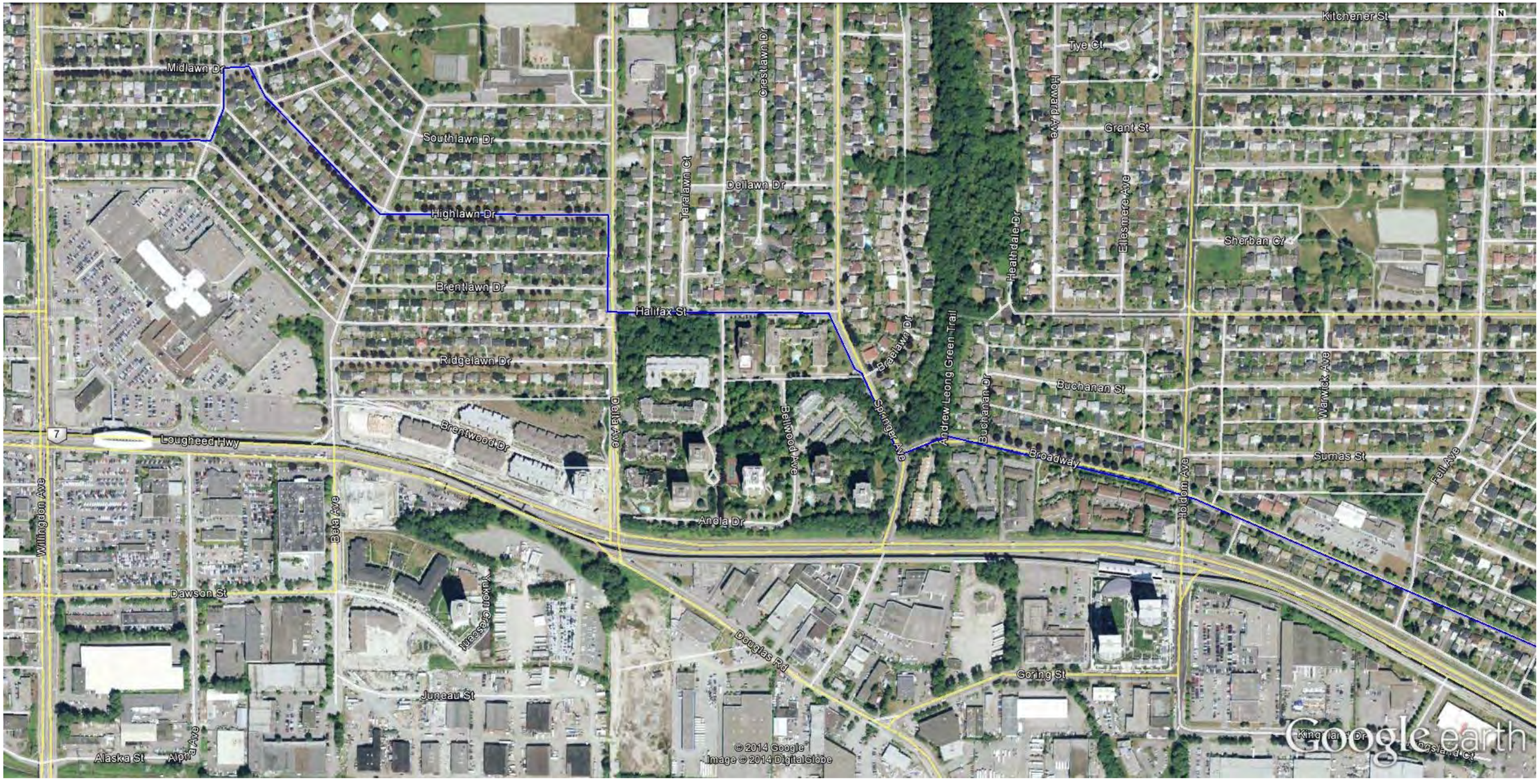
Burnaby Alignment – Section 1

Burnaby Alignment – Section 2

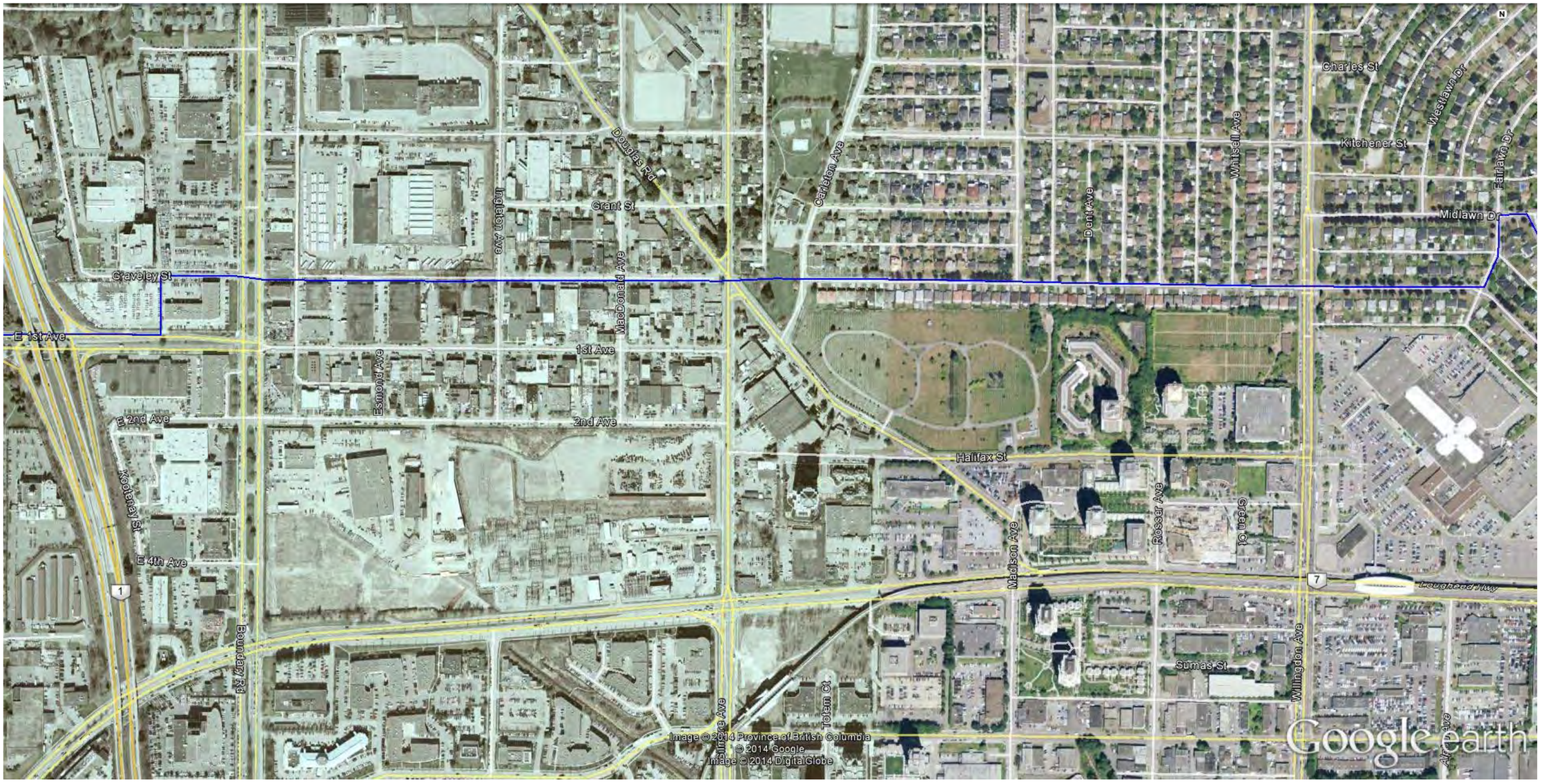
Burnaby Alignment – Section 3



Burnaby Alignment – Section 4



Burnaby Alignment – Section 5

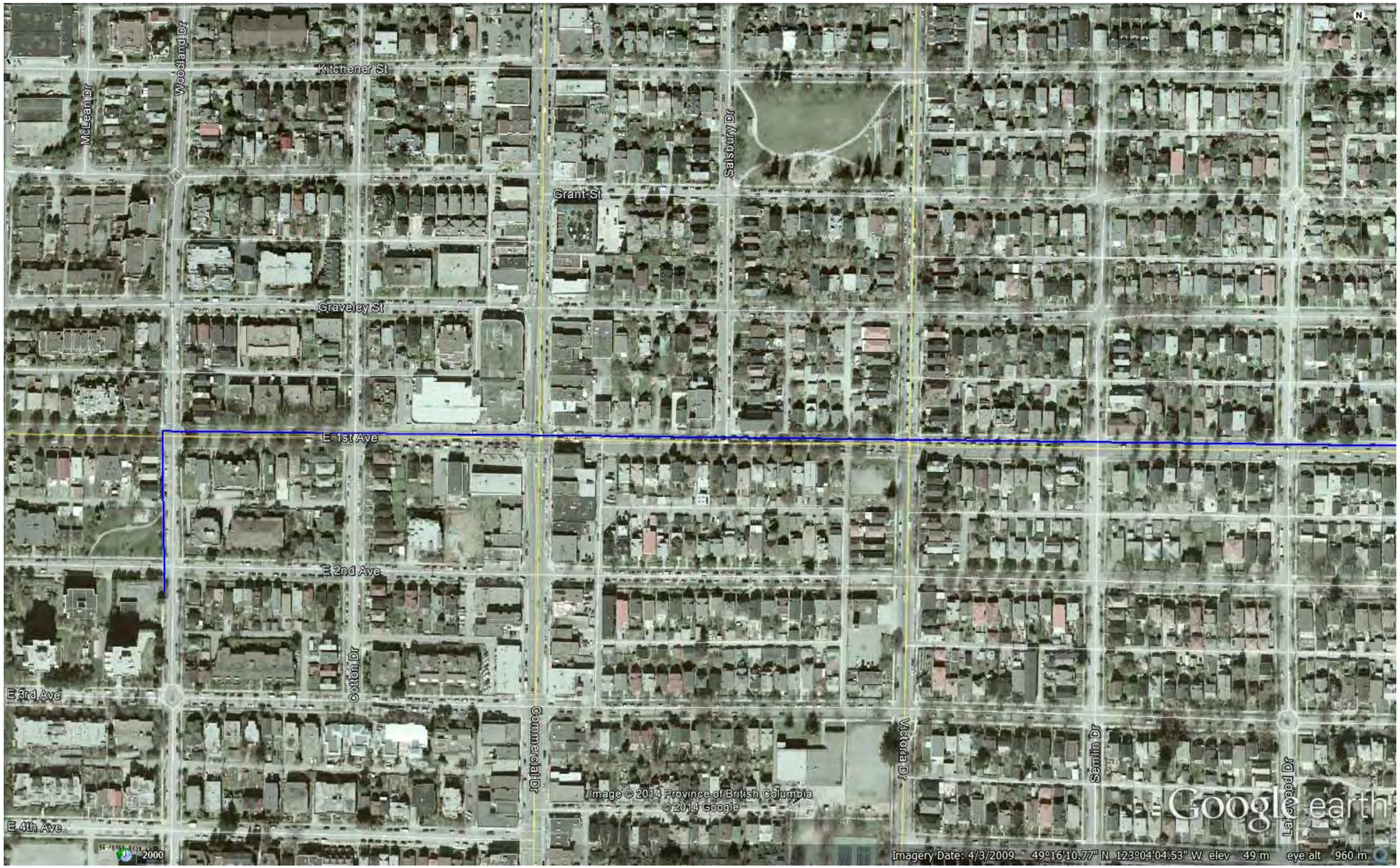


Vancouver Alignment – Section 1

Vancouver Alignment – Section 2

Vancouver Alignment – Section 3

Vancouver Alignment – Section 4



Appendix B – Sample Tube Count

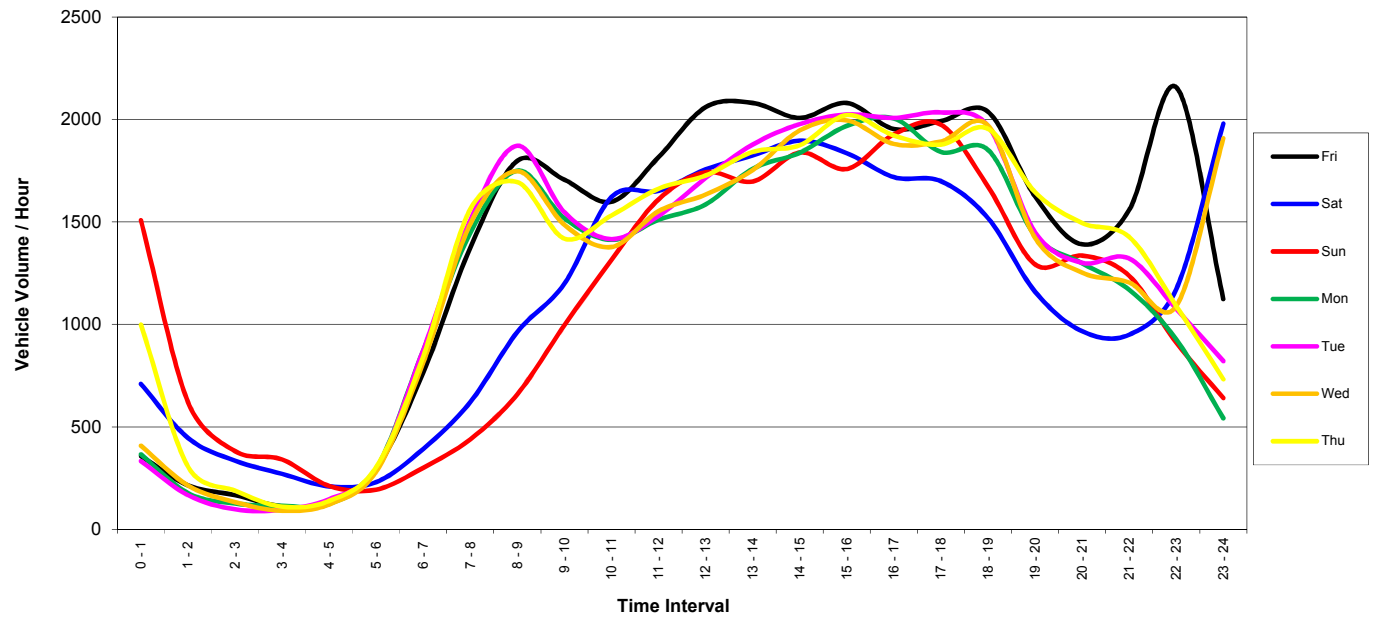
CREATIVE TRANSPORTATION SOLUTIONS LTD.
TRAFFIC & TRANSPORTATION ENGINEERING SPECIALISTS

24 HOUR ROAD TUBE COUNT - VOLUME

LOCATION: E 1st Ave W of Rupert St
DIRECTION: Eastbound
START DAY: 25-Jul-14
PROJECT: 5256 - GNEC - Fortis BC Traffic Counts
NOTES:

Time	Fri 25-Jul-14	Sat 26-Jul-14	Sun 27-Jul-14	Mon 28-Jul-14	Tue 29-Jul-14	Wed 30-Jul-14	Thu 31-Jul-14
0 - 1	358	710	1508	366	333	408	999
1 - 2	215	446	621	177	167	214	306
2 - 3	167	335	382	126	98	133	189
3 - 4	113	271	341	115	96	91	111
4 - 5	127	210	212	124	148	122	139
5 - 6	296	231	194	296	293	283	304
6 - 7	766	393	301	875	877	816	846
7 - 8	1376	622	440	1448	1511	1492	1564
8 - 9	1799	964	660	1751	1872	1748	1695
9 - 10	1706	1200	997	1518	1547	1486	1419
10 - 11	1599	1622	1316	1413	1417	1378	1532
11 - 12	1817	1652	1611	1511	1530	1553	1663
12 - 13	2061	1757	1743	1586	1715	1634	1727
13 - 14	2081	1825	1698	1760	1878	1754	1842
14 - 15	2008	1897	1839	1838	1978	1947	1875
15 - 16	2081	1836	1759	1969	2025	1996	2022
16 - 17	1954	1719	1928	2005	2008	1881	1922
17 - 18	1992	1699	1975	1842	2035	1893	1878
18 - 19	2038	1519	1673	1852	1968	1971	1955
19 - 20	1625	1160	1293	1434	1450	1423	1646
20 - 21	1391	967	1336	1299	1301	1253	1495
21 - 22	1559	950	1237	1169	1322	1205	1427
22 - 23	2157	1173	911	927	1076	1090	1090
23 - 24	1124	1980	641	542	821	1909	733
AM Peak Hr.	**11:00 - 12:00**	**11:00 - 12:00**	**11:00 - 12:00**	**8:00 - 9:00**	**8:00 - 9:00**	**8:00 - 9:00**	**8:00 - 9:00**
AM Peak Vol.	**1817**	**1652**	**1611**	**1751**	**1872**	**1748**	**1695**
PM Peak Hr.	**22:00 - 23:00**	**23:00 - 0:00**	**17:00 - 18:00**	**16:00 - 17:00**	**17:00 - 18:00**	**15:00 - 16:00**	**15:00 - 16:00**
PM Peak Vol.	**2157**	**1980**	**1975**	**2005**	**2035**	**1996**	**2022**
Daily Total	**32410**	**27138**	**26616**	**27943**	**29466**	**29680**	**30379**
Daily %	**55.0%**	**53.0%**	**55.7%**	**53.1%**	**53.4%**	**52.8%**	**54.3%**

E 1st Ave W of Rupert St - Eastbound



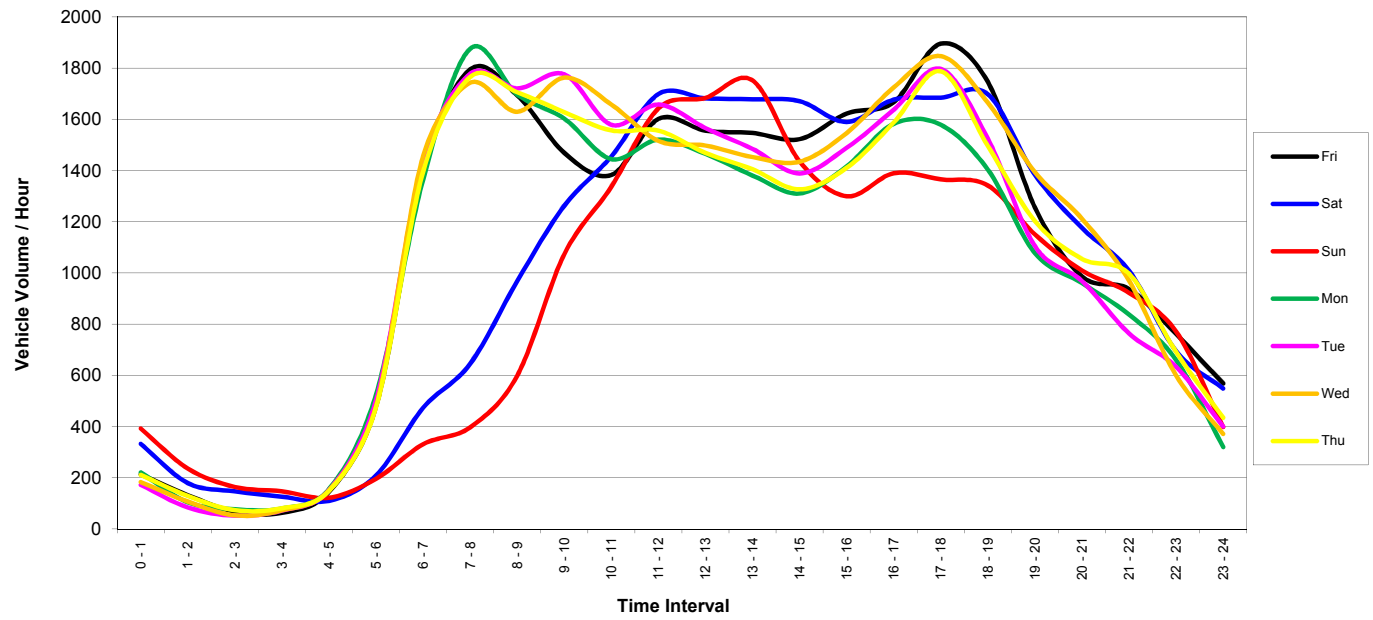
CREATIVE TRANSPORTATION SOLUTIONS LTD.
TRAFFIC & TRANSPORTATION ENGINEERING SPECIALISTS

24 HOUR ROAD TUBE COUNT - VOLUME

LOCATION: E 1st Ave W of Rupert St
DIRECTION: Westbound
START DAY: 25-Jul-14
PROJECT: 5256 - GNEC - Fortis BC Traffic Counts
NOTES:

Time	Fri 25-Jul-14	Sat 26-Jul-14	Sun 27-Jul-14	Mon 28-Jul-14	Tue 29-Jul-14	Wed 30-Jul-14	Thu 31-Jul-14
0 - 1	214	333	393	222	173	184	212
1 - 2	133	180	237	105	85	108	130
2 - 3	69	148	165	78	53	54	74
3 - 4	64	127	148	81	73	74	82
4 - 5	146	111	123	157	153	152	150
5 - 6	480	210	197	527	505	481	477
6 - 7	1406	474	332	1366	1437	1457	1397
7 - 8	1795	646	398	1876	1778	1743	1766
8 - 9	1694	969	600	1697	1721	1630	1706
9 - 10	1469	1263	1074	1603	1776	1763	1628
10 - 11	1383	1456	1337	1445	1579	1658	1557
11 - 12	1602	1699	1643	1521	1658	1516	1556
12 - 13	1556	1682	1684	1465	1566	1498	1469
13 - 14	1547	1679	1752	1381	1485	1453	1405
14 - 15	1523	1671	1436	1311	1389	1435	1327
15 - 16	1623	1590	1300	1417	1489	1547	1411
16 - 17	1667	1677	1390	1583	1638	1725	1588
17 - 18	1896	1685	1366	1579	1797	1847	1788
18 - 19	1746	1698	1342	1404	1524	1665	1496
19 - 20	1256	1384	1151	1078	1105	1394	1203
20 - 21	987	1176	1010	961	969	1212	1055
21 - 22	938	1009	923	838	764	970	997
22 - 23	762	696	772	661	634	600	692
23 - 24	569	549	399	321	401	372	435
AM Peak Hr.	**7:00 - 8:00**	**11:00 - 12:00**	**11:00 - 12:00**	**7:00 - 8:00**	**7:00 - 8:00**	**9:00 - 10:00**	**7:00 - 8:00**
AM Peak Vol.	**1795**	**1699**	**1643**	**1876**	**1778**	**1763**	**1766**
PM Peak Hr.	**17:00 - 18:00**	**18:00 - 19:00**	**13:00 - 14:00**	**16:00 - 17:00**	**17:00 - 18:00**	**17:00 - 18:00**	**17:00 - 18:00**
PM Peak Vol.	**1896**	**1698**	**1752**	**1583**	**1797**	**1847**	**1788**
Daily Total	**26525**	**24112**	**21172**	**24677**	**25752**	**26538**	**25601**
Daily %	**45.0%**	**47.0%**	**44.3%**	**46.9%**	**46.6%**	**47.2%**	**45.7%**

E 1st Ave W of Rupert St - Westbound



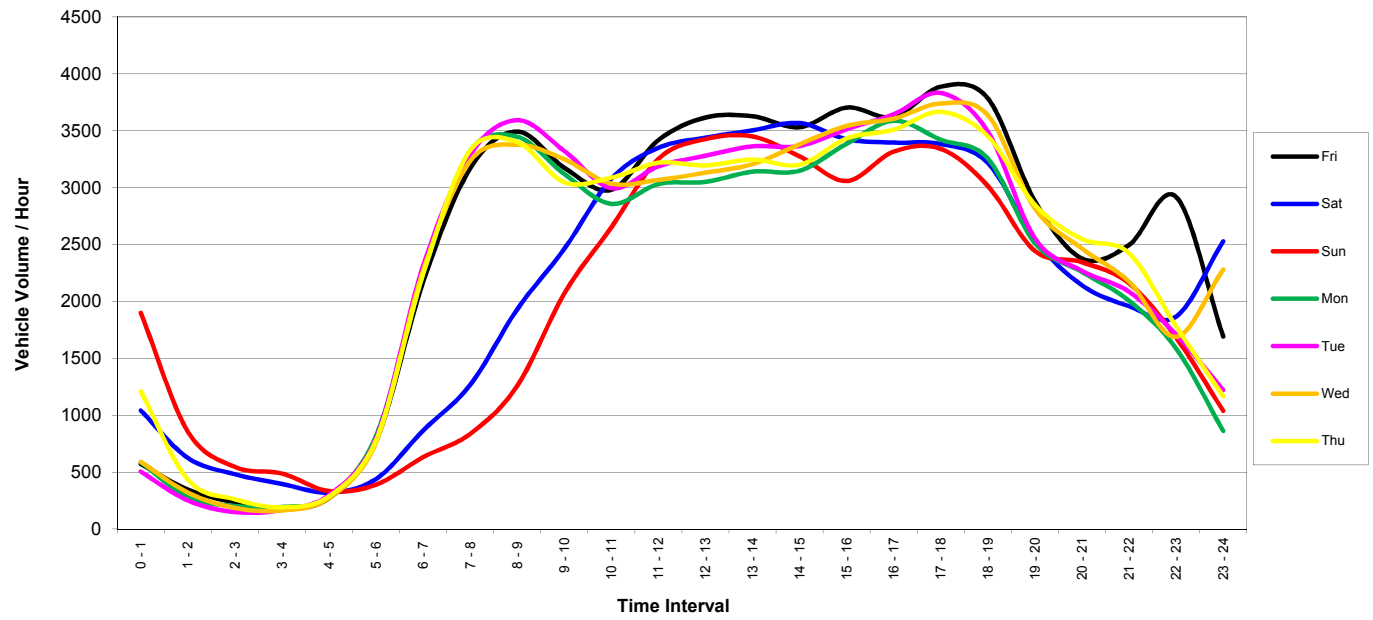
CREATIVE TRANSPORTATION SOLUTIONS LTD.
TRAFFIC & TRANSPORTATION ENGINEERING SPECIALISTS

24 HOUR ROAD TUBE COUNT - VOLUME

LOCATION: E 1st Ave W of Rupert St
DIRECTION: Eastbound and Westbound
START DAY: 25-Jul-14
PROJECT: 5256 - GNEC - Fortis BC Traffic Counts
NOTES:

Time	Fri 25-Jul-14	Sat 26-Jul-14	Sun 27-Jul-14	Mon 28-Jul-14	Tue 29-Jul-14	Wed 30-Jul-14	Thu 31-Jul-14
0 - 1	572	1043	1901	588	506	592	1211
1 - 2	348	626	858	282	252	322	436
2 - 3	236	483	547	204	151	187	263
3 - 4	177	398	489	196	169	165	193
4 - 5	273	321	335	281	301	274	289
5 - 6	776	441	391	823	798	764	781
6 - 7	2172	867	633	2241	2314	2273	2243
7 - 8	3171	1268	838	3324	3289	3235	3330
8 - 9	3493	1933	1260	3448	3593	3378	3401
9 - 10	3175	2463	2071	3121	3323	3249	3047
10 - 11	2982	3078	2653	2858	2996	3036	3089
11 - 12	3419	3351	3254	3032	3188	3069	3219
12 - 13	3617	3439	3427	3051	3281	3132	3196
13 - 14	3628	3504	3450	3141	3363	3207	3247
14 - 15	3531	3568	3275	3149	3367	3382	3202
15 - 16	3704	3426	3059	3386	3514	3543	3433
16 - 17	3621	3396	3318	3588	3646	3606	3510
17 - 18	3888	3384	3341	3421	3832	3740	3666
18 - 19	3784	3217	3015	3256	3492	3636	3451
19 - 20	2881	2544	2444	2512	2555	2817	2849
20 - 21	2378	2143	2346	2260	2270	2465	2550
21 - 22	2497	1959	2160	2007	2086	2175	2424
22 - 23	2919	1869	1683	1588	1710	1690	1782
23 - 24	1693	2529	1040	863	1222	2281	1168
AM Peak Hr.	**8:00 - 9:00**	**11:00 - 12:00**	**11:00 - 12:00**	**8:00 - 9:00**	**8:00 - 9:00**	**8:00 - 9:00**	**8:00 - 9:00**
AM Peak Vol.	**3493**	**3351**	**3254**	**3448**	**3593**	**3378**	**3401**
PM Peak Hr.	**17:00 - 18:00**	**14:00 - 15:00**	**13:00 - 14:00**	**16:00 - 17:00**	**17:00 - 18:00**	**17:00 - 18:00**	**17:00 - 18:00**
PM Peak Vol.	**3888**	**3568**	**3450**	**3588**	**3832**	**3740**	**3666**
Daily Total	**58935**	**51250**	**47788**	**52620**	**55218**	**56218**	**55980**
Daily %	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**

E 1st Ave W of Rupert St - 2-Way



Appendix C – Sample Turning Movement Count

Commercial Dr & E 1st Ave

Tuesday, July 29, 2014

Vehicle Classification Summary

Project: #5256: GNEC - Fortis BC Traffic Counts
Municipality: Vancouver
Weather:

Time Period	Entering Intersection	Vehicle Classification					**Total**
		Passenger Cars	Heavy Vehicles (3 or more axles)	Translink Buses			
Morning (07:00 - 09:00)	Volume	7,221	55	35			**7,311**
	%	98.8%	0.8%	0.5%			**100.0%**
Midday (11:00 - 13:00)	Volume	7,005	47	30			**7,082**
	%	98.9%	0.7%	0.4%			**100.0%**
Afternoon (15:00 - 18:00)	Volume	11,363	57	48			**11,468**
	%	99.1%	0.5%	0.4%			**100.0%**
Total (7 Hours)	**Volume**	**25,589**	**159**	**113**			**25,861**
	%	**98.9%**	**0.6%**	**0.4%**			**100.0%**

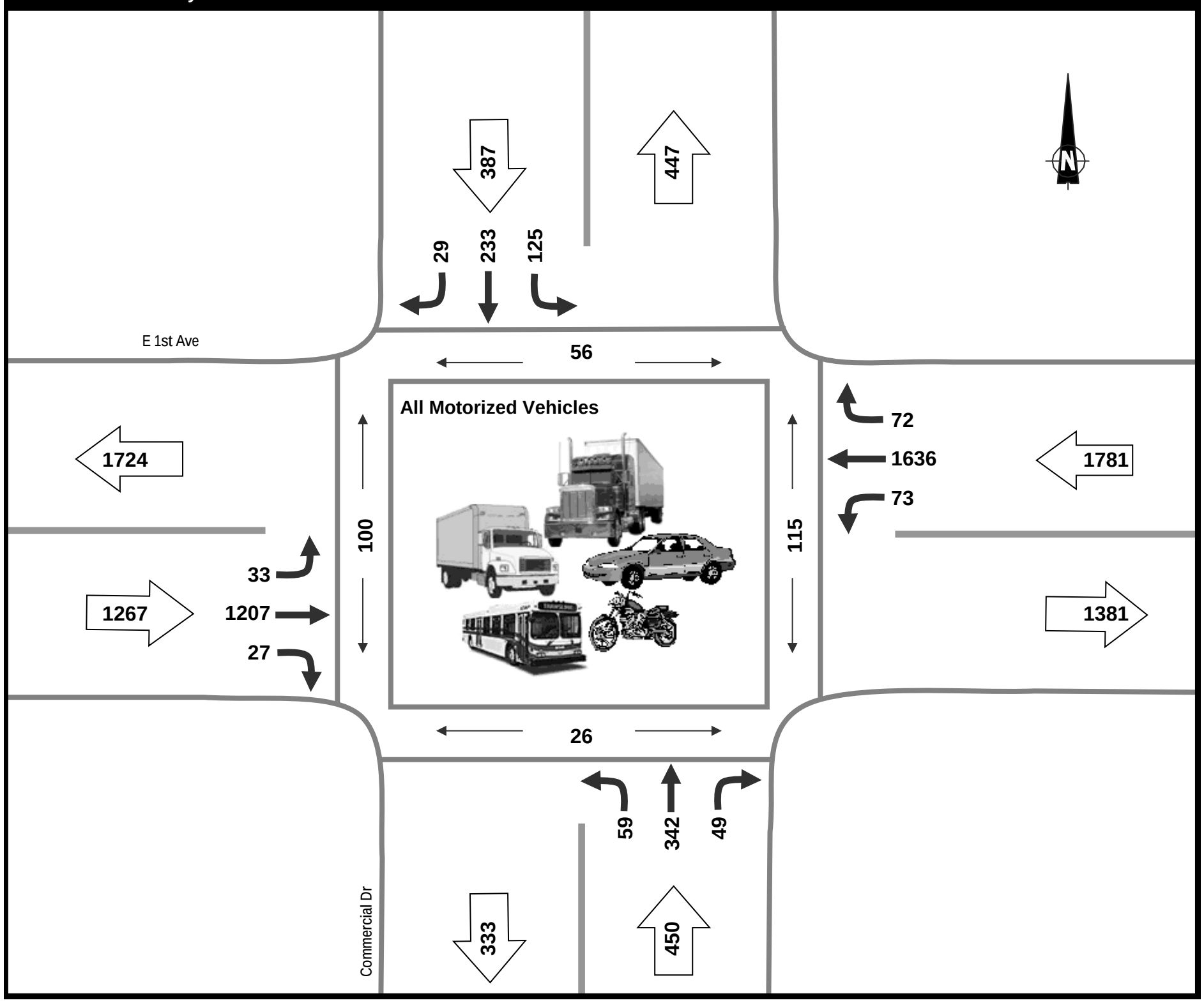
Commercial Dr & E 1st Ave

Tuesday, July 29, 2014

Morning Peak Period

Project: #5256: GNEC - Fortis BC Traffic Counts
Municipality: Vancouver
Weather:
Vehicle Class: All Motorized Vehicles

Peak Hour Traffic by Movement 7:45 AM to 8:45 AM



Time	NORTH Approach			SOUTH Approach			WEST Approach			EAST Approach			PEDESTRIANS				Total Volumes
	left	thru	right	left	thru	right	left	thru	right	left	thru	right	N	S	W	E	
Peak Hour	**125**	**233**	**29**	**59**	**342**	**49**	**33**	**1207**	**27**	**73**	**1636**	**72**	**56**	**26**	**100**	**115**	**3,885**
PH Factor	0.89	0.90	0.73	0.82	0.87	0.72	0.92	0.89	0.68	0.87	0.91	0.86	0.82	0.72	0.93	0.85	0.99
Peak 15 X 4	140	260	40	72	392	68	36	1,360	40	84	1,804	84	68	36	108	136	3,908
Average Hour	103	198	26	55	308	41	27	1,099	35	74	1,624	69	47	26	95	112	3,659
Survey Total	206	396	51	109	615	81	54	2,198	69	147	3,248	137	94	52	190	223	7,311
7:00	22	31	6	8	36	6	4	177	4	14	375	17	3	5	10	20	700
7:15	19	35	5	11	59	5	3	245	5	18	403	19	5	2	15	18	827
7:30	23	43	6	17	71	13	3	296	17	23	422	10	13	4	29	19	944
7:45	35	55	6	14	92	12	7	301	8	12	398	19	13	8	23	31	959
8:00	32	65	5	18	72	17	9	265	3	20	451	15	10	9	23	22	972
8:15	28	53	8	16	98	12	8	301	6	21	405	21	16	3	27	28	977
8:30	30	60	10	11	80	8	9	340	10	20	382	17	17	6	27	34	977
8:45	17	54	5	14	107	8	11	273	16	19	412	19	17	15	36	51	955

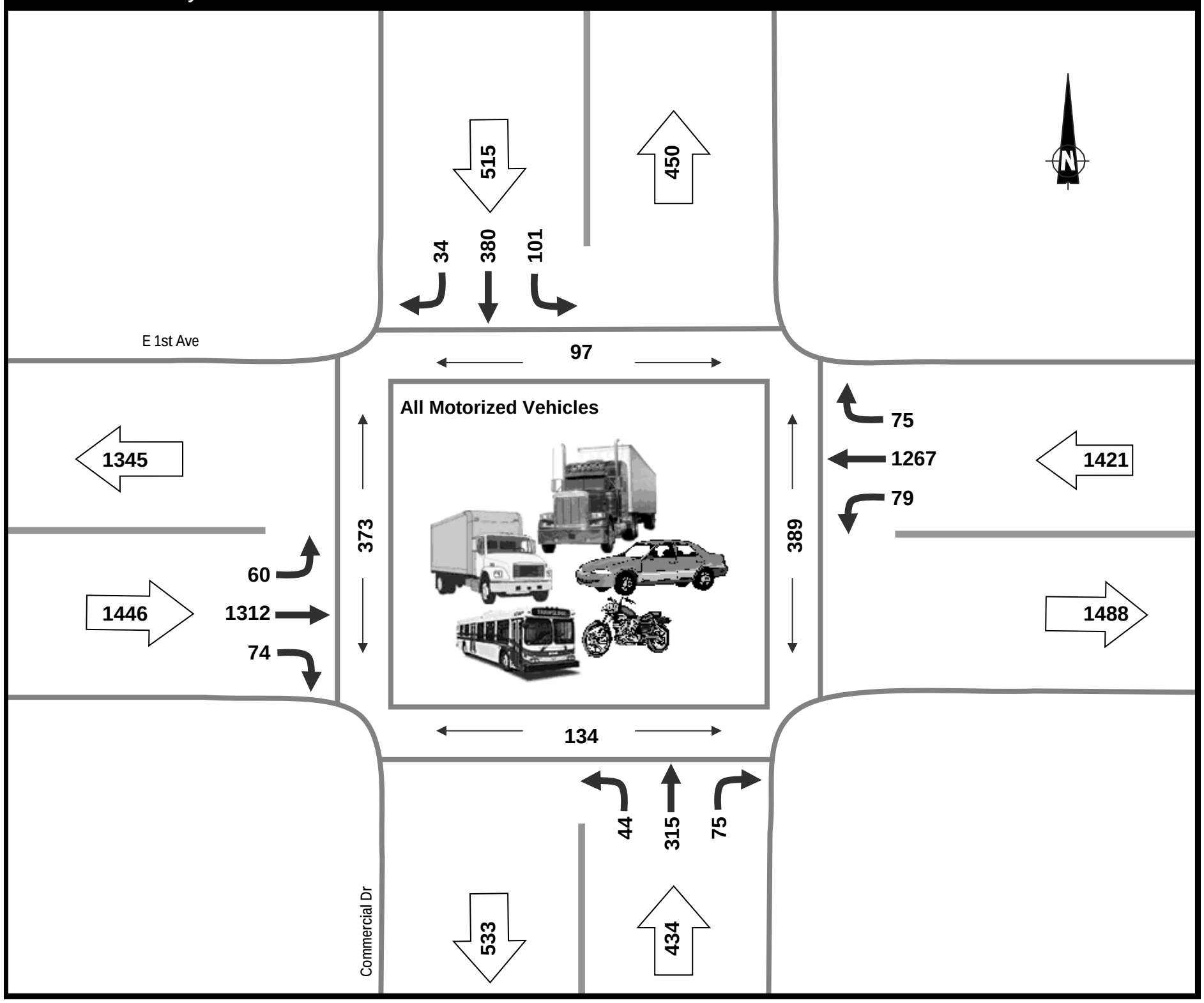
Commercial Dr & E 1st Ave

Tuesday, July 29, 2014

Midday Peak Period

Project: #5256: GNEC - Fortis BC Traffic Counts
Municipality: Vancouver
Weather:
Vehicle Class: All Motorized Vehicles

Peak Hour Traffic by Movement 12:00 PM to 1:00 PM



Time	NORTH Approach			SOUTH Approach			WEST Approach			EAST Approach			PEDESTRIANS				Total Volumes
	left	thru	right	left	thru	right	left	thru	right	left	thru	right	N	S	W	E	
Peak Hour	**101**	**380**	**34**	**44**	**315**	**75**	**60**	**1312**	**74**	**79**	**1267**	**75**	**97**	**134**	**373**	**389**	**3,816**
PH Factor	0.77	0.85	0.71	0.65	0.91	0.82	0.60	0.96	0.80	0.90	0.94	0.89	0.71	0.82	0.88	0.97	0.98
Peak 15 X 4	132	448	48	68	348	92	100	1,368	92	88	1,344	84	136	164	424	400	3,892
Average Hour	101	329	31	46	306	66	58	1,157	57	81	1,235	77	119	115	335	372	3,544
Survey Total	201	658	62	92	612	131	116	2,313	113	161	2,469	154	238	230	670	744	7,082
11:00	9	35	2	11	67	13	13	126	7	17	287	25	24	31	46	102	612
11:15	29	73	4	8	82	16	15	236	13	15	307	15	35	25	75	85	813
11:30	28	98	7	14	65	13	10	311	14	26	282	20	37	21	91	89	888
11:45	34	72	15	15	83	14	18	328	5	24	326	19	45	19	85	79	953
12:00	22	71	5	9	79	23	25	342	13	20	328	15	34	27	97	94	952
12:15	14	112	10	10	78	16	15	295	19	22	323	21	17	41	106	98	935
12:30	33	94	7	17	71	16	6	335	19	21	336	18	20	32	78	97	973
12:45	32	103	12	8	87	20	14	340	23	16	280	21	26	34	92	100	956

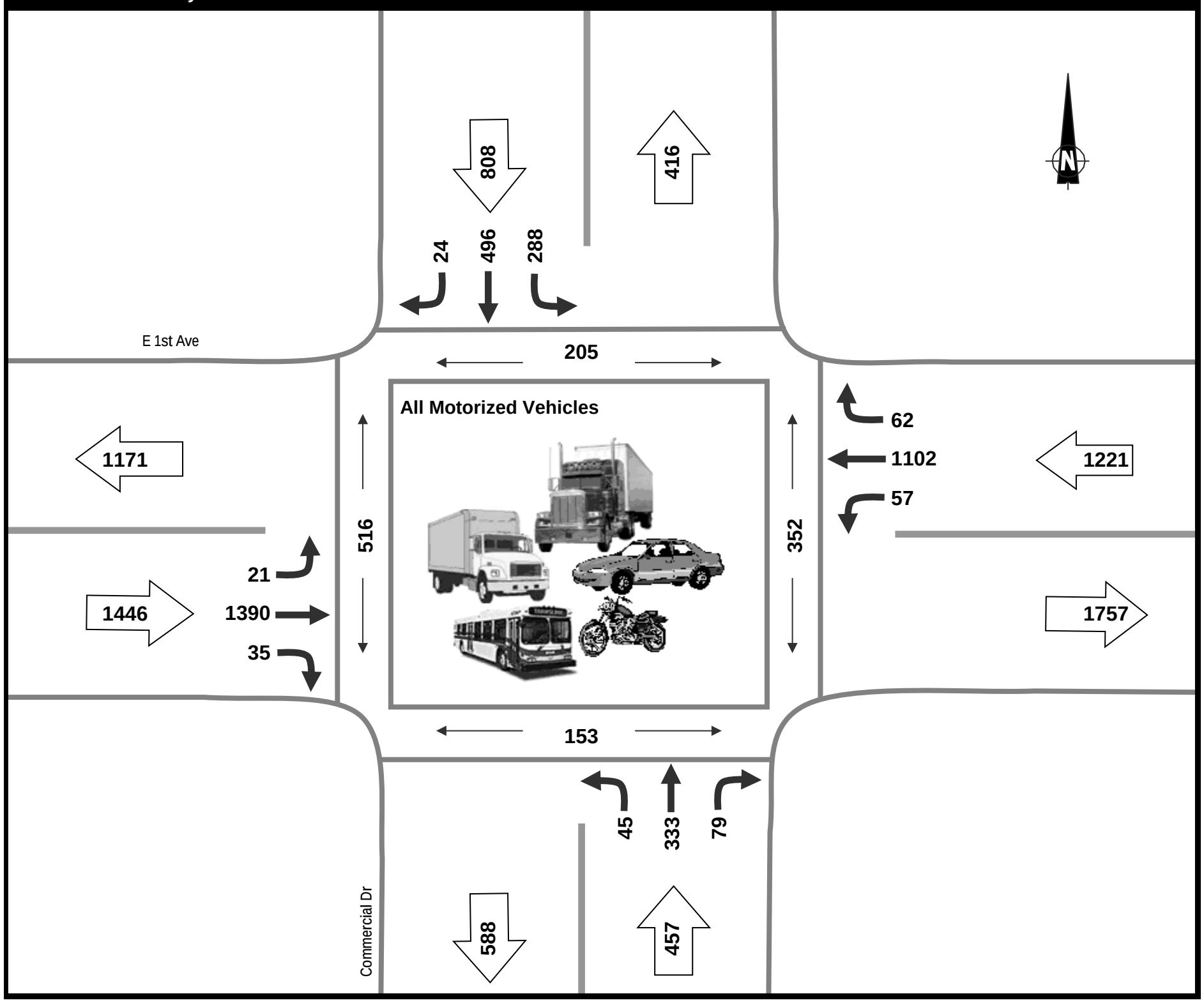
Commercial Dr & E 1st Ave

Tuesday, July 29, 2014

Afternoon Peak Period

Project: #5256: GNEC - Fortis BC Traffic Counts
Municipality: Vancouver
Weather:
Vehicle Class: All Motorized Vehicles

Peak Hour Traffic by Movement 4:30 PM to 5:30 PM



Time	NORTH Approach			SOUTH Approach			WEST Approach			EAST Approach			PEDESTRIANS				Total Volumes
	left	thru	right	left	thru	right	left	thru	right	left	thru	right	N	S	W	E	
Peak Hour	**288**	**496**	**24**	**45**	**333**	**79**	**21**	**1390**	**35**	**57**	**1102**	**62**	**205**	**153**	**516**	**352**	**3,932**
PH Factor	0.90	0.90	0.86	0.75	0.85	0.79	0.75	0.94	0.67	0.79	0.95	0.86	0.85	0.77	0.90	0.87	0.99
Peak 15 X 4	320	552	28	60	392	100	28	1,472	52	72	1,160	72	240	200	572	404	3,984
Average Hour	237	436	29	49	316	74	25	1,361	36	64	1,131	65	216	141	478	391	3,823
Survey Total	710	1,309	86	147	949	222	74	4,082	109	192	3,394	194	647	423	####	####	11,468
15:00	52	87	7	8	73	17	1	330	9	13	282	13	37	34	83	101	892
15:15	49	105	4	13	74	16	10	322	9	12	286	13	49	33	108	80	913
15:30	56	112	11	17	80	11	6	339	10	15	268	14	50	43	115	112	939
15:45	54	86	4	14	96	15	5	398	4	16	247	19	58	27	114	93	958
16:00	41	106	11	8	70	33	9	377	11	15	277	15	55	37	110	82	973
16:15	41	103	9	12	79	12	7	273	15	18	290	20	77	33	139	109	879
16:30	68	112	7	9	90	20	7	363	8	18	276	18	60	31	143	94	996
16:45	78	114	7	15	98	14	3	368	6	18	254	12	48	41	135	86	987
17:00	80	132	3	8	70	20	6	357	8	4	290	18	55	31	97	71	996
17:15	62	138	7	13	75	25	5	302	13	17	282	14	42	50	141	101	953
17:30	67	122	7	17	80	23	4	296	8	24	310	14	79	26	143	119	972
17:45	62	92	9	13	64	16	11	357	8	22	332	24	37	37	106	125	1,010

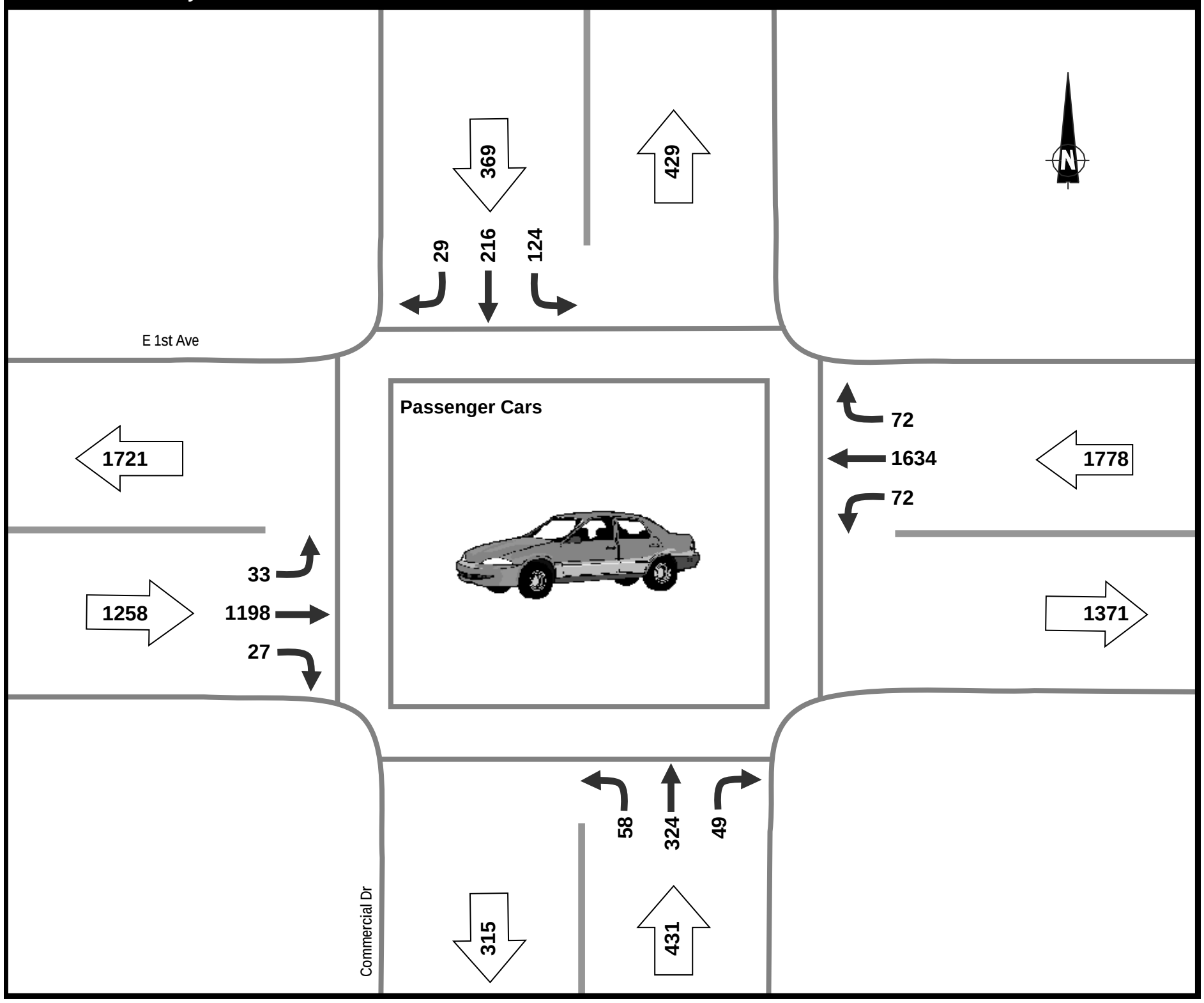
Commercial Dr & E 1st Ave

Tuesday, July 29, 2014

Morning Peak Period

Project: #5256: GNEC - Fortis BC Traffic Counts
Municipality: Vancouver
Weather:
Vehicle Class: Passenger Cars

Peak Hour Traffic by Movement 7:45 AM to 8:45 AM



Time	NORTH Approach			SOUTH Approach			WEST Approach			EAST Approach			PEDESTRIANS				Total Volumes
	left	thru	right	left	thru	right	left	thru	right	left	thru	right	N	S	W	E	
Peak Hour	**124**	**216**	**29**	**58**	**324**	**49**	**33**	**1198**	**27**	**72**	**1634**	**72**					**3,836**
PH Factor	0.89	0.89	0.73	0.81	0.86	0.72	0.92	0.89	0.68	0.86	0.91	0.86					0.99
Peak 15 X 4	140	244	40	72	376	68	36	1,352	40	84	1,800	84					3,864
Average Hour	103	182	25	54	288	41	27	1,095	35	73	1,621	69					3,613
Survey Total	205	364	50	108	576	81	54	2,189	69	146	3,242	137					7,221
7:00	22	28	6	8	32	6	4	177	4	14	373	17					691
7:15	19	33	4	11	53	5	3	245	5	18	403	19					818
7:30	23	39	6	17	65	13	3	296	17	23	422	10					934
7:45	35	51	6	13	87	12	7	300	8	12	398	19					948
8:00	31	61	5	18	66	17	9	261	3	20	450	15					956
8:15	28	48	8	16	94	12	8	299	6	21	405	21					966
8:30	30	56	10	11	77	8	9	338	10	19	381	17					966
8:45	17	48	5	14	102	8	11	273	16	19	410	19					942

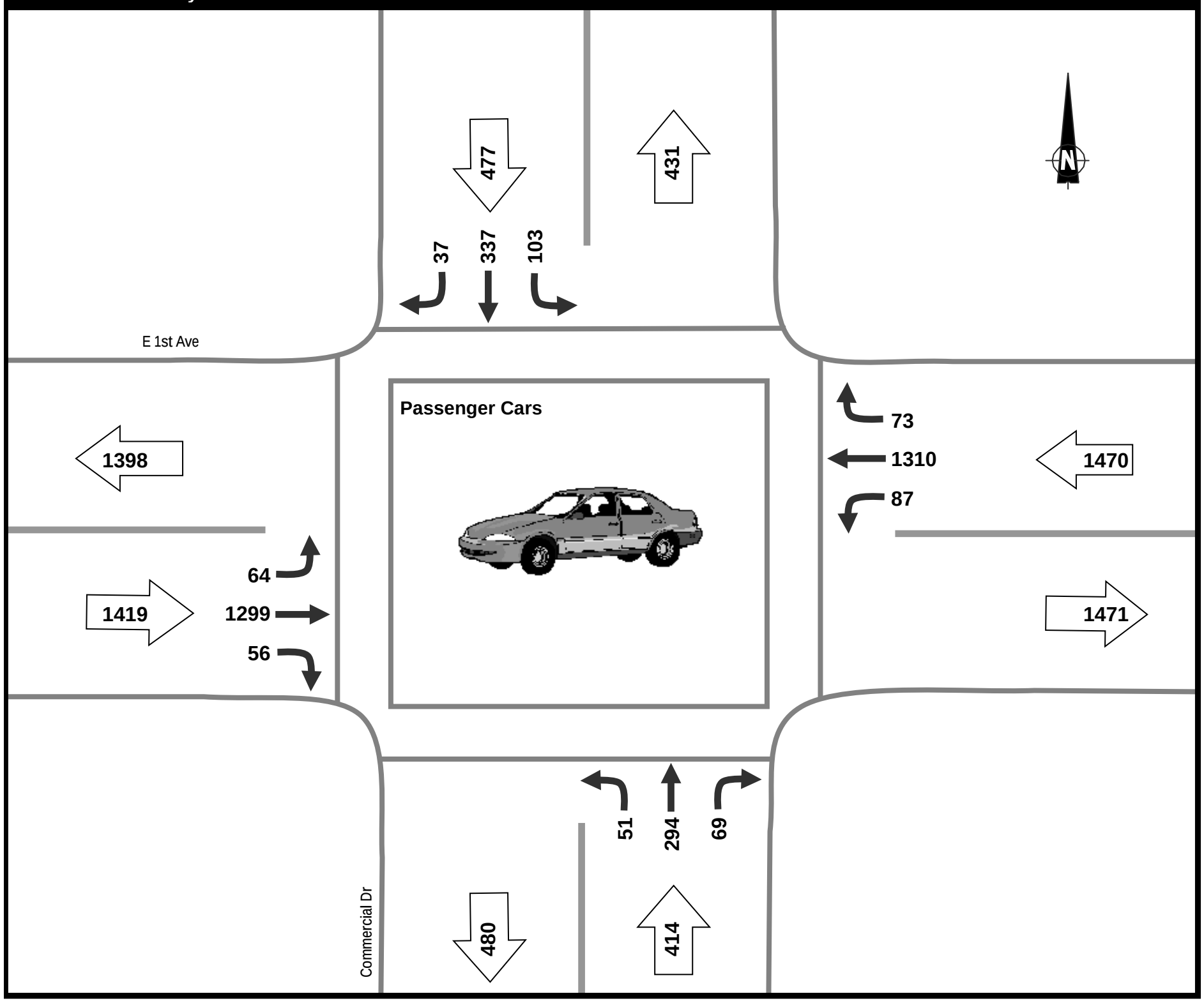
Commercial Dr & E 1st Ave

Tuesday, July 29, 2014

Midday Peak Period

Project: #5256: GNEC - Fortis BC Traffic Counts
Municipality: Vancouver
Weather:
Vehicle Class: Passenger Cars

Peak Hour Traffic by Movement 11:45 AM to 12:45 PM



Time	NORTH Approach			SOUTH Approach			WEST Approach			EAST Approach			PEDESTRIANS				Total Volumes
	left	thru	right	left	thru	right	left	thru	right	left	thru	right	N	S	W	E	
Peak Hour	**103**	**337**	**37**	**51**	**294**	**69**	**64**	**1299**	**56**	**87**	**1310**	**73**					**3,780**
PH Factor	0.76	0.77	0.62	0.75	0.94	0.75	0.64	0.95	0.74	0.91	0.98	0.87					0.98
Peak 15 X 4	136	436	60	68	312	92	100	1,364	76	96	1,340	84					3,860
Average Hour	101	315	31	46	288	66	58	1,155	57	81	1,230	77					3,505
Survey Total	201	630	62	92	575	131	116	2,310	113	161	2,460	154					7,005
11:00	9	31	2	11	62	13	13	126	7	17	285	25					601
11:15	29	71	4	8	77	16	15	236	13	15	305	15					804
11:30	28	95	7	14	61	13	10	310	14	26	280	20					878
11:45	34	69	15	15	78	14	18	328	5	24	326	19					945
12:00	22	69	5	9	75	23	25	341	13	20	327	15					944
12:15	14	109	10	10	73	16	15	295	19	22	322	21					926
12:30	33	90	7	17	68	16	6	335	19	21	335	18					965
12:45	32	96	12	8	81	20	14	339	23	16	280	21					942

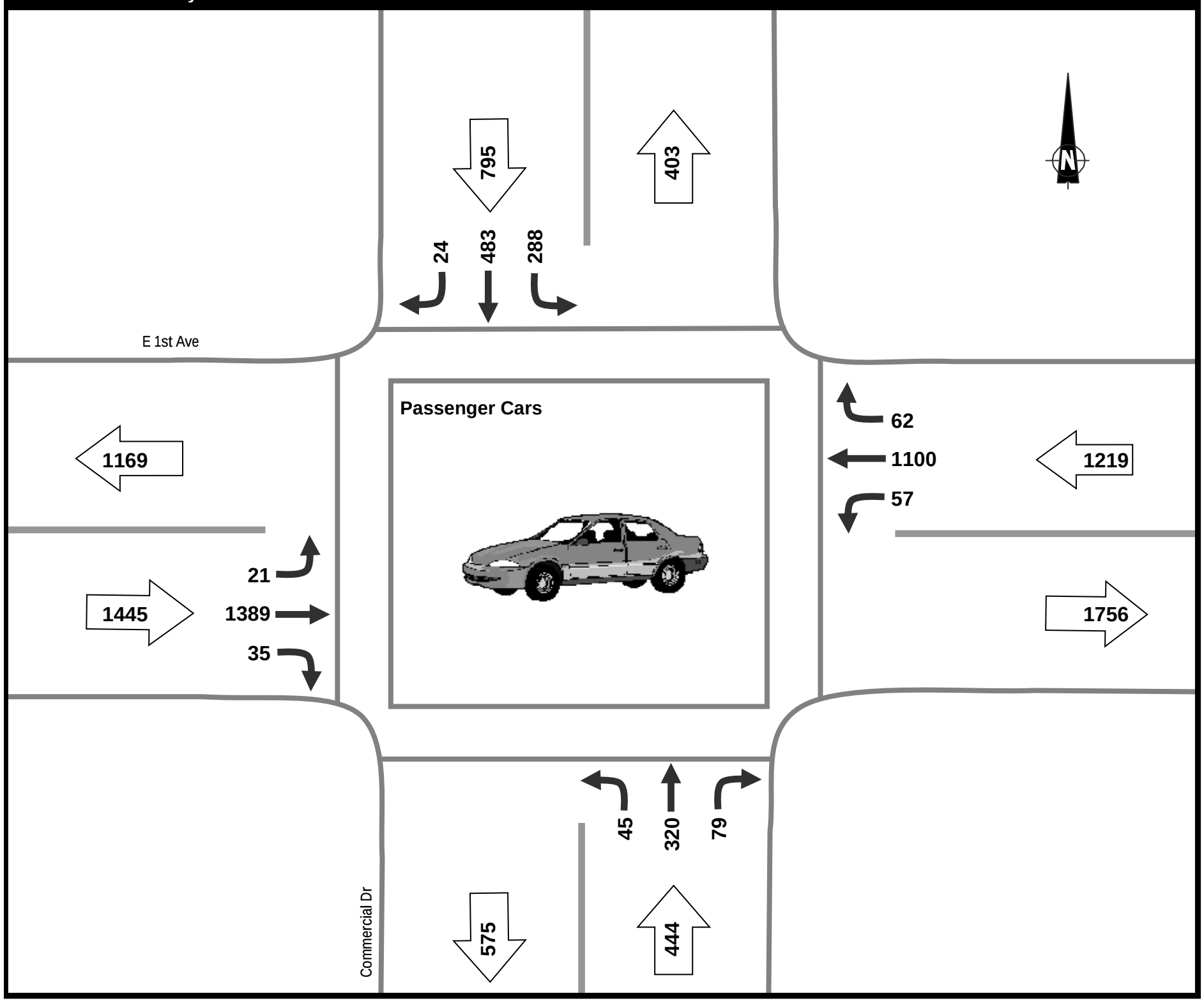
Commercial Dr & E 1st Ave

Tuesday, July 29, 2014

Afternoon Peak Period

Project: #5256: GNEC - Fortis BC Traffic Counts
Municipality: Vancouver
Weather:
Vehicle Class: Passenger Cars

Peak Hour Traffic by Movement 4:30 PM to 5:30 PM



Time	NORTH Approach			SOUTH Approach			WEST Approach			EAST Approach			PEDESTRIANS				Total Volumes
	left	thru	right	left	thru	right	left	thru	right	left	thru	right	N	S	W	E	
Peak Hour	**288**	**483**	**24**	**45**	**320**	**79**	**21**	**1389**	**35**	**57**	**1100**	**62**					**3,903**
PH Factor	0.90	0.89	0.86	0.75	0.85	0.79	0.75	0.95	0.67	0.79	0.95	0.86					0.99
Peak 15 X 4	320	540	28	60	376	100	28	1,468	52	72	1,156	72					3,956
Average Hour	237	421	29	49	301	74	25	1,360	36	64	1,128	65					3,789
Survey Total	710	1,264	86	147	902	222	74	4,079	109	192	3,384	194					11,363
15:00	52	82	7	8	70	17	1	330	9	13	281	13					883
15:15	49	102	4	13	70	16	10	322	9	12	285	13					905
15:30	56	109	11	17	76	11	6	339	10	15	267	14					931
15:45	54	81	4	14	92	15	5	398	4	16	244	19					946
16:00	41	103	11	8	67	33	9	377	11	15	277	15					967
16:15	41	99	9	12	71	12	7	271	15	18	289	20					864
16:30	68	109	7	9	87	20	7	363	8	18	275	18					989
16:45	78	110	7	15	94	14	3	367	6	18	254	12					978
17:00	80	129	3	8	66	20	6	357	8	4	289	18					988
17:15	62	135	7	13	73	25	5	302	13	17	282	14					948
17:30	67	117	7	17	76	23	4	296	8	24	310	14					963
17:45	62	88	9	13	60	16	11	357	8	22	331	24					1,001

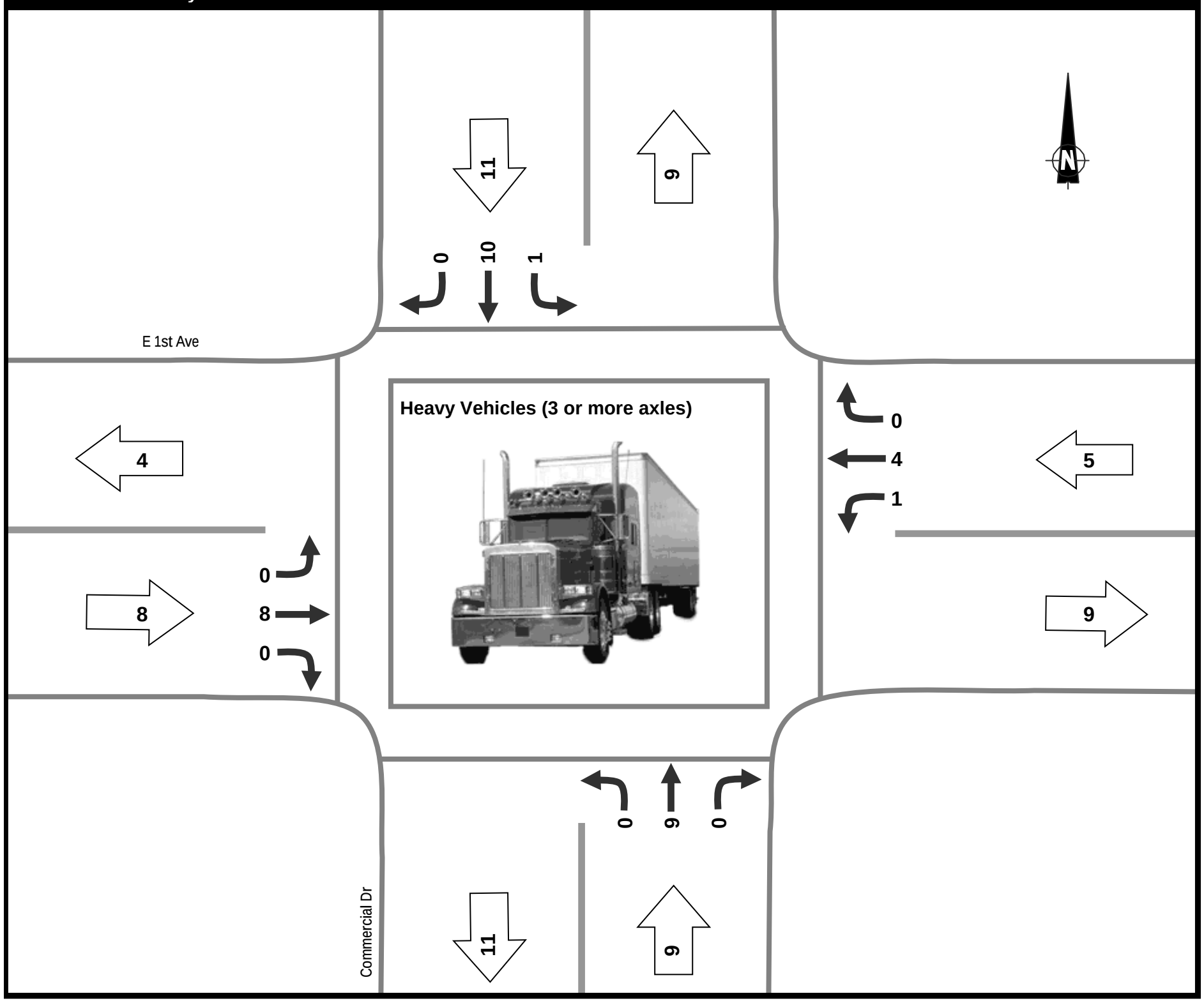
Commercial Dr & E 1st Ave

Tuesday, July 29, 2014

Morning Peak Period

Project: #5256: GNEC - Fortis BC Traffic Counts
Municipality: Vancouver
Weather:
Vehicle Class: Heavy Vehicles (3 or more axles)

Peak Hour Traffic by Movement 8:00 AM to 9:00 AM



Time	NORTH Approach			SOUTH Approach			WEST Approach			EAST Approach			PEDESTRIANS				Total Volumes
	left	thru	right	left	thru	right	left	thru	right	left	thru	right	N	S	W	E	
Peak Hour	**1**	**10**	**0**	**0**	**9**	**0**	**0**	**8**	**0**	**1**	**4**	**0**					**33**
PH Factor	0.25	0.63	0.00	0.00	0.75	0.00	0.00	0.50	0.00	0.25	0.50	0.00					0.75
Peak 15 X 4	4	16	0	0	12	0	0	16	0	4	8	0					44
Average Hour	1	8	1	1	11	0	0	5	0	1	3	0					31
Survey Total	1	15	1	1	21	0	0	9	0	1	6	0					55
7:00	0	1	0	0	2	0	0	0	0	0	2	0					5
7:15	0	0	1	0	3	0	0	0	0	0	0	0					4
7:30	0	2	0	0	4	0	0	0	0	0	0	0					6
7:45	0	2	0	1	3	0	0	1	0	0	0	0					7
8:00	1	2	0	0	3	0	0	4	0	0	1	0					11
8:15	0	2	0	0	2	0	0	2	0	0	0	0					6
8:30	0	2	0	0	1	0	0	2	0	1	1	0					7
8:45	0	4	0	0	3	0	0	0	0	0	2	0					9

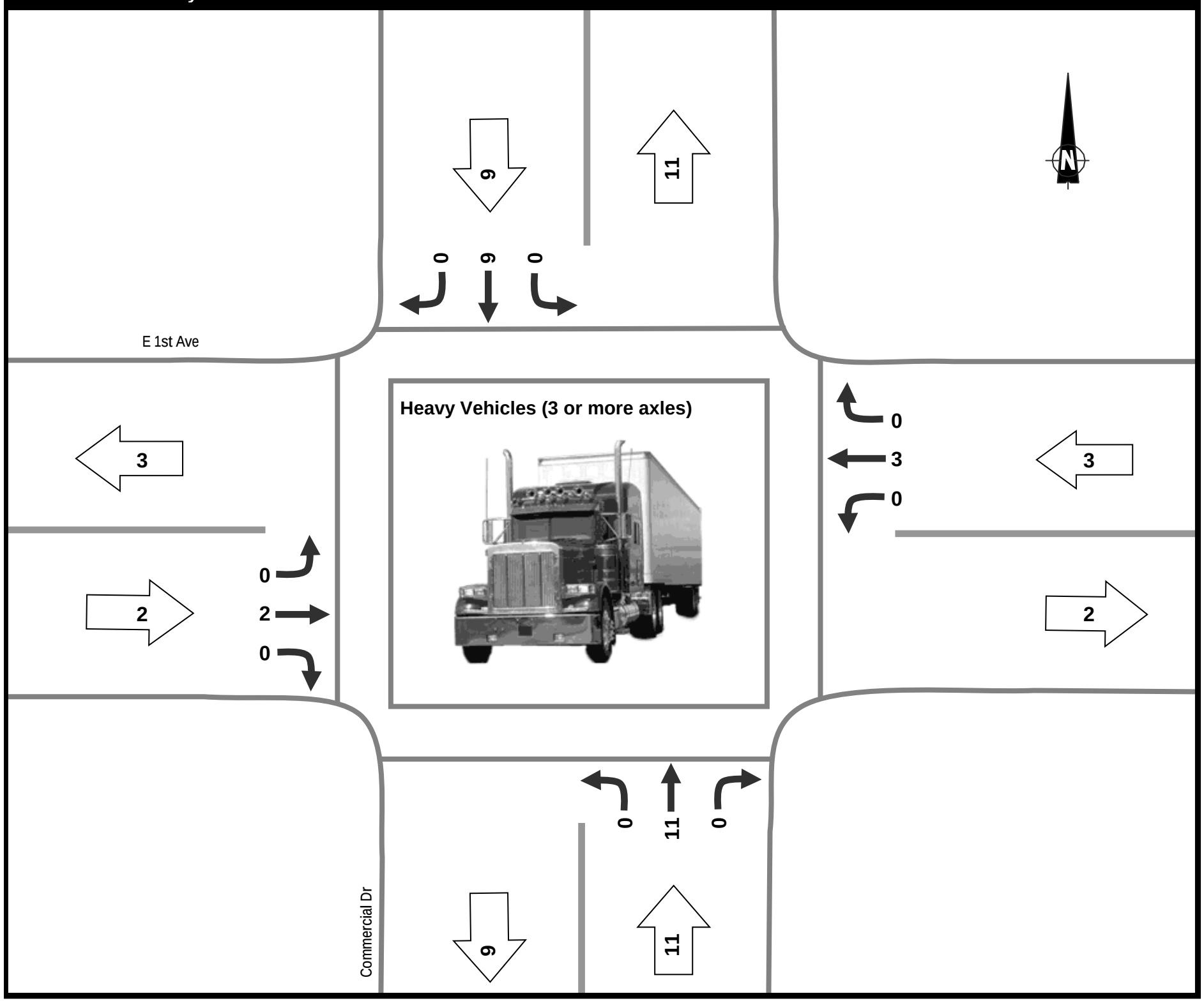
Commercial Dr & E 1st Ave

Tuesday, July 29, 2014

Midday Peak Period

Project: #5256: GNEC - Fortis BC Traffic Counts
Municipality: Vancouver
Weather:
Vehicle Class: Heavy Vehicles (3 or more axles)

Peak Hour Traffic by Movement 12:00 PM to 1:00 PM



Time	NORTH Approach			SOUTH Approach			WEST Approach			EAST Approach			PEDESTRIANS				Total Volumes
	left	thru	right	left	thru	right	left	thru	right	left	thru	right	N	S	W	E	
Peak Hour	**0**	**9**	**0**	**0**	**11**	**0**	**0**	**2**	**0**	**0**	**3**	**0**					**25**
PH Factor	0.00	0.45	0.00	0.00	0.69	0.00	0.00	0.50	0.00	0.00	0.75	0.00					0.63
Peak 15 X 4	0	20	0	0	16	0	0	4	0	0	4	0					40
Average Hour	0	7	0	0	11	0	0	2	0	0	5	0					25
Survey Total	0	13	0	0	22	0	0	3	0	0	9	0					47
11:00	0	2	0	0	3	0	0	0	0	0	2	0					7
11:15	0	0	0	0	3	0	0	0	0	0	2	0					5
11:30	0	1	0	0	2	0	0	1	0	0	2	0					6
11:45	0	1	0	0	3	0	0	0	0	0	0	0					4
12:00	0	1	0	0	2	0	0	1	0	0	1	0					5
12:15	0	1	0	0	4	0	0	0	0	0	1	0					6
12:30	0	2	0	0	1	0	0	0	0	0	1	0					4
12:45	0	5	0	0	4	0	0	1	0	0	0	0					10

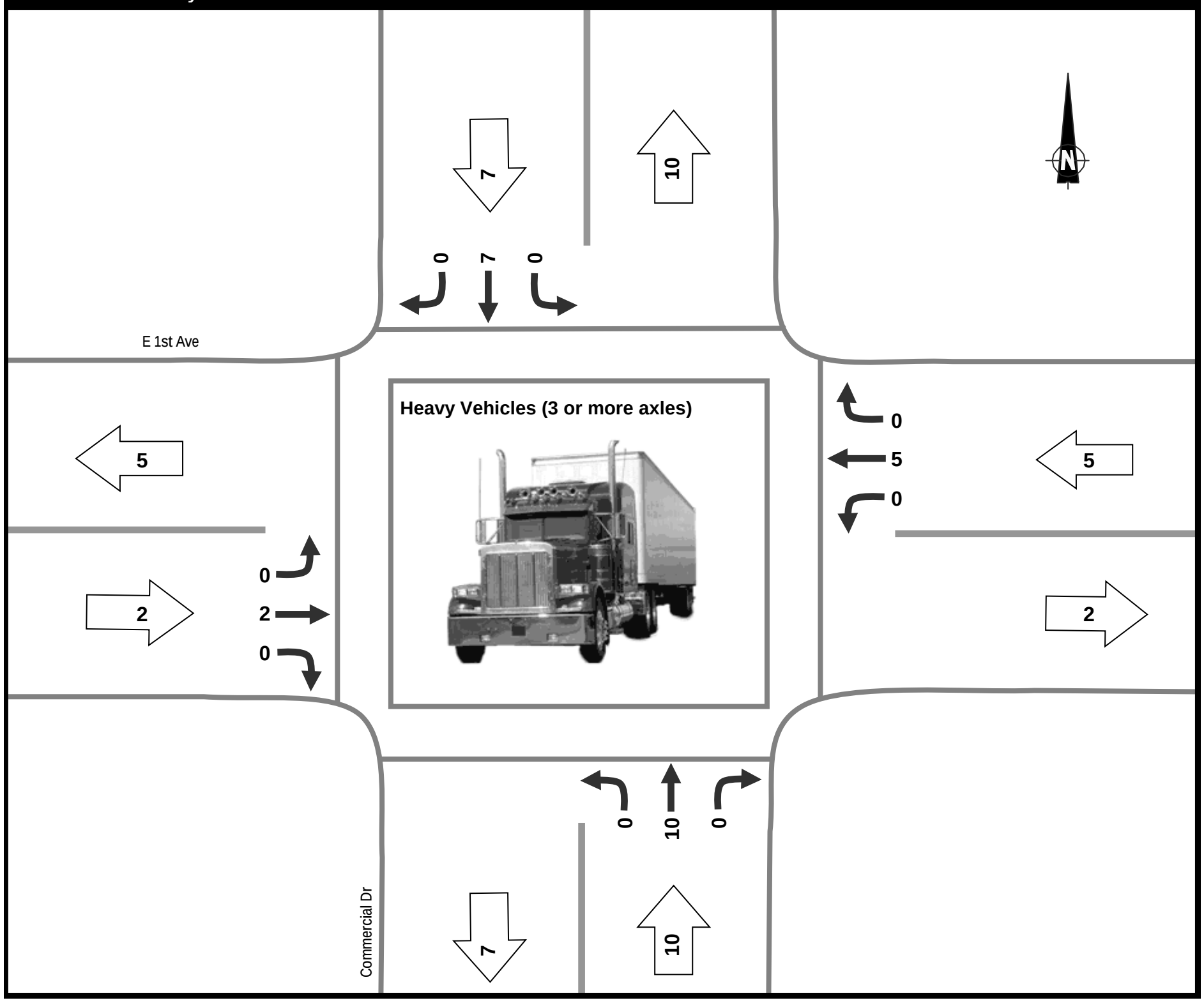
Commercial Dr & E 1st Ave

Tuesday, July 29, 2014

Afternoon Peak Period

Project: #5256: GNEC - Fortis BC Traffic Counts
Municipality: Vancouver
Weather:
Vehicle Class: Heavy Vehicles (3 or more axles)

Peak Hour Traffic by Movement 3:30 PM to 4:30 PM



Time	NORTH Approach			SOUTH Approach			WEST Approach			EAST Approach			PEDESTRIANS				Total Volumes
	left	thru	right	left	thru	right	left	thru	right	left	thru	right	N	S	W	E	
Peak Hour	**0**	**7**	**0**	**0**	**10**	**0**	**0**	**2**	**0**	**0**	**5**	**0**					**24**
PH Factor	0.00	0.58	0.00	0.00	0.50	0.00	0.00	0.25	0.00	0.00	0.42	0.00					0.60
Peak 15 X 4	0	12	0	0	20	0	0	8	0	0	12	0					40
Average Hour	0	7	0	0	8	0	0	1	0	0	3	0					19
Survey Total	0	21	0	0	23	0	0	3	0	0	10	0					57
15:00	0	2	0	0	1	0	0	0	0	0	1	0					4
15:15	0	2	0	0	2	0	0	0	0	0	1	0					5
15:30	0	1	0	0	2	0	0	0	0	0	1	0					4
15:45	0	3	0	0	2	0	0	0	0	0	3	0					8
16:00	0	1	0	0	1	0	0	0	0	0	0	0					2
16:15	0	2	0	0	5	0	0	2	0	0	1	0					10
16:30	0	1	0	0	1	0	0	0	0	0	1	0					3
16:45	0	2	0	0	2	0	0	1	0	0	0	0					5
17:00	0	1	0	0	2	0	0	0	0	0	1	0					4
17:15	0	1	0	0	1	0	0	0	0	0	0	0					2
17:30	0	3	0	0	2	0	0	0	0	0	0	0					5
17:45	0	2	0	0	2	0	0	0	0	0	1	0					5

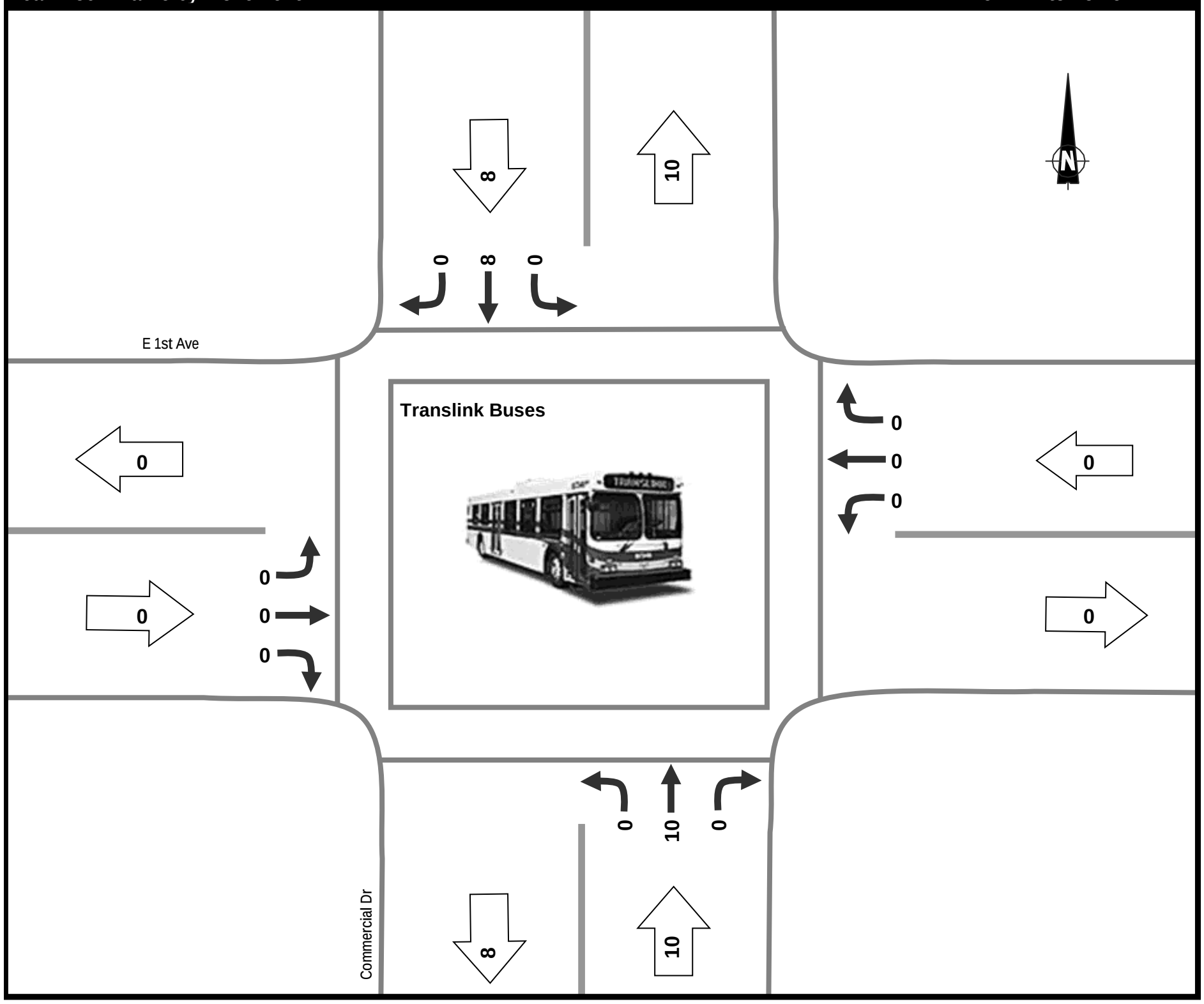
Commercial Dr & E 1st Ave

Tuesday, July 29, 2014

Morning Peak Period

Project: #5256: GNEC - Fortis BC Traffic Counts
Municipality: Vancouver
Weather:
Vehicle Class: Translink Buses
Note: Bus volume based on translink transit schedule.

Peak Hour Traffic by Movement 7:15 AM to 8:15 AM



Time	NORTH Approach			SOUTH Approach			WEST Approach			EAST Approach			PEDESTRIANS				Total Volumes
	left	thru	right	left	thru	right	left	thru	right	left	thru	right	N	S	W	E	
Peak Hour	**0**	**8**	**0**	**0**	**10**	**0**	**0**	**0**	**0**	**0**	**0**	**0**					**18**
PH Factor	0.00	1.00	0.00	0.00	0.83	0.00	0.00	0.00	0.00	0.00	0.00	0.00					0.90
Peak 15 X 4	0	8	0	0	12	0	0	0	0	0	0	0					20
Average Hour	0	9	0	0	9	0	0	0	0	0	0	0					18
Survey Total	0	17	0	0	18	0	0	0	0	0	0	0					35
7:00	0	2	0	0	2	0	0	0	0	0	0	0					4
7:15	0	2	0	0	3	0	0	0	0	0	0	0					5
7:30	0	2	0	0	2	0	0	0	0	0	0	0					4
7:45	0	2	0	0	2	0	0	0	0	0	0	0					4
8:00	0	2	0	0	3	0	0	0	0	0	0	0					5
8:15	0	3	0	0	2	0	0	0	0	0	0	0					5
8:30	0	2	0	0	2	0	0	0	0	0	0	0					4
8:45	0	2	0	0	2	0	0	0	0	0	0	0					4

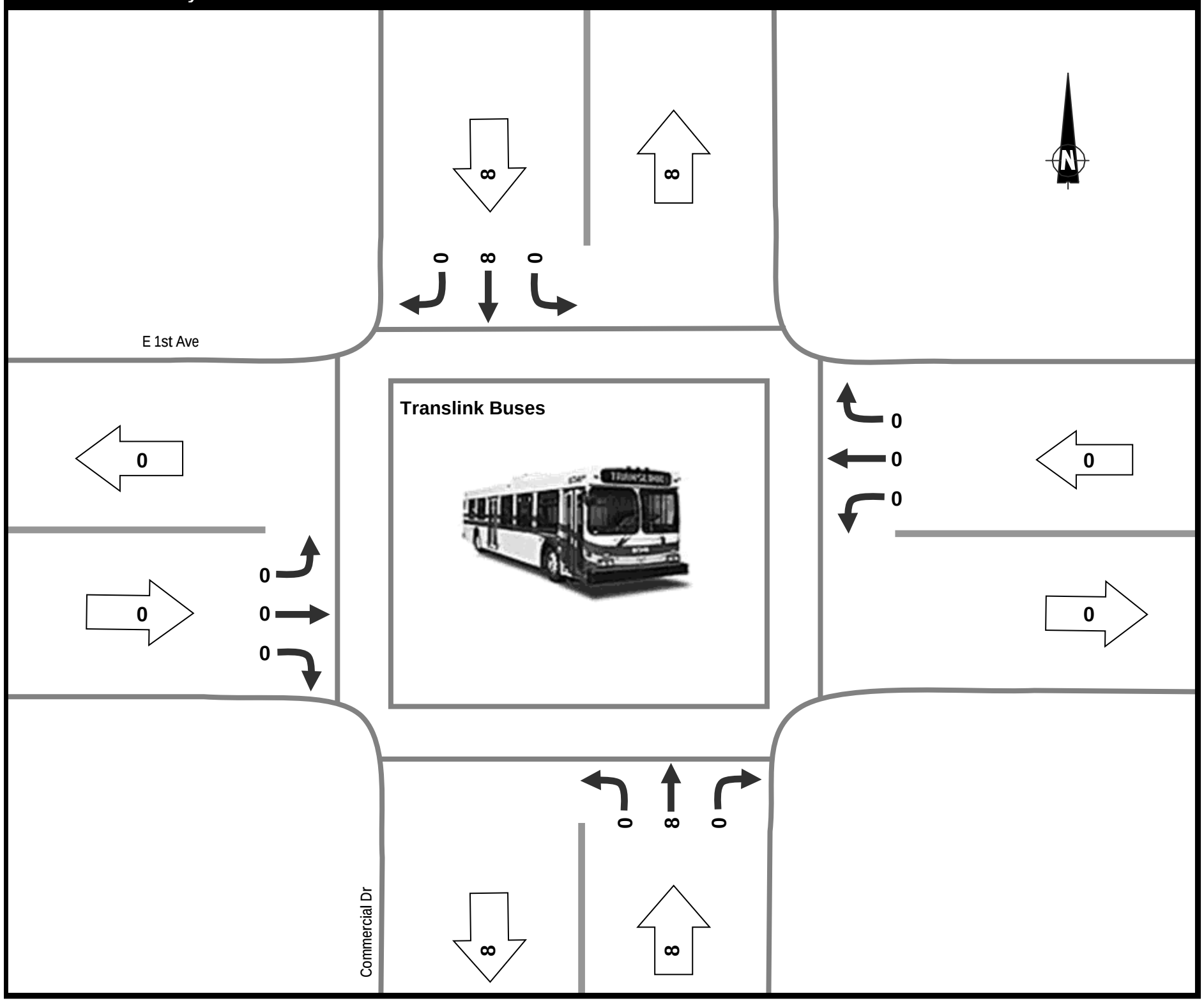
Commercial Dr & E 1st Ave

Tuesday, July 29, 2014

Midday Peak Period

Project: #5256: GNEC - Fortis BC Traffic Counts
Municipality: Vancouver
Weather:
Vehicle Class: Translink Buses
Note: Bus volume based on translink transit schedule.

Peak Hour Traffic by Movement 11:00 AM to 12:00 PM



Time	NORTH Approach			SOUTH Approach			WEST Approach			EAST Approach			PEDESTRIANS				Total Volumes
	left	thru	right	left	thru	right	left	thru	right	left	thru	right	N	S	W	E	
Peak Hour	**0**	**8**	**0**	**0**	**8**	**0**	**0**	**0**	**0**	**0**	**0**	**0**					**16**
PH Factor	0.00	1.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00					1.00
Peak 15 X 4	0	8	0	0	8	0	0	0	0	0	0	0					16
Average Hour	0	8	0	0	8	0	0	0	0	0	0	0					16
Survey Total	0	15	0	0	15	0	0	0	0	0	0	0					30
11:00	0	2	0	0	2	0	0	0	0	0	0	0					4
11:15	0	2	0	0	2	0	0	0	0	0	0	0					4
11:30	0	2	0	0	2	0	0	0	0	0	0	0					4
11:45	0	2	0	0	2	0	0	0	0	0	0	0					4
12:00	0	1	0	0	2	0	0	0	0	0	0	0					3
12:15	0	2	0	0	1	0	0	0	0	0	0	0					3
12:30	0	2	0	0	2	0	0	0	0	0	0	0					4
12:45	0	2	0	0	2	0	0	0	0	0	0	0					4

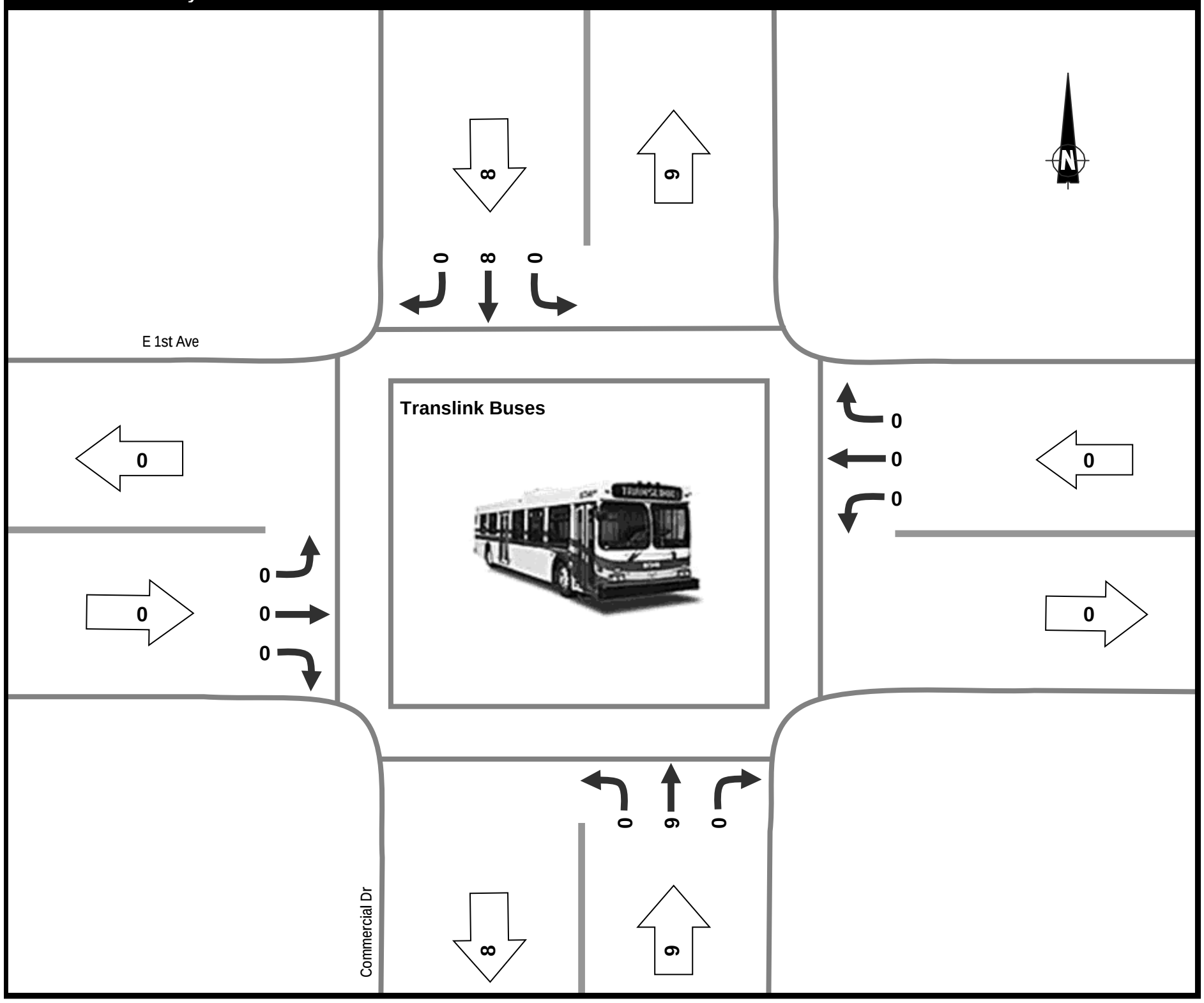
Commercial Dr & E 1st Ave

Tuesday, July 29, 2014

Afternoon Peak Period

Project: #5256: GNEC - Fortis BC Traffic Counts
Municipality: Vancouver
Weather:
Vehicle Class: Translink Buses
Note: Bus volume based on translink transit schedule.

Peak Hour Traffic by Movement 3:30 PM to 4:30 PM



Time	NORTH Approach			SOUTH Approach			WEST Approach			EAST Approach			PEDESTRIANS				Total Volumes
	left	thru	right	left	thru	right	left	thru	right	left	thru	right	N	S	W	E	
Peak Hour	**0**	**8**	**0**	**0**	**9**	**0**	**0**	**0**	**0**	**0**	**0**	**0**					**17**
PH Factor	0.00	1.00	0.00	0.00	0.75	0.00	0.00	0.00	0.00	0.00	0.00	0.00					0.85
Peak 15 X 4	0	8	0	0	12	0	0	0	0	0	0	0					20
Average Hour	0	8	0	0	8	0	0	0	0	0	0	0					16
Survey Total	0	24	0	0	24	0	0	0	0	0	0	0					48
15:00	0	3	0	0	2	0	0	0	0	0	0	0					5
15:15	0	1	0	0	2	0	0	0	0	0	0	0					3
15:30	0	2	0	0	2	0	0	0	0	0	0	0					4
15:45	0	2	0	0	2	0	0	0	0	0	0	0					4
16:00	0	2	0	0	2	0	0	0	0	0	0	0					4
16:15	0	2	0	0	3	0	0	0	0	0	0	0					5
16:30	0	2	0	0	2	0	0	0	0	0	0	0					4
16:45	0	2	0	0	2	0	0	0	0	0	0	0					4
17:00	0	2	0	0	2	0	0	0	0	0	0	0					4
17:15	0	2	0	0	1	0	0	0	0	0	0	0					3
17:30	0	2	0	0	2	0	0	0	0	0	0	0					4
17:45	0	2	0	0	2	0	0	0	0	0	0	0					4

Appendix D – Synchro Output

Vancouver AM

Burnaby AM

Coquitlam AM

Vancouver PM

Burnaby PM

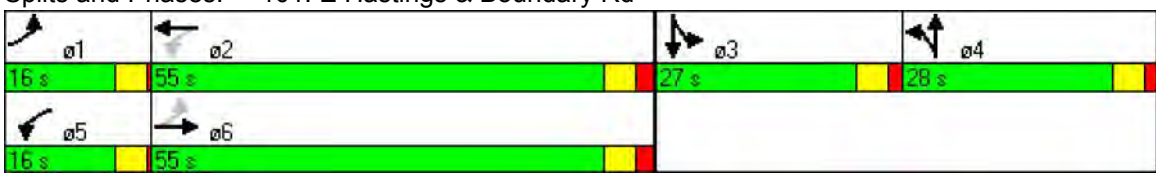
Coquitlam PM

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	3398	0	1770	5070	0	1610	3163	0	1770	3405	0
Flt Permitted	0.096			0.286			0.950	0.975		0.950		
Satd. Flow (perm)	179	3398	0	533	5070	0	1610	3163	0	1770	3405	0
Satd. Flow (RTOR)		50			3			39			33	
Volume (vph)	30	451	165	210	1231	27	362	71	102	11	198	68
Lane Group Flow (vph)	33	669	0	228	1367	0	197	384	0	12	289	0
Turn Type	pm+pt			pm+pt			Split			Split		
Protected Phases	1	6		5	2		4	4		3	3	
Permitted Phases	6			2								
Total Split (s)	16.0	55.0	0.0	16.0	55.0	0.0	28.0	28.0	0.0	27.0	27.0	0.0
Act Effct Green (s)	32.1	25.6		40.7	35.1		16.8	16.8		13.1	13.1	
Actuated g/C Ratio	0.37	0.31		0.49	0.42		0.20	0.20		0.16	0.16	
v/c Ratio	0.18	0.62		0.54	0.64		0.61	0.57		0.04	0.51	
Control Delay	15.3	25.6		18.4	22.4		42.7	33.0		37.8	35.0	
Queue Delay	0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0	
Total Delay	15.3	25.6		18.4	22.4		42.7	33.0		37.8	35.0	
LOS	B	C		B	C		D	C		D	C	
Approach Delay		25.1			21.8			36.3			35.1	
Approach LOS		C			C			D			D	

Intersection Summary

Cycle Length: 126
Actuated Cycle Length: 83.5
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 0.64
Intersection Signal Delay: 26.4 Intersection LOS: C
Intersection Capacity Utilization 60.9% ICU Level of Service B
Analysis Period (min) 15

Splits and Phases: 101: E Hastings & Boundary Rd

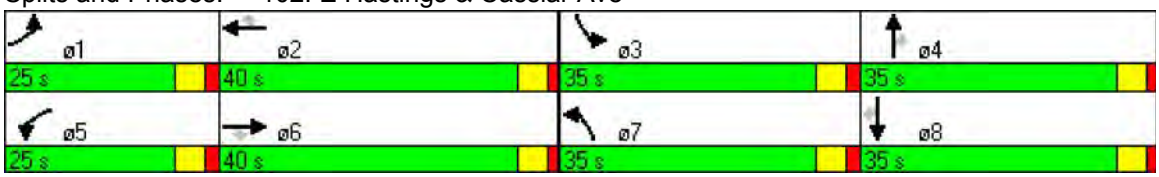


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	3539	1583	1770	5085	1583	3433	3539	1583	3433	3539	1583
Flt Permitted	0.950			0.950			0.950			0.950		
Satd. Flow (perm)	1770	3539	1583	1770	5085	1583	3433	3539	1583	3433	3539	1583
Satd. Flow (RTOR)			346			20			23			107
Volume (vph)	78	376	318	85	1136	27	597	225	21	368	46	98
Lane Group Flow (vph)	85	409	346	92	1235	29	649	245	23	400	50	107
Turn Type	Prot		Perm	Prot		Perm	Prot		Perm	Prot		Perm
Protected Phases	1	6		5	2		7	4		3	8	
Permitted Phases			6			2			4			8
Total Split (s)	25.0	40.0	40.0	25.0	40.0	40.0	35.0	35.0	35.0	35.0	35.0	35.0
Act Effct Green (s)	10.9	30.0	30.0	11.2	30.3	30.3	22.5	14.1	14.1	17.5	8.7	8.7
Actuated g/C Ratio	0.13	0.36	0.36	0.13	0.37	0.37	0.27	0.17	0.17	0.21	0.10	0.10
v/c Ratio	0.37	0.32	0.43	0.39	0.66	0.05	0.69	0.41	0.08	0.55	0.14	0.41
Control Delay	44.8	23.7	4.9	44.8	27.1	13.1	34.0	37.6	15.6	36.8	42.8	14.6
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	44.8	23.7	4.9	44.8	27.1	13.1	34.0	37.6	15.6	36.8	42.8	14.6
LOS	D	C	A	D	C	B	C	D	B	D	D	B
Approach Delay		18.1			28.0			34.5			33.1	
Approach LOS		B			C			C			C	

Intersection Summary

Cycle Length: 135
Actuated Cycle Length: 82.4
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 0.69
Intersection Signal Delay: 28.1 Intersection LOS: C
Intersection Capacity Utilization 60.8% ICU Level of Service B
Analysis Period (min) 15

Splits and Phases: 102: E Hastings & Cassiar Ave

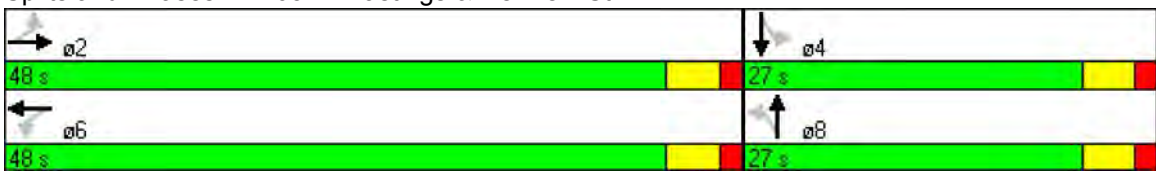


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	3483	0	1770	4928	0	0	4949	0	0	3451	0
Flt Permitted	0.091			0.364				0.858			0.631	
Satd. Flow (perm)	170	3483	0	678	4928	0	0	4272	0	0	2218	0
Satd. Flow (RTOR)		29			147			43			7	
Volume (vph)	39	553	64	69	1309	337	55	362	68	119	185	16
Lane Group Flow (vph)	42	671	0	75	1789	0	0	527	0	0	347	0
Turn Type	Perm			Perm			Perm			Perm		
Protected Phases		2			6			8			4	
Permitted Phases	2			6			8			4		
Total Split (s)	48.0	48.0	0.0	48.0	48.0	0.0	27.0	27.0	0.0	27.0	27.0	0.0
Act Effct Green (s)	44.0	44.0		44.0	44.0			23.0			23.0	
Actuated g/C Ratio	0.59	0.59		0.59	0.59			0.31			0.31	
v/c Ratio	0.42	0.33		0.19	0.61			0.39			0.51	
Control Delay	39.7	20.0		8.7	10.1			19.8			24.0	
Queue Delay	0.0	0.0		0.0	0.0			0.0			0.0	
Total Delay	39.7	20.0		8.7	10.1			19.8			24.0	
LOS	D	C		A	B			B			C	
Approach Delay		21.2			10.0			19.8			24.0	
Approach LOS		C			B			B			C	

Intersection Summary

Cycle Length: 75
Actuated Cycle Length: 75
Offset: 43 (57%), Referenced to phase 2:EBTL and 6:WBTL, Start of Green
Control Type: Pretimed
Maximum v/c Ratio: 0.61
Intersection Signal Delay: 15.2 Intersection LOS: B
Intersection Capacity Utilization 70.7% ICU Level of Service C
Analysis Period (min) 15

Splits and Phases: 103: E Hastings & Renfrew St

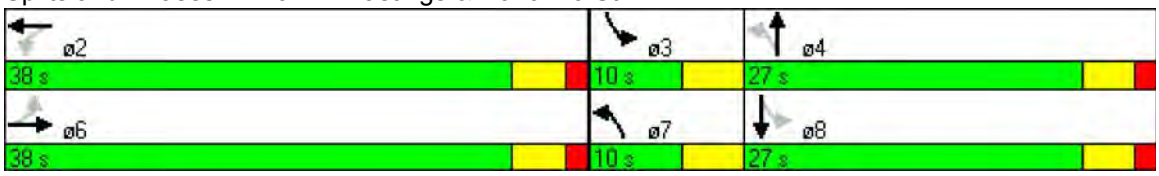


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	0	3506	0	0	5070	0	1770	5041	0	1770	4672	0
Flt Permitted		0.887			0.933		0.395			0.429		
Satd. Flow (perm)	0	3113	0	0	4730	0	714	5041	0	790	4672	0
Satd. Flow (RTOR)		8			4			10			57	
Volume (vph)	17	551	28	12	1331	19	177	429	20	45	315	180
Lane Group Flow (vph)	0	647	0	0	1481	0	192	488	0	49	538	0
Turn Type	Perm			Perm			pm+pt			pm+pt		
Protected Phases		6			2		7	4		3	8	
Permitted Phases	6			2			4			8		
Total Split (s)	38.0	38.0	0.0	38.0	38.0	0.0	10.0	27.0	0.0	10.0	27.0	0.0
Act Effct Green (s)		34.0			34.0		30.6	27.0		28.9	23.0	
Actuated g/C Ratio		0.45			0.45		0.41	0.36		0.39	0.31	
v/c Ratio		0.46			0.69		0.51	0.27		0.13	0.37	
Control Delay		5.2			12.7		19.3	18.2		13.1	18.9	
Queue Delay		0.0			0.0		0.0	0.0		0.0	0.0	
Total Delay		5.2			12.7		19.3	18.2		13.1	18.9	
LOS		A			B		B	B		B	B	
Approach Delay		5.2			12.7			18.5			18.4	
Approach LOS		A			B			B			B	

Intersection Summary

Cycle Length: 75
Actuated Cycle Length: 75
Offset: 20 (27%), Referenced to phase 2:WBTL and 6:EBTL, Start of Green
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 0.69
Intersection Signal Delay: 13.4 Intersection LOS: B
Intersection Capacity Utilization 71.8% ICU Level of Service C
Analysis Period (min) 15

Splits and Phases: 104: E Hastings & Nanaimo St

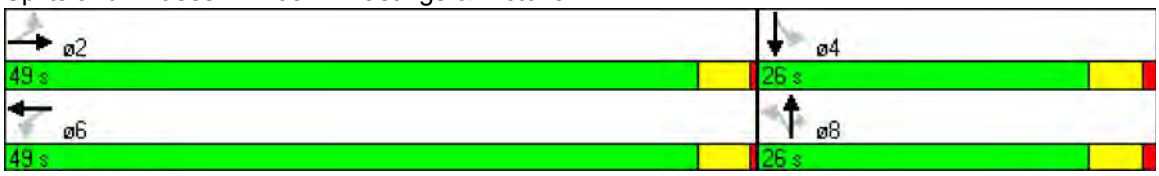


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	3525	0	1770	5055	0	0	1844	1583	0	3409	0
Flt Permitted	0.098			0.436				0.924			0.884	
Satd. Flow (perm)	183	3525	0	812	5055	0	0	1721	1583	0	3044	0
Satd. Flow (RTOR)		6			13				103		23	
Volume (vph)	21	483	12	131	1498	57	37	148	95	24	73	21
Lane Group Flow (vph)	23	538	0	142	1690	0	0	201	103	0	128	0
Turn Type	Perm			Perm			Perm		Perm	Perm		
Protected Phases		2			6			8			4	
Permitted Phases	2			6			8		8	4		
Total Split (s)	49.0	49.0	0.0	49.0	49.0	0.0	26.0	26.0	26.0	26.0	26.0	0.0
Act Effct Green (s)	45.0	45.0		45.0	45.0			22.0	22.0		22.0	
Actuated g/C Ratio	0.60	0.60		0.60	0.60			0.29	0.29		0.29	
v/c Ratio	0.21	0.25		0.29	0.56			0.40	0.19		0.14	
Control Delay	29.3	21.0		5.0	4.5			24.1	5.7		16.5	
Queue Delay	0.0	0.0		0.0	0.0			0.0	0.0		0.0	
Total Delay	29.3	21.0		5.0	4.5			24.1	5.7		16.5	
LOS	C	C		A	A			C	A		B	
Approach Delay		21.3			4.5			17.9			16.5	
Approach LOS		C			A			B			B	

Intersection Summary

Cycle Length: 75
Actuated Cycle Length: 75
Offset: 54 (72%), Referenced to phase 2:EBTL and 6:WBTL, Start of Green
Control Type: Pretimed
Maximum v/c Ratio: 0.56
Intersection Signal Delay: 9.8 Intersection LOS: A
Intersection Capacity Utilization 65.0% ICU Level of Service C
Analysis Period (min) 15

Splits and Phases: 105: E Hastings & Victoria Dr



Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	3493	0	1770	5072	0	1770	1756	0	1770	1740	0
Flt Permitted	0.129			0.327			0.643			0.619		
Satd. Flow (perm)	240	3493	0	600	5072	0	1118	1756	0	1125	1740	0
Satd. Flow (RTOR)		10			4			32			17	
Volume (vph)	21	495	30	71	1502	19	71	110	48	13	110	32
Lane Group Flow (vph)	23	571	0	77	1654	0	77	172	0	14	155	0
Turn Type	Perm			pm+pt			Perm			Perm		
Protected Phases		2		1	6			8			4	
Permitted Phases	2			6			8			4		
Total Split (s)	35.0	35.0	0.0	10.0	45.0	0.0	30.0	30.0	0.0	30.0	30.0	0.0
Act Effct Green (s)	33.0	33.0		41.0	41.0		26.0	26.0		26.0	26.0	
Actuated g/C Ratio	0.44	0.44		0.55	0.55		0.35	0.35		0.35	0.35	
v/c Ratio	0.22	0.37		0.18	0.60		0.20	0.27		0.04	0.25	
Control Delay	9.7	5.7		12.1	14.5		19.0	15.7		16.7	16.9	
Queue Delay	0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0	
Total Delay	9.7	5.7		12.1	14.5		19.0	15.7		16.7	16.9	
LOS	A	A		B	B		B	B		B	B	
Approach Delay		5.8			14.4			16.7			16.9	
Approach LOS		A			B			B			B	

Intersection Summary

Cycle Length: 75
Actuated Cycle Length: 75
Offset: 0 (0%), Referenced to phase 2:EBTL and 6:WBTL, Start of Green
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 0.60
Intersection Signal Delay: 12.9 Intersection LOS: B
Intersection Capacity Utilization 64.5% ICU Level of Service C
Analysis Period (min) 15

Splits and Phases: 106: E Hastings & Commercial Dr

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	3461	0	1770	5055	0	0	3497	1583	0	3529	1583
Flt Permitted	0.190			0.332				0.687			0.912	
Satd. Flow (perm)	354	3461	0	618	5055	0	0	2431	1583	0	3228	1583
Satd. Flow (RTOR)		25			8				127			2
Volume (vph)	61	412	70	369	1135	44	119	364	117	22	401	50
Lane Group Flow (vph)	66	524	0	401	1282	0	0	525	127	0	460	54
Turn Type	pm+pt			pm+pt			Perm		pm+ov	Perm		pm+ov
Protected Phases	1	6		5	2			4	5		8	1
Permitted Phases	6			2			4		4	8		8
Total Split (s)	21.0	25.0	0.0	21.0	25.0	0.0	29.0	29.0	21.0	29.0	29.0	21.0
Act Effct Green (s)	32.3	25.6		41.4	33.1			25.0	41.4		25.0	35.8
Actuated g/C Ratio	0.43	0.34		0.55	0.44			0.33	0.55		0.33	0.48
v/c Ratio	0.24	0.44		0.75	0.57			0.65	0.14		0.43	0.07
Control Delay	11.1	20.7		12.1	7.5			25.8	1.6		21.0	10.3
Queue Delay	0.0	0.0		0.0	0.0			0.0	0.0		0.0	0.0
Total Delay	11.1	20.7		12.1	7.5			25.8	1.6		21.0	10.3
LOS	B	C		B	A			C	A		C	B
Approach Delay		19.7			8.6			21.1			19.9	
Approach LOS		B			A			C			B	

Intersection Summary

Cycle Length: 75
Actuated Cycle Length: 75
Offset: 45 (60%), Referenced to phase 2:WBTL and 6:EBTL, Start of Green
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 0.75
Intersection Signal Delay: 14.6 Intersection LOS: B
Intersection Capacity Utilization 86.3% ICU Level of Service E
Analysis Period (min) 15

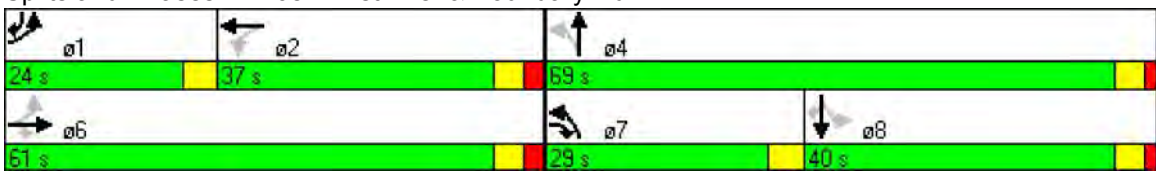
Splits and Phases: 107: E Hastings & Clark Dr

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	1863	1583	1770	1812	0	0	4939	0	0	3536	1583
Flt Permitted	0.150			0.577				0.697			0.905	
Satd. Flow (perm)	279	1863	1583	1075	1812	0	0	3502	0	0	3203	1583
Satd. Flow (RTOR)			18		8			15				207
Volume (vph)	268	276	432	50	292	64	294	489	66	20	768	279
Lane Group Flow (vph)	291	300	470	54	387	0	0	924	0	0	857	303
Turn Type	pm+pt		pm+ov	Perm			pm+pt			Perm		pm+ov
Protected Phases	1	6	7		2		7	4			8	1
Permitted Phases	6		6	2			4			8		8
Total Split (s)	24.0	61.0	29.0	37.0	37.0	0.0	29.0	69.0	0.0	40.0	40.0	24.0
Act Effct Green (s)	48.7	48.7	61.1	28.1	28.1			45.9			33.5	54.1
Actuated g/C Ratio	0.47	0.47	0.59	0.27	0.27			0.45			0.33	0.53
v/c Ratio	0.78	0.34	0.50	0.18	0.77			1.45dl			0.82	0.33
Control Delay	36.8	18.2	13.7	31.9	45.9			21.7			40.5	5.7
Queue Delay	0.0	0.0	0.0	0.0	0.0			0.0			0.0	0.0
Total Delay	36.8	18.2	13.7	31.9	45.9			21.7			40.5	5.7
LOS	D	B	B	C	D			C			D	A
Approach Delay		21.3			44.2			21.7			31.4	
Approach LOS		C			D			C			C	

Intersection Summary

Cycle Length: 130
Actuated Cycle Length: 102.8
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 0.82
Intersection Signal Delay: 27.5 Intersection LOS: C
Intersection Capacity Utilization 86.1% ICU Level of Service E
Analysis Period (min) 15
dl Defacto Left Lane. Recode with 1 though lane as a left lane.

Splits and Phases: 108: E 1st Ave. & Boundary Rd

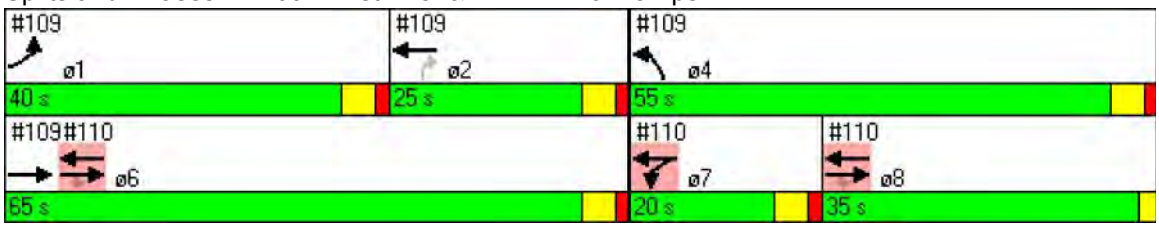


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	3539	0	0	5085	1583	3433	0	1583	0	0	0
Flt Permitted	0.950						0.950					
Satd. Flow (perm)	1770	3539	0	0	5085	1583	3433	0	1583	0	0	0
Satd. Flow (RTOR)						66			56			
Volume (vph)	238	827	0	0	596	167	1064	0	142	0	0	0
Lane Group Flow (vph)	259	899	0	0	648	182	1157	0	154	0	0	0
Turn Type	Prot					Free	Prot		custom			
Protected Phases	1	6			2		4					
Permitted Phases						Free			2			
Total Split (s)	40.0	65.0	0.0	0.0	25.0	0.0	55.0	0.0	25.0	0.0	0.0	0.0
Act Effct Green (s)	36.0	61.0			21.0	120.0	51.0		21.0			
Actuated g/C Ratio	0.30	0.51			0.18	1.00	0.42		0.18			
v/c Ratio	0.49	0.50			0.73	0.11	0.79		0.48			
Control Delay	34.9	17.4			52.3	0.1	34.9		33.5			
Queue Delay	4.3	0.6			0.0	0.0	0.0		0.0			
Total Delay	39.2	18.0			52.3	0.1	34.9		33.5			
LOS	D	B			D	A	C		C			
Approach Delay		22.8			40.8							
Approach LOS		C			D							

Intersection Summary

Cycle Length: 120
Actuated Cycle Length: 120
Offset: 0 (0%), Referenced to phase 2:WBT and 6:EBT, Start of Green
Control Type: Pretimed
Maximum v/c Ratio: 0.89
Intersection Signal Delay: 32.1 Intersection LOS: C
Intersection Capacity Utilization 120.6% ICU Level of Service H
Analysis Period (min) 15

Splits and Phases: 109: E 1st Ave. & HW1 WB on ramps



Lane Group	ø7	ø8
Lane Configurations		
Total Lost Time (s)		
Satd. Flow (prot)		
Flt Permitted		
Satd. Flow (perm)		
Satd. Flow (RTOR)		
Volume (vph)		
Lane Group Flow (vph)		
Turn Type		
Protected Phases	7	8
Permitted Phases		
Total Split (s)	20.0	35.0
Act Effct Green (s)		
Actuated g/C Ratio		
v/c Ratio		
Control Delay		
Queue Delay		
Total Delay		
LOS		
Approach Delay		
Approach LOS		

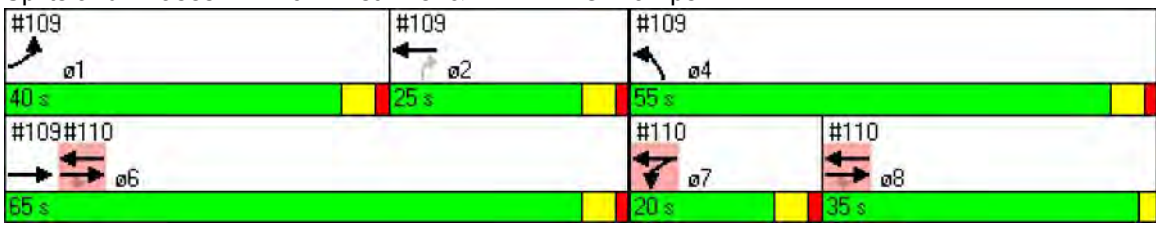
Intersection Summary

Lane Group	EBT	EBR	WBL	WBT	NBL	NBR	ø1	ø2	ø4	ø6	ø8
Lane Configurations											
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0					
Satd. Flow (prot)	5085	1583	1770	5085	0	0					
Flt Permitted			0.950								
Satd. Flow (perm)	5085	1583	1770	5085	0	0					
Satd. Flow (RTOR)		471									
Volume (vph)	1118	1110	80	1646	0	0					
Lane Group Flow (vph)	1215	1207	87	1789	0	0					
Turn Type		Perm	Prot								
Protected Phases	6 8		7	6 7 8			1	2	4	6	8
Permitted Phases		6 8									
Total Split (s)	100.0	100.0	20.0	120.0	0.0	0.0	40.0	25.0	55.0	65.0	35.0
Act Effct Green (s)	96.0	96.0	16.0	120.0							
Actuated g/C Ratio	0.80	0.80	0.13	1.00							
v/c Ratio	0.30	0.89	0.37	0.35							
Control Delay	3.4	14.6	52.1	0.2							
Queue Delay	0.0	0.0	0.0	0.0							
Total Delay	3.4	14.6	52.1	0.2							
LOS	A	B	D	A							
Approach Delay	9.0			2.6							
Approach LOS	A			A							

Intersection Summary

Cycle Length: 120
Actuated Cycle Length: 120
Offset: 0 (0%), Referenced to phase 2:WBT and 6:EBT, Start of Green
Control Type: Pretimed
Maximum v/c Ratio: 0.89
Intersection Signal Delay: 6.2 Intersection LOS: A
Intersection Capacity Utilization 120.6% ICU Level of Service H
Analysis Period (min) 15

Splits and Phases: 110: E 1st Ave. & HW1 EB On ramps

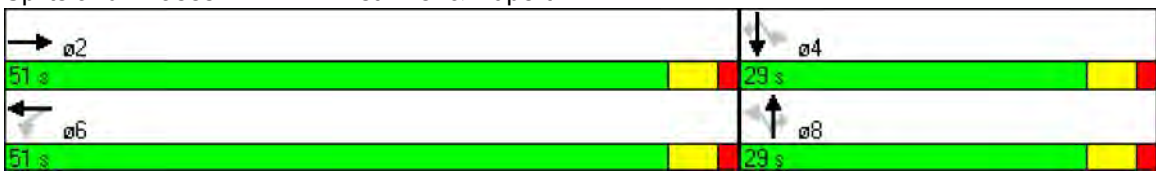


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	0	5070	0	0	3511	0	1770	1522	1504	1770	3539	1583
Flt Permitted					0.823		0.399			0.672		
Satd. Flow (perm)	0	5070	0	0	2892	0	743	1522	1504	1252	3539	1583
Satd. Flow (RTOR)		7			10			19	19			36
Volume (vph)	0	1615	37	39	1372	64	177	7	206	215	422	117
Lane Group Flow (vph)	0	1795	0	0	1603	0	192	120	112	234	459	127
Turn Type				Perm			Perm		Perm	Perm		Perm
Protected Phases		2			6			8			4	
Permitted Phases				6			8		8	4		4
Total Split (s)	0.0	51.0	0.0	51.0	51.0	0.0	29.0	29.0	29.0	29.0	29.0	29.0
Act Effct Green (s)		47.0			47.0		25.0	25.0	25.0	25.0	25.0	25.0
Actuated g/C Ratio		0.59			0.59		0.31	0.31	0.31	0.31	0.31	0.31
v/c Ratio		0.60			0.94		0.83	0.25	0.23	0.60	0.42	0.24
Control Delay		20.2			28.2		56.4	18.8	18.4	30.9	23.1	16.2
Queue Delay		0.0			0.0		0.0	0.0	0.0	0.0	0.0	0.0
Total Delay		20.2			28.2		56.4	18.8	18.4	30.9	23.1	16.2
LOS		C			C		E	B	B	C	C	B
Approach Delay		20.2			28.2			35.7			24.3	
Approach LOS		C			C			D			C	

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 80
Offset: 31 (39%), Referenced to phase 2:EBT and 6:WBTL, Start of Green
Control Type: Pretimed
Maximum v/c Ratio: 0.94
Intersection Signal Delay: 25.1 Intersection LOS: C
Intersection Capacity Utilization 99.7% ICU Level of Service F
Analysis Period (min) 15

Splits and Phases: 111: E 1st Ave. & Rupert

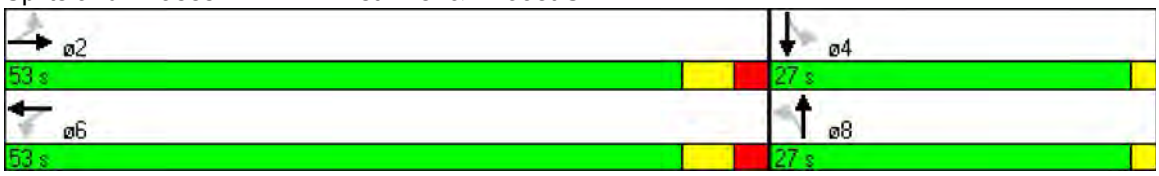


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	0	3539	0	0	3536	0	0	1650	0	0	1709	0
Flt Permitted		0.950			0.951			0.978			0.893	
Satd. Flow (perm)	0	3362	0	0	3362	0	0	1629	0	0	1562	0
Satd. Flow (RTOR)					1			18			15	
Volume (vph)	4	1628	3	4	1761	10	4	1	17	35	6	34
Lane Group Flow (vph)	0	1777	0	0	1929	0	0	23	0	0	82	0
Turn Type	Perm			Perm			Perm			Perm		
Protected Phases		2			6			8			4	
Permitted Phases	2			6			8			4		
Total Split (s)	53.0	53.0	0.0	53.0	53.0	0.0	27.0	27.0	0.0	27.0	27.0	0.0
Act Effct Green (s)		49.0			49.0			23.0			23.0	
Actuated g/C Ratio		0.61			0.61			0.29			0.29	
v/c Ratio		0.86			0.94			0.05			0.18	
Control Delay		29.0			13.4			11.6			19.2	
Queue Delay		0.0			0.0			0.0			0.0	
Total Delay		29.0			13.4			11.6			19.2	
LOS		C			B			B			B	
Approach Delay		29.0			13.4			11.6			19.2	
Approach LOS		C			B			B			B	

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 80
Offset: 56 (70%), Referenced to phase 2:EBTL and 6:WBTL, Start of Green
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 0.94
Intersection Signal Delay: 20.8 Intersection LOS: C
Intersection Capacity Utilization 67.8% ICU Level of Service C
Analysis Period (min) 15

Splits and Phases: 112: E 1st Ave. & Lillooet ST

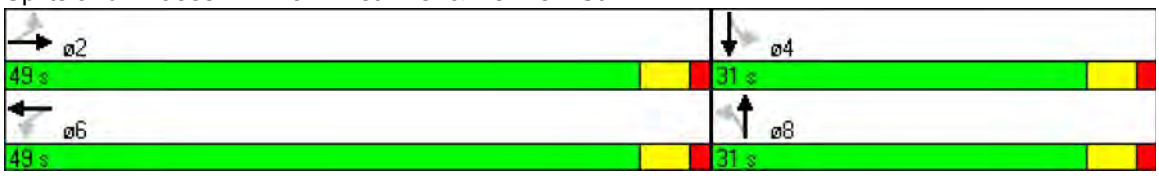


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	3518	0	1770	3504	0	1770	3497	0	1770	3479	0
Flt Permitted	0.089			0.089			0.325			0.347		
Satd. Flow (perm)	166	3518	0	166	3504	0	605	3497	0	646	3479	0
Satd. Flow (RTOR)		8			15			12			19	
Volume (vph)	50	1409	57	49	1523	111	91	465	39	91	470	62
Lane Group Flow (vph)	54	1594	0	53	1776	0	99	547	0	99	578	0
Turn Type	Perm			Perm			Perm			Perm		
Protected Phases		2			6			8			4	
Permitted Phases	2			6			8			4		
Total Split (s)	49.0	49.0	0.0	49.0	49.0	0.0	31.0	31.0	0.0	31.0	31.0	0.0
Act Effct Green (s)	45.0	45.0		45.0	45.0		27.0	27.0		27.0	27.0	
Actuated g/C Ratio	0.56	0.56		0.56	0.56		0.34	0.34		0.34	0.34	
v/c Ratio	0.58	0.80		0.57	0.90		0.49	0.46		0.45	0.49	
Control Delay	36.3	23.4		18.4	7.8		30.8	21.8		29.0	22.0	
Queue Delay	0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0	
Total Delay	36.3	23.4		18.4	7.8		30.8	21.8		29.0	22.0	
LOS	D	C		B	A		C	C		C	C	
Approach Delay		23.8			8.1			23.2			23.0	
Approach LOS		C			A			C			C	

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 80
Offset: 2 (3%), Referenced to phase 2:EBTL and 6:WBTL, Start of Green
Control Type: Pretimed
Maximum v/c Ratio: 0.90
Intersection Signal Delay: 17.6 Intersection LOS: B
Intersection Capacity Utilization 75.6% ICU Level of Service D
Analysis Period (min) 15

Splits and Phases: 113: E 1st Ave. & Renfrew St

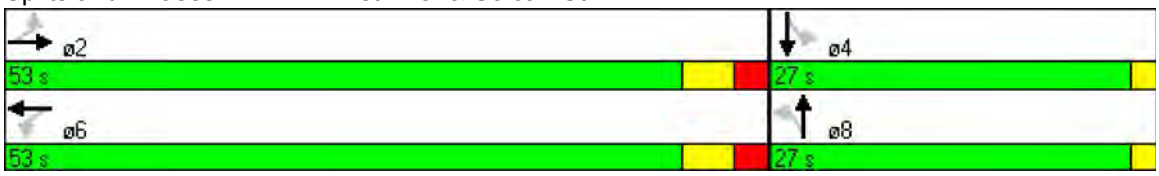


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	0	3539	0	0	3539	0	0	1708	0	0	1681	0
Flt Permitted		0.937			0.951			0.957			0.997	
Satd. Flow (perm)	0	3316	0	0	3366	0	0	1661	0	0	1679	0
Satd. Flow (RTOR)								12			15	
Volume (vph)	9	1536	3	4	1647	4	7	4	11	1	5	14
Lane Group Flow (vph)	0	1683	0	0	1798	0	0	24	0	0	21	0
Turn Type	Perm			Perm			Perm			Perm		
Protected Phases		2			6			8			4	
Permitted Phases	2			6			8			4		
Total Split (s)	53.0	53.0	0.0	53.0	53.0	0.0	27.0	27.0	0.0	27.0	27.0	0.0
Act Effct Green (s)		49.0			49.0			23.0			23.0	
Actuated g/C Ratio		0.61			0.61			0.29			0.29	
v/c Ratio		0.83			0.87			0.05			0.04	
Control Delay		10.8			8.0			14.5			12.5	
Queue Delay		0.0			0.0			0.0			0.0	
Total Delay		10.8			8.0			14.5			12.5	
LOS		B			A			B			B	
Approach Delay		10.8			8.0			14.5			12.5	
Approach LOS		B			A			B			B	

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 80
Offset: 30 (38%), Referenced to phase 2:EBTL and 6:WBTL, Start of Green
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 0.87
Intersection Signal Delay: 9.4 Intersection LOS: A
Intersection Capacity Utilization 59.5% ICU Level of Service B
Analysis Period (min) 15

Splits and Phases: 114: E 1st Ave. & Solcan St

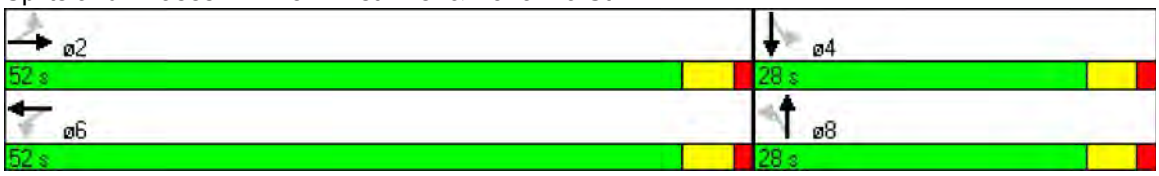


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	3525	0	1770	3525	0	1770	3493	0	1770	4994	0
Flt Permitted	0.083			0.083			0.339			0.223		
Satd. Flow (perm)	155	3525	0	155	3525	0	631	3493	0	415	4994	0
Satd. Flow (RTOR)		6			6			12			20	
Volume (vph)	45	1430	38	54	1613	44	93	582	54	49	498	70
Lane Group Flow (vph)	49	1595	0	59	1801	0	101	692	0	53	617	0
Turn Type	Perm			Perm			Perm			Perm		
Protected Phases		2			6			8			4	
Permitted Phases	2			6			8			4		
Total Split (s)	52.0	52.0	0.0	52.0	52.0	0.0	28.0	28.0	0.0	28.0	28.0	0.0
Act Effct Green (s)	48.0	48.0		48.0	48.0		24.0	24.0		24.0	24.0	
Actuated g/C Ratio	0.60	0.60		0.60	0.60		0.30	0.30		0.30	0.30	
v/c Ratio	0.53	0.75		0.63	0.85		0.53	0.66		0.42	0.41	
Control Delay	39.8	22.9		22.9	3.6		35.6	27.5		35.0	22.6	
Queue Delay	0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0	
Total Delay	39.8	22.9		22.9	3.6		35.6	27.5		35.0	22.6	
LOS	D	C		C	A		D	C		C	C	
Approach Delay		23.4			4.2			28.5			23.5	
Approach LOS		C			A			C			C	

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 80
Offset: 68 (85%), Referenced to phase 2:EBTL and 6:WBTL, Start of Green
Control Type: Pretimed
Maximum v/c Ratio: 0.85
Intersection Signal Delay: 17.0 Intersection LOS: B
Intersection Capacity Utilization 77.1% ICU Level of Service D
Analysis Period (min) 15

Splits and Phases: 115: E 1st Ave. & Nanaimo St

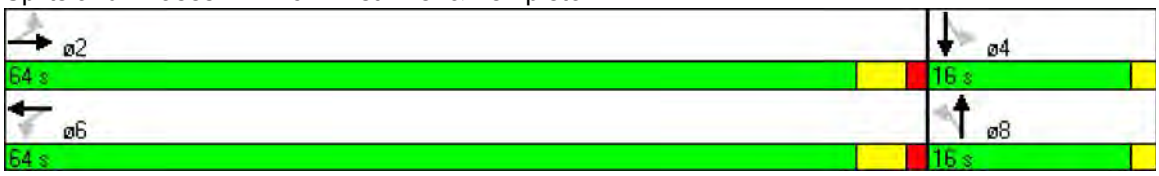


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	0	3539	0	0	3539	0	0	1657	0	0	1611	0
Flt Permitted					0.954			0.994				
Satd. Flow (perm)	0	3539	0	0	3376	0	0	1652	0	0	1611	0
Satd. Flow (RTOR)		1						12			36	
Volume (vph)	0	1510	5	2	1746	2	1	2	11	0	0	3
Lane Group Flow (vph)	0	1646	0	0	1902	0	0	15	0	0	3	0
Turn Type	Perm			Perm			Perm			Perm		
Protected Phases		2			6			8			4	
Permitted Phases	2			6			8			4		
Total Split (s)	64.0	64.0	0.0	64.0	64.0	0.0	16.0	16.0	0.0	16.0	16.0	0.0
Act Effct Green (s)		60.0			60.0			12.0			12.0	
Actuated g/C Ratio		0.75			0.75			0.15			0.15	
v/c Ratio		0.62			0.75			0.06			0.01	
Control Delay		3.7			2.5			18.1			0.0	
Queue Delay		0.1			0.0			0.0			0.0	
Total Delay		3.8			2.5			18.1			0.0	
LOS		A			A			B			A	
Approach Delay		3.8			2.5			18.1			0.0	
Approach LOS		A			A			B			A	

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 80
Offset: 76 (95%), Referenced to phase 2:EBTL and 6:WBTL, Start of Green
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 0.75
Intersection Signal Delay: 3.1 Intersection LOS: A
Intersection Capacity Utilization 59.7% ICU Level of Service B
Analysis Period (min) 15

Splits and Phases: 116: E 1st Ave. & Templeton Dr

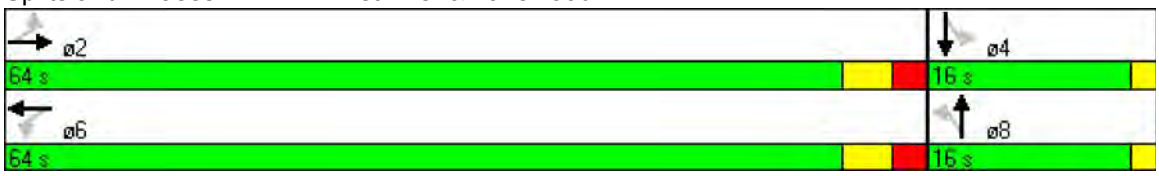


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	0	3539	0	0	3539	0	0	1611	0	0	1736	0
Flt Permitted		0.937			0.946						0.965	
Satd. Flow (perm)	0	3316	0	0	3348	0	0	1611	0	0	1700	0
Satd. Flow (RTOR)		1						55			4	
Volume (vph)	7	1541	3	7	1979	1	0	0	11	3	3	4
Lane Group Flow (vph)	0	1686	0	0	2160	0	0	12	0	0	10	0
Turn Type	Perm			Perm			Perm			Perm		
Protected Phases		2			6			8			4	
Permitted Phases	2			6			8			4		
Total Split (s)	64.0	64.0	0.0	64.0	64.0	0.0	16.0	16.0	0.0	16.0	16.0	0.0
Act Effct Green (s)		60.0			60.0			12.0			12.0	
Actuated g/C Ratio		0.75			0.75			0.15			0.15	
v/c Ratio		0.68			0.86			0.04			0.04	
Control Delay		9.3			5.4			0.3			24.4	
Queue Delay		0.0			0.1			0.0			0.0	
Total Delay		9.3			5.5			0.3			24.4	
LOS		A			A			A			C	
Approach Delay		9.3			5.5			0.3			24.4	
Approach LOS		A			A			A			C	

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 80
Offset: 7 (9%), Referenced to phase 2:EBTL and 6:WBTL, Start of Green
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 0.86
Intersection Signal Delay: 7.2 Intersection LOS: A
Intersection Capacity Utilization 69.6% ICU Level of Service C
Analysis Period (min) 15

Splits and Phases: 117: E 1st Ave. & Lakewood Dr

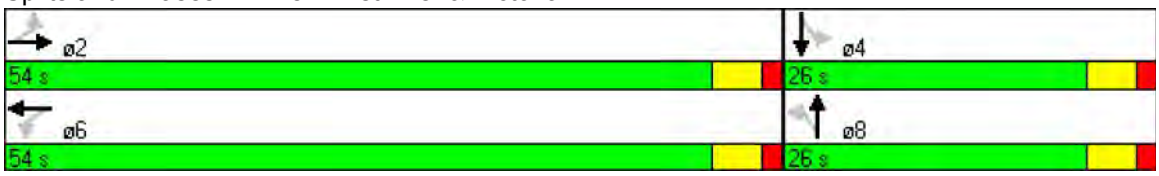


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	0	3536	0	0	3486	0	0	3486	0	0	3430	0
Flt Permitted								0.874			0.695	
Satd. Flow (perm)	0	3536	0	0	3486	0	0	3065	0	0	2423	0
Satd. Flow (RTOR)		2			28			8			14	
Volume (vph)	0	1443	12	0	1799	200	39	261	20	100	180	30
Lane Group Flow (vph)	0	1581	0	0	2172	0	0	348	0	0	338	0
Turn Type	Perm			Perm			Perm			Perm		
Protected Phases		2			6			8			4	
Permitted Phases	2			6			8			4		
Total Split (s)	54.0	54.0	0.0	54.0	54.0	0.0	26.0	26.0	0.0	26.0	26.0	0.0
Act Effct Green (s)		50.0			50.0			22.0			22.0	
Actuated g/C Ratio		0.62			0.62			0.28			0.28	
v/c Ratio		0.72			0.99			0.41			0.50	
Control Delay		13.6			18.7			24.9			26.4	
Queue Delay		0.0			0.0			0.0			0.0	
Total Delay		13.6			18.7			24.9			26.4	
LOS		B			B			C			C	
Approach Delay		13.6			18.7			24.9			26.4	
Approach LOS		B			B			C			C	

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 80
Offset: 35 (44%), Referenced to phase 2:EBTL and 6:WBTL, Start of Green
Control Type: Pretimed
Maximum v/c Ratio: 0.99
Intersection Signal Delay: 17.9 Intersection LOS: B
Intersection Capacity Utilization 83.9% ICU Level of Service E
Analysis Period (min) 15

Splits and Phases: 118: E 1st Ave. & Victoria Dr



Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	3525	0	1770	3506	0	1770	3394	0	1770	3417	0
Flt Permitted	0.095			0.104			0.577			0.325		
Satd. Flow (perm)	177	3525	0	194	3506	0	966	3394	0	563	3417	0
Satd. Flow (RTOR)		4			8			19			8	
Volume (vph)	33	1207	27	73	1636	72	59	342	49	125	233	29
Lane Group Flow (vph)	36	1341	0	79	1856	0	64	425	0	136	285	0
Turn Type	Perm			Perm			Perm			pm+pt		
Protected Phases		2			6			8		7	4	
Permitted Phases	2			6			8			4		
Total Split (s)	46.0	46.0	0.0	46.0	46.0	0.0	24.0	24.0	0.0	10.0	34.0	0.0
Act Effct Green (s)	46.5	46.5		46.5	46.5		15.5	15.5		25.5	25.5	
Actuated g/C Ratio	0.58	0.58		0.58	0.58		0.19	0.19		0.32	0.32	
v/c Ratio	0.35	0.65		0.70	0.91		0.34	0.63		0.50	0.26	
Control Delay	29.2	21.3		24.7	11.5		31.9	32.2		26.1	19.7	
Queue Delay	0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0	
Total Delay	29.2	21.3		24.7	11.5		31.9	32.2		26.1	19.7	
LOS	C	C		C	B		C	C		C	B	
Approach Delay		21.5			12.0			32.2			21.7	
Approach LOS		C			B			C			C	

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 80
Offset: 54 (68%), Referenced to phase 2:EBTL and 6:WBTL, Start of Green
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 0.91
Intersection Signal Delay: 18.4 Intersection LOS: B
Intersection Capacity Utilization 84.6% ICU Level of Service E
Analysis Period (min) 15

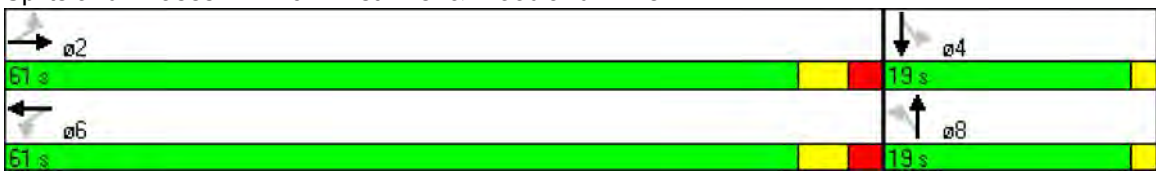
Splits and Phases: 119: E 1st Ave. & Commercial Dr

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	0	3536	0	0	3536	0	0	1700	0	0	1752	0
Flt Permitted		0.937			0.933			0.983			0.979	
Satd. Flow (perm)	0	3313	0	0	3299	0	0	1681	0	0	1729	0
Satd. Flow (RTOR)		1			3			25			10	
Volume (vph)	8	1281	6	16	1644	17	5	10	23	4	11	9
Lane Group Flow (vph)	0	1408	0	0	1822	0	0	41	0	0	26	0
Turn Type	Perm			Perm			Perm			Perm		
Protected Phases		2			6			8			4	
Permitted Phases	2			6			8			4		
Total Split (s)	61.0	61.0	0.0	61.0	61.0	0.0	19.0	19.0	0.0	19.0	19.0	0.0
Act Effct Green (s)		57.0			57.0			15.0			15.0	
Actuated g/C Ratio		0.71			0.71			0.19			0.19	
v/c Ratio		0.60			0.77			0.12			0.08	
Control Delay		10.9			3.2			16.4			20.6	
Queue Delay		0.0			0.0			0.0			0.0	
Total Delay		10.9			3.2			16.4			20.6	
LOS		B			A			B			C	
Approach Delay		10.9			3.2			16.4			20.6	
Approach LOS		B			A			B			C	

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 80
Offset: 70 (88%), Referenced to phase 2:EBTL and 6:WBTL, Start of Green
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 0.77
Intersection Signal Delay: 6.8 Intersection LOS: A
Intersection Capacity Utilization 67.2% ICU Level of Service C
Analysis Period (min) 15

Splits and Phases: 120: E 1st Ave. & Woodland Drive

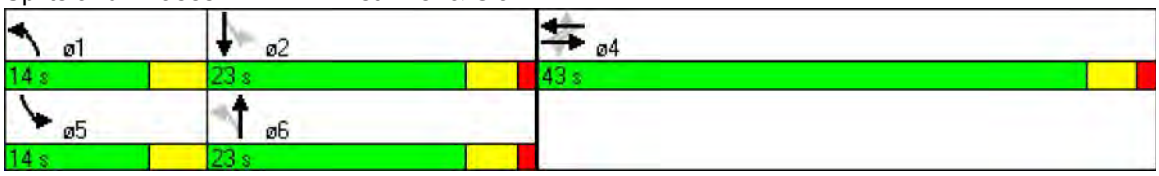


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	0	3437	0	0	3490	0	1770	4963	0	1770	4989	0
Flt Permitted					0.955		0.211			0.211		
Satd. Flow (perm)	0	3437	0	0	3333	0	393	4963	0	393	4989	0
Satd. Flow (RTOR)		52			19			45			29	
Volume (vph)	0	987	239	1	1457	152	309	1078	203	129	782	114
Lane Group Flow (vph)	0	1333	0	0	1750	0	336	1393	0	140	974	0
Turn Type	Perm			Perm			pm+pt			pm+pt		
Protected Phases		4			4		1	6		5	2	
Permitted Phases	4			4			6			2		
Total Split (s)	43.0	43.0	0.0	43.0	43.0	0.0	14.0	23.0	0.0	14.0	23.0	0.0
Act Effct Green (s)		39.0			39.0		30.2	20.2		27.8	19.0	
Actuated g/C Ratio		0.49			0.49		0.38	0.25		0.35	0.24	
v/c Ratio		0.78			1.07		1.05	1.08		0.48	0.81	
Control Delay		20.4			51.4		86.8	81.5		21.3	34.1	
Queue Delay		0.0			0.0		0.0	0.0		0.0	0.0	
Total Delay		20.4			51.4		86.8	81.5		21.3	34.1	
LOS		C			D		F	F		C	C	
Approach Delay		20.4			51.4			82.5			32.5	
Approach LOS		C			D			F			C	

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 80
Offset: 18 (23%), Referenced to phase 4:EBWB, Start of Green
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 1.08
Intersection Signal Delay: 49.9 Intersection LOS: D
Intersection Capacity Utilization 90.6% ICU Level of Service E
Analysis Period (min) 15

Splits and Phases: 121: E 1st Ave. & Clark Dr

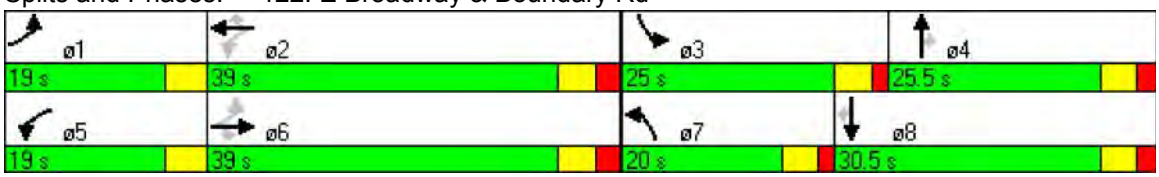


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	3539	1583	1770	3539	1583	3433	3539	1583	1770	3539	1583
Flt Permitted	0.114			0.268			0.950			0.950		
Satd. Flow (perm)	212	3539	1583	499	3539	1583	3433	3539	1583	1770	3539	1583
Satd. Flow (RTOR)			167			172			108			275
Volume (vph)	169	574	154	126	1093	184	309	401	99	231	588	374
Lane Group Flow (vph)	184	624	167	137	1188	200	336	436	108	251	639	407
Turn Type	pm+pt		Perm	pm+pt		Perm	Prot		Perm	Prot		Perm
Protected Phases	1	6		5	2		7	4		3	8	
Permitted Phases	6		6	2		2			4			8
Total Split (s)	19.0	39.0	39.0	19.0	39.0	39.0	20.0	25.5	25.5	25.0	30.5	30.5
Act Effct Green (s)	48.4	36.9	36.9	45.0	35.2	35.2	14.6	20.3	20.3	18.5	24.2	24.2
Actuated g/C Ratio	0.48	0.36	0.36	0.44	0.35	0.35	0.14	0.20	0.20	0.18	0.24	0.24
v/c Ratio	0.66	0.49	0.25	0.40	0.97	0.30	0.68	0.62	0.27	0.78	0.76	0.69
Control Delay	30.8	27.6	4.9	18.5	53.5	7.4	49.8	42.2	9.1	57.5	43.0	18.7
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	30.8	27.6	4.9	18.5	53.5	7.4	49.8	42.2	9.1	57.5	43.0	18.7
LOS	C	C	A	B	D	A	D	D	A	E	D	B
Approach Delay		24.3			44.3			41.0			38.2	
Approach LOS		C			D			D			D	

Intersection Summary

Cycle Length: 108.5
Actuated Cycle Length: 101.6
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 0.97
Intersection Signal Delay: 37.8 Intersection LOS: D
Intersection Capacity Utilization 78.2% ICU Level of Service D
Analysis Period (min) 15

Splits and Phases: 122: E Broadway & Boundary Rd

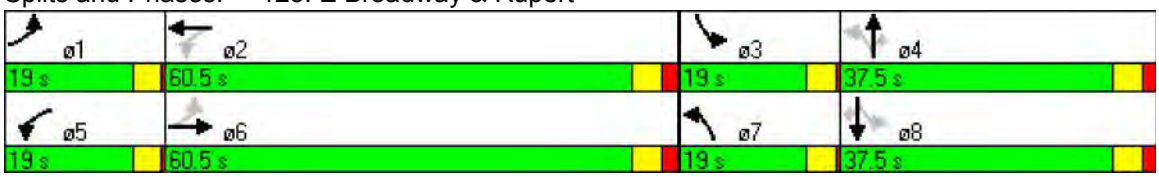


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	4984	0	1770	5070	0	1770	3539	1583	1770	3539	1583
Flt Permitted	0.071			0.218			0.343			0.457		
Satd. Flow (perm)	132	4984	0	406	5070	0	639	3539	1583	851	3539	1583
Satd. Flow (RTOR)		26			2				191			146
Volume (vph)	43	744	113	193	1376	24	262	287	176	56	394	134
Lane Group Flow (vph)	47	932	0	210	1522	0	285	312	191	61	428	146
Turn Type	pm+pt			pm+pt			pm+pt		Perm	pm+pt		Perm
Protected Phases	1	6		5	2		7	4		3	8	
Permitted Phases	6			2			4		4	8		8
Total Split (s)	19.0	60.5	0.0	19.0	60.5	0.0	19.0	37.5	37.5	19.0	37.5	37.5
Act Effct Green (s)	63.5	56.7		73.1	64.3		40.8	30.6	30.6	30.2	21.8	21.8
Actuated g/C Ratio	0.51	0.46		0.60	0.53		0.33	0.25	0.25	0.24	0.18	0.18
v/c Ratio	0.30	0.40		0.55	0.57		0.81	0.35	0.35	0.23	0.68	0.36
Control Delay	16.8	22.2		17.4	21.6		51.7	40.1	7.3	30.7	52.7	9.3
Queue Delay	0.0	0.0		0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	16.8	22.2		17.4	21.6		51.7	40.1	7.3	30.7	52.7	9.3
LOS	B	C		B	C		D	D	A	C	D	A
Approach Delay		21.9			21.1			36.4			40.6	
Approach LOS		C			C			D			D	

Intersection Summary

Cycle Length: 136
Actuated Cycle Length: 122
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 0.81
Intersection Signal Delay: 27.2 Intersection LOS: C
Intersection Capacity Utilization 71.6% ICU Level of Service C
Analysis Period (min) 15

Splits and Phases: 123: E Broadway & Rupert

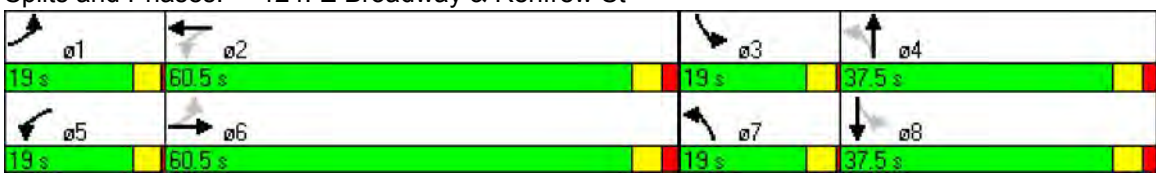


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	5009	0	1770	5060	0	1770	3437	0	1770	3405	0
Flt Permitted	0.071			0.179			0.201			0.281		
Satd. Flow (perm)	132	5009	0	333	5060	0	374	3437	0	523	3405	0
Satd. Flow (RTOR)		17			4			21			33	
Volume (vph)	83	868	98	84	1613	54	124	369	89	66	409	140
Lane Group Flow (vph)	90	1050	0	91	1812	0	135	498	0	72	597	0
Turn Type	pm+pt			pm+pt			pm+pt			pm+pt		
Protected Phases	1	6		5	2		7	4		3	8	
Permitted Phases	6			2			4			8		
Total Split (s)	19.0	60.5	0.0	19.0	60.5	0.0	19.0	37.5	0.0	19.0	37.5	0.0
Act Effct Green (s)	52.9	47.2		52.6	47.0		37.6	29.3		32.7	26.8	
Actuated g/C Ratio	0.50	0.45		0.50	0.45		0.35	0.28		0.31	0.26	
v/c Ratio	0.45	0.46		0.33	0.79		0.48	0.51		0.27	0.66	
Control Delay	23.7	22.0		16.4	29.6		31.4	36.0		27.8	41.2	
Queue Delay	0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0	
Total Delay	23.7	22.0		16.4	29.6		31.4	36.0		27.8	41.2	
LOS	C	C		B	C		C	D		C	D	
Approach Delay		22.1			29.0			35.0			39.8	
Approach LOS		C			C			D			D	

Intersection Summary

Cycle Length: 136
Actuated Cycle Length: 104.3
Control Type: Semi Act-Uncoord
Maximum v/c Ratio: 0.79
Intersection Signal Delay: 29.7 Intersection LOS: C
Intersection Capacity Utilization 72.9% ICU Level of Service C
Analysis Period (min) 15

Splits and Phases: 124: E Broadway & Renfrew St

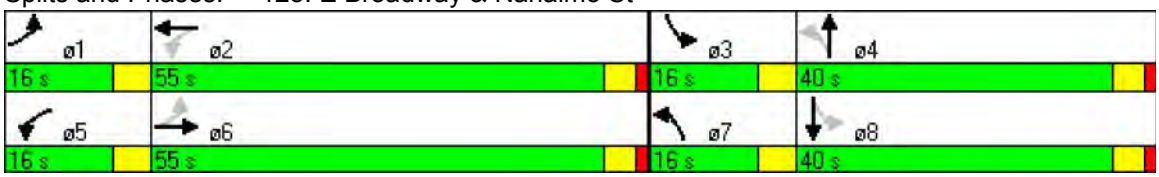


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	5050	0	1770	5065	0	1770	4984	0	1770	4867	0
Flt Permitted	0.078			0.174			0.277			0.278		
Satd. Flow (perm)	145	5050	0	324	5065	0	516	4984	0	518	4867	0
Satd. Flow (RTOR)		7			4			23			79	
Volume (vph)	90	924	46	116	1759	51	149	528	83	61	438	175
Lane Group Flow (vph)	98	1054	0	126	1967	0	162	664	0	66	666	0
Turn Type	pm+pt			pm+pt			pm+pt			pm+pt		
Protected Phases	1	6		5	2		7	4		3	8	
Permitted Phases	6			2			4			8		
Total Split (s)	16.0	55.0	0.0	16.0	55.0	0.0	16.0	40.0	0.0	16.0	40.0	0.0
Act Effct Green (s)	56.8	48.7		59.0	51.7		33.5	24.6		27.6	19.5	
Actuated g/C Ratio	0.54	0.47		0.57	0.50		0.32	0.24		0.26	0.19	
v/c Ratio	0.48	0.45		0.41	0.78		0.55	0.56		0.29	0.68	
Control Delay	21.7	20.1		14.6	26.4		33.5	37.1		28.4	38.8	
Queue Delay	0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0	
Total Delay	21.7	20.1		14.6	26.4		33.5	37.1		28.4	38.8	
LOS	C	C		B	C		C	D		C	D	
Approach Delay		20.2			25.7			36.4			37.9	
Approach LOS		C			C			D			D	

Intersection Summary

Cycle Length: 127
Actuated Cycle Length: 104.1
Control Type: Semi Act-Uncoord
Maximum v/c Ratio: 0.78
Intersection Signal Delay: 28.1 Intersection LOS: C
Intersection Capacity Utilization 74.1% ICU Level of Service D
Analysis Period (min) 15

Splits and Phases: 125: E Broadway & Nanaimo St



Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	5065	0	1770	5060	0	1770	1863	1583	1770	1794	0
Flt Permitted	0.098			0.286			0.455			0.559		
Satd. Flow (perm)	183	5065	0	533	5060	0	848	1863	1583	1041	1794	0
Satd. Flow (RTOR)		9			11				70		7	
Volume (vph)	30	784	23	89	1863	68	88	199	64	78	205	66
Lane Group Flow (vph)	33	877	0	97	2099	0	96	216	70	85	295	0
Turn Type	Perm			Perm			Perm		Perm	Perm		
Protected Phases		2			6			8			4	
Permitted Phases	2			6			8		8	4		
Total Split (s)	45.0	45.0	0.0	45.0	45.0	0.0	30.0	30.0	30.0	30.0	30.0	0.0
Act Effct Green (s)	41.0	41.0		41.0	41.0		26.0	26.0	26.0	26.0	26.0	
Actuated g/C Ratio	0.55	0.55		0.55	0.55		0.35	0.35	0.35	0.35	0.35	
v/c Ratio	0.33	0.32		0.33	0.76		0.33	0.33	0.12	0.24	0.47	
Control Delay	23.6	7.2		13.5	15.3		22.0	19.9	5.3	19.7	21.7	
Queue Delay	0.0	0.0		0.0	0.0		0.0	0.0	0.0	0.0	0.0	
Total Delay	23.6	7.2		13.5	15.3		22.0	19.9	5.3	19.7	21.7	
LOS	C	A		B	B		C	B	A	B	C	
Approach Delay		7.8			15.3			17.8			21.3	
Approach LOS		A			B			B			C	

Intersection Summary

Cycle Length: 75
Actuated Cycle Length: 75
Offset: 34 (45%), Referenced to phase 2:EBTL and 6:WBTL, Start of Green
Control Type: Pretimed
Maximum v/c Ratio: 0.76
Intersection Signal Delay: 14.3 Intersection LOS: B
Intersection Capacity Utilization 73.9% ICU Level of Service D
Analysis Period (min) 15

Splits and Phases: 126: E Broadway & Victoria Dr

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	5034	0	1770	5065	0	0	4989	0	0	4888	0
Flt Permitted	0.154			0.209				0.823			0.838	
Satd. Flow (perm)	287	5034	0	389	5065	0	0	4139	0	0	4121	0
Satd. Flow (RTOR)		17			5			19			61	
Volume (vph)	62	800	60	55	1566	40	101	452	45	31	167	56
Lane Group Flow (vph)	67	935	0	60	1745	0	0	650	0	0	277	0
Turn Type	pm+pt			pm+pt			Perm			Perm		
Protected Phases	1	6		5	2			4			4	
Permitted Phases	6			2			4			4		
Total Split (s)	15.0	30.0	0.0	15.0	30.0	0.0	30.0	30.0	0.0	30.0	30.0	0.0
Act Effct Green (s)	46.0	41.7		45.9	41.6			18.6			18.6	
Actuated g/C Ratio	0.61	0.56		0.61	0.55			0.25			0.25	
v/c Ratio	0.22	0.33		0.17	0.62			0.62			0.26	
Control Delay	8.0	11.1		9.3	13.7			26.5			17.1	
Queue Delay	0.0	0.0		0.0	0.0			0.0			0.0	
Total Delay	8.0	11.1		9.3	13.7			26.5			17.1	
LOS	A	B		A	B			C			B	
Approach Delay		10.9			13.5			26.5			17.1	
Approach LOS		B			B			C			B	

Intersection Summary

Cycle Length: 75
Actuated Cycle Length: 75
Offset: 47 (63%), Referenced to phase 2:WBTL and 6:EBTL, Start of Green
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 0.62
Intersection Signal Delay: 15.4 Intersection LOS: B
Intersection Capacity Utilization 65.5% ICU Level of Service C
Analysis Period (min) 15

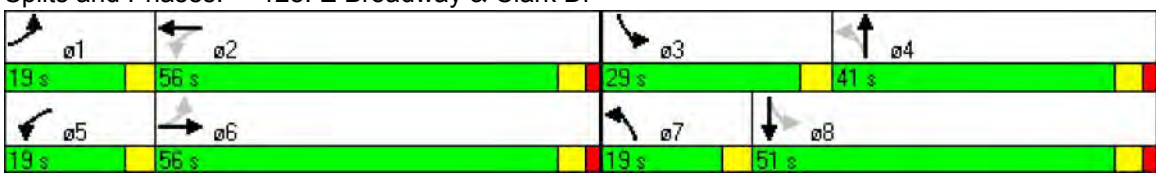
Splits and Phases: 127: E Broadway & Commercial Dr

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	5024	0	1770	4989	0	1770	5024	0	1770	4938	0
Flt Permitted	0.077			0.272			0.297			0.098		
Satd. Flow (perm)	143	5024	0	507	4989	0	553	5024	0	183	4938	0
Satd. Flow (RTOR)		10			20			9			40	
Volume (vph)	138	629	52	155	1335	192	64	1030	88	250	588	139
Lane Group Flow (vph)	150	741	0	168	1660	0	70	1216	0	272	790	0
Turn Type	pm+pt			pm+pt			pm+pt			pm+pt		
Protected Phases	1	6		5	2		7	4		3	8	
Permitted Phases	6			2			4			8		
Total Split (s)	19.0	56.0	0.0	19.0	56.0	0.0	19.0	41.0	0.0	29.0	51.0	0.0
Act Effct Green (s)	64.2	52.2		64.8	52.5		44.8	36.3		60.8	50.5	
Actuated g/C Ratio	0.47	0.38		0.47	0.38		0.32	0.26		0.44	0.37	
v/c Ratio	0.72	0.39		0.48	0.87		0.28	0.91		0.86	0.43	
Control Delay	49.0	32.2		24.8	45.4		26.7	60.1		61.2	32.5	
Queue Delay	0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0	
Total Delay	49.0	32.2		24.8	45.4		26.7	60.1		61.2	32.5	
LOS	D	C		C	D		C	E		E	C	
Approach Delay		35.0			43.5			58.3			39.9	
Approach LOS		D			D			E			D	

Intersection Summary

Cycle Length: 145
Actuated Cycle Length: 137.4
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 0.91
Intersection Signal Delay: 45.0 Intersection LOS: D
Intersection Capacity Utilization 86.8% ICU Level of Service E
Analysis Period (min) 15

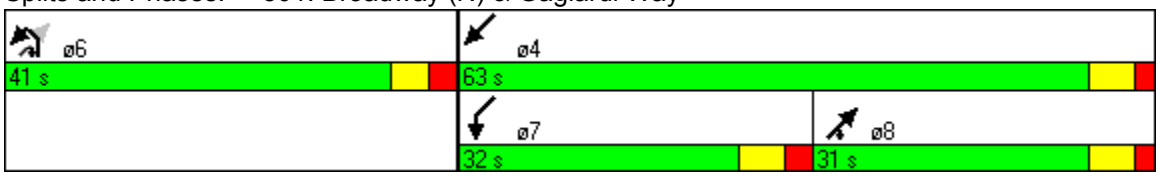
Splits and Phases: 128: E Broadway & Clark Dr



Lane Group	NBL	NBR	NET	NER	SWL	SWT
Lane Configurations						
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0
Lane Util. Factor	0.97	1.00	0.95	0.88	0.97	0.95
Frt		0.850		0.850		
Flt Protected	0.950				0.950	
Satd. Flow (prot)	3433	1583	3539	2787	3433	3539
Flt Permitted	0.950				0.950	
Satd. Flow (perm)	3433	1583	3539	2787	3433	3539
Satd. Flow (RTOR)		489				
Headway Factor	1.00	1.00	1.00	1.00	1.00	1.00
Volume (vph)	1116	450	436	271	158	233
Adj. Flow (vph)	1213	489	474	295	172	253
Lane Group Flow (vph)	1213	489	474	295	172	253
Turn Type		Perm		pt+ov	Prot	
Protected Phases	6		8	8 6	7	4
Permitted Phases		6				
Total Split (s)	41.0	41.0	31.0	72.0	32.0	63.0
Act Effct Green (s)	37.1	37.1	19.1	60.2	12.2	35.4
Actuated g/C Ratio	0.46	0.46	0.24	0.75	0.15	0.44
v/c Ratio	0.77	0.49	0.56	0.14	0.33	0.16
Control Delay	23.6	3.6	29.8	3.2	33.2	13.5
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	23.6	3.6	29.8	3.2	33.2	13.5
LOS	C	A	C	A	C	B
Approach Delay	17.8		19.6			21.5
Approach LOS	B		B			C

Intersection Summary	
Cycle Length: 104	
Actuated Cycle Length: 80.5	
Control Type: Actuated-Uncoordinated	
Maximum v/c Ratio: 0.77	
Intersection Signal Delay: 18.8	Intersection LOS: B
Intersection Capacity Utilization 59.7%	ICU Level of Service B
Analysis Period (min) 15	

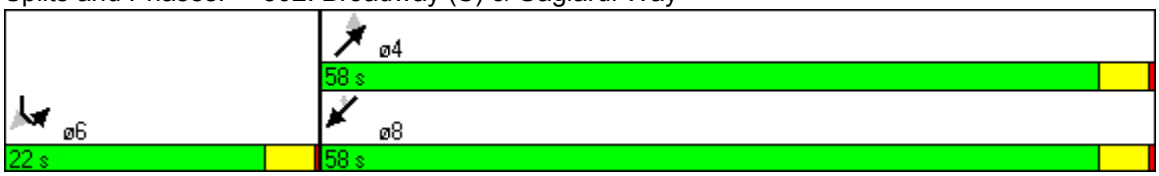
Splits and Phases: 301: Broadway (N) & Gaglardi Way



Lane Group	SBL	SBR	NEL	NET	SWT	SWR
Lane Configurations						
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0
Lane Util. Factor	1.00	1.00	1.00	0.95	0.95	1.00
Frt		0.850				0.850
Flt Protected	0.950		0.950			
Satd. Flow (prot)	1770	1583	1770	3539	3539	1583
Flt Permitted	0.950		0.283			
Satd. Flow (perm)	1770	1583	527	3539	3539	1583
Satd. Flow (RTOR)		68				545
Headway Factor	1.00	1.00	1.00	1.00	1.00	1.00
Volume (vph)	162	63	176	532	834	501
Adj. Flow (vph)	176	68	191	578	907	545
Lane Group Flow (vph)	176	68	191	578	907	545
Turn Type		Perm	Perm			Perm
Protected Phases	6			4	8	
Permitted Phases		6	4			8
Total Split (s)	22.0	22.0	58.0	58.0	58.0	58.0
Act Effct Green (s)	19.1	19.1	25.4	25.4	25.4	25.4
Actuated g/C Ratio	0.36	0.36	0.48	0.48	0.48	0.48
v/c Ratio	0.28	0.11	0.75	0.34	0.54	0.52
Control Delay	18.6	6.9	29.6	8.1	9.8	2.5
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	18.6	6.9	29.6	8.1	9.8	2.5
LOS	B	A	C	A	A	A
Approach Delay	15.3			13.4	7.1	
Approach LOS	B			B	A	

Intersection Summary	
Cycle Length: 80	
Actuated Cycle Length: 53	
Control Type: Actuated-Uncoordinated	
Maximum v/c Ratio: 0.75	
Intersection Signal Delay: 9.9	Intersection LOS: A
Intersection Capacity Utilization 51.8%	ICU Level of Service A
Analysis Period (min) 15	

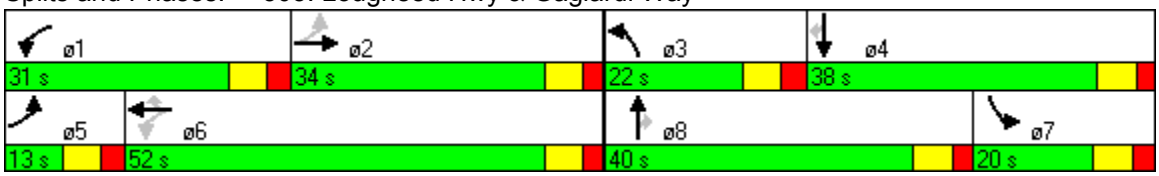
Splits and Phases: 302: Broadway (S) & Gaglardi Way



Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Lane Util. Factor	1.00	0.95	0.95	1.00	0.95	1.00	0.97	0.95	1.00	1.00	0.95	1.00
Frt		0.934				0.850			0.850			0.850
Flt Protected	0.950			0.950			0.950			0.950		
Satd. Flow (prot)	1770	3306	0	1770	3539	1583	3433	3539	1583	1770	3539	1583
Flt Permitted	0.342			0.161			0.950			0.950		
Satd. Flow (perm)	637	3306	0	300	3539	1583	3433	3539	1583	1770	3539	1583
Satd. Flow (RTOR)		149				70			200			162
Headway Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Volume (vph)	78	318	249	318	724	96	437	565	184	68	579	235
Adj. Flow (vph)	85	346	271	346	787	104	475	614	200	74	629	255
Lane Group Flow (vph)	85	617	0	346	787	104	475	614	200	74	629	255
Turn Type	pm+pt			pm+pt		Perm	Prot		Perm	Prot		Perm
Protected Phases	5	2		1	6		3	8		7	4	
Permitted Phases	2			6		6			8			4
Total Split (s)	13.0	34.0	0.0	31.0	52.0	52.0	22.0	40.0	40.0	20.0	38.0	38.0
Act Effct Green (s)	48.2	38.2		65.2	51.3	51.3	18.0	34.0	34.0	16.6	29.8	29.8
Actuated g/C Ratio	0.39	0.31		0.52	0.41	0.41	0.14	0.27	0.27	0.13	0.24	0.24
v/c Ratio	0.25	0.55		0.81	0.54	0.15	0.96	0.64	0.35	0.31	0.75	0.51
Control Delay	20.0	30.8		39.4	30.3	10.3	85.2	44.2	6.4	52.3	49.7	18.1
Queue Delay	0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	20.0	30.8		39.4	30.3	10.3	85.2	44.2	6.4	52.3	49.7	18.1
LOS	C	C		D	C	B	F	D	A	D	D	B
Approach Delay		29.5			31.2			53.4			41.5	
Approach LOS		C			C			D			D	

Intersection Summary	
Cycle Length: 125	
Actuated Cycle Length: 125	
Offset: 32 (26%), Referenced to phase 2:EBTL and 6:WBTL, Start of Green	
Control Type: Actuated-Coordinated	
Maximum v/c Ratio: 0.96	
Intersection Signal Delay: 40.1	Intersection LOS: D
Intersection Capacity Utilization 76.2%	ICU Level of Service D
Analysis Period (min) 15	

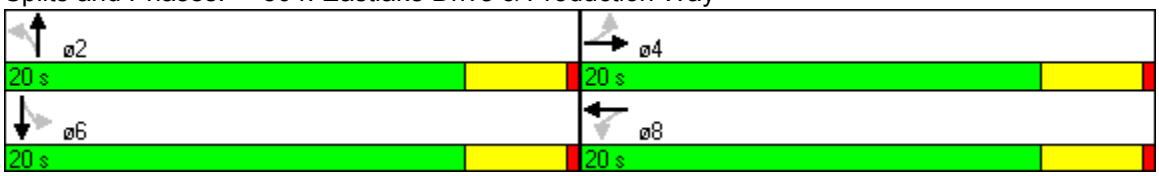
Splits and Phases: 303: Lougheed Hwy & Gaglardi Way



Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Lane Util. Factor	0.95	0.95	0.95	0.95	0.95	0.95	1.00	1.00	1.00	1.00	1.00	1.00
Frt		0.948			0.977			0.977			0.929	
Flt Protected		0.982			0.979		0.950			0.950		
Satd. Flow (prot)	0	3295	0	0	3385	0	1770	1820	0	1770	1730	0
Flt Permitted		0.802			0.783		0.295			0.609		
Satd. Flow (perm)	0	2691	0	0	2707	0	550	1820	0	1134	1730	0
Satd. Flow (RTOR)		62			43			27			135	
Headway Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Volume (vph)	61	48	57	110	111	40	54	188	34	27	255	230
Adj. Flow (vph)	66	52	62	120	121	43	59	204	37	29	277	250
Lane Group Flow (vph)	0	180	0	0	284	0	59	241	0	29	527	0
Turn Type	Perm			Perm			Perm			Perm		
Protected Phases		4			8			2			6	
Permitted Phases	4			8			2			6		
Total Split (s)	20.0	20.0	0.0	20.0	20.0	0.0	20.0	20.0	0.0	20.0	20.0	0.0
Act Effct Green (s)		16.0			16.0		16.0	16.0		16.0	16.0	
Actuated g/C Ratio		0.40			0.40		0.40	0.40		0.40	0.40	
v/c Ratio		0.16			0.26		0.27	0.32		0.06	0.68	
Control Delay		5.8			7.5		12.1	8.8		7.9	13.2	
Queue Delay		0.0			0.0		0.0	0.0		0.0	0.0	
Total Delay		5.8			7.5		12.1	8.8		7.9	13.2	
LOS		A			A		B	A		A	B	
Approach Delay		5.8			7.5			9.4			12.9	
Approach LOS		A			A			A			B	

Intersection Summary	
Cycle Length: 40	
Actuated Cycle Length: 40	
Offset: 0 (0%), Referenced to phase 2:NBTL and 6:SBTL, Start of Green	
Control Type: Pretimed	
Maximum v/c Ratio: 0.68	
Intersection Signal Delay: 10.0	Intersection LOS: A
Intersection Capacity Utilization 56.6%	ICU Level of Service B
Analysis Period (min) 15	

Splits and Phases: 304: Eastlake Drive & Production Way



Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Lane Util. Factor	1.00	0.95	1.00	1.00	0.95	1.00	1.00	1.00	1.00	1.00	0.95	0.95
Frt			0.850			0.850			0.850		0.908	
Flt Protected	0.950			0.950			0.950			0.950		
Satd. Flow (prot)	1770	3539	1583	1770	3539	1583	1770	1863	1583	1770	3214	0
Flt Permitted	0.950			0.950			0.434			0.590		
Satd. Flow (perm)	1770	3539	1583	1770	3539	1583	808	1863	1583	1099	3214	0
Satd. Flow (RTOR)			78			382			64		165	
Headway Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Volume (vph)	98	442	72	114	961	351	65	101	59	105	97	152
Adj. Flow (vph)	107	480	78	124	1045	382	71	110	64	114	105	165
Lane Group Flow (vph)	107	480	78	124	1045	382	71	110	64	114	270	0
Turn Type	Prot		Perm	Prot		Perm	pm+pt		Perm	pm+pt		
Protected Phases	5	2		1	6		3	8		7	4	
Permitted Phases			2			6	8		8	4		
Total Split (s)	21.0	52.0	52.0	26.0	57.0	57.0	16.0	21.0	21.0	16.0	21.0	0.0
Act Effct Green (s)	13.4	40.0	40.0	14.4	41.0	41.0	21.5	13.7	13.7	22.5	14.2	
Actuated g/C Ratio	0.15	0.45	0.45	0.16	0.47	0.47	0.24	0.16	0.16	0.25	0.16	
v/c Ratio	0.41	0.30	0.10	0.44	0.63	0.41	0.23	0.38	0.21	0.32	0.41	
Control Delay	45.0	19.1	4.9	43.5	23.0	3.3	28.8	44.3	12.6	29.6	18.5	
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
Total Delay	45.0	19.1	4.9	43.5	23.0	3.3	28.8	44.3	12.6	29.6	18.5	
LOS	D	B	A	D	C	A	C	D	B	C	B	
Approach Delay		21.6			19.8			31.5			21.8	
Approach LOS		C			B			C			C	

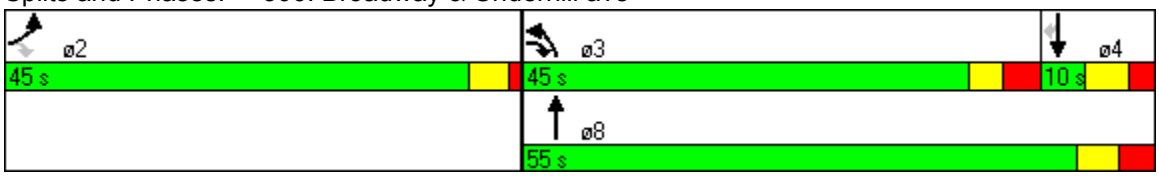
Intersection Summary	
Cycle Length: 115	
Actuated Cycle Length: 88.1	
Control Type: Actuated-Uncoordinated	
Maximum v/c Ratio: 0.63	
Intersection Signal Delay: 21.5	Intersection LOS: C
Intersection Capacity Utilization 59.1%	ICU Level of Service B
Analysis Period (min) 15	

Splits and Phases: 305: Lougheed Hwy & Production Way

Lane Group	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0
Lane Util. Factor	1.00	1.00	1.00	1.00	1.00	1.00
Frt		0.850				0.850
Flt Protected	0.950		0.950			
Satd. Flow (prot)	1770	1583	1770	1863	1863	1583
Flt Permitted	0.950		0.950			
Satd. Flow (perm)	1770	1583	1770	1863	1863	1583
Satd. Flow (RTOR)		114				51
Headway Factor	1.00	1.00	1.00	1.00	1.00	1.00
Volume (vph)	57	105	235	54	81	47
Adj. Flow (vph)	62	114	255	59	88	51
Lane Group Flow (vph)	62	114	255	59	88	51
Turn Type		pm+ov	Prot			Perm
Protected Phases	2	3	3	8	4	
Permitted Phases		2				4
Total Split (s)	45.0	45.0	45.0	55.0	10.0	10.0
Act Effct Green (s)	15.3	29.5	13.9	22.8	6.1	6.1
Actuated g/C Ratio	0.37	0.66	0.31	0.51	0.14	0.14
v/c Ratio	0.10	0.10	0.46	0.06	0.34	0.19
Control Delay	14.8	0.9	12.8	3.6	20.8	8.9
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	14.8	0.9	12.8	3.6	20.8	8.9
LOS	B	A	B	A	C	A
Approach Delay	5.8			11.1	16.4	
Approach LOS	A			B	B	

Intersection Summary	
Cycle Length: 100	
Actuated Cycle Length: 41.8	
Control Type: Actuated-Uncoordinated	
Maximum v/c Ratio: 0.46	
Intersection Signal Delay: 10.8	Intersection LOS: B
Intersection Capacity Utilization 32.2%	ICU Level of Service A
Analysis Period (min) 15	

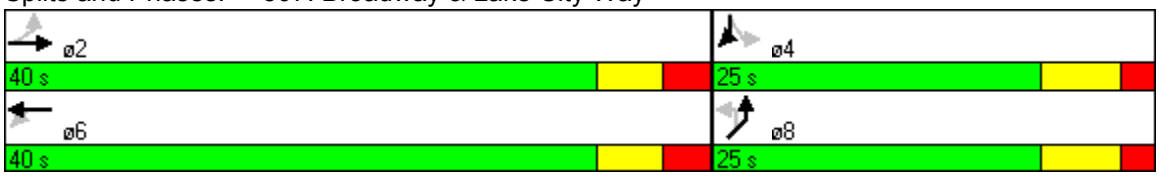
Splits and Phases: 306: Broadway & Underhill ave



Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	SBL	SBR	SBR2	NEL2	NEL	NER
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Lane Util. Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Frt		0.935			0.982			0.850			0.952	
Flt Protected		0.998			0.992		0.950			0.950	0.967	
Satd. Flow (prot)	0	1738	0	0	1815	0	1770	1583	0	1770	1715	0
Flt Permitted		0.984			0.938		0.690			0.660	0.967	
Satd. Flow (perm)	0	1714	0	0	1716	0	1285	1583	0	1229	1715	0
Satd. Flow (RTOR)		70			19			18			33	
Headway Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Volume (vph)	6	63	64	48	210	40	66	114	25	40	65	30
Adj. Flow (vph)	7	68	70	52	228	43	72	124	27	43	71	33
Lane Group Flow (vph)	0	145	0	0	323	0	72	151	0	43	104	0
Turn Type	Perm			Perm			Perm			Perm		
Protected Phases		2			6			4			8	
Permitted Phases	2			6			4			8		
Total Split (s)	40.0	40.0	0.0	40.0	40.0	0.0	25.0	25.0	0.0	25.0	25.0	0.0
Act Effct Green (s)		14.9			14.9		11.3	11.3		11.3	11.3	
Actuated g/C Ratio		0.41			0.41		0.31	0.31		0.31	0.31	
v/c Ratio		0.20			0.45		0.18	0.29		0.11	0.18	
Control Delay		4.5			8.8		10.1	10.0		9.6	7.6	
Queue Delay		0.0			0.0		0.0	0.0		0.0	0.0	
Total Delay		4.5			8.8		10.1	10.0		9.6	7.6	
LOS		A			A		B	A		A	A	
Approach Delay		4.5			8.8		10.0				8.1	
Approach LOS		A			A		B				A	

Intersection Summary	
Cycle Length: 65	
Actuated Cycle Length: 33.2	
Control Type: Actuated-Uncoordinated	
Maximum v/c Ratio: 0.45	
Intersection Signal Delay: 8.3	Intersection LOS: A
Intersection Capacity Utilization 49.5%	ICU Level of Service A
Analysis Period (min) 15	

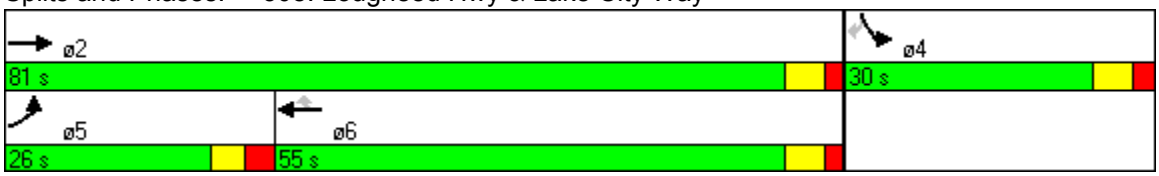
Splits and Phases: 307: Broadway & Lake City Way



Lane Group	EBL	EBT	WBT	WBR	SBL	SBR
Lane Configurations						
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0
Lane Util. Factor	1.00	0.95	0.95	1.00	1.00	1.00
Frt				0.850		0.850
Flt Protected	0.950				0.950	
Satd. Flow (prot)	1770	3539	3539	1583	1770	1583
Flt Permitted	0.950				0.950	
Satd. Flow (perm)	1770	3539	3539	1583	1770	1583
Satd. Flow (RTOR)				129		135
Headway Factor	1.00	1.00	1.00	1.00	1.00	1.00
Volume (vph)	136	530	1141	142	141	124
Adj. Flow (vph)	148	576	1240	154	153	135
Lane Group Flow (vph)	148	576	1240	154	153	135
Turn Type	Prot			Perm		Perm
Protected Phases	5	2	6		4	
Permitted Phases				6		4
Total Split (s)	26.0	81.0	55.0	55.0	30.0	30.0
Act Effct Green (s)	14.3	61.4	46.4	46.4	14.5	14.5
Actuated g/C Ratio	0.17	0.77	0.58	0.58	0.18	0.18
v/c Ratio	0.48	0.21	0.60	0.16	0.49	0.35
Control Delay	37.0	4.0	17.4	4.3	36.9	9.1
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	37.0	4.0	17.4	4.3	36.9	9.1
LOS	D	A	B	A	D	A
Approach Delay		10.7	16.0		23.8	
Approach LOS		B	B		C	

Intersection Summary	
Cycle Length: 111	
Actuated Cycle Length: 79.7	
Control Type: Actuated-Uncoordinated	
Maximum v/c Ratio: 0.60	
Intersection Signal Delay: 15.4	Intersection LOS: B
Intersection Capacity Utilization 56.9%	ICU Level of Service B
Analysis Period (min) 15	

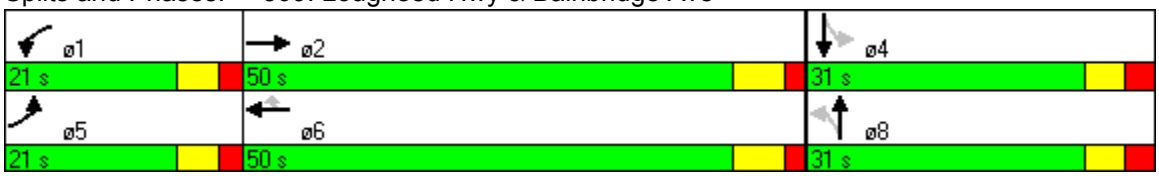
Splits and Phases: 308: Lougheed Hwy & Lake City Way



Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Lane Util. Factor	1.00	0.95	0.95	1.00	0.95	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Frt		0.995				0.850		0.972			0.933	
Flt Protected	0.950			0.950				0.977			0.981	
Satd. Flow (prot)	1770	3522	0	1770	3539	1583	0	1769	0	0	1705	0
Flt Permitted	0.950			0.950				0.809			0.863	
Satd. Flow (perm)	1770	3522	0	1770	3539	1583	0	1465	0	0	1500	0
Satd. Flow (RTOR)		5				45		13			48	
Headway Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Volume (vph)	46	531	19	19	1182	92	33	22	15	76	24	99
Adj. Flow (vph)	50	577	21	21	1285	100	36	24	16	83	26	108
Lane Group Flow (vph)	50	598	0	21	1285	100	0	76	0	0	217	0
Turn Type	Prot			Prot		Perm	Perm			Perm		
Protected Phases	5	2		1	6			8			4	
Permitted Phases						6	8			4		
Total Split (s)	21.0	50.0	0.0	21.0	50.0	50.0	31.0	31.0	0.0	31.0	31.0	0.0
Act Effct Green (s)	10.3	42.2		9.5	39.0	39.0		16.3			16.3	
Actuated g/C Ratio	0.13	0.59		0.12	0.54	0.54		0.23			0.23	
v/c Ratio	0.21	0.29		0.10	0.67	0.11		0.22			0.57	
Control Delay	36.5	9.5		39.1	16.4	7.8		24.0			27.3	
Queue Delay	0.0	0.0		0.0	0.0	0.0		0.0			0.0	
Total Delay	36.5	9.5		39.1	16.4	7.8		24.0			27.3	
LOS	D	A		D	B	A		C			C	
Approach Delay		11.5			16.1			24.0			27.3	
Approach LOS		B			B			C			C	

Intersection Summary	
Cycle Length: 102	
Actuated Cycle Length: 71.6	
Control Type: Actuated-Uncoordinated	
Maximum v/c Ratio: 0.67	
Intersection Signal Delay: 16.1	Intersection LOS: B
Intersection Capacity Utilization 58.5%	ICU Level of Service B
Analysis Period (min) 15	

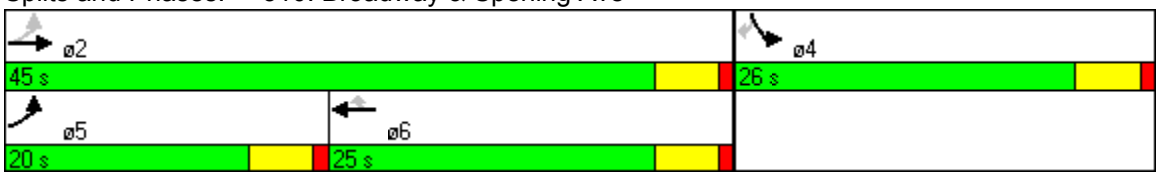
Splits and Phases: 309: Lougheed Hwy & Bainbridge Ave



Lane Group	EBL	EBT	WBT	WBR	SBL	SBR
Lane Configurations						
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0
Lane Util. Factor	1.00	1.00	1.00	1.00	1.00	1.00
Frt				0.850		0.850
Flt Protected	0.950				0.950	
Satd. Flow (prot)	1770	1863	1863	1583	1770	1583
Flt Permitted	0.160				0.950	
Satd. Flow (perm)	298	1863	1863	1583	1770	1583
Satd. Flow (RTOR)				24		334
Headway Factor	1.00	1.00	1.00	1.00	1.00	1.00
Volume (vph)	101	154	465	32	32	307
Adj. Flow (vph)	110	167	505	35	35	334
Lane Group Flow (vph)	110	167	505	35	35	334
Turn Type	pm+pt			Perm		Perm
Protected Phases	5	2	6		4	
Permitted Phases	2			6		4
Total Split (s)	20.0	45.0	25.0	25.0	26.0	26.0
Act Effct Green (s)	32.1	32.1	21.3	21.3	9.8	9.8
Actuated g/C Ratio	0.61	0.64	0.43	0.43	0.20	0.20
v/c Ratio	0.24	0.14	0.64	0.05	0.10	0.58
Control Delay	5.1	4.2	19.6	7.5	18.8	7.3
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	5.1	4.2	19.6	7.5	18.8	7.3
LOS	A	A	B	A	B	A
Approach Delay		4.5	18.8		8.4	
Approach LOS		A	B		A	

Intersection Summary	
Cycle Length: 71	
Actuated Cycle Length: 50.1	
Control Type: Actuated-Uncoordinated	
Maximum v/c Ratio: 0.64	
Intersection Signal Delay: 12.2	Intersection LOS: B
Intersection Capacity Utilization 50.1%	ICU Level of Service A
Analysis Period (min) 15	

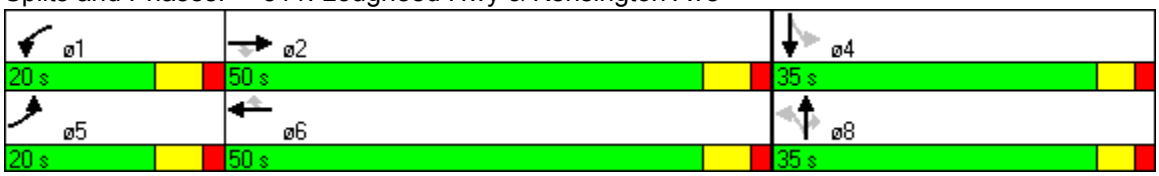
Splits and Phases: 310: Broadway & Sperling Ave



Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Lane Util. Factor	1.00	0.91	1.00	1.00	0.95	1.00	1.00	1.00	1.00	1.00	0.95	0.95
Frt			0.850			0.850			0.850		0.906	
Flt Protected	0.950			0.950			0.950			0.950		
Satd. Flow (prot)	1770	5085	1583	1770	3539	1583	1770	1863	1583	1770	3207	0
Flt Permitted	0.950			0.950			0.699			0.324		
Satd. Flow (perm)	1770	5085	1583	1770	3539	1583	1302	1863	1583	604	3207	0
Satd. Flow (RTOR)			152			167			20		53	
Headway Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Volume (vph)	9	613	140	11	938	285	293	309	18	16	29	49
Adj. Flow (vph)	10	666	152	12	1020	310	318	336	20	17	32	53
Lane Group Flow (vph)	10	666	152	12	1020	310	318	336	20	17	85	0
Turn Type	Prot		Perm	Prot		Perm	Perm		Perm	Perm		
Protected Phases	5	2		1	6			8			4	
Permitted Phases			2			6	8		8	4		
Total Split (s)	20.0	50.0	50.0	20.0	50.0	50.0	35.0	35.0	35.0	35.0	35.0	0.0
Act Effct Green (s)	10.0	27.9	27.9	10.1	27.9	27.9	22.1	22.1	22.1	22.1	22.1	
Actuated g/C Ratio	0.14	0.46	0.46	0.14	0.46	0.46	0.36	0.36	0.36	0.36	0.36	
v/c Ratio	0.04	0.29	0.19	0.05	0.63	0.38	0.68	0.50	0.03	0.08	0.07	
Control Delay	36.8	11.5	3.3	36.7	15.5	7.5	28.4	21.0	9.4	19.4	9.2	
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
Total Delay	36.8	11.5	3.3	36.7	15.5	7.5	28.4	21.0	9.4	19.4	9.2	
LOS	D	B	A	D	B	A	C	C	A	B	A	
Approach Delay		10.3			13.9			24.2			10.9	
Approach LOS		B			B			C			B	

Intersection Summary	
Cycle Length: 105	
Actuated Cycle Length: 60.9	
Control Type: Actuated-Uncoordinated	
Maximum v/c Ratio: 0.68	
Intersection Signal Delay: 15.1	Intersection LOS: B
Intersection Capacity Utilization 55.5%	ICU Level of Service B
Analysis Period (min) 15	

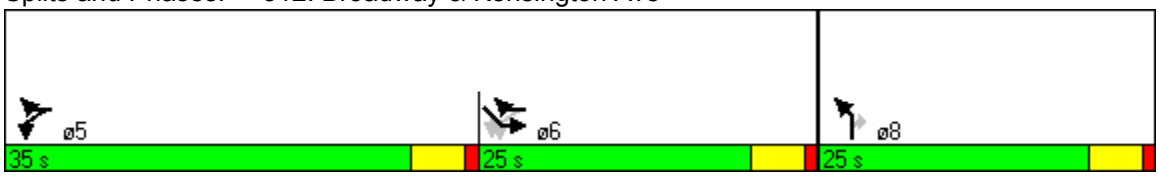
Splits and Phases: 311: Lougheed Hwy & Kensington Ave



Lane Group	WBL	WBR	NBL	NBR	SEL	SER
Lane Configurations						
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0
Lane Util. Factor	1.00	1.00	1.00	1.00	1.00	1.00
Frt		0.850		0.850		0.850
Flt Protected	0.950		0.950		0.950	
Satd. Flow (prot)	1770	1583	1770	1583	1770	1583
Flt Permitted	0.711		0.950		0.950	
Satd. Flow (perm)	1324	1583	1770	1583	1770	1583
Satd. Flow (RTOR)		214		228		212
Headway Factor	1.00	1.00	1.00	1.00	1.00	1.00
Volume (vph)	522	197	200	210	65	195
Adj. Flow (vph)	567	214	217	228	71	212
Lane Group Flow (vph)	567	214	217	228	71	212
Turn Type	pm+pt			Perm		Perm
Protected Phases	5	5 6	8		6	
Permitted Phases	5 6			8		6
Total Split (s)	35.0	60.0	25.0	25.0	25.0	25.0
Act Effct Green (s)	27.9	32.2	12.8	12.8	10.0	10.0
Actuated g/C Ratio	0.52	0.60	0.24	0.24	0.19	0.19
v/c Ratio	0.68	0.21	0.51	0.41	0.21	0.45
Control Delay	11.5	1.5	24.4	6.1	24.6	8.1
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	11.6	1.5	24.4	6.1	24.6	8.1
LOS	B	A	C	A	C	A
Approach Delay	8.8		15.1		12.2	
Approach LOS	A		B		B	

Intersection Summary	
Cycle Length: 85	
Actuated Cycle Length: 53.6	
Control Type: Actuated-Uncoordinated	
Maximum v/c Ratio: 0.68	
Intersection Signal Delay: 11.3	Intersection LOS: B
Intersection Capacity Utilization 55.8%	ICU Level of Service B
Analysis Period (min) 15	

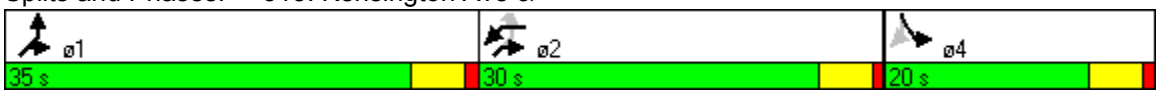
Splits and Phases: 312: Broadway & Kensington Ave



Lane Group	WBL	WBR	SBL	SBR	NEL	NER
Lane Configurations						
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0
Lane Util. Factor	0.97	1.00	1.00	1.00	1.00	0.95
Frt		0.850		0.850		0.850
Flt Protected	0.950		0.950		0.950	
Satd. Flow (prot)	3433	1583	1770	1583	1770	1504
Flt Permitted	0.950		0.950			
Satd. Flow (perm)	3433	1583	1770	1583	1863	1504
Satd. Flow (RTOR)		104		630		32
Headway Factor	1.00	1.00	1.00	1.00	1.00	1.00
Volume (vph)	560	96	50	628	277	29
Adj. Flow (vph)	609	104	54	683	301	32
Lane Group Flow (vph)	609	104	54	683	301	32
Turn Type		Perm		Perm	pm+pt	
Protected Phases	2		4		1	1 2
Permitted Phases		2		4	1 2	
Total Split (s)	30.0	30.0	20.0	20.0	35.0	65.0
Act Effct Green (s)	15.9	15.9	11.9	11.9	30.9	30.9
Actuated g/C Ratio	0.31	0.31	0.23	0.23	0.60	0.60
v/c Ratio	0.57	0.18	0.13	0.80	0.27	0.03
Control Delay	17.5	4.6	18.7	12.0	5.7	2.0
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	17.5	4.6	18.7	12.0	5.7	2.0
LOS	B	A	B	B	A	A
Approach Delay	15.6		12.5		5.4	
Approach LOS	B		B		A	

Intersection Summary	
Cycle Length: 85	
Actuated Cycle Length: 51.2	
Control Type: Actuated-Uncoordinated	
Maximum v/c Ratio: 0.80	
Intersection Signal Delay: 12.4	Intersection LOS: B
Intersection Capacity Utilization 47.7%	ICU Level of Service A
Analysis Period (min) 15	

Splits and Phases: 313: Kensington Ave &

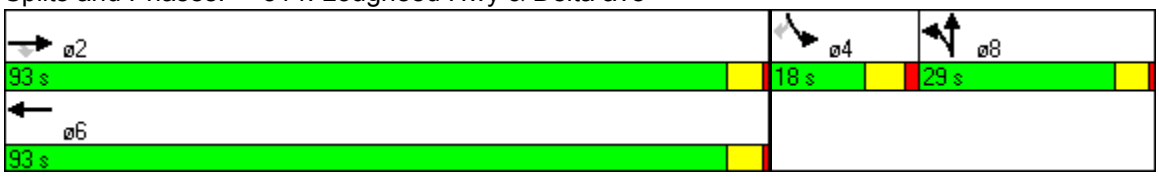


Lanes, Volumes, Timings
314: Lougheed Hwy & Delta ave 2014-09-29

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Lane Util. Factor	1.00	0.95	1.00	1.00	0.95	0.95	0.95	0.95	1.00	1.00	1.00	1.00
Frt			0.850		0.998							0.850
Flt Protected							0.950	0.962		0.950		
Satd. Flow (prot)	0	3539	1583	0	3532	0	1681	1702	0	1770	0	1583
Flt Permitted							0.950	0.962		0.950		
Satd. Flow (perm)	0	3539	1583	0	3532	0	1681	1702	0	1770	0	1583
Satd. Flow (RTOR)			267		2							11
Headway Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Volume (vph)	0	632	246	0	1817	24	315	39	0	65	0	10
Adj. Flow (vph)	0	687	267	0	1975	26	342	42	0	71	0	11
Lane Group Flow (vph)	0	687	267	0	2001	0	187	197	0	71	0	11
Turn Type			Perm				Split			Prot		custom
Protected Phases		2			6		8	8		4		
Permitted Phases			2									4
Total Split (s)	0.0	93.0	93.0	0.0	93.0	0.0	29.0	29.0	0.0	18.0	0.0	18.0
Act Effct Green (s)		97.0	97.0		97.0		21.2	21.2		12.6		12.6
Actuated g/C Ratio		0.69	0.69		0.69		0.15	0.15		0.09		0.09
v/c Ratio		0.28	0.23		0.82		0.74	0.77		0.45		0.07
Control Delay		9.7	1.6		21.0		73.6	76.0		69.1		27.8
Queue Delay		0.0	0.0		0.0		0.0	0.0		0.0		0.0
Total Delay		9.7	1.6		21.0		73.6	76.0		69.1		27.8
LOS		A	A		C		E	E		E		C
Approach Delay		7.4			21.0			74.8				
Approach LOS		A			C			E				

Intersection Summary	
Cycle Length: 140	
Actuated Cycle Length: 140	
Offset: 36 (26%), Referenced to phase 2:EBT and 6:WBT, Start of Green	
Control Type: Actuated-Coordinated	
Maximum v/c Ratio: 0.82	
Intersection Signal Delay: 24.3	Intersection LOS: C
Intersection Capacity Utilization 76.6%	ICU Level of Service D
Analysis Period (min) 15	

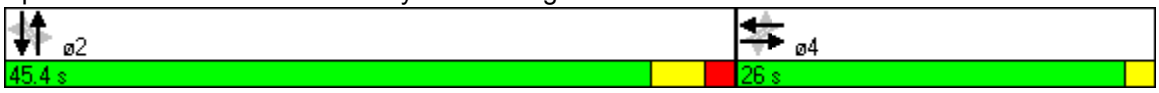
Splits and Phases: 314: Lougheed Hwy & Delta ave



Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Lane Util. Factor	1.00	1.00	1.00	1.00	1.00	1.00	0.95	0.95	0.95	0.95	0.95	0.95
Frt		0.910			0.958			0.992			0.997	
Flt Protected		0.997			0.982			0.996			0.999	
Satd. Flow (prot)	0	1690	0	0	1752	0	0	3497	0	0	3525	0
Flt Permitted		0.995			0.927			0.858			0.946	
Satd. Flow (perm)	0	1687	0	0	1654	0	0	3012	0	0	3338	0
Satd. Flow (RTOR)		26			21			13			4	
Headway Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Volume (vph)	2	10	24	22	20	19	31	368	21	14	805	15
Adj. Flow (vph)	2	11	26	24	22	21	34	400	23	15	875	16
Lane Group Flow (vph)	0	39	0	0	67	0	0	457	0	0	906	0
Turn Type	Perm			Perm			Perm			Perm		
Protected Phases		4			4			2			2	
Permitted Phases	4			4			2			2		
Total Split (s)	26.0	26.0	0.0	26.0	26.0	0.0	45.4	45.4	0.0	45.4	45.4	0.0
Act Effct Green (s)		22.0			22.0			41.4			41.4	
Actuated g/C Ratio		0.31			0.31			0.58			0.58	
v/c Ratio		0.07			0.13			0.26			0.47	
Control Delay		10.1			14.1			7.7			9.6	
Queue Delay		0.0			0.0			0.0			0.0	
Total Delay		10.1			14.1			7.7			9.6	
LOS		B			B			A			A	
Approach Delay		10.1			14.1			7.7			9.6	
Approach LOS		B			B			A			A	

Intersection Summary	
Cycle Length: 71.4	
Actuated Cycle Length: 71.4	
Control Type: Actuated-Uncoordinated	
Maximum v/c Ratio: 0.47	
Intersection Signal Delay: 9.2	Intersection LOS: A
Intersection Capacity Utilization 51.4%	ICU Level of Service A
Analysis Period (min) 15	

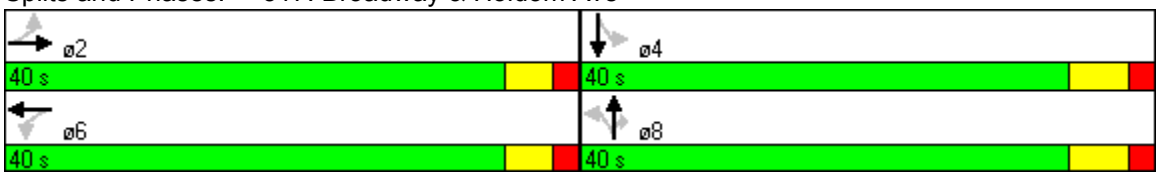
Splits and Phases: 316: Gravely St & Willingdon ave



Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Lane Util. Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Frt		0.934			0.961				0.850		0.986	
Flt Protected		0.993		0.950				0.997			0.996	
Satd. Flow (prot)	0	1728	0	1770	1790	0	0	1857	1583	0	1829	0
Flt Permitted		0.950		0.672				0.976			0.974	
Satd. Flow (perm)	0	1653	0	1252	1790	0	0	1818	1583	0	1789	0
Satd. Flow (RTOR)		73			29				58		10	
Headway Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Volume (vph)	20	50	67	146	126	44	6	105	53	29	327	42
Adj. Flow (vph)	22	54	73	159	137	48	7	114	58	32	355	46
Lane Group Flow (vph)	0	149	0	159	185	0	0	121	58	0	433	0
Turn Type	Perm			Perm			Perm		Perm	Perm		
Protected Phases		2			6			8			4	
Permitted Phases	2			6			8		8	4		
Total Split (s)	40.0	40.0	0.0	40.0	40.0	0.0	40.0	40.0	40.0	40.0	40.0	0.0
Act Effct Green (s)		14.8		14.8	14.8			28.8	28.8		28.8	
Actuated g/C Ratio		0.28		0.28	0.28			0.57	0.57		0.57	
v/c Ratio		0.29		0.46	0.36			0.12	0.06		0.43	
Control Delay		7.4		15.3	10.8			6.5	2.7		8.5	
Queue Delay		0.1		0.1	0.0			0.0	0.0		0.1	
Total Delay		7.5		15.4	10.8			6.5	2.7		8.6	
LOS		A		B	B			A	A		A	
Approach Delay		7.5			13.0			5.3			8.6	
Approach LOS		A			B			A			A	

Intersection Summary	
Cycle Length: 80	
Actuated Cycle Length: 50.9	
Control Type: Actuated-Uncoordinated	
Maximum v/c Ratio: 0.46	
Intersection Signal Delay: 9.3	Intersection LOS: A
Intersection Capacity Utilization 55.2%	ICU Level of Service B
Analysis Period (min) 15	

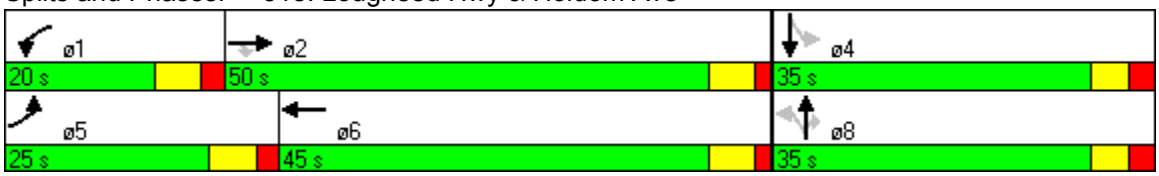
Splits and Phases: 317: Broadway & Holdom Ave



Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Lane Util. Factor	1.00	0.95	1.00	1.00	0.95	0.95	0.95	0.95	1.00	0.95	0.95	0.95
Frt			0.850		0.996				0.850		0.958	
Flt Protected	0.950			0.950				0.983			0.991	
Satd. Flow (prot)	1770	3539	1583	1770	3525	0	0	3479	1583	0	3360	0
Flt Permitted	0.950			0.950				0.646			0.846	
Satd. Flow (perm)	1770	3539	1583	1770	3525	0	0	2286	1583	0	2868	0
Satd. Flow (RTOR)			71		3				110		55	
Headway Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Volume (vph)	47	575	65	213	1121	30	48	93	101	108	303	159
Adj. Flow (vph)	51	625	71	232	1218	33	52	101	110	117	329	173
Lane Group Flow (vph)	51	625	71	232	1251	0	0	153	110	0	619	0
Turn Type	Prot		Perm	Prot			Perm		Perm	Perm		
Protected Phases	5	2		1	6			8			4	
Permitted Phases			2				8		8	4		
Total Split (s)	25.0	50.0	50.0	20.0	45.0	0.0	35.0	35.0	35.0	35.0	35.0	0.0
Act Effct Green (s)	11.0	26.3	26.3	15.5	38.3			22.4	22.4		22.4	
Actuated g/C Ratio	0.13	0.34	0.34	0.20	0.50			0.29	0.29		0.29	
v/c Ratio	0.22	0.52	0.12	0.65	0.72			0.23	0.20		0.71	
Control Delay	38.7	21.9	5.4	44.0	21.4			24.1	6.2		28.6	
Queue Delay	0.0	0.0	0.0	0.0	0.0			0.0	0.0		1.4	
Total Delay	38.7	21.9	5.4	44.0	21.4			24.1	6.2		30.0	
LOS	D	C	A	D	C			C	A		C	
Approach Delay		21.5			24.9			16.6			30.0	
Approach LOS		C			C			B			C	

Intersection Summary	
Cycle Length: 105	
Actuated Cycle Length: 77.3	
Control Type: Actuated-Uncoordinated	
Maximum v/c Ratio: 0.72	
Intersection Signal Delay: 24.4	Intersection LOS: C
Intersection Capacity Utilization 73.5%	ICU Level of Service D
Analysis Period (min) 15	

Splits and Phases: 318: Lougheed Hwy & Holdom Ave



Lane Group	WBL	WBR	NBR	NBR2	SWL2	SWL
Lane Configurations						
Lane Util. Factor	1.00	1.00	1.00	1.00	1.00	1.00
Frt		0.850	0.850	0.850		
Flt Protected	0.950				0.950	0.950
Satd. Flow (prot)	1770	1583	1583	1583	1770	1770
Flt Permitted	0.950				0.950	0.950
Satd. Flow (perm)	1770	1583	1583	1583	1770	1770
Headway Factor	1.00	1.00	1.00	1.00	1.00	1.00
Volume (vph)	632	34	25	125	90	72
Adj. Flow (vph)	687	37	27	136	98	78
Lane Group Flow (vph)	687	37	27	136	98	78
Sign Control	Free		Free			Stop

Intersection Summary	
Control Type: Unsignalized	
Intersection Capacity Utilization 46.7%	ICU Level of Service A
Analysis Period (min) 15	

Lane Group	EBL	EBT	WBT	WBR	SBL	SBR
Lane Configurations						
Lane Util. Factor	1.00	0.95	0.95	1.00	1.00	1.00
Frt				0.850		0.850
Flt Protected	0.950				0.950	
Satd. Flow (prot)	1770	3539	3539	1583	1770	1583
Flt Permitted	0.950				0.950	
Satd. Flow (perm)	1770	3539	3539	1583	1770	1583
Headway Factor	1.00	1.00	1.00	1.00	1.00	1.00
Volume (vph)	94	562	1094	207	78	93
Adj. Flow (vph)	102	611	1189	225	85	101
Lane Group Flow (vph)	102	611	1189	225	85	101
Sign Control		Free	Free		Stop	

Intersection Summary	
Control Type: Unsignalized	
Intersection Capacity Utilization 49.8%	ICU Level of Service A
Analysis Period (min) 15	

Lane Group	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Lane Util. Factor	1.00	1.00	1.00	1.00	1.00	1.00
Frt	0.916		0.956			
Flt Protected	0.981					0.973
Satd. Flow (prot)	1674	0	1781	0	0	1812
Flt Permitted	0.981					0.973
Satd. Flow (perm)	1674	0	1781	0	0	1812
Headway Factor	1.00	1.00	1.00	1.00	1.00	1.00
Volume (vph)	135	222	88	42	90	71
Adj. Flow (vph)	147	241	96	46	98	77
Lane Group Flow (vph)	388	0	142	0	0	175
Sign Control	Stop		Free			Free

Intersection Summary	
Control Type: Unsignalized	
Intersection Capacity Utilization 47.0%	ICU Level of Service A
Analysis Period (min) 15	

Lane Group	EBL	EBT	WBT	WBR	SBL	SBR
Lane Configurations						
Lane Util. Factor	1.00	1.00	1.00	1.00	1.00	1.00
Frt			0.986		0.889	
Flt Protected		0.973			0.991	
Satd. Flow (prot)	0	1812	1837	0	1641	0
Flt Permitted		0.973			0.991	
Satd. Flow (perm)	0	1812	1837	0	1641	0
Headway Factor	1.00	1.00	1.00	1.00	1.00	1.00
Volume (vph)	115	89	268	31	47	220
Adj. Flow (vph)	125	97	291	34	51	239
Lane Group Flow (vph)	0	222	325	0	290	0
Sign Control		Stop	Stop		Stop	

Intersection Summary			
Control Type: Unsignalized			
Intersection Capacity Utilization	53.2%	ICU Level of Service	A
Analysis Period (min)	15		

Lane Group	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Lane Util. Factor	1.00	1.00	1.00	1.00	1.00	1.00
Frt	0.953				0.908	
Flt Protected				0.986	0.984	
Satd. Flow (prot)	1775	0	0	1837	1664	0
Flt Permitted				0.986	0.984	
Satd. Flow (perm)	1775	0	0	1837	1664	0
Headway Factor	1.00	1.00	1.00	1.00	1.00	1.00
Volume (vph)	122	64	142	374	36	77
Adj. Flow (vph)	133	70	154	407	39	84
Lane Group Flow (vph)	203	0	0	561	123	0
Sign Control	Free			Free	Stop	

Intersection Summary	
Control Type: Unsignalized	
Intersection Capacity Utilization 54.6%	ICU Level of Service A
Analysis Period (min) 15	

Lane Group	EBL	EBR	SBL	SBR	NWL	NWR
Lane Configurations						
Lane Util. Factor	1.00	1.00	1.00	1.00	1.00	1.00
Frt	0.887		0.966			0.850
Flt Protected	0.992		0.964		0.950	
Satd. Flow (prot)	1639	0	1735	0	1770	1583
Flt Permitted	0.992		0.964		0.950	
Satd. Flow (perm)	1639	0	1735	0	1770	1583
Headway Factor	1.00	1.00	1.00	1.00	1.00	1.00
Volume (vph)	23	117	158	53	259	105
Adj. Flow (vph)	25	127	172	58	282	114
Lane Group Flow (vph)	152	0	230	0	282	114
Sign Control	Stop		Stop		Stop	

Intersection Summary	
Control Type: Unsignalized	
Intersection Capacity Utilization 44.8%	ICU Level of Service A
Analysis Period (min) 15	

Lane Group	NBL	NBT	SBT	SBR	SEL	SER
Lane Configurations						
Lane Util. Factor	1.00	1.00	1.00	1.00	1.00	1.00
Frt			0.972		0.928	
Flt Protected		0.977			0.977	
Satd. Flow (prot)	0	1820	1811	0	1689	0
Flt Permitted		0.977			0.977	
Satd. Flow (perm)	0	1820	1811	0	1689	0
Headway Factor	1.00	1.00	1.00	1.00	1.00	1.00
Volume (vph)	33	38	168	44	90	102
Adj. Flow (vph)	36	41	183	48	98	111
Lane Group Flow (vph)	0	77	231	0	209	0
Sign Control		Free	Stop		Free	

Intersection Summary	
Control Type: Unsignalized	
Intersection Capacity Utilization 36.6%	ICU Level of Service A
Analysis Period (min) 15	

Lane Group	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Lane Util. Factor	1.00	1.00	1.00	1.00	1.00	1.00
Frt	0.955				0.992	
Flt Protected	0.968			0.999		
Satd. Flow (prot)	1722	0	0	1861	1848	0
Flt Permitted	0.968			0.999		
Satd. Flow (perm)	1722	0	0	1861	1848	0
Headway Factor	1.00	1.00	1.00	1.00	1.00	1.00
Volume (vph)	13	6	1	86	61	4
Adj. Flow (vph)	14	7	1	93	66	4
Lane Group Flow (vph)	21	0	0	94	70	0
Sign Control	Stop			Free	Free	

Intersection Summary	
Control Type: Unsignalized	
Intersection Capacity Utilization 15.3%	ICU Level of Service A
Analysis Period (min) 15	

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Lane Util. Factor	1.00	0.95	0.95	1.00	0.95	0.95	1.00	1.00	1.00	1.00	1.00	1.00
Frt		0.993			0.998				0.865			0.865
Flt Protected	0.950											
Satd. Flow (prot)	1770	3514	0	0	3532	0	0	0	1611	0	0	1611
Flt Permitted	0.950											
Satd. Flow (perm)	1770	3514	0	0	3532	0	0	0	1611	0	0	1611
Headway Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Volume (vph)	49	600	30	0	1298	18	0	0	40	0	0	282
Adj. Flow (vph)	53	652	33	0	1411	20	0	0	43	0	0	307
Lane Group Flow (vph)	53	685	0	0	1431	0	0	0	43	0	0	307
Sign Control		Free			Free			Stop			Stop	

Intersection Summary		
Control Type: Unsignalized		
Intersection Capacity Utilization 60.6%	ICU Level of Service B	
Analysis Period (min) 15		

Lane Group	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Lane Util. Factor	1.00	1.00	1.00	1.00	1.00	1.00
Frt	0.917		0.989			
Flt Protected	0.981					0.995
Satd. Flow (prot)	1676	0	1842	0	0	1853
Flt Permitted	0.981					0.995
Satd. Flow (perm)	1676	0	1842	0	0	1853
Headway Factor	1.00	1.00	1.00	1.00	1.00	1.00
Volume (vph)	17	27	52	5	8	70
Adj. Flow (vph)	18	29	57	5	9	76
Lane Group Flow (vph)	47	0	62	0	0	85
Sign Control	Stop		Free			Free

Intersection Summary			
Control Type: Unsignalized			
Intersection Capacity Utilization 20.4%		ICU Level of Service A	
Analysis Period (min) 15			

Lane Group	WBU	WBL	WBR	NBL	NBT	NBR	SBL	SBT	SBR	SEL2	SEL	SER
Lane Configurations												
Lane Util. Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Frt		0.983			0.960			0.986			0.921	
Flt Protected		0.958			0.990						0.980	
Satd. Flow (prot)	0	1754	0	0	1770	0	0	1837	0	0	1681	0
Flt Permitted		0.958			0.990						0.980	
Satd. Flow (perm)	0	1754	0	0	1770	0	0	1837	0	0	1681	0
Headway Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Volume (vph)	4	3	1	2	5	3	0	17	2	2	3	6
Adj. Flow (vph)	4	3	1	2	5	3	0	18	2	2	3	7
Lane Group Flow (vph)	0	8	0	0	10	0	0	20	0	0	12	0
Sign Control		Stop			Free			Free			Stop	

Intersection Summary		
Control Type: Unsignalized		
Intersection Capacity Utilization 20.0%	ICU Level of Service A	
Analysis Period (min) 15		

Lane Group	EBL	EBR	EBR2	NBL	NBT	NBR	SBL	SBT	SBR	NWL	NWR
Lane Configurations											
Lane Util. Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Frt	0.874				0.932			0.949		0.991	
Flt Protected	0.997				0.976			0.970		0.955	
Satd. Flow (prot)	1623	0	0	0	1694	0	0	1715	0	1763	0
Flt Permitted	0.997				0.976			0.970		0.955	
Satd. Flow (perm)	1623	0	0	0	1694	0	0	1715	0	1763	0
Headway Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Volume (vph)	3	38	1	2	0	2	21	0	13	53	4
Adj. Flow (vph)	3	41	1	2	0	2	23	0	14	58	4
Lane Group Flow (vph)	45	0	0	0	4	0	0	37	0	62	0
Sign Control	Free				Stop			Stop		Free	

Intersection Summary	
Control Type: Unsignalized	
Intersection Capacity Utilization 20.0%	ICU Level of Service A
Analysis Period (min) 15	

Lane Group	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Lane Util. Factor	1.00	1.00	1.00	1.00	1.00	1.00
Frt	0.995		0.928			
Flt Protected	0.954					0.998
Satd. Flow (prot)	1768	0	1729	0	0	1859
Flt Permitted	0.954					0.998
Satd. Flow (perm)	1768	0	1729	0	0	1859
Headway Factor	1.00	1.00	1.00	1.00	1.00	1.00
Volume (vph)	75	3	18	21	3	57
Adj. Flow (vph)	82	3	20	23	3	62
Lane Group Flow (vph)	85	0	43	0	0	65
Sign Control	Stop		Free			Free

Intersection Summary	
Control Type: Unsignalized	
Intersection Capacity Utilization 16.5%	ICU Level of Service A
Analysis Period (min) 15	

Lane Group	NBL	NBT	NBR	SBL	SBT	SBR	SEL	SET	SER	NWL	NWT	NWR
Lane Configurations												
Lane Util. Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Frt		0.984			0.996			0.938			0.991	
Flt Protected		0.985			0.997			0.999			0.978	
Satd. Flow (prot)	0	1805	0	0	1850	0	0	1746	0	0	1805	0
Flt Permitted		0.985			0.997			0.999			0.978	
Satd. Flow (perm)	0	1805	0	0	1850	0	0	1746	0	0	1805	0
Headway Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Volume (vph)	71	133	28	22	284	9	3	79	70	144	151	20
Adj. Flow (vph)	77	145	30	24	309	10	3	86	76	157	164	22
Lane Group Flow (vph)	0	252	0	0	343	0	0	165	0	0	343	0
Sign Control		Stop			Stop			Stop			Stop	

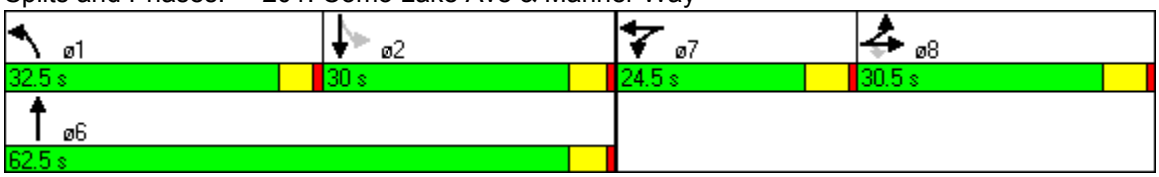
Intersection Summary		
Control Type: Unsignalized		
Intersection Capacity Utilization 68.4%	ICU Level of Service C	
Analysis Period (min) 15		

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1681	1699	1583	1770	1840	0	1770	3483	0	1770	3539	1583
Flt Permitted	0.950	0.960		0.950			0.950			0.632		
Satd. Flow (perm)	1681	1699	1583	1770	1840	0	1770	3483	0	1177	3539	1583
Satd. Flow (RTOR)			143		3			16				543
Volume (vph)	197	18	132	47	74	6	148	156	19	2	358	500
Lane Group Flow (vph)	114	120	143	51	87	0	161	191	0	2	389	543
Turn Type	Split		Perm	Split			Prot			Perm		Free
Protected Phases	8	8		7	7		1	6			2	
Permitted Phases			8							2		Free
Total Split (s)	30.5	30.5	30.5	24.5	24.5	0.0	32.5	62.5	0.0	30.0	30.0	0.0
Act Effct Green (s)	12.3	12.3	12.3	10.6	10.6		11.8	25.6		13.7	13.7	57.9
Actuated g/C Ratio	0.21	0.21	0.21	0.18	0.18		0.20	0.44		0.24	0.24	1.00
v/c Ratio	0.32	0.33	0.32	0.16	0.27		0.46	0.12		0.01	0.46	0.34
Control Delay	28.3	28.5	7.9	27.5	27.8		29.6	9.3		23.5	24.4	0.6
Queue Delay	0.0	0.0	0.0	0.0	0.0		0.0	0.0		0.0	0.0	0.0
Total Delay	28.3	28.5	7.9	27.5	27.8		29.6	9.3		23.5	24.4	0.6
LOS	C	C	A	C	C		C	A		C	C	A
Approach Delay		20.6			27.7			18.6			10.5	
Approach LOS		C			C			B			B	

Intersection Summary

Cycle Length: 117.5
Actuated Cycle Length: 57.9
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 0.46
Intersection Signal Delay: 15.5 Intersection LOS: B
Intersection Capacity Utilization 40.7% ICU Level of Service A
Analysis Period (min) 15

Splits and Phases: 201: Como Lake Ave & Mariner Way

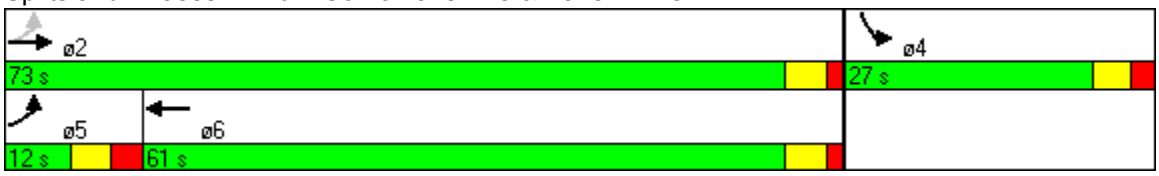


Lane Group	EBL	EBT	WBT	WBR	SBL	SBR
Lane Configurations						
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	3539	3536	0	1679	0
Flt Permitted	0.264				0.980	
Satd. Flow (perm)	492	3539	3536	0	1679	0
Satd. Flow (RTOR)			2		13	
Volume (vph)	7	309	752	7	8	12
Lane Group Flow (vph)	8	336	825	0	22	0
Turn Type	pm+pt					
Protected Phases	5	2	6		4	
Permitted Phases	2					
Total Split (s)	12.0	73.0	61.0	0.0	27.0	0.0
Act Effct Green (s)	90.8	93.2	90.7		8.8	
Actuated g/C Ratio	0.91	0.93	0.91		0.09	
v/c Ratio	0.01	0.10	0.26		0.14	
Control Delay	1.4	0.9	2.2		28.4	
Queue Delay	0.0	0.0	0.0		0.0	
Total Delay	1.4	0.9	2.2		28.4	
LOS	A	A	A		C	
Approach Delay		0.9	2.2		28.4	
Approach LOS		A	A		C	

Intersection Summary

Cycle Length: 100
Actuated Cycle Length: 100
Offset: 28 (28%), Referenced to phase 2:EBTL and 6:WBT, Start of Green
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 0.26
Intersection Signal Delay: 2.3 Intersection LOS: A
Intersection Capacity Utilization 33.5% ICU Level of Service A
Analysis Period (min) 15

Splits and Phases: 202: Como Lake Ave & Baker Drive

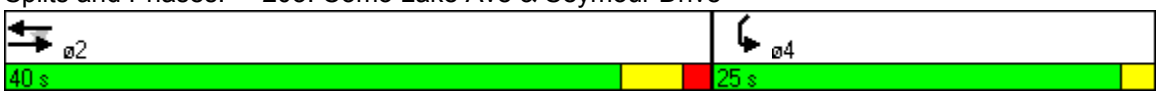


Lane Group	EBL	EBT	WBT	WBR	SWL	SWR
Lane Configurations						
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	3539	3536	0	1668	0
Flt Permitted	0.271				0.984	
Satd. Flow (perm)	505	3539	3536	0	1668	0
Satd. Flow (RTOR)			2		16	
Volume (vph)	5	310	796	7	7	15
Lane Group Flow (vph)	5	337	873	0	24	0
Turn Type	Perm					
Protected Phases		2	2		4	
Permitted Phases	2					
Total Split (s)	40.0	40.0	40.0	0.0	25.0	0.0
Act Effct Green (s)	20.2	20.2	20.2		18.3	
Actuated g/C Ratio	0.43	0.43	0.43		0.39	
v/c Ratio	0.02	0.22	0.57		0.04	
Control Delay	6.8	8.1	11.1		8.1	
Queue Delay	0.0	0.0	0.0		0.0	
Total Delay	6.8	8.1	11.1		8.1	
LOS	A	A	B		A	
Approach Delay		8.1	11.1		8.1	
Approach LOS		A	B		A	

Intersection Summary

Cycle Length: 65
Actuated Cycle Length: 46.7
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 0.57
Intersection Signal Delay: 10.2 Intersection LOS: B
Intersection Capacity Utilization 33.1% ICU Level of Service A
Analysis Period (min) 15

Splits and Phases: 203: Como Lake Ave & Seymour Drive

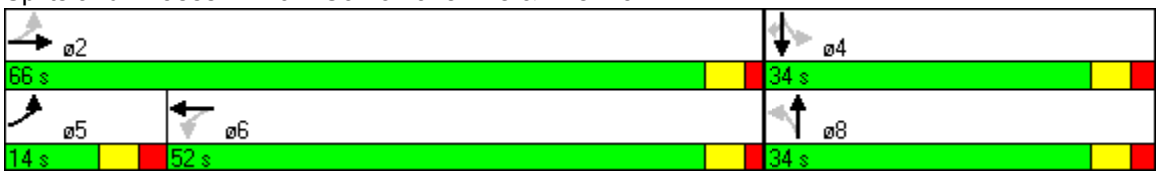


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	3507	0	1770	3532	0	0	1725	0	0	1799	1583
Flt Permitted	0.222			0.544				0.938			0.888	
Satd. Flow (perm)	414	3507	0	1013	3532	0	0	1658	0	0	1654	1583
Satd. Flow (RTOR)		12			2			3				
Volume (vph)	131	300	18	14	773	10	4	1	3	11	5	260
Lane Group Flow (vph)	142	346	0	15	851	0	0	8	0	0	17	283
Turn Type	pm+pt			Perm			Perm			Perm		Perm
Protected Phases	5	2			6			8			4	
Permitted Phases	2			6			8			4		4
Total Split (s)	14.0	66.0	0.0	52.0	52.0	0.0	34.0	34.0	0.0	34.0	34.0	34.0
Act Effct Green (s)	68.3	68.3		53.9	53.9			23.7			23.7	23.7
Actuated g/C Ratio	0.68	0.68		0.54	0.54			0.24			0.24	0.24
v/c Ratio	0.34	0.14		0.03	0.45			0.02			0.04	0.75
Control Delay	8.9	6.4		14.9	16.4			21.0			26.1	47.5
Queue Delay	0.0	0.0		0.0	0.0			0.0			0.0	0.0
Total Delay	8.9	6.4		14.9	16.4			21.0			26.1	47.5
LOS	A	A		B	B			C			C	D
Approach Delay		7.1			16.4			21.0			46.3	
Approach LOS		A			B			C			D	

Intersection Summary

Cycle Length: 100
Actuated Cycle Length: 100
Offset: 64 (64%), Referenced to phase 2:EBTL and 6:WBTL, Start of Green
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 0.75
Intersection Signal Delay: 19.1 Intersection LOS: B
Intersection Capacity Utilization 53.6% ICU Level of Service A
Analysis Period (min) 15

Splits and Phases: 204: Como Lake Ave & Thermal Dr



Lane Group	EBL	EBT	WBT	WBR	SBL	SBR
Lane Configurations						
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	0	3539	3539	0	1685	0
Flt Permitted					0.978	
Satd. Flow (perm)	0	3539	3539	0	1685	0
Satd. Flow (RTOR)			1		5	
Volume (vph)	0	398	983	3	4	5
Lane Group Flow (vph)	0	433	1071	0	9	0
Turn Type	Perm					
Protected Phases		2	2		4	
Permitted Phases	2					
Total Split (s)	45.0	45.0	45.0	0.0	24.0	0.0
Act Effct Green (s)		25.5	25.5		17.8	
Actuated g/C Ratio		0.50	0.50		0.35	
v/c Ratio		0.25	0.61		0.02	
Control Delay		7.3	10.5		12.2	
Queue Delay		0.0	0.0		0.0	
Total Delay		7.3	10.5		12.2	
LOS		A	B		B	
Approach Delay		7.3	10.5		12.3	
Approach LOS		A	B		B	

Intersection Summary

Cycle Length: 69
Actuated Cycle Length: 51.5
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 0.61
Intersection Signal Delay: 9.6 Intersection LOS: A
Intersection Capacity Utilization 38.1% ICU Level of Service A
Analysis Period (min) 15

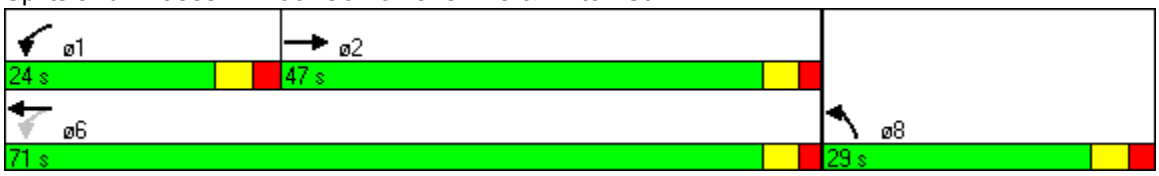
Splits and Phases: 205: Como Lake Ave & Custer CT

Lane Group	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	3497	0	1770	3539	1709	0
Flt Permitted			0.438		0.971	
Satd. Flow (perm)	3497	0	816	3539	1709	0
Satd. Flow (RTOR)	12				33	
Volume (vph)	332	29	118	854	89	62
Lane Group Flow (vph)	393	0	128	928	164	0
Turn Type			pm+pt			
Protected Phases	2		1	6	8	
Permitted Phases			6			
Total Split (s)	47.0	0.0	24.0	71.0	29.0	0.0
Act Effct Green (s)	62.6		75.6	75.6	16.4	
Actuated g/C Ratio	0.63		0.76	0.76	0.16	
v/c Ratio	0.18		0.18	0.35	0.53	
Control Delay	7.5		4.4	4.8	36.0	
Queue Delay	0.0		0.0	0.0	0.0	
Total Delay	7.5		4.4	4.8	36.0	
LOS	A		A	A	D	
Approach Delay	7.5			4.8	36.0	
Approach LOS	A			A	D	

Intersection Summary

Cycle Length: 100
Actuated Cycle Length: 100
Offset: 0 (0%), Referenced to phase 2:EBT and 6:WBTL, Start of Green
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 0.53
Intersection Signal Delay: 8.6 Intersection LOS: A
Intersection Capacity Utilization 39.0% ICU Level of Service A
Analysis Period (min) 15

Splits and Phases: 206: Como Lake Ave & Linton St

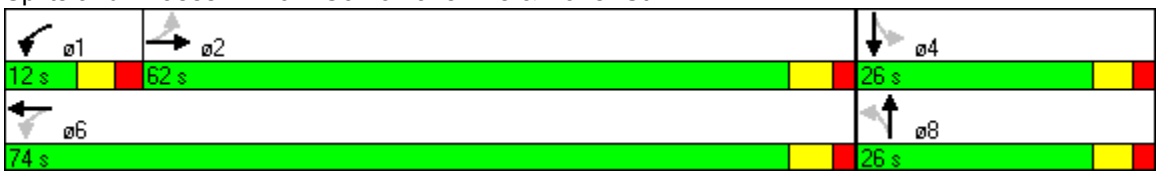


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	3514	0	1770	3514	0	0	1714	0	0	1727	0
Flt Permitted	0.306			0.493				0.861			0.882	
Satd. Flow (perm)	570	3514	0	918	3514	0	0	1506	0	0	1549	0
Satd. Flow (RTOR)		8			11			37			34	
Volume (vph)	12	317	15	74	822	39	31	10	34	32	20	39
Lane Group Flow (vph)	13	361	0	80	935	0	0	82	0	0	99	0
Turn Type	Perm			pm+pt			Perm			Perm		
Protected Phases		2		1	6			8			4	
Permitted Phases	2			6			8			4		
Total Split (s)	62.0	62.0	0.0	12.0	74.0	0.0	26.0	26.0	0.0	26.0	26.0	0.0
Act Effct Green (s)	74.4	74.4		83.1	83.9			11.4			11.4	
Actuated g/C Ratio	0.74	0.74		0.83	0.84			0.11			0.11	
v/c Ratio	0.03	0.14		0.10	0.32			0.40			0.48	
Control Delay	6.2	5.3		2.2	2.2			29.9			35.2	
Queue Delay	0.0	0.0		0.0	0.0			0.0			0.0	
Total Delay	6.2	5.3		2.2	2.2			29.9			35.2	
LOS	A	A		A	A			C			D	
Approach Delay		5.4			2.2			29.9			35.2	
Approach LOS		A			A			C			D	

Intersection Summary

Cycle Length: 100
Actuated Cycle Length: 100
Offset: 0 (0%), Referenced to phase 2:EBTL and 6:WBTL, Start of Green
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 0.48
Intersection Signal Delay: 6.5 Intersection LOS: A
Intersection Capacity Utilization 48.6% ICU Level of Service A
Analysis Period (min) 15

Splits and Phases: 207: Como Lake Ave & Poirer St

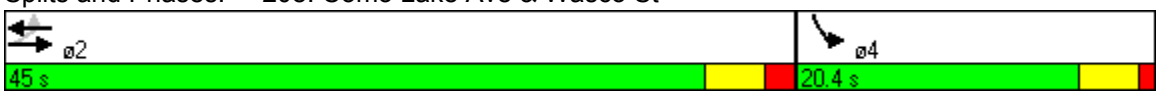


Lane Group	EBL	EBT	WBT	WBR	SBL	SBR
Lane Configurations						
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	0	3529	3536	0	1655	0
Flt Permitted		0.896			0.987	
Satd. Flow (perm)	0	3171	3536	0	1655	0
Satd. Flow (RTOR)			2		23	
Volume (vph)	18	347	908	7	7	21
Lane Group Flow (vph)	0	397	995	0	31	0
Turn Type	Perm					
Protected Phases		2	2		4	
Permitted Phases	2					
Total Split (s)	45.0	45.0	45.0	0.0	20.4	0.0
Act Effct Green (s)		22.7	22.7		16.8	
Actuated g/C Ratio		0.48	0.48		0.35	
v/c Ratio		0.26	0.59		0.05	
Control Delay		7.4	10.1		8.6	
Queue Delay		0.0	0.0		0.0	
Total Delay		7.4	10.1		8.6	
LOS		A	B		A	
Approach Delay		7.4	10.1		8.6	
Approach LOS		A	B		A	

Intersection Summary

Cycle Length: 65.4
Actuated Cycle Length: 47.7
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 0.59
Intersection Signal Delay: 9.3 Intersection LOS: A
Intersection Capacity Utilization 37.8% ICU Level of Service A
Analysis Period (min) 15

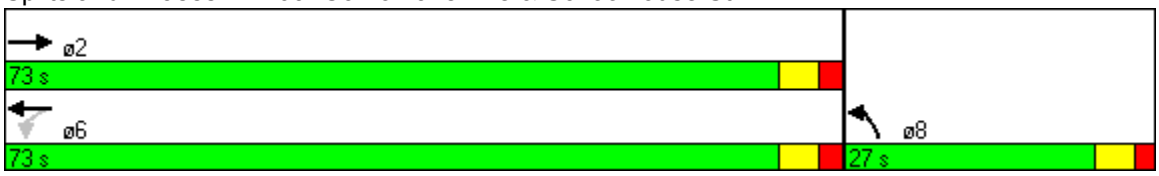
Splits and Phases: 208: Como Lake Ave & Wasco St



Lane Group	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	3504	0	0	3529	1709	0
Flt Permitted				0.912	0.972	
Satd. Flow (perm)	3504	0	0	3228	1709	0
Satd. Flow (RTOR)	18				33	
Volume (vph)	306	23	47	862	56	40
Lane Group Flow (vph)	358	0	0	988	104	0
Turn Type			Perm			
Protected Phases	2			6	8	
Permitted Phases			6			
Total Split (s)	73.0	0.0	73.0	73.0	27.0	0.0
Act Effct Green (s)	84.1			84.1	11.1	
Actuated g/C Ratio	0.84			0.84	0.11	
v/c Ratio	0.12			0.36	0.47	
Control Delay	1.2			3.0	35.4	
Queue Delay	0.0			0.2	0.0	
Total Delay	1.2			3.2	35.4	
LOS	A			A	D	
Approach Delay	1.2			3.2	35.4	
Approach LOS	A			A	D	

Intersection Summary	
Cycle Length: 100	
Actuated Cycle Length: 100	
Offset: 50 (50%), Referenced to phase 2:EBT and 6:WBTL, Start of Green	
Control Type: Actuated-Coordinated	
Maximum v/c Ratio: 0.47	
Intersection Signal Delay: 5.0	Intersection LOS: A
Intersection Capacity Utilization 50.2%	ICU Level of Service A
Analysis Period (min) 15	

Splits and Phases: 209: Como Lake Ave & Schoolhouse St

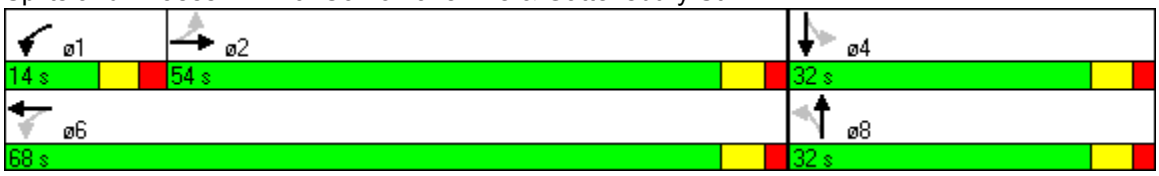


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	3532	0	1770	3525	0	0	1757	0	0	1700	0
Flt Permitted	0.301			0.527				0.933			0.970	
Satd. Flow (perm)	561	3532	0	982	3525	0	0	1655	0	0	1657	0
Satd. Flow (RTOR)		1			5			28			80	
Volume (vph)	47	261	3	27	852	21	14	34	27	19	55	120
Lane Group Flow (vph)	51	287	0	29	949	0	0	81	0	0	211	0
Turn Type	Perm			pm+pt			Perm			Perm		
Protected Phases		2		1	6			8			4	
Permitted Phases	2			6			8			4		
Total Split (s)	54.0	54.0	0.0	14.0	68.0	0.0	32.0	32.0	0.0	32.0	32.0	0.0
Act Effct Green (s)	69.8	69.8		77.1	77.1			14.9			14.9	
Actuated g/C Ratio	0.70	0.70		0.77	0.77			0.15			0.15	
v/c Ratio	0.13	0.12		0.04	0.35			0.30			0.67	
Control Delay	7.6	5.7		7.6	9.2			27.3			34.5	
Queue Delay	0.0	0.0		0.0	0.0			0.0			0.0	
Total Delay	7.6	5.7		7.6	9.2			27.3			34.5	
LOS	A	A		A	A			C			C	
Approach Delay		6.0			9.1			27.3			34.5	
Approach LOS		A			A			C			C	

Intersection Summary

Cycle Length: 100
Actuated Cycle Length: 100
Offset: 10 (10%), Referenced to phase 2:EBTL and 6:WBTL, Start of Green
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 0.67
Intersection Signal Delay: 12.7 Intersection LOS: B
Intersection Capacity Utilization 55.6% ICU Level of Service B
Analysis Period (min) 15

Splits and Phases: 210: Como Lake Ave & Gattensbury St

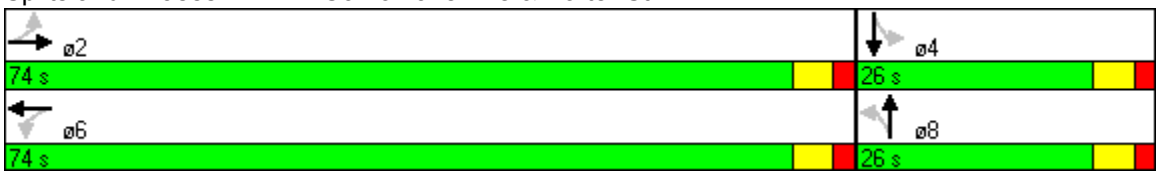


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	0	3522	0	0	3525	0	0	1690	0	0	1711	0
Flt Permitted		0.930			0.925			0.899			0.948	
Satd. Flow (perm)	0	3278	0	0	3267	0	0	1549	0	0	1641	0
Satd. Flow (RTOR)		6			2			24			34	
Volume (vph)	7	284	7	40	935	10	16	2	22	13	16	31
Lane Group Flow (vph)	0	325	0	0	1070	0	0	43	0	0	65	0
Turn Type	Perm			Perm			Perm			Perm		
Protected Phases		2			6			8			4	
Permitted Phases	2			6			8			4		
Total Split (s)	74.0	74.0	0.0	74.0	74.0	0.0	26.0	26.0	0.0	26.0	26.0	0.0
Act Effct Green (s)		85.6			85.6			9.7			9.7	
Actuated g/C Ratio		0.86			0.86			0.10			0.10	
v/c Ratio		0.12			0.38			0.25			0.34	
Control Delay		3.8			2.5			27.0			28.5	
Queue Delay		0.0			0.0			0.0			0.0	
Total Delay		3.8			2.5			27.0			28.5	
LOS		A			A			C			C	
Approach Delay		3.8			2.5			27.0			28.5	
Approach LOS		A			A			C			C	

Intersection Summary

Cycle Length: 100
Actuated Cycle Length: 100
Offset: 32 (32%), Referenced to phase 2:EBTL and 6:WBTL, Start of Green
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 0.38
Intersection Signal Delay: 4.6 Intersection LOS: A
Intersection Capacity Utilization 51.5% ICU Level of Service A
Analysis Period (min) 15

Splits and Phases: 211: Como Lake Ave & Porter St

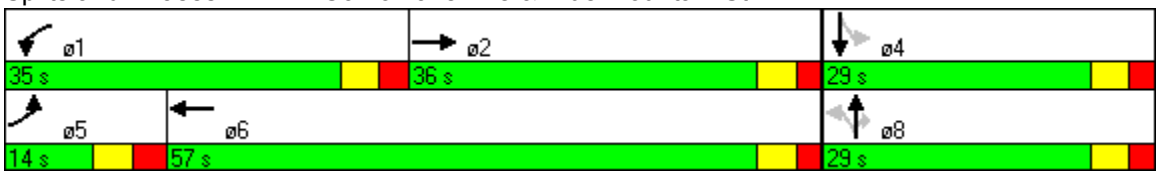


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	3391	0	1770	3522	0	0	1788	1583	0	1744	0
Flt Permitted	0.950			0.950				0.730			0.947	
Satd. Flow (perm)	1770	3391	0	1770	3522	0	0	1360	1583	0	1667	0
Satd. Flow (RTOR)		61			5				100		33	
Volume (vph)	3	216	85	223	763	25	73	14	92	17	39	38
Lane Group Flow (vph)	3	327	0	242	856	0	0	94	100	0	101	0
Turn Type	Prot			Prot			Perm		Perm	Perm		
Protected Phases	5	2		1	6			8			4	
Permitted Phases							8		8	4		
Total Split (s)	14.0	36.0	0.0	35.0	57.0	0.0	29.0	29.0	29.0	29.0	29.0	0.0
Act Effct Green (s)	8.3	54.7		19.5	75.8			13.7	13.7		13.7	
Actuated g/C Ratio	0.08	0.55		0.20	0.76			0.14	0.14		0.14	
v/c Ratio	0.02	0.17		0.70	0.32			0.50	0.33		0.39	
Control Delay	42.7	11.3		39.6	2.3			48.5	10.5		30.4	
Queue Delay	0.0	0.0		0.0	0.0			0.0	0.0		0.0	
Total Delay	42.7	11.3		39.6	2.3			48.5	10.5		30.4	
LOS	D	B		D	A			D	B		C	
Approach Delay		11.6			10.5			28.9			30.4	
Approach LOS		B			B			C			C	

Intersection Summary

Cycle Length: 100
Actuated Cycle Length: 100
Offset: 78 (78%), Referenced to phase 2:EBT and 6:WBT, Start of Green
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 0.70
Intersection Signal Delay: 13.9 Intersection LOS: B
Intersection Capacity Utilization 48.9% ICU Level of Service A
Analysis Period (min) 15

Splits and Phases: 212: Como Lake Ave & Blue Mountain St

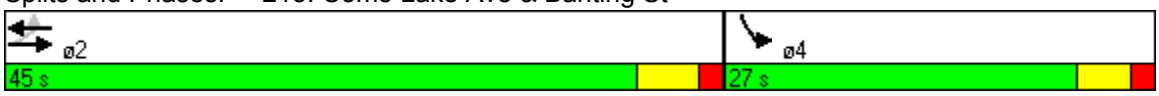


Lane Group	EBL	EBT	WBT	WBR	SBL	SBR
Lane Configurations						
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	0	3536	3539	0	1655	0
Flt Permitted		0.946			0.988	
Satd. Flow (perm)	0	3348	3539	0	1655	0
Satd. Flow (RTOR)			1		9	
Volume (vph)	4	276	861	3	3	8
Lane Group Flow (vph)	0	304	939	0	12	0
Turn Type	Perm					
Protected Phases		2	2		4	
Permitted Phases	2					
Total Split (s)	45.0	45.0	45.0	0.0	27.0	0.0
Act Effct Green (s)		23.7	23.7		23.3	
Actuated g/C Ratio		0.43	0.43		0.42	
v/c Ratio		0.21	0.62		0.02	
Control Delay		9.7	13.7		8.5	
Queue Delay		0.0	0.0		0.0	
Total Delay		9.7	13.7		8.5	
LOS		A	B		A	
Approach Delay		9.7	13.7		8.5	
Approach LOS		A	B		A	

Intersection Summary

Cycle Length: 72
Actuated Cycle Length: 55.1
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 0.62
Intersection Signal Delay: 12.7 Intersection LOS: B
Intersection Capacity Utilization 34.7% ICU Level of Service A
Analysis Period (min) 15

Splits and Phases: 213: Como Lake Ave & Banting St



Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	0	3518	0	0	3504	0	0	1735	0	0	1771	0
Flt Permitted		0.898			0.948			0.949			0.826	
Satd. Flow (perm)	0	3169	0	0	3325	0	0	1658	0	0	1496	0
Satd. Flow (RTOR)		3			16			32			19	
Volume (vph)	11	149	3	18	793	51	9	26	29	100	73	45
Lane Group Flow (vph)	0	177	0	0	937	0	0	70	0	0	237	0
Turn Type	Perm			Perm			Perm			Perm		
Protected Phases		2			6			8			4	
Permitted Phases	2			6			8			4		
Total Split (s)	45.0	45.0	0.0	45.0	45.0	0.0	25.0	25.0	0.0	25.0	25.0	0.0
Act Effct Green (s)		26.6			26.6			14.0			14.0	
Actuated g/C Ratio		0.59			0.59			0.29			0.29	
v/c Ratio		0.10			0.48			0.14			0.53	
Control Delay		6.4			8.4			8.4			16.2	
Queue Delay		0.0			0.0			0.0			0.0	
Total Delay		6.4			8.4			8.4			16.2	
LOS		A			A			A			B	
Approach Delay		6.4			8.4			8.4			16.2	
Approach LOS		A			A			A			B	

Intersection Summary

Cycle Length: 70
Actuated Cycle Length: 45.4
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 0.53
Intersection Signal Delay: 9.4 Intersection LOS: A
Intersection Capacity Utilization 61.2% ICU Level of Service B
Analysis Period (min) 15

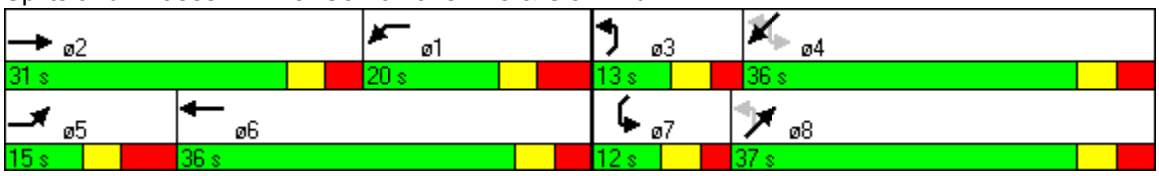
Splits and Phases: 214: Como Lake Ave & Robinson St

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NEL	NET	NER	SWL	SWT	SWR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	3433	3486	0	1770	3532	0	1863	3433	0	1770	3539	1583
Flt Permitted	0.950			0.950						0.528		
Satd. Flow (perm)	3433	3486	0	1770	3532	0	1863	3433	0	984	3539	1583
Satd. Flow (RTOR)		12			1			33				426
Volume (vph)	155	122	14	89	828	11	0	233	58	1	357	715
Lane Group Flow (vph)	168	148	0	97	912	0	0	316	0	1	388	777
Turn Type	Prot			Prot			pm+pt			pm+pt		Perm
Protected Phases	5	2		1	6		3	8		7	4	
Permitted Phases							8			4		4
Total Split (s)	15.0	31.0	0.0	20.0	36.0	0.0	13.0	37.0	0.0	12.0	36.0	36.0
Act Effct Green (s)	11.0	18.2		26.5	30.9			43.7		46.1	46.1	46.1
Actuated g/C Ratio	0.11	0.18		0.26	0.31			0.44		0.46	0.46	0.46
v/c Ratio	0.44	0.23		0.21	0.83			0.21		0.00	0.24	0.81
Control Delay	45.7	36.4		27.9	39.8			12.8		15.0	17.1	18.2
Queue Delay	0.0	0.0		0.0	0.0			0.0		0.0	0.0	0.0
Total Delay	45.7	36.4		27.9	39.8			12.8		15.0	17.1	18.2
LOS	D	D		C	D			B		B	B	B
Approach Delay		41.4			38.7			12.8			17.9	
Approach LOS		D			D			B			B	

Intersection Summary

Cycle Length: 100
Actuated Cycle Length: 100
Offset: 90 (90%), Referenced to phase 4:SWTL and 8:NETL, Start of Green
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 0.83
Intersection Signal Delay: 27.4 Intersection LOS: C
Intersection Capacity Utilization 74.2% ICU Level of Service D
Analysis Period (min) 15

Splits and Phases: 215: Como Lake Ave & Clark Rd



Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	3479	0	1770	3539	0	0	1770	0	0	1651	0
Flt Permitted	0.098			0.543				0.686			0.992	
Satd. Flow (perm)	183	3479	0	1011	3539	0	0	1270	0	0	1639	0
Satd. Flow (RTOR)		31						3			21	
Volume (vph)	13	283	37	4	1499	1	233	6	11	3	15	87
Lane Group Flow (vph)	14	348	0	4	1630	0	0	272	0	0	114	0
Turn Type	Perm			Perm			Perm			Perm		
Protected Phases		2			6			8			4	
Permitted Phases	2			6			8			4		
Total Split (s)	45.0	45.0	0.0	45.0	45.0	0.0	28.0	28.0	0.0	28.0	28.0	0.0
Act Effct Green (s)	38.0	38.0		38.0	38.0			18.8			18.8	
Actuated g/C Ratio	0.58	0.58		0.58	0.58			0.29			0.29	
v/c Ratio	0.13	0.17		0.01	0.79			0.74			0.23	
Control Delay	11.2	6.5		7.0	14.8			33.4			16.2	
Queue Delay	0.0	0.0		0.0	0.0			0.0			0.0	
Total Delay	11.2	6.5		7.0	14.8			33.4			16.2	
LOS	B	A		A	B			C			B	
Approach Delay		6.7			14.8			33.4			16.2	
Approach LOS		A			B			C			B	

Intersection Summary

Cycle Length: 73
Actuated Cycle Length: 65
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 0.79
Intersection Signal Delay: 15.7 Intersection LOS: B
Intersection Capacity Utilization 68.7% ICU Level of Service C
Analysis Period (min) 15

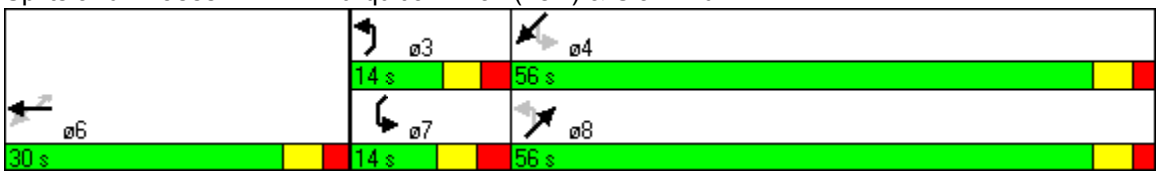
Splits and Phases: 216: Como Lake Ave & North Rd

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NEL	NET	NER	SWL	SWT	SWR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	0	0	0	0	1770	1583	1770	3447	0	1770	3525	0
Flt Permitted					0.950		0.476			0.553		
Satd. Flow (perm)	0	0	0	0	1770	1583	887	3447	0	1030	3525	0
Satd. Flow (RTOR)						52		37			4	
Volume (vph)	0	0	0	68	0	48	2	237	50	72	382	11
Lane Group Flow (vph)	0	0	0	0	74	52	2	312	0	78	427	0
Turn Type				Perm		Perm	pm+pt			pm+pt		
Protected Phases					6		3	8		7	4	
Permitted Phases				6		6	8			4		
Total Split (s)	0.0	0.0	0.0	30.0	30.0	30.0	14.0	56.0	0.0	14.0	56.0	0.0
Act Effct Green (s)					11.3	11.3	79.6	74.1		82.6	81.7	
Actuated g/C Ratio					0.11	0.11	0.80	0.74		0.83	0.82	
v/c Ratio					0.37	0.23	0.00	0.12		0.09	0.15	
Control Delay					45.8	13.7	2.5	4.4		1.7	1.9	
Queue Delay					0.0	0.0	0.0	0.0		0.0	0.0	
Total Delay					45.8	13.7	2.5	4.4		1.7	1.9	
LOS					D	B	A	A		A	A	
Approach Delay					32.6			4.4			1.9	
Approach LOS					C			A			A	

Intersection Summary

Cycle Length: 100
Actuated Cycle Length: 100
Offset: 4 (4%), Referenced to phase 4:SWTL and 8:NETL, Start of Green
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 0.37
Intersection Signal Delay: 6.8 Intersection LOS: A
Intersection Capacity Utilization 31.7% ICU Level of Service A
Analysis Period (min) 15

Splits and Phases: 217: Burquitlam Mall (new) & Clark Rd



Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Satd. Flow (prot)	0	1798	0	0	1833	0	0	1813	0	0	1809	0
Flt Permitted		0.990			0.997			0.980			0.997	
Satd. Flow (perm)	0	1798	0	0	1833	0	0	1813	0	0	1809	0
Volume (vph)	8	25	7	6	77	9	31	41	4	6	76	19
Lane Group Flow (vph)	0	44	0	0	101	0	0	83	0	0	111	0
Sign Control		Stop			Stop			Stop			Stop	

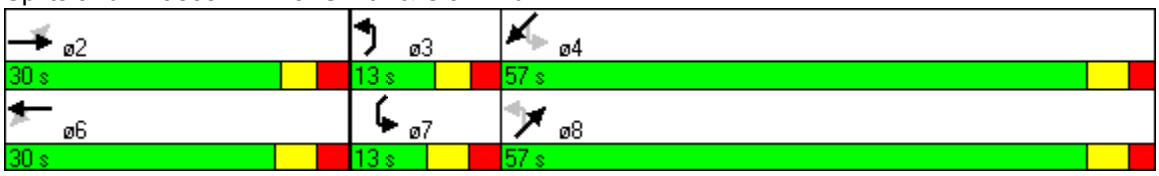
Intersection Summary	
Control Type: Unsignalized	
Intersection Capacity Utilization 22.8%	ICU Level of Service A
Analysis Period (min) 15	

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NEL	NET	NER	SWL	SWT	SWR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	1740	0	1770	1840	0	1770	3500	0	1770	3525	0
Flt Permitted	0.573			0.741			0.450			0.570		
Satd. Flow (perm)	1067	1740	0	1380	1840	0	838	3500	0	1062	3525	0
Satd. Flow (RTOR)		11			4			13			4	
Volume (vph)	6	13	10	65	136	12	8	247	20	16	421	12
Lane Group Flow (vph)	7	25	0	71	161	0	9	290	0	17	471	0
Turn Type	Perm			Perm			pm+pt			pm+pt		
Protected Phases		2			6		3	8		7	4	
Permitted Phases	2			6			8			4		
Total Split (s)	30.0	30.0	0.0	30.0	30.0	0.0	13.0	57.0	0.0	13.0	57.0	0.0
Act Effct Green (s)	16.0	16.0		16.0	16.0		74.1	71.0		75.4	73.7	
Actuated g/C Ratio	0.16	0.16		0.16	0.16		0.74	0.71		0.75	0.74	
v/c Ratio	0.04	0.09		0.32	0.54		0.01	0.12		0.02	0.18	
Control Delay	33.5	23.7		39.8	43.8		4.0	5.9		4.1	5.4	
Queue Delay	0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0	
Total Delay	33.5	23.7		39.8	43.8		4.0	5.9		4.1	5.4	
LOS	C	C		D	D		A	A		A	A	
Approach Delay		25.8			42.6			5.8			5.4	
Approach LOS		C			D			A			A	

Intersection Summary

Cycle Length: 100
Actuated Cycle Length: 100
Offset: 18 (18%), Referenced to phase 4:SWTL and 8:NETL, Start of Green
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 0.54
Intersection Signal Delay: 14.3 Intersection LOS: B
Intersection Capacity Utilization 30.2% ICU Level of Service A
Analysis Period (min) 15

Splits and Phases: 219: Smith & Clark Rd



Lane Group	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Satd. Flow (prot)	1615	0	1827	0	0	1840
Flt Permitted	0.999					0.988
Satd. Flow (perm)	1615	0	1827	0	0	1840
Volume (vph)	3	140	61	10	16	51
Lane Group Flow (vph)	155	0	77	0	0	72
Sign Control	Stop		Free			Free

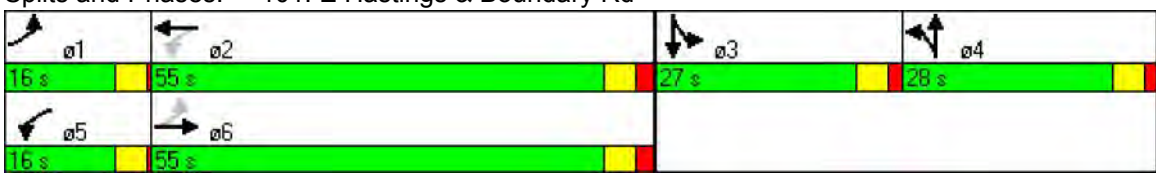
Intersection Summary	
Control Type: Unsignalized	
Intersection Capacity Utilization 25.7%	ICU Level of Service A
Analysis Period (min) 15	

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	5004	0	1770	3522	0	1610	3157	0	1770	3429	0
Flt Permitted	0.190			0.078			0.950	0.995		0.950		
Satd. Flow (perm)	354	5004	0	145	3522	0	1610	3157	0	1770	3429	0
Satd. Flow (RTOR)		19			3			126			22	
Volume (vph)	156	1299	151	169	770	27	246	211	194	43	121	31
Lane Group Flow (vph)	170	1576	0	184	866	0	215	492	0	47	166	0
Turn Type	pm+pt			pm+pt			Split			Split		
Protected Phases	1	6		5	2		4	4		3	3	
Permitted Phases	6			2								
Total Split (s)	16.0	55.0	0.0	16.0	55.0	0.0	28.0	28.0	0.0	27.0	27.0	0.0
Act Effct Green (s)	50.2	40.6		53.3	42.1		18.7	18.7		11.1	11.1	
Actuated g/C Ratio	0.51	0.41		0.54	0.43		0.19	0.19		0.11	0.11	
v/c Ratio	0.53	0.76		0.70	0.57		0.70	0.70		0.23	0.41	
Control Delay	17.4	27.3		38.2	23.5		52.4	34.3		47.9	41.3	
Queue Delay	0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0	
Total Delay	17.4	27.3		38.2	23.5		52.4	34.3		47.9	41.3	
LOS	B	C		D	C		D	C		D	D	
Approach Delay		26.3			26.1			39.8			42.8	
Approach LOS		C			C			D			D	

Intersection Summary

Cycle Length: 126
Actuated Cycle Length: 98.2
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 0.76
Intersection Signal Delay: 29.8 Intersection LOS: C
Intersection Capacity Utilization 70.6% ICU Level of Service C
Analysis Period (min) 15

Splits and Phases: 101: E Hastings & Boundary Rd

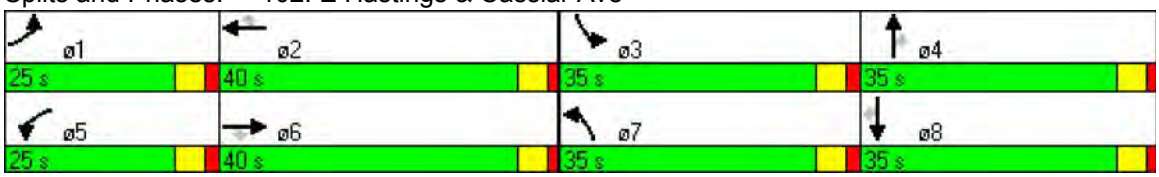


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	5085	1583	1770	3539	1583	3433	3539	1583	3433	3539	1583
Flt Permitted	0.950			0.950			0.950			0.950		
Satd. Flow (perm)	1770	5085	1583	1770	3539	1583	3433	3539	1583	3433	3539	1583
Satd. Flow (RTOR)			404			532			74			163
Volume (vph)	132	937	575	67	561	509	404	327	68	721	66	150
Lane Group Flow (vph)	143	1018	625	73	610	553	439	355	74	784	72	163
Turn Type	Prot		Perm	Prot		Perm	Prot		Perm	Prot		Perm
Protected Phases	1	6		5	2		7	4		3	8	
Permitted Phases			6			2			4			8
Total Split (s)	25.0	40.0	40.0	25.0	40.0	40.0	35.0	35.0	35.0	35.0	35.0	35.0
Act Effct Green (s)	14.5	34.3	34.3	10.7	27.6	27.6	19.5	16.9	16.9	30.2	27.5	27.5
Actuated g/C Ratio	0.14	0.32	0.32	0.10	0.26	0.26	0.18	0.16	0.16	0.29	0.26	0.26
v/c Ratio	0.59	0.62	0.80	0.41	0.66	0.69	0.69	0.63	0.23	0.80	0.08	0.31
Control Delay	56.0	33.6	20.8	56.1	39.6	8.7	47.8	48.4	11.9	44.5	35.2	7.8
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	56.0	33.6	20.8	56.1	39.6	8.7	47.8	48.4	11.9	44.5	35.2	7.8
LOS	E	C	C	E	D	A	D	D	B	D	D	A
Approach Delay		30.9			26.8			45.0			38.0	
Approach LOS		C			C			D			D	

Intersection Summary

Cycle Length: 135
Actuated Cycle Length: 105.7
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 0.80
Intersection Signal Delay: 33.8 Intersection LOS: C
Intersection Capacity Utilization 65.8% ICU Level of Service C
Analysis Period (min) 15

Splits and Phases: 102: E Hastings & Cassiar Ave

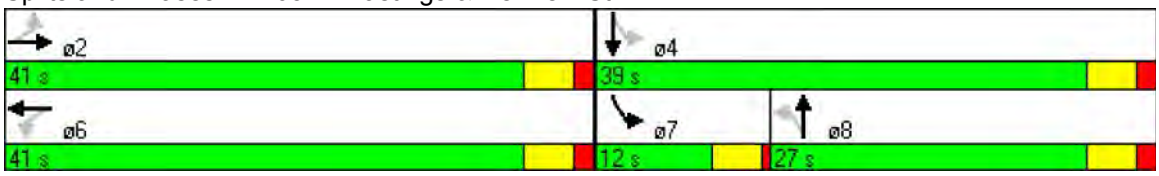


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	5040	0	1770	3472	0	0	4984	0	0	3437	0
Flt Permitted	0.140			0.135				0.790			0.575	
Satd. Flow (perm)	261	5040	0	251	3472	0	0	3965	0	0	2019	0
Satd. Flow (RTOR)		16			27			20			9	
Volume (vph)	57	1134	73	137	894	132	67	387	43	251	308	32
Lane Group Flow (vph)	62	1312	0	149	1115	0	0	541	0	0	643	0
Turn Type	Perm			Perm			Perm			pm+pt		
Protected Phases		2			6			8		7	4	
Permitted Phases	2			6			8			4		
Total Split (s)	41.0	41.0	0.0	41.0	41.0	0.0	27.0	27.0	0.0	12.0	39.0	0.0
Act Effct Green (s)	37.0	37.0		37.0	37.0			23.0			35.0	
Actuated g/C Ratio	0.46	0.46		0.46	0.46			0.29			0.44	
v/c Ratio	0.51	0.56		1.28	0.69			0.47			0.62	
Control Delay	37.5	24.9		204.5	19.2			10.2			18.8	
Queue Delay	0.0	0.0		0.0	0.0			0.0			0.0	
Total Delay	37.5	24.9		204.5	19.2			10.2			18.8	
LOS	D	C		F	B			B			B	
Approach Delay		25.5			41.1			10.2			18.8	
Approach LOS		C			D			B			B	

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 80
Offset: 60 (75%), Referenced to phase 2:EBTL and 6:WBTL, Start of Green
Control Type: Pretimed
Maximum v/c Ratio: 1.28
Intersection Signal Delay: 27.4 Intersection LOS: C
Intersection Capacity Utilization 74.7% ICU Level of Service D
Analysis Period (min) 15

Splits and Phases: 103: E Hastings & Renfrew St

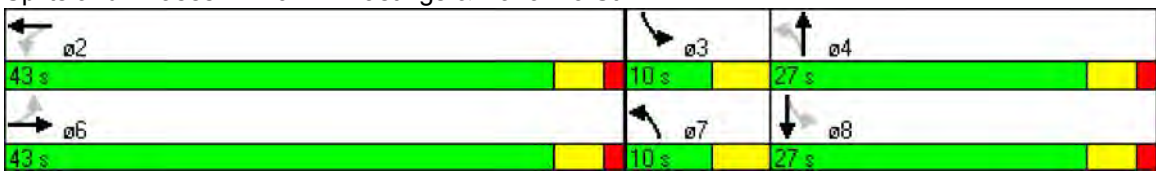


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	0	4947	0	0	3514	0	1770	4900	0	1770	4745	0
Flt Permitted		0.939			0.666		0.320			0.426		
Satd. Flow (perm)	0	4645	0	0	2344	0	535	4900	0	713	4745	0
Satd. Flow (RTOR)		16			2			24			47	
Volume (vph)	2	1442	88	60	890	10	89	395	44	59	496	92
Lane Group Flow (vph)	0	1665	0	0	1043	0	97	477	0	64	639	0
Turn Type	Perm			Perm			pm+pt			pm+pt		
Protected Phases		6			2		7	4		3	8	
Permitted Phases	6			2			4			8		
Total Split (s)	43.0	43.0	0.0	43.0	43.0	0.0	10.0	27.0	0.0	10.0	27.0	0.0
Act Effct Green (s)		39.0			39.0		29.8	25.0		29.8	25.0	
Actuated g/C Ratio		0.49			0.49		0.37	0.31		0.37	0.31	
v/c Ratio		0.73			0.91		0.33	0.31		0.19	0.42	
Control Delay		12.4			30.6		15.0	21.3		15.9	21.8	
Queue Delay		0.0			0.0		0.0	0.0		0.0	0.0	
Total Delay		12.4			30.6		15.0	21.3		15.9	21.8	
LOS		B			C		B	C		B	C	
Approach Delay		12.4			30.6			20.3			21.2	
Approach LOS		B			C			C			C	

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 80
Offset: 23 (29%), Referenced to phase 2:WBTL and 6:EBTL, Start of Green
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 0.91
Intersection Signal Delay: 19.9 Intersection LOS: B
Intersection Capacity Utilization 92.9% ICU Level of Service F
Analysis Period (min) 15

Splits and Phases: 104: E Hastings & Nanaimo St

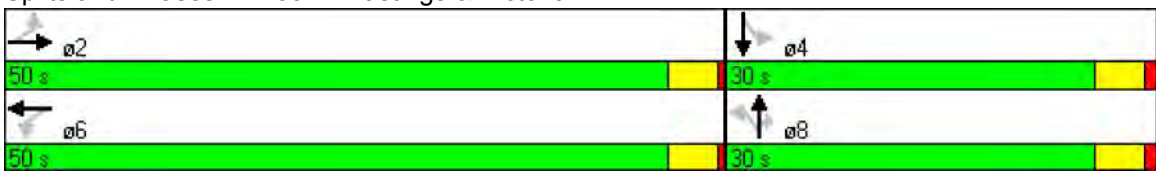


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	5060	0	1770	3522	0	0	1840	1583	0	3434	0
Flt Permitted	0.248			0.094				0.869			0.773	
Satd. Flow (perm)	462	5060	0	175	3522	0	0	1619	1583	0	2700	0
Satd. Flow (RTOR)		10			7				24		13	
Volume (vph)	26	1495	48	78	831	28	48	148	258	82	139	20
Lane Group Flow (vph)	28	1677	0	85	933	0	0	213	280	0	262	0
Turn Type	Perm			Perm			Perm		Perm	Perm		
Protected Phases		2			6			8			4	
Permitted Phases	2			6			8		8	4		
Total Split (s)	50.0	50.0	0.0	50.0	50.0	0.0	30.0	30.0	30.0	30.0	30.0	0.0
Act Effct Green (s)	46.0	46.0		46.0	46.0			26.0	26.0		26.0	
Actuated g/C Ratio	0.58	0.58		0.58	0.58			0.32	0.32		0.32	
v/c Ratio	0.11	0.58		0.84	0.46			0.40	0.53		0.30	
Control Delay	3.0	3.4		49.9	4.2			26.3	26.7		20.2	
Queue Delay	0.0	0.0		0.0	0.0			0.0	0.0		0.0	
Total Delay	3.0	3.4		49.9	4.2			26.3	26.7		20.2	
LOS	A	A		D	A			C	C		C	
Approach Delay		3.4			8.0			26.5			20.2	
Approach LOS		A			A			C			C	

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 80
Offset: 65 (81%), Referenced to phase 2:EBTL and 6:WBTL, Start of Green
Control Type: Pretimed
Maximum v/c Ratio: 0.84
Intersection Signal Delay: 9.3 Intersection LOS: A
Intersection Capacity Utilization 67.3% ICU Level of Service C
Analysis Period (min) 15

Splits and Phases: 105: E Hastings & Victoria Dr



Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	5033	0	1770	3524	0	1770	1709	0	1770	1814	0
Flt Permitted	0.332			0.100			0.577			0.493		
Satd. Flow (perm)	606	5033	0	185	3524	0	965	1709	0	890	1814	0
Satd. Flow (RTOR)		10			4			45			6	
Volume (vph)	62	1422	62	116	768	16	52	138	93	84	161	16
Lane Group Flow (vph)	67	1613	0	126	852	0	57	251	0	91	192	0
Turn Type	Perm			pm+pt			Perm			Perm		
Protected Phases		2		1	6			8			4	
Permitted Phases	2			6			8			4		
Total Split (s)	40.0	40.0	0.0	10.0	50.0	0.0	30.0	30.0	0.0	30.0	30.0	0.0
Act Effct Green (s)	38.0	38.0		46.0	46.0		26.0	26.0		26.0	26.0	
Actuated g/C Ratio	0.48	0.48		0.58	0.58		0.32	0.32		0.32	0.32	
v/c Ratio	0.23	0.67		0.56	0.42		0.18	0.43		0.31	0.32	
Control Delay	10.3	10.8		23.1	17.4		18.1	18.1		24.1	21.6	
Queue Delay	0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0	
Total Delay	10.3	10.8		23.1	17.4		18.1	18.1		24.1	21.6	
LOS	B	B		C	B		B	B		C	C	
Approach Delay		10.7			18.1			18.1			22.4	
Approach LOS		B			B			B			C	

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 80
Offset: 50 (63%), Referenced to phase 2:EBTL and 6:WBTL, Start of Green
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 0.67
Intersection Signal Delay: 14.7 Intersection LOS: B
Intersection Capacity Utilization 68.1% ICU Level of Service C
Analysis Period (min) 15

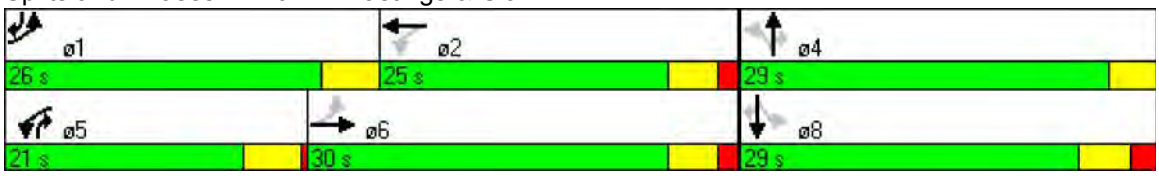
Splits and Phases: 106: E Hastings & Commercial Dr

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	5024	0	1770	3522	0	0	3522	1583	0	3518	1583
Flt Permitted	0.160			0.190				0.802			0.701	
Satd. Flow (perm)	298	5024	0	354	3522	0	0	2838	1583	0	2481	1583
Satd. Flow (RTOR)		18			4				8			33
Volume (vph)	128	1078	92	275	627	23	71	604	277	54	402	32
Lane Group Flow (vph)	139	1272	0	299	707	0	0	734	301	0	496	35
Turn Type	pm+pt			pm+pt			Perm		pm+ov	Perm		pm+ov
Protected Phases	1	6		5	2			4	5		8	1
Permitted Phases	6			2			4		4	8		8
Total Split (s)	26.0	30.0	0.0	21.0	25.0	0.0	29.0	29.0	21.0	29.0	29.0	26.0
Act Effct Green (s)	35.7	27.4		47.0	36.7			25.0	44.6		25.0	37.4
Actuated g/C Ratio	0.45	0.34		0.59	0.46			0.31	0.56		0.31	0.47
v/c Ratio	0.48	0.74		0.62	0.44			0.83	0.34		0.64	0.05
Control Delay	16.1	26.2		9.9	16.1			35.6	26.9		28.2	4.5
Queue Delay	0.0	0.0		0.0	0.0			0.0	0.0		0.0	0.0
Total Delay	16.1	26.2		9.9	16.1			35.6	26.9		28.2	4.5
LOS	B	C		A	B			D	C		C	A
Approach Delay		25.2			14.3			33.0			26.6	
Approach LOS		C			B			C			C	

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 80
Offset: 26 (33%), Referenced to phase 2:WBTL and 6:EBTL, Start of Green
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 0.83
Intersection Signal Delay: 24.7 Intersection LOS: C
Intersection Capacity Utilization 88.5% ICU Level of Service E
Analysis Period (min) 15

Splits and Phases: 107: E Hastings & Clark Dr

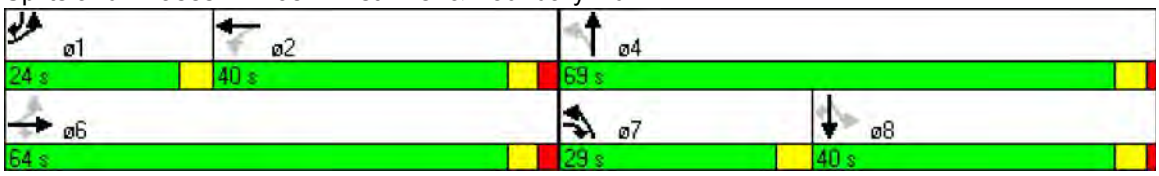


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	1863	1583	1770	1844	0	0	4964	0	0	3536	1583
Flt Permitted	0.162			0.553				0.676			0.877	
Satd. Flow (perm)	302	1863	1583	1030	1844	0	0	3410	0	0	3104	1583
Satd. Flow (RTOR)			37		3			9				228
Volume (vph)	400	319	241	73	343	25	366	668	61	19	626	348
Lane Group Flow (vph)	435	347	262	79	400	0	0	1190	0	0	701	378
Turn Type	pm+pt		pm+ov	Perm			pm+pt			Perm		pm+ov
Protected Phases	1	6	7		2		7	4			8	1
Permitted Phases	6		6	2			4			8		8
Total Split (s)	24.0	64.0	29.0	40.0	40.0	0.0	29.0	69.0	0.0	40.0	40.0	24.0
Act Effct Green (s)	53.9	53.9	66.2	29.3	29.3			45.7			33.3	58.0
Actuated g/C Ratio	0.50	0.50	0.61	0.27	0.27			0.42			0.31	0.54
v/c Ratio	1.01	0.37	0.27	0.28	0.80			1.71dl			0.73	0.39
Control Delay	74.5	19.7	10.5	36.6	50.3			28.3			37.8	6.8
Queue Delay	0.0	0.0	0.0	0.0	0.0			0.0			0.0	0.0
Total Delay	74.5	19.7	10.5	36.6	50.3			28.3			37.8	6.8
LOS	E	B	B	D	D			C			D	A
Approach Delay		40.2			48.0			28.3			27.0	
Approach LOS		D			D			C			C	

Intersection Summary

Cycle Length: 133
Actuated Cycle Length: 107.8
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 1.01
Intersection Signal Delay: 33.7 Intersection LOS: C
Intersection Capacity Utilization 94.6% ICU Level of Service F
Analysis Period (min) 15
dl Defacto Left Lane. Recode with 1 though lane as a left lane.

Splits and Phases: 108: E 1st Ave. & Boundary Rd

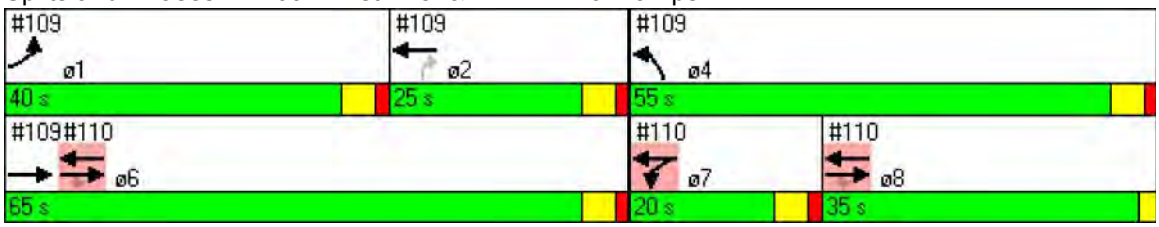


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	3539	0	0	5085	1583	3433	0	1583	0	0	0
Flt Permitted	0.950						0.950					
Satd. Flow (perm)	1770	3539	0	0	5085	1583	3433	0	1583	0	0	0
Satd. Flow (RTOR)						101			35			
Volume (vph)	366	837	0	0	684	294	969	0	81	0	0	0
Lane Group Flow (vph)	398	910	0	0	743	320	1053	0	88	0	0	0
Turn Type	Prot					Free	Prot		custom			
Protected Phases	1	6			2		4					
Permitted Phases						Free			2			
Total Split (s)	40.0	65.0	0.0	0.0	25.0	0.0	55.0	0.0	25.0	0.0	0.0	0.0
Act Effct Green (s)	36.0	61.0			21.0	120.0	51.0		21.0			
Actuated g/C Ratio	0.30	0.51			0.18	1.00	0.42		0.18			
v/c Ratio	0.75	0.51			0.83	0.20	0.72		0.29			
Control Delay	44.3	17.3			57.2	0.3	32.1		29.7			
Queue Delay	21.1	0.6			0.6	0.0	0.1		0.0			
Total Delay	65.5	17.9			57.8	0.3	32.2		29.7			
LOS	E	B			E	A	C		C			
Approach Delay		32.4			40.5							
Approach LOS		C			D							

Intersection Summary

Cycle Length: 120
Actuated Cycle Length: 120
Offset: 0 (0%), Referenced to phase 2:WBT and 6:EBT, Start of Green
Control Type: Pretimed
Maximum v/c Ratio: 0.98
Intersection Signal Delay: 34.7 Intersection LOS: C
Intersection Capacity Utilization 123.3% ICU Level of Service H
Analysis Period (min) 15

Splits and Phases: 109: E 1st Ave. & HW1 WB on ramps



Lane Group	ø7	ø8
Lane Configurations		
Total Lost Time (s)		
Satd. Flow (prot)		
Flt Permitted		
Satd. Flow (perm)		
Satd. Flow (RTOR)		
Volume (vph)		
Lane Group Flow (vph)		
Turn Type		
Protected Phases	7	8
Permitted Phases		
Total Split (s)	20.0	35.0
Act Effct Green (s)		
Actuated g/C Ratio		
v/c Ratio		
Control Delay		
Queue Delay		
Total Delay		
LOS		
Approach Delay		
Approach LOS		

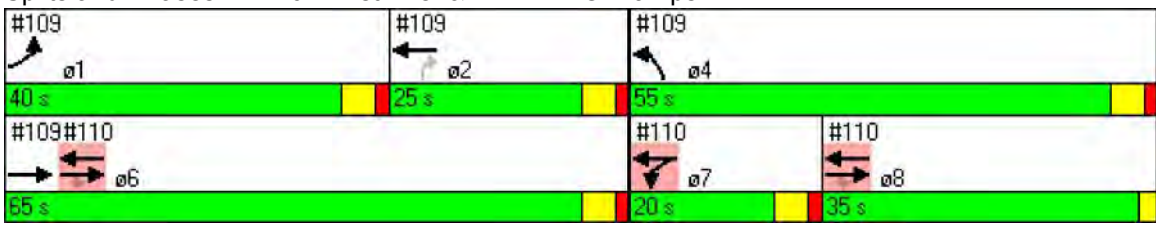
Intersection Summary

Lane Group	EBT	EBR	WBL	WBT	NBL	NBR	ø1	ø2	ø4	ø6	ø8
Lane Configurations											
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0					
Satd. Flow (prot)	5085	1583	1770	5085	0	0					
Flt Permitted			0.950								
Satd. Flow (perm)	5085	1583	1770	5085	0	0					
Satd. Flow (RTOR)		190									
Volume (vph)	1304	1170	164	1689	0	0					
Lane Group Flow (vph)	1417	1272	178	1836	0	0					
Turn Type		Perm	Prot								
Protected Phases	6 8		7	6 7 8			1	2	4	6	8
Permitted Phases		6 8									
Total Split (s)	100.0	100.0	20.0	120.0	0.0	0.0	40.0	25.0	55.0	65.0	35.0
Act Effct Green (s)	96.0	96.0	16.0	120.0							
Actuated g/C Ratio	0.80	0.80	0.13	1.00							
v/c Ratio	0.35	0.98	0.75	0.36							
Control Delay	3.6	30.5	62.8	0.2							
Queue Delay	0.0	0.0	4.0	0.0							
Total Delay	3.6	30.5	66.8	0.2							
LOS	A	C	E	A							
Approach Delay	16.3			6.1							
Approach LOS	B			A							

Intersection Summary

Cycle Length: 120
Actuated Cycle Length: 120
Offset: 0 (0%), Referenced to phase 2:WBT and 6:EBT, Start of Green
Control Type: Pretimed
Maximum v/c Ratio: 0.98
Intersection Signal Delay: 11.9 Intersection LOS: B
Intersection Capacity Utilization 123.3% ICU Level of Service H
Analysis Period (min) 15

Splits and Phases: 110: E 1st Ave. & HW1 EB On ramps

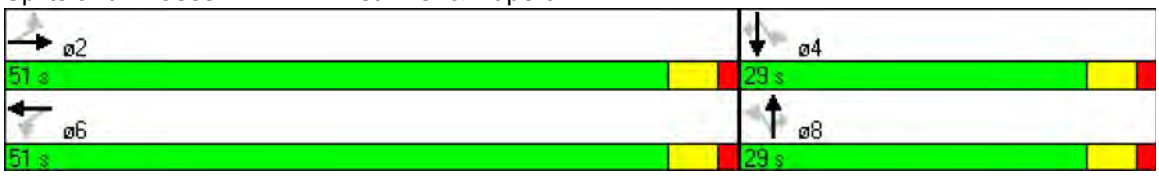


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	0	5070	0	0	3532	0	1770	1513	1504	1770	3539	1583
Flt Permitted		0.898			0.670		0.421			0.492		
Satd. Flow (perm)	0	4553	0	0	2371	0	784	1513	1504	916	3539	1583
Satd. Flow (RTOR)		7						10	10			21
Volume (vph)	12	1862	41	62	1573	0	175	7	417	113	398	103
Lane Group Flow (vph)	0	2082	0	0	1777	0	190	234	227	123	433	112
Turn Type	Perm			Perm			Perm		Perm	Perm		Perm
Protected Phases		2			6			8			4	
Permitted Phases	2			6			8		8	4		4
Total Split (s)	51.0	51.0	0.0	51.0	51.0	0.0	29.0	29.0	29.0	29.0	29.0	29.0
Act Effct Green (s)		47.0			47.0		25.0	25.0	25.0	25.0	25.0	25.0
Actuated g/C Ratio		0.59			0.59		0.31	0.31	0.31	0.31	0.31	0.31
v/c Ratio		0.78			1.28		0.78	0.49	0.48	0.43	0.39	0.22
Control Delay		5.3			150.1		48.9	25.5	25.2	27.6	22.8	17.8
Queue Delay		0.0			0.0		0.0	0.0	0.0	0.0	0.0	0.0
Total Delay		5.3			150.1		48.9	25.5	25.2	27.6	22.8	17.8
LOS		A			F		D	C	C	C	C	B
Approach Delay		5.3			150.1			32.2			22.9	
Approach LOS		A			F			C			C	

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 80
Offset: 9 (11%), Referenced to phase 2:EBTL and 6:WBTL, Start of Green
Control Type: Pretimed
Maximum v/c Ratio: 1.28
Intersection Signal Delay: 60.6 Intersection LOS: E
Intersection Capacity Utilization 116.4% ICU Level of Service H
Analysis Period (min) 15

Splits and Phases: 111: E 1st Ave. & Rupert

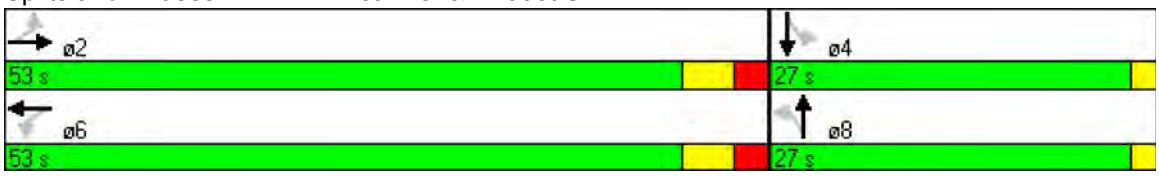


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	0	3532	0	0	3529	0	0	1743	0	0	1721	0
Flt Permitted		0.740			0.702			0.957			0.937	
Satd. Flow (perm)	0	2616	0	0	2480	0	0	1694	0	0	1641	0
Satd. Flow (RTOR)		2			3			9			14	
Volume (vph)	26	1982	17	19	1794	28	7	8	9	17	10	21
Lane Group Flow (vph)	0	2200	0	0	2001	0	0	27	0	0	52	0
Turn Type	Perm			Perm			Perm			Perm		
Protected Phases		2			6			8			4	
Permitted Phases	2			6			8			4		
Total Split (s)	53.0	53.0	0.0	53.0	53.0	0.0	27.0	27.0	0.0	27.0	27.0	0.0
Act Effct Green (s)		49.0			49.0			23.0			23.0	
Actuated g/C Ratio		0.61			0.61			0.29			0.29	
v/c Ratio		1.37			1.32			0.05			0.11	
Control Delay		184.3			169.1			16.2			17.3	
Queue Delay		0.0			0.0			0.0			0.0	
Total Delay		184.3			169.1			16.2			17.3	
LOS		F			F			B			B	
Approach Delay		184.3			169.1			16.2			17.3	
Approach LOS		F			F			B			B	

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 80
Offset: 67 (84%), Referenced to phase 2:EBTL and 6:WBTL, Start of Green
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 1.37
Intersection Signal Delay: 174.1 Intersection LOS: F
Intersection Capacity Utilization 84.3% ICU Level of Service E
Analysis Period (min) 15

Splits and Phases: 112: E 1st Ave. & Lillooet ST

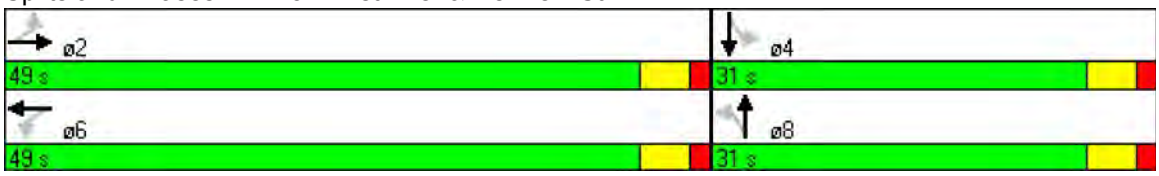


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	3525	0	1770	3511	0	1770	3476	0	1770	3500	0
Flt Permitted	0.089			0.089			0.292			0.196		
Satd. Flow (perm)	166	3525	0	166	3511	0	544	3476	0	365	3500	0
Satd. Flow (RTOR)		5			12			14			11	
Volume (vph)	56	1648	40	77	1549	87	70	639	89	71	536	42
Lane Group Flow (vph)	61	1834	0	84	1779	0	76	792	0	77	629	0
Turn Type	Perm			Perm			Perm			Perm		
Protected Phases		2			6			8			4	
Permitted Phases	2			6			8			4		
Total Split (s)	49.0	49.0	0.0	49.0	49.0	0.0	31.0	31.0	0.0	31.0	31.0	0.0
Act Effct Green (s)	45.0	45.0		45.0	45.0		27.0	27.0		27.0	27.0	
Actuated g/C Ratio	0.56	0.56		0.56	0.56		0.34	0.34		0.34	0.34	
v/c Ratio	0.66	0.92		0.90	0.90		0.41	0.67		0.63	0.53	
Control Delay	20.7	8.1		44.1	24.9		28.9	25.6		46.7	25.1	
Queue Delay	0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0	
Total Delay	20.7	8.1		44.1	24.9		28.9	25.6		46.7	25.1	
LOS	C	A		D	C		C	C		D	C	
Approach Delay		8.6			25.7			25.9			27.5	
Approach LOS		A			C			C			C	

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 80
Offset: 43 (54%), Referenced to phase 2:EBTL and 6:WBTL, Start of Green
Control Type: Pretimed
Maximum v/c Ratio: 0.92
Intersection Signal Delay: 19.9 Intersection LOS: B
Intersection Capacity Utilization 88.9% ICU Level of Service E
Analysis Period (min) 15

Splits and Phases: 113: E 1st Ave. & Renfrew St

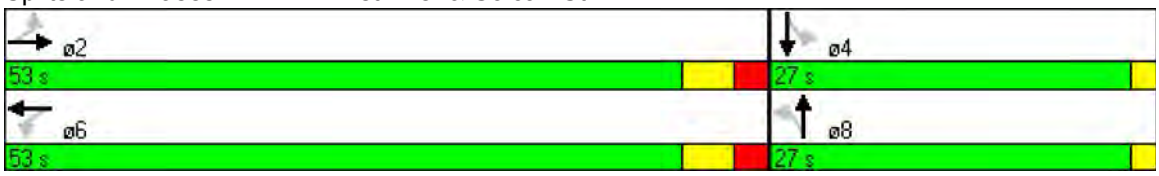


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	0	3536	0	0	3536	0	0	1745	0	0	1724	0
Flt Permitted		0.909			0.911			0.971			0.992	
Satd. Flow (perm)	0	3214	0	0	3221	0	0	1711	0	0	1717	0
Satd. Flow (RTOR)		1			2			16			20	
Volume (vph)	16	1740	8	7	1573	16	7	15	15	3	14	18
Lane Group Flow (vph)	0	1917	0	0	1735	0	0	40	0	0	38	0
Turn Type	Perm			Perm			Perm			Perm		
Protected Phases		2			6			8			4	
Permitted Phases	2			6			8			4		
Total Split (s)	53.0	53.0	0.0	53.0	53.0	0.0	27.0	27.0	0.0	27.0	27.0	0.0
Act Effct Green (s)		49.0			49.0			23.0			23.0	
Actuated g/C Ratio		0.61			0.61			0.29			0.29	
v/c Ratio		0.97			0.88			0.08			0.07	
Control Delay		12.6			27.6			15.1			13.5	
Queue Delay		0.0			0.0			0.0			0.0	
Total Delay		12.6			27.6			15.1			13.5	
LOS		B			C			B			B	
Approach Delay		12.6			27.6			15.1			13.5	
Approach LOS		B			C			B			B	

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 80
Offset: 16 (20%), Referenced to phase 2:EBTL and 6:WBTL, Start of Green
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 0.97
Intersection Signal Delay: 19.7 Intersection LOS: B
Intersection Capacity Utilization 70.0% ICU Level of Service C
Analysis Period (min) 15

Splits and Phases: 114: E 1st Ave. & Solcan St

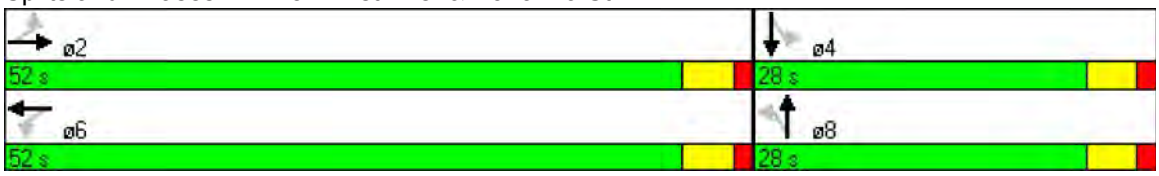


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	3522	0	1770	3514	0	1770	3497	0	1770	5024	0
Flt Permitted	0.083			0.083			0.219			0.167		
Satd. Flow (perm)	155	3522	0	155	3514	0	408	3497	0	311	5024	0
Satd. Flow (RTOR)		8			11			12			19	
Volume (vph)	72	1764	63	77	1490	73	54	722	65	80	714	64
Lane Group Flow (vph)	78	1985	0	84	1699	0	59	856	0	87	846	0
Turn Type	Perm			Perm			Perm			Perm		
Protected Phases		2			6			8			4	
Permitted Phases	2			6			8			4		
Total Split (s)	52.0	52.0	0.0	52.0	52.0	0.0	28.0	28.0	0.0	28.0	28.0	0.0
Act Effct Green (s)	48.0	48.0		48.0	48.0		24.0	24.0		24.0	24.0	
Actuated g/C Ratio	0.60	0.60		0.60	0.60		0.30	0.30		0.30	0.30	
v/c Ratio	0.84	0.94		0.90	0.80		0.48	0.81		0.94	0.56	
Control Delay	52.5	11.0		63.1	6.9		38.7	32.8		108.8	24.8	
Queue Delay	0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0	
Total Delay	52.5	11.0		63.1	6.9		38.7	32.8		108.8	24.8	
LOS	D	B		E	A		D	C		F	C	
Approach Delay		12.6			9.5			33.2			32.6	
Approach LOS		B			A			C			C	

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 80
Offset: 60 (75%), Referenced to phase 2:EBTL and 6:WBTL, Start of Green
Control Type: Pretimed
Maximum v/c Ratio: 0.94
Intersection Signal Delay: 18.2 Intersection LOS: B
Intersection Capacity Utilization 94.8% ICU Level of Service F
Analysis Period (min) 15

Splits and Phases: 115: E 1st Ave. & Nanaimo St

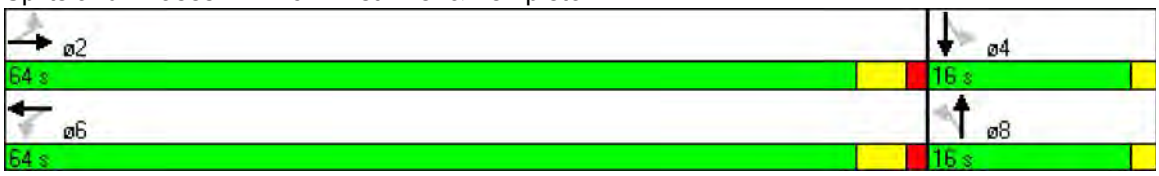


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	0	3536	0	0	3536	0	0	1653	0	0	1662	0
Flt Permitted		0.946			0.938			0.990				
Satd. Flow (perm)	0	3345	0	0	3316	0	0	1645	0	0	1662	0
Satd. Flow (RTOR)		1			2			8			12	
Volume (vph)	7	1869	6	8	1563	7	1	1	7	0	3	11
Lane Group Flow (vph)	0	2047	0	0	1716	0	0	10	0	0	15	0
Turn Type	Perm			Perm			Perm			Perm		
Protected Phases		2			6			8			4	
Permitted Phases	2			6			8			4		
Total Split (s)	64.0	64.0	0.0	64.0	64.0	0.0	16.0	16.0	0.0	16.0	16.0	0.0
Act Effct Green (s)		60.0			60.0			12.0			12.0	
Actuated g/C Ratio		0.75			0.75			0.15			0.15	
v/c Ratio		0.82			0.69			0.04			0.06	
Control Delay		3.2			11.4			19.2			18.1	
Queue Delay		0.0			0.0			0.0			0.0	
Total Delay		3.2			11.4			19.2			18.1	
LOS		A			B			B			B	
Approach Delay		3.2			11.4			19.2			18.1	
Approach LOS		A			B			B			B	

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 80
Offset: 35 (44%), Referenced to phase 2:EBTL and 6:WBTL, Start of Green
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 0.82
Intersection Signal Delay: 7.0 Intersection LOS: A
Intersection Capacity Utilization 66.7% ICU Level of Service C
Analysis Period (min) 15

Splits and Phases: 116: E 1st Ave. & Templeton Dr

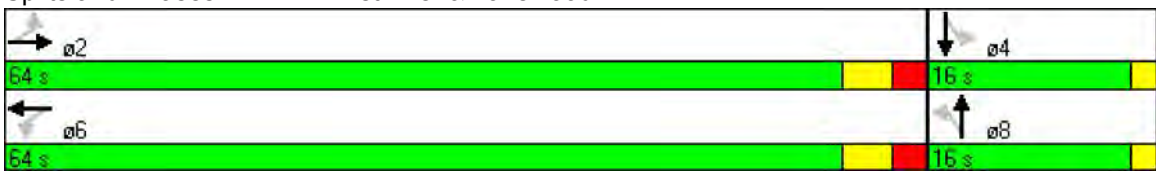


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	0	3539	0	0	3536	0	0	1700	0	0	1665	0
Flt Permitted		0.940			0.951			0.981			0.973	
Satd. Flow (perm)	0	3327	0	0	3362	0	0	1679	0	0	1638	0
Satd. Flow (RTOR)		1			3			12			10	
Volume (vph)	11	1788	5	3	1444	12	3	5	11	3	1	9
Lane Group Flow (vph)	0	1960	0	0	1586	0	0	20	0	0	14	0
Turn Type	Perm			Perm			Perm			Perm		
Protected Phases		2			6			8			4	
Permitted Phases	2			6			8			4		
Total Split (s)	64.0	64.0	0.0	64.0	64.0	0.0	16.0	16.0	0.0	16.0	16.0	0.0
Act Effct Green (s)		60.0			60.0			12.0			12.0	
Actuated g/C Ratio		0.75			0.75			0.15			0.15	
v/c Ratio		0.79			0.63			0.08			0.06	
Control Delay		2.9			7.0			20.1			19.5	
Queue Delay		0.0			0.1			0.0			0.0	
Total Delay		2.9			7.1			20.1			19.5	
LOS		A			A			C			B	
Approach Delay		2.9			7.1			20.1			19.5	
Approach LOS		A			A			C			B	

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 80
Offset: 32 (40%), Referenced to phase 2:EBTL and 6:WBTL, Start of Green
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 0.79
Intersection Signal Delay: 4.9 Intersection LOS: A
Intersection Capacity Utilization 67.3% ICU Level of Service C
Analysis Period (min) 15

Splits and Phases: 117: E 1st Ave. & Lakewood Dr

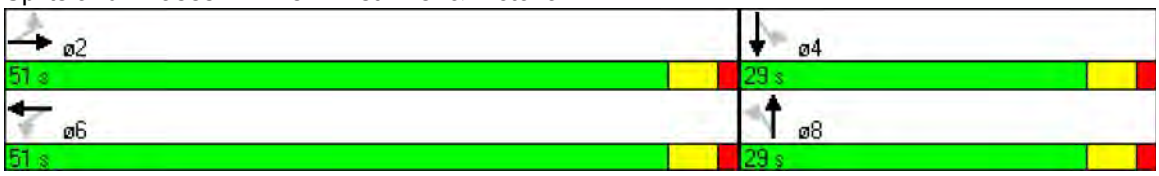


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	0	3525	0	0	3472	0	0	3472	0	0	3483	0
Flt Permitted		0.791			0.953			0.899			0.713	
Satd. Flow (perm)	0	2791	0	0	3309	0	0	3131	0	0	2511	0
Satd. Flow (RTOR)		4			34			16			5	
Volume (vph)	39	1591	34	2	1277	183	19	310	39	146	486	23
Lane Group Flow (vph)	0	1808	0	0	1589	0	0	400	0	0	712	0
Turn Type	Perm			Perm			Perm			Perm		
Protected Phases		2			6			8			4	
Permitted Phases	2			6			8			4		
Total Split (s)	51.0	51.0	0.0	51.0	51.0	0.0	29.0	29.0	0.0	29.0	29.0	0.0
Act Effct Green (s)		47.0			47.0			25.0			25.0	
Actuated g/C Ratio		0.59			0.59			0.31			0.31	
v/c Ratio		1.10			0.81			0.40			0.90	
Control Delay		65.5			26.2			14.6			44.0	
Queue Delay		0.0			0.0			0.0			0.0	
Total Delay		65.5			26.2			14.6			44.0	
LOS		E			C			B			D	
Approach Delay		65.5			26.2			14.6			44.0	
Approach LOS		E			C			B			D	

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 80
Offset: 12 (15%), Referenced to phase 2:EBTL and 6:WBTL, Start of Green
Control Type: Pretimed
Maximum v/c Ratio: 1.10
Intersection Signal Delay: 43.8 Intersection LOS: D
Intersection Capacity Utilization 111.9% ICU Level of Service H
Analysis Period (min) 15

Splits and Phases: 118: E 1st Ave. & Victoria Dr

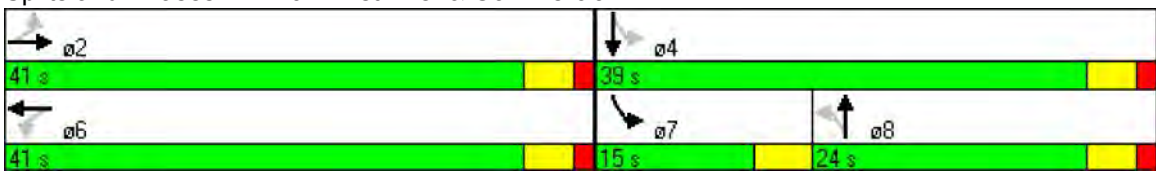


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	3508	0	1770	3461	0	1770	3205	0	1770	3450	0
Flt Permitted	0.108			0.108			0.440			0.307		
Satd. Flow (perm)	201	3508	0	201	3461	0	672	3205	0	496	3450	0
Satd. Flow (RTOR)		4			9			34			8	
Volume (vph)	21	1390	35	57	1102	62	45	333	79	288	496	24
Lane Group Flow (vph)	23	1549	0	62	1265	0	49	448	0	313	565	0
Turn Type	Perm			Perm			Perm			pm+pt		
Protected Phases		2			6			8		7	4	
Permitted Phases	2			6			8			4		
Total Split (s)	41.0	41.0	0.0	41.0	41.0	0.0	24.0	24.0	0.0	15.0	39.0	0.0
Act Effct Green (s)	40.1	40.1		40.1	40.1		16.9	16.9		31.9	31.9	
Actuated g/C Ratio	0.50	0.50		0.50	0.50		0.21	0.21		0.40	0.40	
v/c Ratio	0.23	0.88		0.61	0.73		0.35	0.64		0.84	0.41	
Control Delay	10.4	16.0		50.7	33.2		25.8	23.6		38.1	16.2	
Queue Delay	0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0	
Total Delay	10.4	16.0		50.7	33.2		25.8	23.6		38.1	16.2	
LOS	B	B		D	C		C	C		D	B	
Approach Delay		15.9			34.0			23.8			24.0	
Approach LOS		B			C			C			C	

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 80
Offset: 74 (93%), Referenced to phase 2:EBTL and 6:WBTL, Start of Green
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 0.88
Intersection Signal Delay: 24.1 Intersection LOS: C
Intersection Capacity Utilization 85.8% ICU Level of Service E
Analysis Period (min) 15

Splits and Phases: 119: E 1st Ave. & Commercial Dr

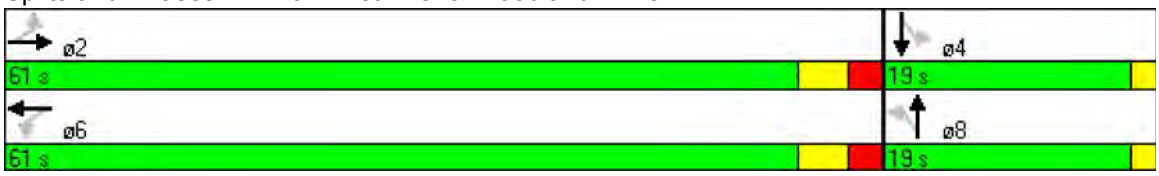


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	0	3532	0	0	3522	0	0	1738	0	0	1826	0
Flt Permitted		0.941			0.748			0.993			0.933	
Satd. Flow (perm)	0	3324	0	0	2642	0	0	1731	0	0	1728	0
Satd. Flow (RTOR)		5			4			28			3	
Volume (vph)	12	1393	22	61	1043	13	3	26	26	17	39	3
Lane Group Flow (vph)	0	1551	0	0	1214	0	0	59	0	0	63	0
Turn Type	Perm			Perm			Perm			Perm		
Protected Phases		2			6			8			4	
Permitted Phases	2			6			8			4		
Total Split (s)	61.0	61.0	0.0	61.0	61.0	0.0	19.0	19.0	0.0	19.0	19.0	0.0
Act Effct Green (s)		57.0			57.0			15.0			15.0	
Actuated g/C Ratio		0.71			0.71			0.19			0.19	
v/c Ratio		0.65			0.64			0.17			0.19	
Control Delay		6.2			14.0			18.4			28.2	
Queue Delay		0.0			0.0			0.0			0.0	
Total Delay		6.2			14.0			18.4			28.2	
LOS		A			B			B			C	
Approach Delay		6.2			14.0			18.4			28.2	
Approach LOS		A			B			B			C	

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 80
Offset: 53 (66%), Referenced to phase 2:EBTL and 6:WBTL, Start of Green
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 0.65
Intersection Signal Delay: 10.2 Intersection LOS: B
Intersection Capacity Utilization 89.5% ICU Level of Service E
Analysis Period (min) 15

Splits and Phases: 120: E 1st Ave. & Woodland Drive

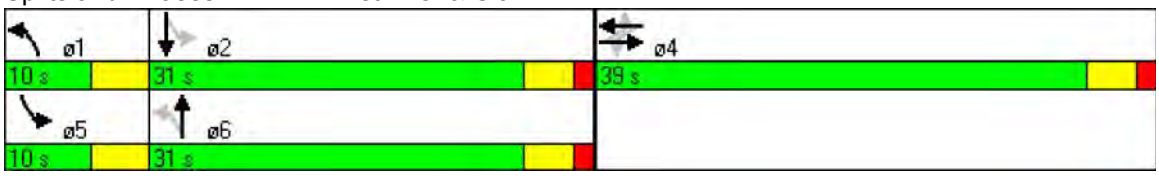


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	0	3398	0	0	3493	0	1770	4917	0	1770	5019	0
Flt Permitted		0.954					0.148			0.148		
Satd. Flow (perm)	0	3241	0	0	3493	0	276	4917	0	276	5019	0
Satd. Flow (RTOR)		81			16			63			20	
Volume (vph)	1	899	325	0	951	91	167	1055	298	202	1132	104
Lane Group Flow (vph)	0	1331	0	0	1133	0	182	1471	0	220	1343	0
Turn Type	Perm			Perm			pm+pt			pm+pt		
Protected Phases		4			4		1	6		5	2	
Permitted Phases	4			4			6			2		
Total Split (s)	39.0	39.0	0.0	39.0	39.0	0.0	10.0	31.0	0.0	10.0	31.0	0.0
Act Effct Green (s)		35.2			35.2		32.8	26.8		32.8	26.8	
Actuated g/C Ratio		0.44			0.44		0.41	0.34		0.41	0.34	
v/c Ratio		0.90			0.73		0.81	0.87		0.98	0.79	
Control Delay		30.1			27.2		43.4	30.8		71.3	23.9	
Queue Delay		0.0			0.0		0.0	0.0		0.0	0.0	
Total Delay		30.1			27.2		43.4	30.8		71.3	23.9	
LOS		C			C		D	C		E	C	
Approach Delay		30.1			27.2			32.2			30.6	
Approach LOS		C			C			C			C	

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 80
Offset: 34 (43%), Referenced to phase 4:EBWB, Start of Green
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 0.98
Intersection Signal Delay: 30.3 Intersection LOS: C
Intersection Capacity Utilization 84.2% ICU Level of Service E
Analysis Period (min) 15

Splits and Phases: 121: E 1st Ave. & Clark Dr

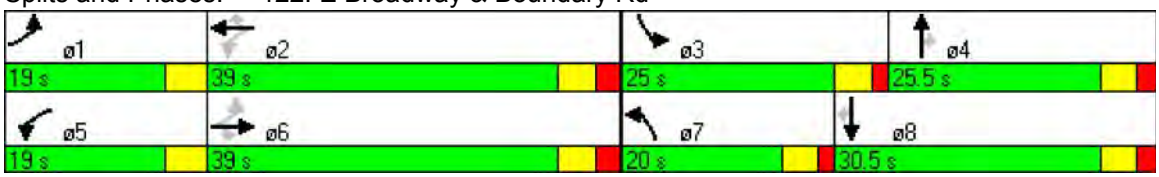


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	3539	1583	1770	3539	1583	3433	3539	1583	1770	3539	1583
Flt Permitted	0.114			0.114			0.950			0.950		
Satd. Flow (perm)	212	3539	1583	212	3539	1583	3433	3539	1583	1770	3539	1583
Satd. Flow (RTOR)			209			125			104			253
Volume (vph)	236	892	192	199	967	118	357	604	101	240	585	233
Lane Group Flow (vph)	257	970	209	216	1051	128	388	657	110	261	636	253
Turn Type	pm+pt		Perm	pm+pt		Perm	Prot		Perm	Prot		Perm
Protected Phases	1	6		5	2		7	4		3	8	
Permitted Phases	6		6	2		2			4			8
Total Split (s)	19.0	39.0	39.0	19.0	39.0	39.0	20.0	25.5	25.5	25.0	30.5	30.5
Act Effct Green (s)	48.7	34.9	34.9	46.5	33.8	33.8	15.3	21.3	21.3	19.0	25.0	25.0
Actuated g/C Ratio	0.47	0.34	0.34	0.45	0.32	0.32	0.15	0.20	0.20	0.18	0.24	0.24
v/c Ratio	0.84	0.82	0.31	0.76	0.91	0.21	0.77	0.91	0.27	0.81	0.75	0.44
Control Delay	49.1	39.1	5.1	40.1	47.2	6.1	54.7	59.2	10.2	61.0	43.3	6.9
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	49.1	39.1	5.1	40.1	47.2	6.1	54.7	59.2	10.2	61.0	43.3	6.9
LOS	D	D	A	D	D	A	D	E	B	E	D	A
Approach Delay		35.9			42.3			53.0			39.3	
Approach LOS		D			D			D			D	

Intersection Summary

Cycle Length: 108.5
Actuated Cycle Length: 104
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 0.91
Intersection Signal Delay: 42.3 Intersection LOS: D
Intersection Capacity Utilization 83.1% ICU Level of Service E
Analysis Period (min) 15

Splits and Phases: 122: E Broadway & Boundary Rd

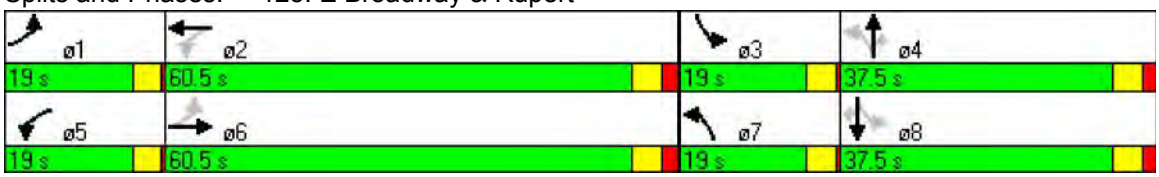


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	4912	0	1770	5055	0	1770	3539	1583	1770	3539	1583
Flt Permitted	0.108			0.071			0.281			0.294		
Satd. Flow (perm)	201	4912	0	132	5055	0	523	3539	1583	548	3539	1583
Satd. Flow (RTOR)		67			5				216			80
Volume (vph)	125	1194	351	223	1172	46	217	443	199	45	458	83
Lane Group Flow (vph)	136	1680	0	242	1324	0	236	482	216	49	498	90
Turn Type	pm+pt			pm+pt			pm+pt		Perm	pm+pt		Perm
Protected Phases	1	6		5	2		7	4		3	8	
Permitted Phases	6			2			4		4	8		8
Total Split (s)	19.0	60.5	0.0	19.0	60.5	0.0	19.0	37.5	37.5	19.0	37.5	37.5
Act Effct Green (s)	66.7	56.6		74.9	61.5		43.5	33.7	33.7	32.6	24.7	24.7
Actuated g/C Ratio	0.52	0.45		0.59	0.48		0.34	0.27	0.27	0.25	0.19	0.19
v/c Ratio	0.59	0.76		0.89	0.54		0.73	0.51	0.37	0.23	0.72	0.24
Control Delay	25.7	31.5		66.0	24.9		45.9	42.6	6.7	30.8	54.4	12.6
Queue Delay	0.0	0.0		0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	25.7	31.5		66.0	24.9		45.9	42.6	6.7	30.8	54.4	12.6
LOS	C	C		E	C		D	D	A	C	D	B
Approach Delay		31.0			31.2			35.1			46.7	
Approach LOS		C			C			D			D	

Intersection Summary

Cycle Length: 136
Actuated Cycle Length: 127.1
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 0.89
Intersection Signal Delay: 33.9 Intersection LOS: C
Intersection Capacity Utilization 81.3% ICU Level of Service D
Analysis Period (min) 15

Splits and Phases: 123: E Broadway & Rupert

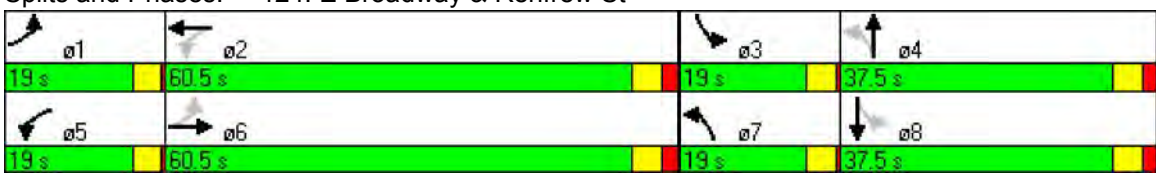


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	5019	0	1770	5029	0	1770	3429	0	1770	3465	0
Flt Permitted	0.071			0.071			0.165			0.119		
Satd. Flow (perm)	132	5019	0	132	5029	0	307	3429	0	222	3465	0
Satd. Flow (RTOR)		13			11			23			13	
Volume (vph)	202	1442	132	148	1475	112	154	581	155	135	510	85
Lane Group Flow (vph)	220	1710	0	161	1725	0	167	800	0	147	646	0
Turn Type	pm+pt			pm+pt			pm+pt			pm+pt		
Protected Phases	1	6		5	2		7	4		3	8	
Permitted Phases	6			2			4			8		
Total Split (s)	19.0	60.5	0.0	19.0	60.5	0.0	19.0	37.5	0.0	19.0	37.5	0.0
Act Effct Green (s)	67.0	53.1		62.9	51.0		44.1	31.5		43.0	31.0	
Actuated g/C Ratio	0.54	0.43		0.50	0.41		0.35	0.25		0.34	0.25	
v/c Ratio	0.86	0.80		0.72	0.84		0.65	0.91		0.65	0.74	
Control Delay	64.4	35.1		47.8	37.8		40.4	59.8		43.1	49.6	
Queue Delay	0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0	
Total Delay	64.4	35.1		47.8	37.8		40.4	59.8		43.1	49.6	
LOS	E	D		D	D		D	E		D	D	
Approach Delay		38.5			38.7			56.4			48.4	
Approach LOS		D			D			E			D	

Intersection Summary

Cycle Length: 136
Actuated Cycle Length: 124.9
Control Type: Semi Act-Uncoord
Maximum v/c Ratio: 0.91
Intersection Signal Delay: 43.1 Intersection LOS: D
Intersection Capacity Utilization 84.0% ICU Level of Service E
Analysis Period (min) 15

Splits and Phases: 124: E Broadway & Renfrew St

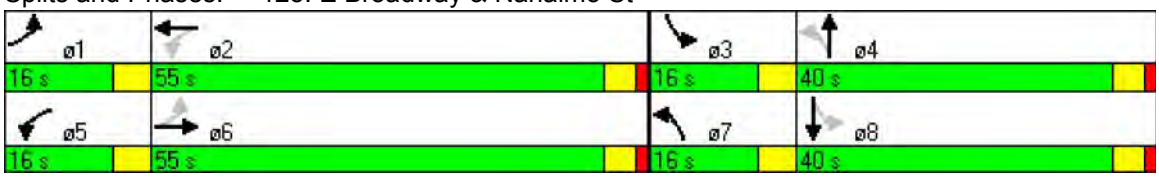


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	5045	0	1770	5050	0	1770	4953	0	1770	4887	0
Flt Permitted	0.078			0.078			0.181			0.199		
Satd. Flow (perm)	145	5045	0	145	5050	0	337	4953	0	371	4887	0
Satd. Flow (RTOR)		8			7			34			70	
Volume (vph)	167	1486	81	141	1582	79	87	627	129	121	587	208
Lane Group Flow (vph)	182	1703	0	153	1806	0	95	822	0	132	864	0
Turn Type	pm+pt			pm+pt			pm+pt			pm+pt		
Protected Phases	1	6		5	2		7	4		3	8	
Permitted Phases	6			2			4			8		
Total Split (s)	16.0	55.0	0.0	16.0	55.0	0.0	16.0	40.0	0.0	16.0	40.0	0.0
Act Effct Green (s)	63.2	52.2		61.4	51.3		34.9	25.5		37.7	28.9	
Actuated g/C Ratio	0.55	0.46		0.54	0.45		0.30	0.22		0.33	0.25	
v/c Ratio	0.77	0.74		0.69	0.80		0.44	0.73		0.53	0.67	
Control Delay	47.0	29.1		39.3	31.4		31.9	43.5		33.7	38.8	
Queue Delay	0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0	
Total Delay	47.0	29.1		39.3	31.4		31.9	43.5		33.7	38.8	
LOS	D	C		D	C		C	D		C	D	
Approach Delay		30.8			32.0			42.3			38.1	
Approach LOS		C			C			D			D	

Intersection Summary

Cycle Length: 127
Actuated Cycle Length: 114.3
Control Type: Semi Act-Uncoord
Maximum v/c Ratio: 0.80
Intersection Signal Delay: 34.3 Intersection LOS: C
Intersection Capacity Utilization 76.6% ICU Level of Service D
Analysis Period (min) 15

Splits and Phases: 125: E Broadway & Nanaimo St



Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	5070	0	1770	5055	0	1770	1863	1583	1770	1837	0
Flt Permitted	0.087			0.126			0.245			0.488		
Satd. Flow (perm)	162	5070	0	235	5055	0	456	1863	1583	909	1837	0
Satd. Flow (RTOR)		6			12				36		7	
Volume (vph)	78	1340	27	101	1588	62	37	235	109	211	367	38
Lane Group Flow (vph)	85	1486	0	110	1793	0	40	255	118	229	440	0
Turn Type	Perm			Perm			Perm		Perm	Perm		
Protected Phases		2			6			8			4	
Permitted Phases	2			6			8		8	4		
Total Split (s)	50.0	50.0	0.0	50.0	50.0	0.0	30.0	30.0	30.0	30.0	30.0	0.0
Act Effct Green (s)	46.0	46.0		46.0	46.0		26.0	26.0	26.0	26.0	26.0	
Actuated g/C Ratio	0.58	0.58		0.58	0.58		0.32	0.32	0.32	0.32	0.32	
v/c Ratio	0.91	0.51		0.81	0.62		0.27	0.42	0.22	0.78	0.73	
Control Delay	85.3	4.3		60.9	12.2		25.9	23.8	15.1	57.0	48.8	
Queue Delay	0.0	0.0		0.0	0.0		0.0	0.0	0.0	0.0	0.0	
Total Delay	85.3	4.3		60.9	12.2		25.9	23.8	15.1	57.0	48.8	
LOS	F	A		E	B		C	C	B	E	D	
Approach Delay		8.7			15.1			21.5			51.6	
Approach LOS		A			B			C			D	

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 80
Offset: 47 (59%), Referenced to phase 2:EBTL and 6:WBTL, Start of Green
Control Type: Pretimed
Maximum v/c Ratio: 0.91
Intersection Signal Delay: 18.8 Intersection LOS: B
Intersection Capacity Utilization 74.7% ICU Level of Service D
Analysis Period (min) 15

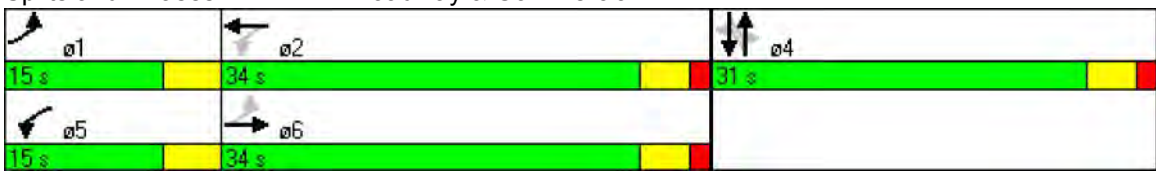
Splits and Phases: 126: E Broadway & Victoria Dr

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	5050	0	1770	5055	0	0	4969	0	0	4999	0
Flt Permitted	0.133			0.133				0.784			0.832	
Satd. Flow (perm)	248	5050	0	248	5055	0	0	3927	0	0	4184	0
Satd. Flow (RTOR)		11			8			25			18	
Volume (vph)	86	1375	70	82	1346	53	70	337	44	61	446	41
Lane Group Flow (vph)	93	1571	0	89	1521	0	0	490	0	0	596	0
Turn Type	pm+pt			pm+pt			Perm			Perm		
Protected Phases	1	6		5	2			4			4	
Permitted Phases	6			2			4			4		
Total Split (s)	15.0	34.0	0.0	15.0	34.0	0.0	31.0	31.0	0.0	31.0	31.0	0.0
Act Effct Green (s)	52.0	46.1		53.8	47.0			15.9			15.9	
Actuated g/C Ratio	0.65	0.58		0.67	0.59			0.20			0.20	
v/c Ratio	0.32	0.54		0.28	0.51			0.61			0.70	
Control Delay	7.7	12.6		12.5	17.8			30.8			42.8	
Queue Delay	0.0	0.0		0.0	0.0			0.0			0.0	
Total Delay	7.7	12.6		12.5	17.8			30.8			42.8	
LOS	A	B		B	B			C			D	
Approach Delay		12.3			17.5			30.8			42.8	
Approach LOS		B			B			C			D	

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 80
Offset: 47 (59%), Referenced to phase 2:WBTL and 6:EBTL, Start of Green
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 0.70
Intersection Signal Delay: 20.5 Intersection LOS: C
Intersection Capacity Utilization 65.7% ICU Level of Service C
Analysis Period (min) 15

Splits and Phases: 127: E Broadway & Commercial Dr

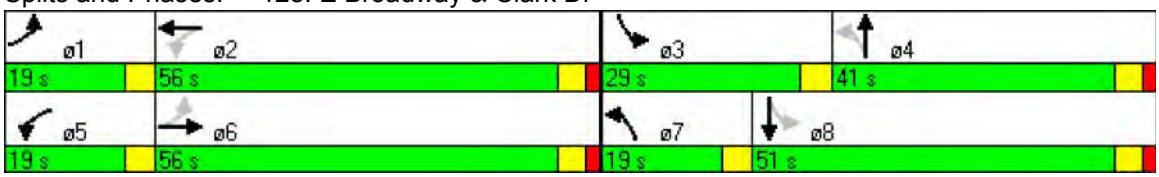


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	5040	0	1770	4979	0	1770	4943	0	1770	5014	0
Flt Permitted	0.077			0.077			0.108			0.098		
Satd. Flow (perm)	143	5040	0	143	4979	0	201	4943	0	183	5014	0
Satd. Flow (RTOR)		8			24			35			12	
Volume (vph)	112	1286	82	181	1148	189	71	767	178	372	1215	121
Lane Group Flow (vph)	122	1487	0	197	1453	0	77	1027	0	404	1453	0
Turn Type	pm+pt			pm+pt			pm+pt			pm+pt		
Protected Phases	1	6		5	2		7	4		3	8	
Permitted Phases	6			2			4			8		
Total Split (s)	19.0	56.0	0.0	19.0	56.0	0.0	19.0	41.0	0.0	29.0	51.0	0.0
Act Effct Green (s)	63.2	52.1		69.0	55.1		43.7	34.7		63.7	52.9	
Actuated g/C Ratio	0.45	0.37		0.49	0.39		0.30	0.24		0.45	0.37	
v/c Ratio	0.64	0.80		0.85	0.75		0.48	0.83		1.12	0.77	
Control Delay	41.9	44.6		65.1	40.4		35.6	56.0		122.9	43.3	
Queue Delay	0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0	
Total Delay	41.9	44.6		65.1	40.4		35.6	56.0		122.9	43.3	
LOS	D	D		E	D		D	E		F	D	
Approach Delay		44.4			43.3			54.5			60.6	
Approach LOS		D			D			D			E	

Intersection Summary

Cycle Length: 145
Actuated Cycle Length: 142
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 1.12
Intersection Signal Delay: 50.8 Intersection LOS: D
Intersection Capacity Utilization 89.4% ICU Level of Service E
Analysis Period (min) 15

Splits and Phases: 128: E Broadway & Clark Dr

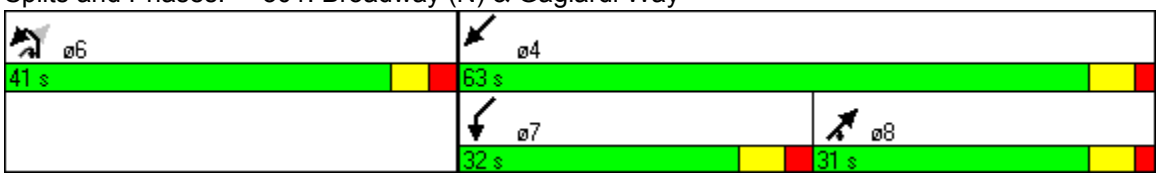


Lane Group	NBL	NBR	NET	NER	SWL	SWT
Lane Configurations						
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	3433	1583	3539	2787	3433	3539
Flt Permitted	0.950				0.950	
Satd. Flow (perm)	3433	1583	3539	2787	3433	3539
Satd. Flow (RTOR)		120				
Volume (vph)	410	110	158	1274	506	364
Lane Group Flow (vph)	446	120	172	1385	550	396
Turn Type		Perm		pt+ov	Prot	
Protected Phases	6		8	8 6	7	4
Permitted Phases		6				
Total Split (s)	41.0	41.0	31.0	72.0	32.0	63.0
Act Effct Green (s)	28.5	28.5	26.9	59.6	22.1	53.1
Actuated g/C Ratio	0.32	0.32	0.30	0.66	0.25	0.59
v/c Ratio	0.41	0.21	0.16	0.75	0.65	0.19
Control Delay	25.3	5.4	27.0	13.9	35.4	9.7
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	25.3	5.4	27.0	13.9	35.4	9.7
LOS	C	A	C	B	D	A
Approach Delay	21.1		15.4			24.7
Approach LOS	C		B			C

Intersection Summary

Cycle Length: 104
Actuated Cycle Length: 89.9
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 0.75
Intersection Signal Delay: 19.3 Intersection LOS: B
Intersection Capacity Utilization 65.7% ICU Level of Service C
Analysis Period (min) 15

Splits and Phases: 301: Broadway (N) & Gaglardi Way

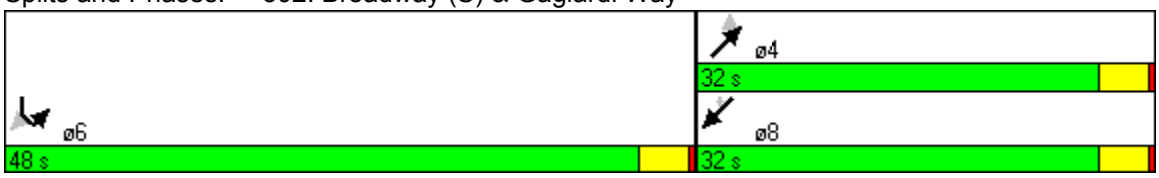


Lane Group	SBL	SBR	NEL	NET	SWT	SWR
Lane Configurations						
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	1583	1770	3539	3539	1583
Flt Permitted	0.950		0.267			
Satd. Flow (perm)	1770	1583	497	3539	3539	1583
Satd. Flow (RTOR)		82				158
Volume (vph)	612	131	68	760	627	145
Lane Group Flow (vph)	665	142	74	826	682	158
Turn Type		Perm	Perm			Perm
Protected Phases	6			4	8	
Permitted Phases		6	4			8
Total Split (s)	48.0	48.0	32.0	32.0	32.0	32.0
Act Effct Green (s)	44.2	44.2	23.0	23.0	23.0	23.0
Actuated g/C Ratio	0.59	0.59	0.31	0.31	0.31	0.31
v/c Ratio	0.64	0.15	0.49	0.76	0.63	0.27
Control Delay	14.9	4.4	33.0	28.6	25.1	4.6
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	14.9	4.4	33.0	28.6	25.1	4.6
LOS	B	A	C	C	C	A
Approach Delay	13.0			29.0	21.2	
Approach LOS	B			C	C	

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 75.2
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 0.76
Intersection Signal Delay: 21.4 Intersection LOS: C
Intersection Capacity Utilization 65.0% ICU Level of Service C
Analysis Period (min) 15

Splits and Phases: 302: Broadway (S) & Gaglardi Way

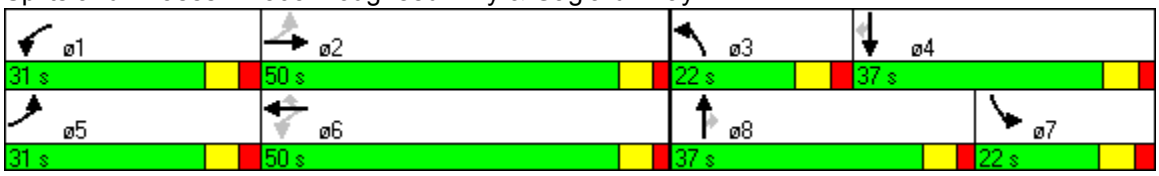


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	3352	0	1770	3539	1583	3433	3539	1583	1770	3539	1583
Flt Permitted	0.304			0.087			0.950			0.950		
Satd. Flow (perm)	566	3352	0	162	3539	1583	3433	3539	1583	1770	3539	1583
Satd. Flow (RTOR)		80				52			384			114
Volume (vph)	234	820	453	285	514	61	233	637	496	125	495	105
Lane Group Flow (vph)	254	1383	0	310	559	66	253	692	539	136	538	114
Turn Type	pm+pt			pm+pt		Perm	Prot		Perm	Prot		Perm
Protected Phases	5	2		1	6		3	8		7	4	
Permitted Phases	2			6		6			8			4
Total Split (s)	31.0	50.0	0.0	31.0	50.0	50.0	22.0	37.0	37.0	22.0	37.0	37.0
Act Effct Green (s)	68.7	50.0		78.7	56.2	56.2	17.0	32.3	32.3	16.7	32.0	32.0
Actuated g/C Ratio	0.49	0.36		0.56	0.40	0.40	0.12	0.23	0.23	0.12	0.23	0.23
v/c Ratio	0.58	1.11		0.82	0.39	0.10	0.61	0.85	0.82	0.64	0.67	0.25
Control Delay	22.4	99.9		53.2	32.0	10.8	64.8	62.2	25.1	73.1	53.5	8.6
Queue Delay	0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	22.4	99.9		53.2	32.0	10.8	64.8	62.2	25.1	73.1	53.5	8.6
LOS	C	F		D	C	B	E	E	C	E	D	A
Approach Delay		87.9			37.5			49.2			50.4	
Approach LOS		F			D			D			D	

Intersection Summary

Cycle Length: 140
Actuated Cycle Length: 140
Offset: 32 (23%), Referenced to phase 2:EBTL and 6:WBTL, Start of Green
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 1.11
Intersection Signal Delay: 60.2 Intersection LOS: E
Intersection Capacity Utilization 90.8% ICU Level of Service E
Analysis Period (min) 15

Splits and Phases: 303: Lougheed Hwy & Gaglardi Way

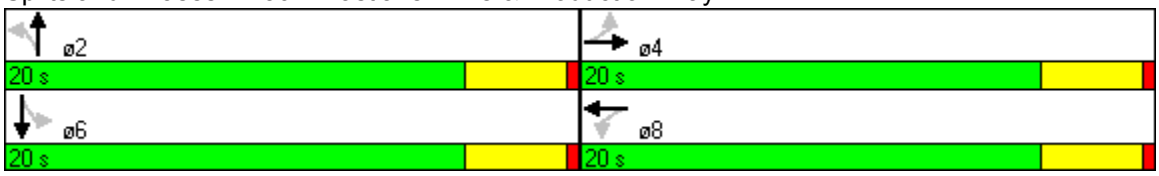


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	0	3378	0	0	3375	0	1770	1766	0	1770	1775	0
Flt Permitted		0.735			0.763		0.611			0.445		
Satd. Flow (perm)	0	2541	0	0	2614	0	1138	1766	0	829	1775	0
Satd. Flow (RTOR)		60			48			79			68	
Volume (vph)	239	198	77	63	102	44	47	235	123	61	150	68
Lane Group Flow (vph)	0	559	0	0	227	0	51	389	0	66	237	0
Turn Type	Perm			Perm			Perm			Perm		
Protected Phases		4			8			2			6	
Permitted Phases	4			8			2			6		
Total Split (s)	20.0	20.0	0.0	20.0	20.0	0.0	20.0	20.0	0.0	20.0	20.0	0.0
Act Effct Green (s)		16.0			16.0		16.0	16.0		16.0	16.0	
Actuated g/C Ratio		0.40			0.40		0.40	0.40		0.40	0.40	
v/c Ratio		0.53			0.21		0.11	0.52		0.20	0.32	
Control Delay		10.4			6.8		8.4	10.1		9.8	7.3	
Queue Delay		0.0			0.0		0.0	0.0		0.0	0.0	
Total Delay		10.4			6.8		8.4	10.1		9.8	7.3	
LOS		B			A		A	B		A	A	
Approach Delay		10.4			6.8			9.9			7.8	
Approach LOS		B			A			A			A	

Intersection Summary

Cycle Length: 40
Actuated Cycle Length: 40
Offset: 0 (0%), Referenced to phase 2:NBTL and 6:SBTL, Start of Green
Control Type: Pretimed
Maximum v/c Ratio: 0.53
Intersection Signal Delay: 9.2 Intersection LOS: A
Intersection Capacity Utilization 57.5% ICU Level of Service B
Analysis Period (min) 15

Splits and Phases: 304: Eastlake Drive & Production Way

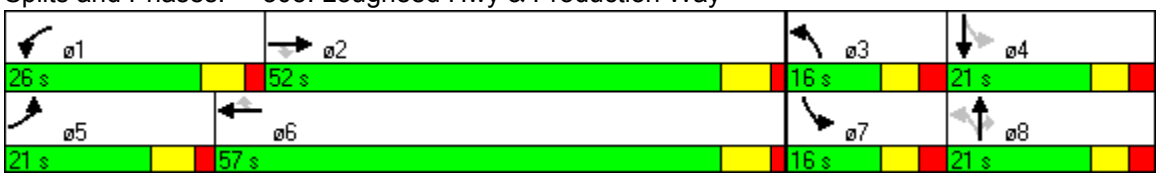


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	3539	1583	1770	3539	1583	1770	1863	1583	1770	3228	0
Flt Permitted	0.950			0.950			0.351			0.363		
Satd. Flow (perm)	1770	3539	1583	1770	3539	1583	654	1863	1583	676	3228	0
Satd. Flow (RTOR)			55			116			268		190	
Volume (vph)	59	999	99	153	688	107	113	172	265	236	123	175
Lane Group Flow (vph)	64	1086	108	166	748	116	123	187	288	257	324	0
Turn Type	Prot		Perm	Prot		Perm	pm+pt		Perm	pm+pt		
Protected Phases	5	2		1	6		3	8		7	4	
Permitted Phases			2			6	8		8	4		
Total Split (s)	21.0	52.0	52.0	26.0	57.0	57.0	16.0	21.0	21.0	16.0	21.0	0.0
Act Effct Green (s)	11.8	38.9	38.9	16.5	47.1	47.1	26.6	15.3	15.3	28.9	19.8	
Actuated g/C Ratio	0.12	0.39	0.39	0.17	0.47	0.47	0.26	0.15	0.15	0.29	0.20	
v/c Ratio	0.31	0.78	0.17	0.56	0.45	0.14	0.42	0.65	0.61	0.77	0.41	
Control Delay	48.4	31.5	11.7	48.2	19.4	3.6	33.3	54.1	13.3	48.8	19.1	
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
Total Delay	48.4	31.5	11.7	48.2	19.4	3.6	33.3	54.1	13.3	48.8	19.1	
LOS	D	C	B	D	B	A	C	D	B	D	B	
Approach Delay		30.6			22.3			30.2			32.2	
Approach LOS		C			C			C			C	

Intersection Summary

Cycle Length: 115
Actuated Cycle Length: 99.5
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 0.78
Intersection Signal Delay: 28.3 Intersection LOS: C
Intersection Capacity Utilization 71.6% ICU Level of Service C
Analysis Period (min) 15

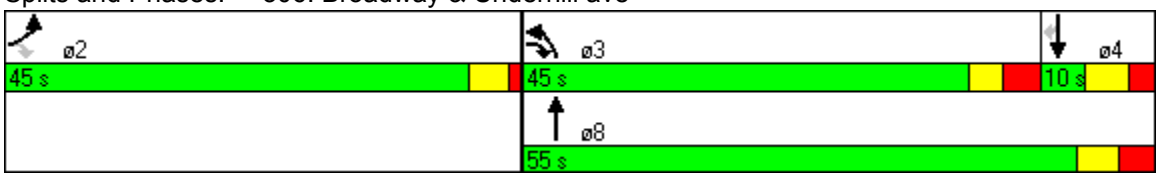
Splits and Phases: 305: Lougheed Hwy & Production Way



Lane Group	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	1583	1770	1863	1863	1583
Flt Permitted	0.950		0.950			
Satd. Flow (perm)	1770	1583	1770	1863	1863	1583
Satd. Flow (RTOR)		92				50
Volume (vph)	57	327	266	53	103	46
Lane Group Flow (vph)	62	355	289	58	112	50
Turn Type		pm+ov	Prot			Perm
Protected Phases	2	3	3	8	4	
Permitted Phases		2				4
Total Split (s)	45.0	45.0	45.0	55.0	10.0	10.0
Act Effct Green (s)	8.4	27.3	14.8	25.0	6.1	6.1
Actuated g/C Ratio	0.20	0.66	0.36	0.60	0.15	0.15
v/c Ratio	0.17	0.33	0.46	0.05	0.41	0.18
Control Delay	16.9	2.9	12.6	3.4	23.8	9.3
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	16.9	2.9	12.6	3.4	23.8	9.3
LOS	B	A	B	A	C	A
Approach Delay	5.0			11.0	19.3	
Approach LOS	A			B	B	

Intersection Summary	
Cycle Length: 100	
Actuated Cycle Length: 41.6	
Control Type: Actuated-Uncoordinated	
Maximum v/c Ratio: 0.46	
Intersection Signal Delay: 9.8	Intersection LOS: A
Intersection Capacity Utilization 33.9%	ICU Level of Service A
Analysis Period (min) 15	

Splits and Phases: 306: Broadway & Underhill ave

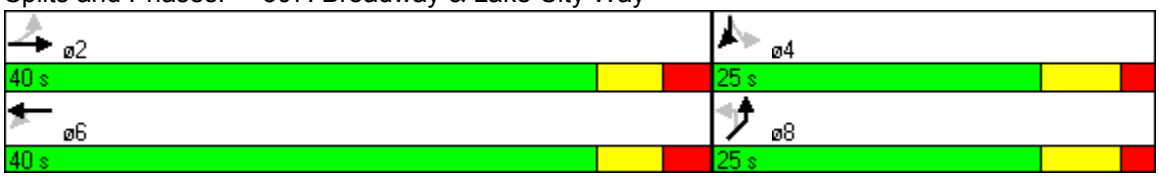


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	SBL	SBR	SBR2	NEL2	NEL	NER
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	0	1820	0	0	1764	0	1770	1583	0	1770	1717	0
Flt Permitted		0.973			0.962		0.663			0.711	0.967	
Satd. Flow (perm)	0	1776	0	0	1704	0	1235	1583	0	1324	1717	0
Satd. Flow (RTOR)		21			71			18			37	
Volume (vph)	20	262	49	20	149	97	84	48	17	47	93	42
Lane Group Flow (vph)	0	360	0	0	289	0	91	70	0	51	147	0
Turn Type	Perm			Perm			Perm			Perm		
Protected Phases		2			6			4			8	
Permitted Phases	2			6			4			8		
Total Split (s)	40.0	40.0	0.0	40.0	40.0	0.0	25.0	25.0	0.0	25.0	25.0	0.0
Act Effct Green (s)		15.1			15.1		11.2	11.2		11.2	11.2	
Actuated g/C Ratio		0.45			0.45		0.35	0.35		0.35	0.35	
v/c Ratio		0.44			0.36		0.21	0.12		0.11	0.24	
Control Delay		7.7			6.0		10.4	7.9		9.6	8.2	
Queue Delay		0.0			0.0		0.0	0.0		0.0	0.0	
Total Delay		7.7			6.0		10.4	7.9		9.6	8.2	
LOS		A			A		B	A		A	A	
Approach Delay		7.7			6.0		9.3				8.6	
Approach LOS		A			A		A				A	

Intersection Summary

Cycle Length: 65
Actuated Cycle Length: 27
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 0.44
Intersection Signal Delay: 7.6 Intersection LOS: A
Intersection Capacity Utilization 45.7% ICU Level of Service A
Analysis Period (min) 15

Splits and Phases: 307: Broadway & Lake City Way

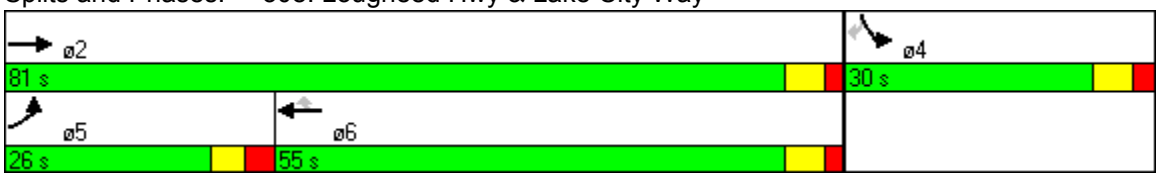


Lane Group	EBL	EBT	WBT	WBR	SBL	SBR
Lane Configurations						
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	3539	3539	1583	1770	1583
Flt Permitted	0.950				0.950	
Satd. Flow (perm)	1770	3539	3539	1583	1770	1583
Satd. Flow (RTOR)				195		173
Volume (vph)	108	1288	877	179	187	159
Lane Group Flow (vph)	117	1400	953	195	203	173
Turn Type	Prot			Perm		Perm
Protected Phases	5	2	6		4	
Permitted Phases				6		4
Total Split (s)	26.0	81.0	55.0	55.0	30.0	30.0
Act Effct Green (s)	12.7	46.9	33.3	33.3	15.4	15.4
Actuated g/C Ratio	0.17	0.66	0.47	0.47	0.22	0.22
v/c Ratio	0.38	0.60	0.57	0.23	0.52	0.36
Control Delay	32.2	8.3	17.6	3.3	30.6	7.1
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	32.2	8.3	17.6	3.3	30.6	7.1
LOS	C	A	B	A	C	A
Approach Delay		10.1	15.2		19.8	
Approach LOS		B	B		B	

Intersection Summary

Cycle Length: 111
Actuated Cycle Length: 70.7
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 0.60
Intersection Signal Delay: 13.2 Intersection LOS: B
Intersection Capacity Utilization 52.6% ICU Level of Service A
Analysis Period (min) 15

Splits and Phases: 308: Lougheed Hwy & Lake City Way

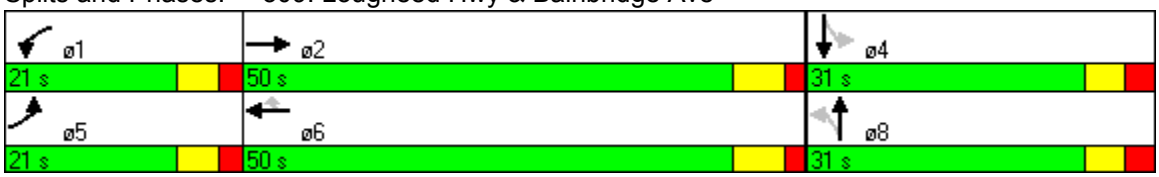


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	3518	0	1770	3539	1583	0	1780	0	0	1742	0
Flt Permitted	0.950			0.950				0.858			0.779	
Satd. Flow (perm)	1770	3518	0	1770	3539	1583	0	1552	0	0	1387	0
Satd. Flow (RTOR)		5				55		13			23	
Volume (vph)	115	1116	48	28	894	85	41	62	28	83	40	59
Lane Group Flow (vph)	125	1265	0	30	972	92	0	142	0	0	197	0
Turn Type	Prot			Prot		Perm	Perm			Perm		
Protected Phases	5	2		1	6			8			4	
Permitted Phases						6	8			4		
Total Split (s)	21.0	50.0	0.0	21.0	50.0	50.0	31.0	31.0	0.0	31.0	31.0	0.0
Act Effct Green (s)	12.4	49.2		9.5	40.4	40.4		17.0			17.0	
Actuated g/C Ratio	0.16	0.66		0.12	0.54	0.54		0.22			0.22	
v/c Ratio	0.44	0.55		0.15	0.51	0.10		0.41			0.61	
Control Delay	35.8	12.6		38.7	17.0	7.8		26.9			32.2	
Queue Delay	0.0	0.0		0.0	0.0	0.0		0.0			0.0	
Total Delay	35.8	12.6		38.7	17.0	7.8		26.9			32.2	
LOS	D	B		D	B	A		C			C	
Approach Delay		14.7			16.8			26.9			32.2	
Approach LOS		B			B			C			C	

Intersection Summary

Cycle Length: 102
Actuated Cycle Length: 74.8
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 0.61
Intersection Signal Delay: 17.4 Intersection LOS: B
Intersection Capacity Utilization 64.2% ICU Level of Service C
Analysis Period (min) 15

Splits and Phases: 309: Lougheed Hwy & Bainbridge Ave

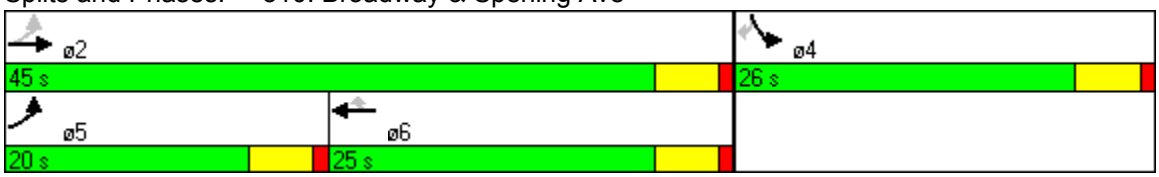


Lane Group	EBL	EBT	WBT	WBR	SBL	SBR
Lane Configurations						
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	1863	1863	1583	1770	1583
Flt Permitted	0.404				0.950	
Satd. Flow (perm)	753	1863	1863	1583	1770	1583
Satd. Flow (RTOR)				66		150
Volume (vph)	347	554	234	61	46	138
Lane Group Flow (vph)	377	602	254	66	50	150
Turn Type	pm+pt			Perm		Perm
Protected Phases	5	2	6		4	
Permitted Phases	2			6		4
Total Split (s)	20.0	45.0	25.0	25.0	26.0	26.0
Act Effct Green (s)	31.9	33.2	14.1	14.1	8.8	8.8
Actuated g/C Ratio	0.70	0.73	0.31	0.31	0.18	0.18
v/c Ratio	0.46	0.44	0.44	0.12	0.15	0.36
Control Delay	5.5	5.3	17.6	5.2	19.8	7.4
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	5.5	5.3	17.6	5.2	19.8	7.4
LOS	A	A	B	A	B	A
Approach Delay		5.3	15.1		10.5	
Approach LOS		A	B		B	

Intersection Summary

Cycle Length: 71
Actuated Cycle Length: 45.7
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 0.46
Intersection Signal Delay: 8.1 Intersection LOS: A
Intersection Capacity Utilization 47.4% ICU Level of Service A
Analysis Period (min) 15

Splits and Phases: 310: Broadway & Sperling Ave

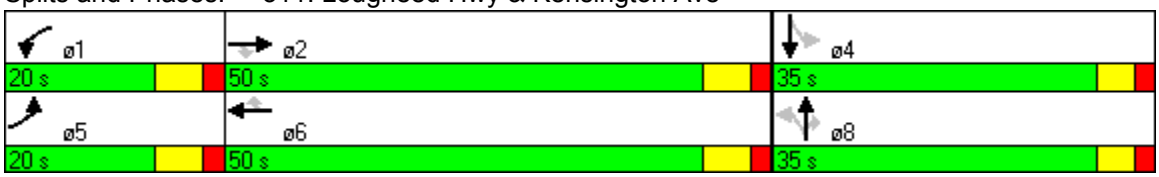


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	5085	1583	1770	3539	1583	1770	1863	1583	1770	3348	0
Flt Permitted	0.950			0.950			0.691			0.377		
Satd. Flow (perm)	1770	5085	1583	1770	3539	1583	1287	1863	1583	702	3348	0
Satd. Flow (RTOR)			120			161			20		35	
Volume (vph)	49	1323	231	14	788	231	232	275	18	64	57	32
Lane Group Flow (vph)	53	1438	251	15	857	251	252	299	20	70	97	0
Turn Type	Prot		Perm	Prot		Perm	Perm		Perm	Perm		
Protected Phases	5	2		1	6			8			4	
Permitted Phases			2			6	8		8	4		
Total Split (s)	20.0	50.0	50.0	20.0	50.0	50.0	35.0	35.0	35.0	35.0	35.0	0.0
Act Effct Green (s)	11.1	33.9	33.9	10.4	28.4	28.4	19.2	19.2	19.2	19.2	19.2	
Actuated g/C Ratio	0.16	0.53	0.53	0.14	0.44	0.44	0.30	0.30	0.30	0.30	0.30	
v/c Ratio	0.19	0.54	0.28	0.06	0.55	0.32	0.66	0.54	0.04	0.33	0.09	
Control Delay	34.0	12.1	6.8	39.4	17.6	7.8	32.3	25.8	10.4	27.3	14.4	
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
Total Delay	34.0	12.1	6.8	39.4	17.6	7.8	32.3	25.8	10.4	27.3	14.4	
LOS	C	B	A	D	B	A	C	C	B	C	B	
Approach Delay		12.0			15.7			28.1			19.9	
Approach LOS		B			B			C			B	

Intersection Summary

Cycle Length: 105
Actuated Cycle Length: 64.4
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 0.66
Intersection Signal Delay: 16.1 Intersection LOS: B
Intersection Capacity Utilization 65.0% ICU Level of Service C
Analysis Period (min) 15

Splits and Phases: 311: Lougheed Hwy & Kensington Ave

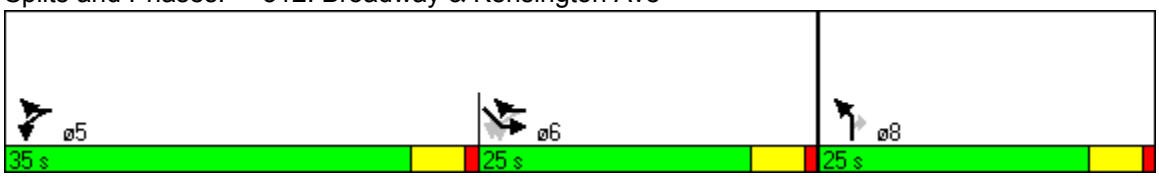


Lane Group	WBL	WBR	NBL	NBR	SEL	SER
Lane Configurations						
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	1583	1770	1583	1770	1583
Flt Permitted	0.405		0.950		0.950	
Satd. Flow (perm)	754	1583	1770	1583	1770	1583
Satd. Flow (RTOR)		124		627		205
Volume (vph)	263	114	352	577	239	189
Lane Group Flow (vph)	286	124	383	627	260	205
Turn Type	pm+pt			Perm		Perm
Protected Phases	5	5 6	8		6	
Permitted Phases	5 6			8		6
Total Split (s)	35.0	60.0	25.0	25.0	25.0	25.0
Act Effct Green (s)	26.4	30.6	18.3	18.3	14.4	14.4
Actuated g/C Ratio	0.46	0.53	0.32	0.32	0.25	0.25
v/c Ratio	0.51	0.14	0.68	0.67	0.58	0.37
Control Delay	11.3	1.9	26.1	6.1	25.7	5.5
Queue Delay	0.0	0.0	0.1	0.0	0.0	0.0
Total Delay	11.3	1.9	26.2	6.1	25.7	5.5
LOS	B	A	C	A	C	A
Approach Delay	8.4		13.7		16.8	
Approach LOS	A		B		B	

Intersection Summary

Cycle Length: 85
Actuated Cycle Length: 57.3
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 0.68
Intersection Signal Delay: 13.3 Intersection LOS: B
Intersection Capacity Utilization 57.3% ICU Level of Service B
Analysis Period (min) 15

Splits and Phases: 312: Broadway & Kensington Ave

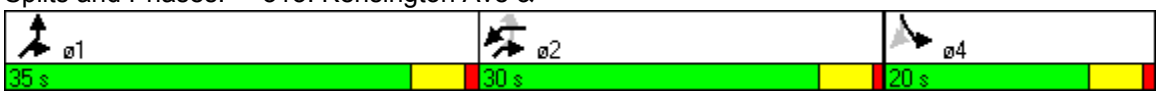


Lane Group	WBL	WBR	SBL	SBR	NEL	NER
Lane Configurations						
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	3433	1583	1770	1583	1770	1504
Flt Permitted	0.950		0.950			
Satd. Flow (perm)	3433	1583	1770	1583	1863	1504
Satd. Flow (RTOR)		143		311		68
Volume (vph)	375	132	78	286	697	63
Lane Group Flow (vph)	408	143	85	311	758	68
Turn Type		Perm		Perm	pm+pt	
Protected Phases	2		4		1	1 2
Permitted Phases		2		4	1 2	
Total Split (s)	30.0	30.0	20.0	20.0	35.0	65.0
Act Effct Green (s)	13.5	13.5	10.3	10.3	37.6	37.6
Actuated g/C Ratio	0.24	0.24	0.18	0.18	0.67	0.67
v/c Ratio	0.50	0.29	0.26	0.57	0.61	0.07
Control Delay	22.1	6.4	25.8	8.4	7.7	1.2
Queue Delay	0.0	0.0	0.0	0.0	0.1	0.0
Total Delay	22.1	6.4	25.8	8.4	7.7	1.2
LOS	C	A	C	A	A	A
Approach Delay	18.0		12.1		7.2	
Approach LOS	B		B		A	

Intersection Summary

Cycle Length: 85
Actuated Cycle Length: 56.4
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 0.61
Intersection Signal Delay: 11.7 Intersection LOS: B
Intersection Capacity Utilization 66.4% ICU Level of Service C
Analysis Period (min) 15

Splits and Phases: 313: Kensington Ave &

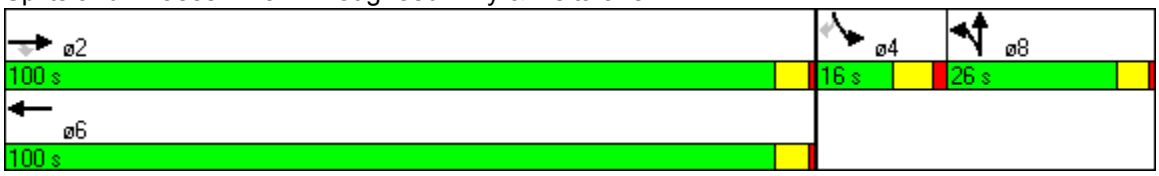


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	0	3539	1583	0	3500	0	1681	1711	0	1770	0	1583
Flt Permitted							0.950	0.967		0.950		
Satd. Flow (perm)	0	3539	1583	0	3500	0	1681	1711	0	1770	0	1583
Satd. Flow (RTOR)			272		12							14
Volume (vph)	0	1760	310	0	1132	87	253	50	0	74	0	13
Lane Group Flow (vph)	0	1913	337	0	1325	0	160	169	0	80	0	14
Turn Type			Perm				Split			Prot		custom
Protected Phases		2			6		8	8		4		
Permitted Phases			2									4
Total Split (s)	0.0	100.0	100.0	0.0	100.0	0.0	26.0	26.0	0.0	16.0	0.0	16.0
Act Effct Green (s)		99.6	99.6		99.6		18.9	18.9		11.6		11.6
Actuated g/C Ratio		0.70	0.70		0.70		0.13	0.13		0.08		0.08
v/c Ratio		0.77	0.28		0.54		0.72	0.74		0.56		0.10
Control Delay		17.2	2.4		11.5		76.6	78.6		77.6		27.0
Queue Delay		0.0	0.0		0.0		0.0	0.0		0.0		0.0
Total Delay		17.2	2.4		11.5		76.6	78.6		77.6		27.0
LOS		B	A		B		E	E		E		C
Approach Delay		15.0			11.5			77.6				
Approach LOS		B			B			E				

Intersection Summary

Cycle Length: 142
Actuated Cycle Length: 142
Offset: 58 (41%), Referenced to phase 2:EBT and 6:WBT, Start of Green
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 0.77
Intersection Signal Delay: 20.3 Intersection LOS: C
Intersection Capacity Utilization 70.3% ICU Level of Service C
Analysis Period (min) 15

Splits and Phases: 314: Lougheed Hwy & Delta ave

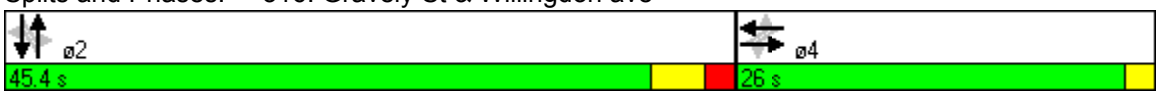


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	0	1681	0	0	1701	0	0	3500	0	0	3514	0
Flt Permitted		0.986			0.931			0.877			0.865	
Satd. Flow (perm)	0	1666	0	0	1611	0	0	3079	0	0	3046	0
Satd. Flow (RTOR)		51			28			14			7	
Volume (vph)	6	15	47	17	6	26	53	905	56	32	609	20
Lane Group Flow (vph)	0	74	0	0	53	0	0	1103	0	0	719	0
Turn Type	Perm			Perm			Perm			Perm		
Protected Phases		4			4			2			2	
Permitted Phases	4			4			2			2		
Total Split (s)	26.0	26.0	0.0	26.0	26.0	0.0	45.4	45.4	0.0	45.4	45.4	0.0
Act Effct Green (s)		22.0			22.0			41.4			41.4	
Actuated g/C Ratio		0.31			0.31			0.58			0.58	
v/c Ratio		0.13			0.10			0.62			0.41	
Control Delay		9.1			10.2			11.5			9.0	
Queue Delay		0.0			0.0			0.0			0.0	
Total Delay		9.1			10.2			11.5			9.0	
LOS		A			B			B			A	
Approach Delay		9.1			10.2			11.5			9.0	
Approach LOS		A			B			B			A	

Intersection Summary

Cycle Length: 71.4
Actuated Cycle Length: 71.4
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 0.62
Intersection Signal Delay: 10.5 Intersection LOS: B
Intersection Capacity Utilization 80.6% ICU Level of Service D
Analysis Period (min) 15

Splits and Phases: 316: Gravely St & Willingdon ave

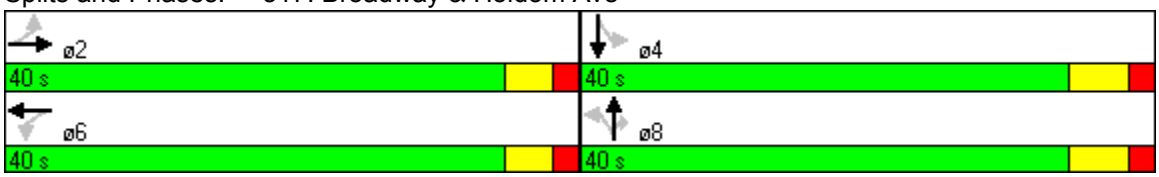


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	0	1816	0	1770	1751	0	0	1853	1583	0	1829	0
Flt Permitted		0.914		0.498				0.944			0.906	
Satd. Flow (perm)	0	1675	0	928	1751	0	0	1758	1583	0	1671	0
Satd. Flow (RTOR)		11			54				160		7	
Volume (vph)	57	223	39	90	110	73	29	242	147	46	208	20
Lane Group Flow (vph)	0	346	0	98	199	0	0	295	160	0	298	0
Turn Type	Perm			Perm			Perm		Perm	Perm		
Protected Phases		2			6			8			4	
Permitted Phases	2			6			8		8	4		
Total Split (s)	40.0	40.0	0.0	40.0	40.0	0.0	40.0	40.0	40.0	40.0	40.0	0.0
Act Effct Green (s)		13.9		13.9	13.9			14.8	14.8		14.8	
Actuated g/C Ratio		0.37		0.37	0.37			0.40	0.40		0.40	
v/c Ratio		0.54		0.28	0.29			0.42	0.22		0.44	
Control Delay		12.6		11.0	7.5			11.2	3.0		11.4	
Queue Delay		0.0		0.0	0.0			0.0	0.0		0.0	
Total Delay		12.7		11.0	7.5			11.3	3.0		11.4	
LOS		B		B	A			B	A		B	
Approach Delay		12.7			8.7			8.4			11.4	
Approach LOS		B			A			A			B	

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 37.1
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 0.54
Intersection Signal Delay: 10.1 Intersection LOS: B
Intersection Capacity Utilization 69.9% ICU Level of Service C
Analysis Period (min) 15

Splits and Phases: 317: Broadway & Holdom Ave

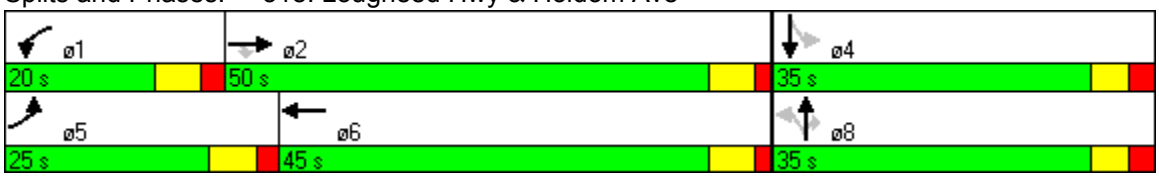


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	3539	1583	1770	3511	0	0	3514	1583	0	3329	0
Flt Permitted	0.950			0.950				0.817			0.704	
Satd. Flow (perm)	1770	3539	1583	1770	3511	0	0	2892	1583	0	2372	0
Satd. Flow (RTOR)			29		7				236		76	
Volume (vph)	114	1274	52	111	1012	60	50	304	217	88	165	120
Lane Group Flow (vph)	124	1385	57	121	1165	0	0	384	236	0	405	0
Turn Type	Prot		Perm	Prot			Perm		Perm	Perm		
Protected Phases	5	2		1	6			8			4	
Permitted Phases			2				8		8	4		
Total Split (s)	25.0	50.0	50.0	20.0	45.0	0.0	35.0	35.0	35.0	35.0	35.0	0.0
Act Effct Green (s)	14.3	38.9	38.9	13.5	38.2			19.4	19.4		19.4	
Actuated g/C Ratio	0.17	0.48	0.48	0.16	0.47			0.24	0.24		0.24	
v/c Ratio	0.41	0.81	0.07	0.42	0.70			0.55	0.42		0.64	
Control Delay	39.8	24.5	8.9	41.6	21.6			33.0	6.7		30.0	
Queue Delay	0.0	0.0	0.0	0.0	0.0			0.0	0.0		0.2	
Total Delay	39.9	24.5	8.9	41.6	21.6			33.0	6.7		30.1	
LOS	D	C	A	D	C			C	A		C	
Approach Delay		25.1			23.5			23.0			30.1	
Approach LOS		C			C			C			C	

Intersection Summary

Cycle Length: 105
Actuated Cycle Length: 80.5
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 0.81
Intersection Signal Delay: 24.8 Intersection LOS: C
Intersection Capacity Utilization 75.5% ICU Level of Service D
Analysis Period (min) 15

Splits and Phases: 318: Lougheed Hwy & Holdom Ave



Lane Group	WBL	WBR	NBR	NBR2	SWL2	SWL
Lane Configurations						
Satd. Flow (prot)	1770	1583	1583	1583	1770	1770
Flt Permitted	0.950				0.950	0.950
Satd. Flow (perm)	1770	1583	1583	1583	1770	1770
Volume (vph)	118	91	79	689	66	44
Lane Group Flow (vph)	128	99	86	749	72	48
Sign Control	Free		Free			Stop

Intersection Summary	
Control Type: Unsignalized	
Intersection Capacity Utilization 46.0%	ICU Level of Service A
Analysis Period (min) 15	

Lane Group	EBL	EBT	WBT	WBR	SBL	SBR
Lane Configurations						
Satd. Flow (prot)	1770	3539	3539	1583	1770	1583
Flt Permitted	0.950				0.950	
Satd. Flow (perm)	1770	3539	3539	1583	1770	1583
Volume (vph)	273	1170	926	104	148	73
Lane Group Flow (vph)	297	1272	1007	113	161	79
Sign Control		Free	Free		Stop	

Intersection Summary	
Control Type: Unsignalized	
Intersection Capacity Utilization 58.9%	ICU Level of Service B
Analysis Period (min) 15	

Lane Group	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Satd. Flow (prot)	1631	0	1693	0	0	1796
Flt Permitted	0.994					0.964
Satd. Flow (perm)	1631	0	1693	0	0	1796
Volume (vph)	26	192	133	275	324	107
Lane Group Flow (vph)	237	0	444	0	0	468
Sign Control	Stop		Free			Free

Intersection Summary	
Control Type: Unsignalized	
Intersection Capacity Utilization 70.8%	ICU Level of Service C
Analysis Period (min) 15	

Lane Group	EBL	EBT	WBT	WBR	SBL	SBR
Lane Configurations						
Satd. Flow (prot)	0	1812	1790	0	1672	0
Flt Permitted		0.973			0.983	
Satd. Flow (perm)	0	1812	1790	0	1672	0
Volume (vph)	310	242	146	59	80	146
Lane Group Flow (vph)	0	600	223	0	246	0
Sign Control		Stop	Stop		Stop	

Intersection Summary	
Control Type: Unsignalized	
Intersection Capacity Utilization 64.6%	ICU Level of Service C
Analysis Period (min) 15	

Lane Group	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Satd. Flow (prot)	1820	0	0	1835	1660	0
Flt Permitted				0.985	0.985	
Satd. Flow (perm)	1820	0	0	1835	1660	0
Volume (vph)	383	77	86	202	83	196
Lane Group Flow (vph)	500	0	0	313	303	0
Sign Control	Free			Free	Stop	

Intersection Summary	
Control Type: Unsignalized	
Intersection Capacity Utilization 66.9%	ICU Level of Service C
Analysis Period (min) 15	

Lane Group	EBL	EBR	SBL	SBR	NWL	NWR
Lane Configurations						
Satd. Flow (prot)	1664	0	1742	0	1770	1583
Flt Permitted	0.985		0.962		0.950	
Satd. Flow (perm)	1664	0	1742	0	1770	1583
Volume (vph)	112	248	144	39	223	244
Lane Group Flow (vph)	392	0	199	0	242	265
Sign Control	Stop		Stop		Stop	

Intersection Summary	
Control Type: Unsignalized	
Intersection Capacity Utilization 54.2%	ICU Level of Service A
Analysis Period (min) 15	

Lane Group	NBL	NBT	SBT	SBR	SEL	SER
Lane Configurations						
Satd. Flow (prot)	0	1829	1725	0	1694	0
Flt Permitted		0.982			0.976	
Satd. Flow (perm)	0	1829	1725	0	1694	0
Volume (vph)	161	271	74	90	88	90
Lane Group Flow (vph)	0	470	178	0	194	0
Sign Control		Free	Stop		Free	

Intersection Summary	
Control Type: Unsignalized	
Intersection Capacity Utilization 53.0%	ICU Level of Service A
Analysis Period (min) 15	

Lane Group	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Satd. Flow (prot)	1683	0	0	1857	1837	0
Flt Permitted	0.979			0.997		
Satd. Flow (perm)	1683	0	0	1857	1837	0
Volume (vph)	8	11	8	114	103	12
Lane Group Flow (vph)	21	0	0	133	125	0
Sign Control	Stop			Free	Free	

Intersection Summary	
Control Type: Unsignalized	
Intersection Capacity Utilization 22.6%	ICU Level of Service A
Analysis Period (min) 15	

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Satd. Flow (prot)	1770	3532	0	0	3522	0	0	0	1611	0	0	1611
Flt Permitted	0.950											
Satd. Flow (perm)	1770	3532	0	0	3522	0	0	0	1611	0	0	1611
Volume (vph)	377	1277	20	0	1125	35	0	0	33	0	0	178
Lane Group Flow (vph)	410	1410	0	0	1261	0	0	0	36	0	0	193
Sign Control		Free			Free			Stop			Stop	

Intersection Summary	
Control Type: Unsignalized	
Intersection Capacity Utilization 59.8%	ICU Level of Service B
Analysis Period (min) 15	

Lane Group	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Satd. Flow (prot)	1676	0	1844	0	0	1835
Flt Permitted	0.981					0.985
Satd. Flow (perm)	1676	0	1844	0	0	1835
Volume (vph)	12	19	105	8	30	73
Lane Group Flow (vph)	34	0	123	0	0	112
Sign Control	Stop		Free			Free

Intersection Summary	
Control Type: Unsignalized	
Intersection Capacity Utilization 22.2%	ICU Level of Service A
Analysis Period (min) 15	

Lane Group	WBU	WBL	WBR	NBL	NBT	NBR	SBL	SBT	SBR	SEL	SER
Lane Configurations											
Satd. Flow (prot)	0	1758	0	0	1827	0	0	1816	0	1711	0
Flt Permitted		0.957			0.985					0.971	
Satd. Flow (perm)	0	1758	0	0	1827	0	0	1816	0	1711	0
Volume (vph)	5	4	1	10	21	1	0	8	2	3	2
Lane Group Flow (vph)	0	10	0	0	35	0	0	11	0	5	0
Sign Control		Stop			Free			Free		Stop	

Intersection Summary	
Control Type: Unsignalized	
Intersection Capacity Utilization 25.1%	ICU Level of Service A
Analysis Period (min) 15	

Lane Group	EBU	EBL	EBR	NBL	NBT	NBR	SBL	SBT	SBR	NWL	NWR
Lane Configurations											
Satd. Flow (prot)	0	1770	0	0	1809	0	0	1770	0	1736	0
Flt Permitted		0.954			0.988			0.958		0.963	
Satd. Flow (perm)	0	1770	0	0	1809	0	0	1770	0	1736	0
Volume (vph)	8	76	3	2	5	1	26	2	2	38	12
Lane Group Flow (vph)	0	95	0	0	8	0	0	32	0	54	0
Sign Control		Free			Stop			Stop		Free	

Intersection Summary	
Control Type: Unsignalized	
Intersection Capacity Utilization 22.9%	ICU Level of Service A
Analysis Period (min) 15	

Lane Group	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Satd. Flow (prot)	1751	0	1760	0	0	1859
Flt Permitted	0.959					0.998
Satd. Flow (perm)	1751	0	1760	0	0	1859
Volume (vph)	42	7	95	65	2	48
Lane Group Flow (vph)	54	0	174	0	0	54
Sign Control	Stop		Free			Free

Intersection Summary	
Control Type: Unsignalized	
Intersection Capacity Utilization 19.0%	ICU Level of Service A
Analysis Period (min) 15	

Lane Group	NBL	NBT	NBR	SBL	SBT	SBR	SEL	SET	SER	NWL	NWT	NWR
Lane Configurations												
Satd. Flow (prot)	0	1805	0	0	1844	0	0	1807	0	0	1776	0
Flt Permitted		0.993			0.992			0.999			0.986	
Satd. Flow (perm)	0	1805	0	0	1844	0	0	1807	0	0	1776	0
Volume (vph)	77	347	91	33	180	3	4	175	48	81	142	71
Lane Group Flow (vph)	0	560	0	0	235	0	0	246	0	0	319	0
Sign Control		Stop			Stop			Stop			Stop	

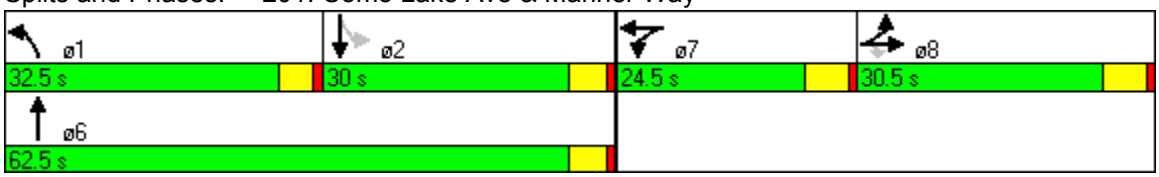
Intersection Summary	
Control Type: Unsignalized	
Intersection Capacity Utilization 75.9%	ICU Level of Service D
Analysis Period (min) 15	

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1681	1708	1583	1770	1863	0	1770	3479	0	1770	3539	1583
Flt Permitted	0.950	0.965		0.950			0.950			0.356		
Satd. Flow (perm)	1681	1708	1583	1770	1863	0	1770	3479	0	663	3539	1583
Satd. Flow (RTOR)			233					17				427
Volume (vph)	688	109	219	22	53	0	209	636	83	6	249	393
Lane Group Flow (vph)	422	444	238	24	58	0	227	781	0	7	271	427
Turn Type	Split		Perm	Split			Prot			Perm		Free
Protected Phases	8	8		7	7		1	6			2	
Permitted Phases			8							2		Free
Total Split (s)	30.5	30.5	30.5	24.5	24.5	0.0	32.5	62.5	0.0	30.0	30.0	0.0
Act Effct Green (s)	27.5	27.5	27.5	10.0	10.0		15.6	32.0		12.3	12.3	78.5
Actuated g/C Ratio	0.35	0.35	0.35	0.12	0.12		0.20	0.41		0.16	0.16	1.00
v/c Ratio	0.72	0.74	0.34	0.11	0.25		0.65	0.55		0.07	0.49	0.27
Control Delay	34.9	35.9	5.5	36.1	38.0		39.4	19.0		33.8	35.3	0.4
Queue Delay	0.0	0.0	0.0	0.0	0.0		0.0	0.0		0.0	0.0	0.0
Total Delay	34.9	35.9	5.5	36.1	38.0		39.4	19.0		33.8	35.3	0.4
LOS	C	D	A	D	D		D	B		C	D	A
Approach Delay		29.0			37.5			23.6			14.2	
Approach LOS		C			D			C			B	

Intersection Summary

Cycle Length: 117.5
Actuated Cycle Length: 78.5
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 0.74
Intersection Signal Delay: 23.7 Intersection LOS: C
Intersection Capacity Utilization 64.6% ICU Level of Service C
Analysis Period (min) 15

Splits and Phases: 201: Como Lake Ave & Mariner Way

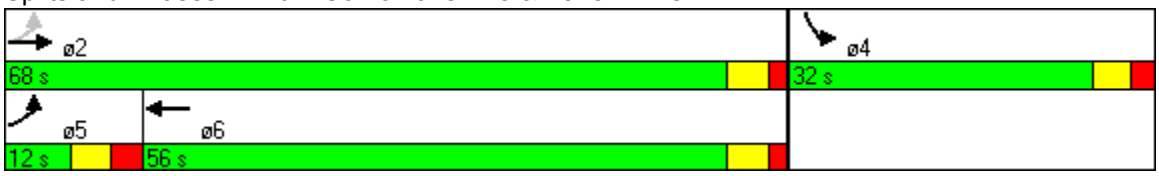


Lane Group	EBL	EBT	WBT	WBR	SBL	SBR
Lane Configurations						
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	3539	3532	0	1715	0
Flt Permitted	0.312				0.970	
Satd. Flow (perm)	581	3539	3532	0	1715	0
Satd. Flow (RTOR)			2		11	
Volume (vph)	10	1075	614	7	17	10
Lane Group Flow (vph)	11	1168	675	0	29	0
Turn Type	pm+pt					
Protected Phases	5	2	6		4	
Permitted Phases	2					
Total Split (s)	12.0	68.0	56.0	0.0	32.0	0.0
Act Effct Green (s)	90.6	93.0	90.6		8.9	
Actuated g/C Ratio	0.91	0.93	0.91		0.09	
v/c Ratio	0.02	0.35	0.21		0.18	
Control Delay	1.4	1.5	2.1		32.7	
Queue Delay	0.0	0.0	0.0		0.0	
Total Delay	1.4	1.5	2.1		32.7	
LOS	A	A	A		C	
Approach Delay		1.5	2.1		32.7	
Approach LOS		A	A		C	

Intersection Summary

Cycle Length: 100
Actuated Cycle Length: 100
Offset: 78 (78%), Referenced to phase 2:EBTL and 6:WBT, Start of Green
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 0.35
Intersection Signal Delay: 2.2 Intersection LOS: A
Intersection Capacity Utilization 42.2% ICU Level of Service A
Analysis Period (min) 15

Splits and Phases: 202: Como Lake Ave & Baker Drive

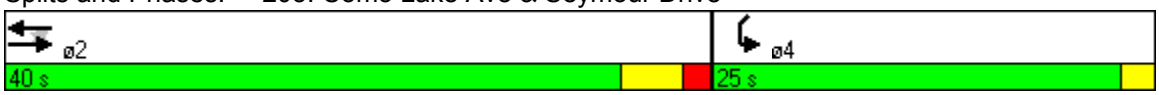


Lane Group	EBL	EBT	WBT	WBR	SWL	SWR
Lane Configurations						
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	3539	3529	0	1698	0
Flt Permitted	0.341				0.974	
Satd. Flow (perm)	635	3539	3529	0	1698	0
Satd. Flow (RTOR)			4		8	
Volume (vph)	10	1045	647	11	8	7
Lane Group Flow (vph)	11	1136	715	0	17	0
Turn Type	Perm					
Protected Phases		2	2		4	
Permitted Phases	2					
Total Split (s)	40.0	40.0	40.0	0.0	25.0	0.0
Act Effct Green (s)	28.6	28.6	28.6		18.3	
Actuated g/C Ratio	0.52	0.52	0.52		0.33	
v/c Ratio	0.03	0.62	0.39		0.03	
Control Delay	6.0	10.6	8.2		12.2	
Queue Delay	0.0	0.0	0.0		0.0	
Total Delay	6.0	10.6	8.2		12.2	
LOS	A	B	A		B	
Approach Delay		10.6	8.2		12.3	
Approach LOS		B	A		B	

Intersection Summary

Cycle Length: 65
Actuated Cycle Length: 55.1
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 0.62
Intersection Signal Delay: 9.7 Intersection LOS: A
Intersection Capacity Utilization 39.7% ICU Level of Service A
Analysis Period (min) 15

Splits and Phases: 203: Como Lake Ave & Seymour Drive

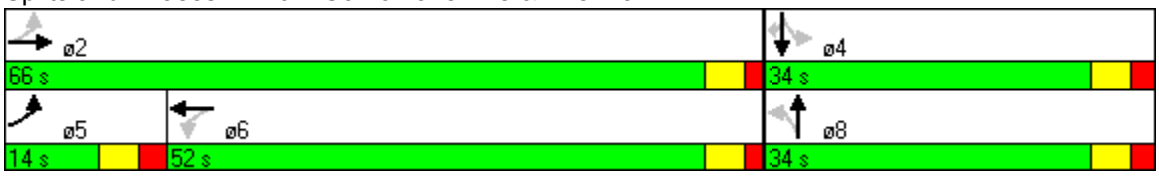


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	3539	0	1863	3518	0	0	1736	0	0	1770	1583
Flt Permitted	0.283										0.757	
Satd. Flow (perm)	527	3539	0	1863	3518	0	0	1736	0	0	1410	1583
Satd. Flow (RTOR)					6			1				
Volume (vph)	470	1029	2	0	623	28	0	1	1	15	0	215
Lane Group Flow (vph)	511	1120	0	0	707	0	0	2	0	0	16	234
Turn Type	pm+pt			Perm			Perm			Perm		Perm
Protected Phases	5	2			6			8			4	
Permitted Phases	2			6			8			4		4
Total Split (s)	14.0	66.0	0.0	52.0	52.0	0.0	34.0	34.0	0.0	34.0	34.0	34.0
Act Effct Green (s)	71.5	71.5			35.5			20.5			20.5	20.5
Actuated g/C Ratio	0.72	0.72			0.36			0.20			0.20	0.20
v/c Ratio	0.66	0.44			0.56			0.01			0.06	0.72
Control Delay	13.4	7.3			28.2			23.5			29.3	49.3
Queue Delay	0.0	0.0			0.0			0.0			0.0	0.0
Total Delay	13.4	7.3			28.2			23.5			29.3	49.3
LOS	B	A			C			C			C	D
Approach Delay		9.2			28.2			23.5			48.0	
Approach LOS		A			C			C			D	

Intersection Summary

Cycle Length: 100
Actuated Cycle Length: 100
Offset: 33 (33%), Referenced to phase 2:EBTL and 6:WBTL, Start of Green
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 0.72
Intersection Signal Delay: 18.1 Intersection LOS: B
Intersection Capacity Utilization 61.6% ICU Level of Service B
Analysis Period (min) 15

Splits and Phases: 204: Como Lake Ave & Thermal Dr



Lane Group	EBL	EBT	WBT	WBR	SBL	SBR
Lane Configurations						
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	0	3539	3536	0	1649	0
Flt Permitted		0.952			0.989	
Satd. Flow (perm)	0	3369	3536	0	1649	0
Satd. Flow (RTOR)			1		7	
Volume (vph)	6	1403	724	4	2	6
Lane Group Flow (vph)	0	1532	791	0	9	0
Turn Type	Perm					
Protected Phases		2	2		4	
Permitted Phases	2					
Total Split (s)	45.0	45.0	45.0	0.0	24.0	0.0
Act Effct Green (s)		38.0	38.0		17.5	
Actuated g/C Ratio		0.60	0.60		0.28	
v/c Ratio		0.76	0.37		0.02	
Control Delay		12.3	7.1		12.6	
Queue Delay		0.0	0.0		0.0	
Total Delay		12.3	7.1		12.6	
LOS		B	A		B	
Approach Delay		12.3	7.1		12.6	
Approach LOS		B	A		B	

Intersection Summary

Cycle Length: 69
Actuated Cycle Length: 63.6
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 0.76
Intersection Signal Delay: 10.5 Intersection LOS: B
Intersection Capacity Utilization 53.8% ICU Level of Service A
Analysis Period (min) 15

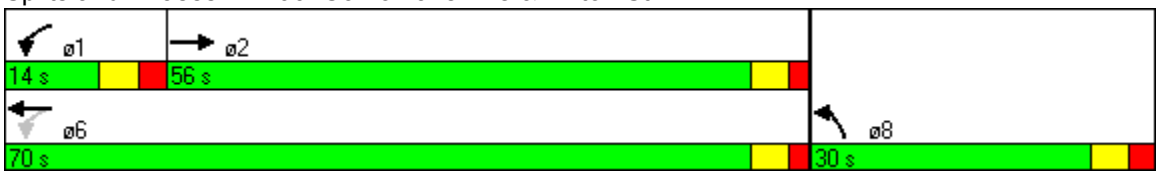
Splits and Phases: 205: Como Lake Ave & Custer CT

Lane Group	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	3493	0	1770	3539	1678	0
Flt Permitted			0.071		0.981	
Satd. Flow (perm)	3493	0	132	3539	1678	0
Satd. Flow (RTOR)	15				76	
Volume (vph)	1230	120	122	601	136	213
Lane Group Flow (vph)	1467	0	133	653	380	0
Turn Type			pm+pt			
Protected Phases	2		1	6	8	
Permitted Phases			6			
Total Split (s)	56.0	0.0	14.0	70.0	30.0	0.0
Act Effct Green (s)	54.2		67.4	67.4	24.6	
Actuated g/C Ratio	0.54		0.67	0.67	0.25	
v/c Ratio	0.77		0.55	0.27	0.81	
Control Delay	24.5		22.5	7.1	42.5	
Queue Delay	0.0		0.0	0.0	0.0	
Total Delay	24.5		22.5	7.1	42.5	
LOS	C		C	A	D	
Approach Delay	24.5			9.7	42.5	
Approach LOS	C			A	D	

Intersection Summary

Cycle Length: 100
Actuated Cycle Length: 100
Offset: 0 (0%), Referenced to phase 2:EBT and 6:WBTL, Start of Green
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 0.81
Intersection Signal Delay: 22.7 Intersection LOS: C
Intersection Capacity Utilization 75.2% ICU Level of Service D
Analysis Period (min) 15

Splits and Phases: 206: Como Lake Ave & Linton St

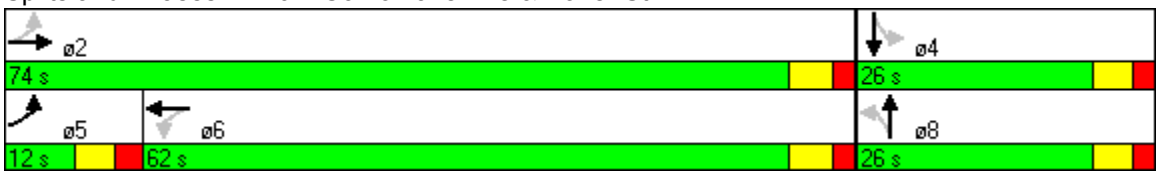


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	3511	0	1770	3490	0	0	1704	0	0	1760	0
Flt Permitted	0.361			0.222				0.908			0.666	
Satd. Flow (perm)	672	3511	0	414	3490	0	0	1566	0	0	1205	0
Satd. Flow (RTOR)		13			19			56			13	
Volume (vph)	27	1081	58	133	505	52	42	36	96	64	26	25
Lane Group Flow (vph)	29	1238	0	145	606	0	0	189	0	0	125	0
Turn Type	pm+pt			Perm			Perm			Perm		
Protected Phases	5	2			6			8			4	
Permitted Phases	2			6			8			4		
Total Split (s)	12.0	74.0	0.0	62.0	62.0	0.0	26.0	26.0	0.0	26.0	26.0	0.0
Act Effct Green (s)	76.4	76.4		69.2	69.2			15.6			15.6	
Actuated g/C Ratio	0.76	0.76		0.69	0.69			0.16			0.16	
v/c Ratio	0.05	0.46		0.51	0.25			0.65			0.63	
Control Delay	4.0	5.4		22.2	8.4			37.3			48.3	
Queue Delay	0.0	0.0		0.0	0.0			0.0			0.0	
Total Delay	4.0	5.4		22.2	8.4			37.3			48.3	
LOS	A	A		C	A			D			D	
Approach Delay		5.4			11.1			37.3			48.3	
Approach LOS		A			B			D			D	

Intersection Summary

Cycle Length: 100
Actuated Cycle Length: 100
Offset: 43 (43%), Referenced to phase 2:EBTL and 6:WBTL, Start of Green
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 0.65
Intersection Signal Delay: 12.1 Intersection LOS: B
Intersection Capacity Utilization 63.3% ICU Level of Service B
Analysis Period (min) 15

Splits and Phases: 207: Como Lake Ave & Poirer St

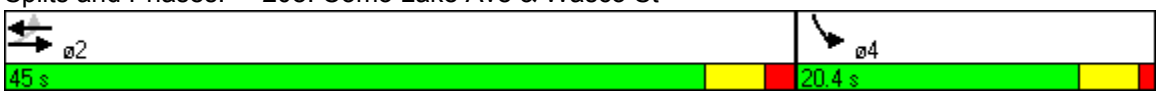


Lane Group	EBL	EBT	WBT	WBR	SBL	SBR
Lane Configurations						
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	0	3536	3536	0	1645	0
Flt Permitted		0.947			0.990	
Satd. Flow (perm)	0	3352	3536	0	1645	0
Satd. Flow (RTOR)			2		12	
Volume (vph)	14	1184	572	5	3	11
Lane Group Flow (vph)	0	1302	627	0	15	0
Turn Type	Perm					
Protected Phases		2	2		4	
Permitted Phases	2					
Total Split (s)	45.0	45.0	45.0	0.0	20.4	0.0
Act Effct Green (s)		33.1	33.1		16.7	
Actuated g/C Ratio		0.57	0.57		0.29	
v/c Ratio		0.68	0.31		0.03	
Control Delay		10.4	6.5		11.8	
Queue Delay		0.0	0.0		0.0	
Total Delay		10.4	6.5		11.8	
LOS		B	A		B	
Approach Delay		10.4	6.5		11.8	
Approach LOS		B	A		B	

Intersection Summary

Cycle Length: 65.4
Actuated Cycle Length: 58
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 0.68
Intersection Signal Delay: 9.2 Intersection LOS: A
Intersection Capacity Utilization 55.1% ICU Level of Service B
Analysis Period (min) 15

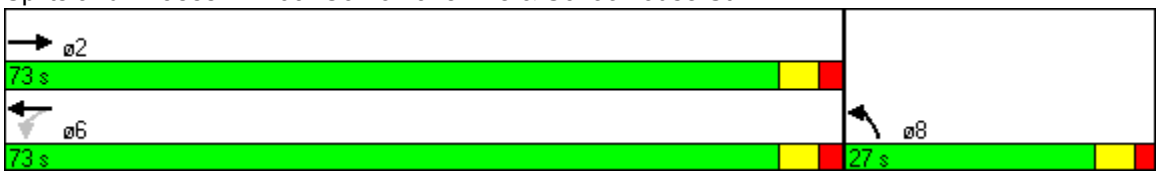
Splits and Phases: 208: Como Lake Ave & Wasco St



Lane Group	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	3511	0	0	3525	1685	0
Flt Permitted				0.773	0.978	
Satd. Flow (perm)	3511	0	0	2736	1685	0
Satd. Flow (RTOR)	12				58	
Volume (vph)	1058	56	45	496	57	71
Lane Group Flow (vph)	1211	0	0	588	139	0
Turn Type			Perm			
Protected Phases	2			6	8	
Permitted Phases			6			
Total Split (s)	73.0	0.0	73.0	73.0	27.0	0.0
Act Effct Green (s)	80.1			80.1	11.9	
Actuated g/C Ratio	0.80			0.80	0.12	
v/c Ratio	0.43			0.27	0.55	
Control Delay	1.9			3.1	32.4	
Queue Delay	0.0			0.0	0.0	
Total Delay	1.9			3.1	32.4	
LOS	A			A	C	
Approach Delay	1.9			3.1	32.4	
Approach LOS	A			A	C	

Intersection Summary	
Cycle Length: 100	
Actuated Cycle Length: 100	
Offset: 26 (26%), Referenced to phase 2:EBT and 6:WBTL, Start of Green	
Control Type: Actuated-Coordinated	
Maximum v/c Ratio: 0.55	
Intersection Signal Delay: 4.5	Intersection LOS: A
Intersection Capacity Utilization 62.5%	ICU Level of Service B
Analysis Period (min) 15	

Splits and Phases: 209: Como Lake Ave & Schoolhouse St

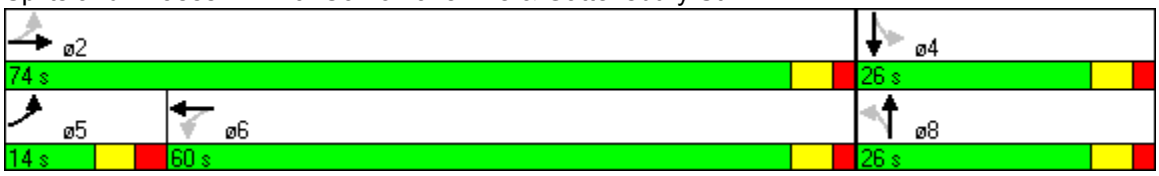


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	3532	0	1770	3497	0	0	1764	0	0	1737	0
Flt Permitted	0.381			0.241				0.944			0.817	
Satd. Flow (perm)	710	3532	0	449	3497	0	0	1674	0	0	1435	0
Satd. Flow (RTOR)		3			15			25			34	
Volume (vph)	151	1066	13	35	470	41	18	98	64	51	79	95
Lane Group Flow (vph)	164	1173	0	38	556	0	0	197	0	0	244	0
Turn Type	pm+pt			Perm			Perm			Perm		
Protected Phases	5	2			6			8			4	
Permitted Phases	2			6			8			4		
Total Split (s)	14.0	74.0	0.0	60.0	60.0	0.0	26.0	26.0	0.0	26.0	26.0	0.0
Act Effct Green (s)	72.4	72.4		59.7	59.7			19.6			19.6	
Actuated g/C Ratio	0.72	0.72		0.60	0.60			0.20			0.20	
v/c Ratio	0.27	0.46		0.14	0.27			0.57			0.79	
Control Delay	3.8	3.8		14.0	12.0			37.7			51.4	
Queue Delay	0.0	0.0		0.0	0.0			0.0			0.0	
Total Delay	3.8	3.8		14.0	12.0			37.7			51.4	
LOS	A	A		B	B			D			D	
Approach Delay		3.8			12.2			37.7			51.4	
Approach LOS		A			B			D			D	

Intersection Summary

Cycle Length: 100
Actuated Cycle Length: 100
Offset: 77 (77%), Referenced to phase 2:EBTL and 6:WBTL, Start of Green
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 0.79
Intersection Signal Delay: 13.6 Intersection LOS: B
Intersection Capacity Utilization 71.8% ICU Level of Service C
Analysis Period (min) 15

Splits and Phases: 210: Como Lake Ave & Gattensbury St

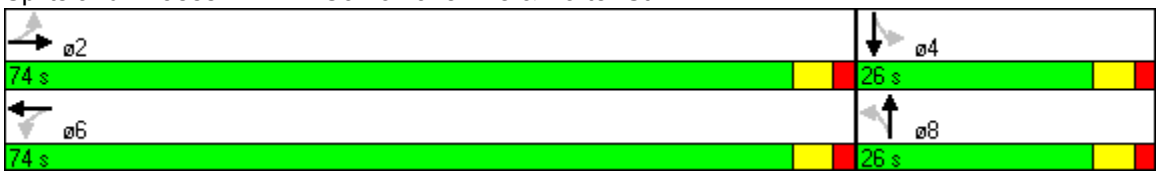


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	0	3525	0	0	3507	0	0	1696	0	0	1745	0
Flt Permitted		0.941			0.722			0.957			0.899	
Satd. Flow (perm)	0	3320	0	0	2545	0	0	1636	0	0	1596	0
Satd. Flow (RTOR)		5			6			68			16	
Volume (vph)	18	1170	26	55	489	15	17	24	63	15	13	15
Lane Group Flow (vph)	0	1320	0	0	608	0	0	112	0	0	46	0
Turn Type	Perm			Perm			Perm			Perm		
Protected Phases		2			6			8			4	
Permitted Phases	2			6			8			4		
Total Split (s)	74.0	74.0	0.0	74.0	74.0	0.0	26.0	26.0	0.0	26.0	26.0	0.0
Act Effct Green (s)		81.4			81.4			10.6			10.6	
Actuated g/C Ratio		0.81			0.81			0.11			0.11	
v/c Ratio		0.49			0.29			0.48			0.25	
Control Delay		2.3			2.5			25.5			32.3	
Queue Delay		0.0			0.0			0.0			0.0	
Total Delay		2.3			2.5			25.5			32.3	
LOS		A			A			C			C	
Approach Delay		2.3			2.5			25.5			32.3	
Approach LOS		A			A			C			C	

Intersection Summary

Cycle Length: 100
Actuated Cycle Length: 100
Offset: 66 (66%), Referenced to phase 2:EBTL and 6:WBTL, Start of Green
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 0.49
Intersection Signal Delay: 4.2 Intersection LOS: A
Intersection Capacity Utilization 66.0% ICU Level of Service C
Analysis Period (min) 15

Splits and Phases: 211: Como Lake Ave & Porter St

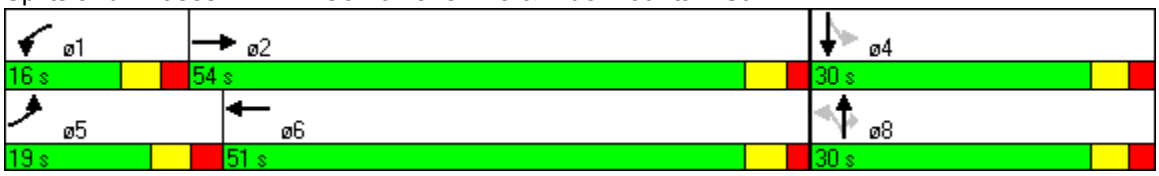


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	3490	0	1770	3483	0	0	1798	1583	0	1789	0
Flt Permitted	0.950			0.950				0.732			0.734	
Satd. Flow (perm)	1770	3490	0	1770	3483	0	0	1364	1583	0	1347	0
Satd. Flow (RTOR)		16			17				255		6	
Volume (vph)	32	952	100	175	355	42	143	56	352	45	34	10
Lane Group Flow (vph)	35	1144	0	190	432	0	0	216	383	0	97	0
Turn Type	Prot			Prot			Perm		Perm	Perm		
Protected Phases	5	2		1	6			8			4	
Permitted Phases							8		8	4		
Total Split (s)	19.0	54.0	0.0	16.0	51.0	0.0	30.0	30.0	30.0	30.0	30.0	0.0
Act Effct Green (s)	9.5	49.8		16.3	61.5			22.0	22.0		22.0	
Actuated g/C Ratio	0.10	0.50		0.16	0.62			0.22	0.22		0.22	
v/c Ratio	0.21	0.66		0.66	0.20			0.72	0.70		0.32	
Control Delay	44.2	21.6		63.1	8.8			49.4	18.7		32.0	
Queue Delay	0.0	0.0		0.0	0.0			0.0	0.0		0.0	
Total Delay	44.2	21.6		63.1	8.8			49.4	18.7		32.0	
LOS	D	C		E	A			D	B		C	
Approach Delay		22.3			25.4			29.7			32.0	
Approach LOS		C			C			C			C	

Intersection Summary

Cycle Length: 100
Actuated Cycle Length: 100
Offset: 40 (40%), Referenced to phase 2:EBT and 6:WBT, Start of Green
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 0.72
Intersection Signal Delay: 25.2 Intersection LOS: C
Intersection Capacity Utilization 67.1% ICU Level of Service C
Analysis Period (min) 15

Splits and Phases: 212: Como Lake Ave & Blue Mountain St

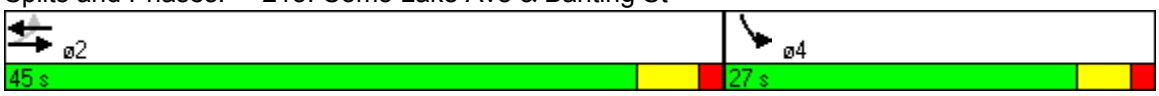


Lane Group	EBL	EBT	WBT	WBR	SBL	SBR
Lane Configurations						
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	0	3539	3536	0	1683	0
Flt Permitted		0.954			0.979	
Satd. Flow (perm)	0	3376	3536	0	1683	0
Satd. Flow (RTOR)			2		4	
Volume (vph)	2	1024	488	4	3	4
Lane Group Flow (vph)	0	1115	534	0	7	0
Turn Type	Perm					
Protected Phases		2	2		4	
Permitted Phases	2					
Total Split (s)	45.0	45.0	45.0	0.0	27.0	0.0
Act Effct Green (s)		30.9	30.9		23.4	
Actuated g/C Ratio		0.50	0.50		0.38	
v/c Ratio		0.67	0.30		0.01	
Control Delay		13.6	9.3		12.7	
Queue Delay		0.0	0.0		0.0	
Total Delay		13.6	9.3		12.7	
LOS		B	A		B	
Approach Delay		13.6	9.3		12.7	
Approach LOS		B	A		B	

Intersection Summary

Cycle Length: 72
Actuated Cycle Length: 62.4
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 0.67
Intersection Signal Delay: 12.3 Intersection LOS: B
Intersection Capacity Utilization 40.5% ICU Level of Service A
Analysis Period (min) 15

Splits and Phases: 213: Como Lake Ave & Banting St

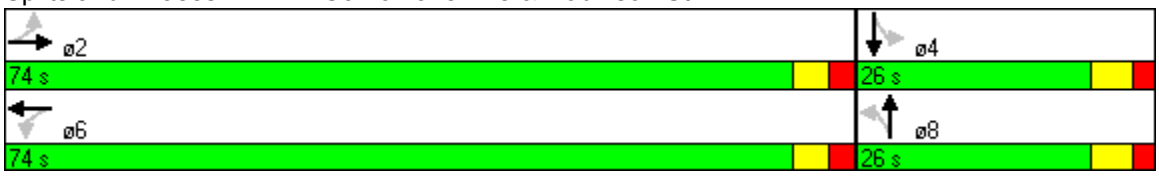


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	0	3529	0	0	3359	0	0	1753	0	0	1789	0
Flt Permitted		0.936			0.865			0.975			0.600	
Satd. Flow (perm)	0	3306	0	0	2914	0	0	1714	0	0	1102	0
Satd. Flow (RTOR)		3			170			33			5	
Volume (vph)	20	873	13	28	309	156	11	84	67	119	77	23
Lane Group Flow (vph)	0	985	0	0	536	0	0	176	0	0	238	0
Turn Type	Perm			Perm			Perm			Perm		
Protected Phases		2			6			8			4	
Permitted Phases	2			6			8			4		
Total Split (s)	74.0	74.0	0.0	74.0	74.0	0.0	26.0	26.0	0.0	26.0	26.0	0.0
Act Effct Green (s)		56.4			56.4			35.6			35.6	
Actuated g/C Ratio		0.56			0.56			0.36			0.36	
v/c Ratio		0.53			0.31			0.28			0.60	
Control Delay		16.1			9.2			18.1			31.4	
Queue Delay		0.0			0.0			0.0			0.0	
Total Delay		16.1			9.2			18.1			31.4	
LOS		B			A			B			C	
Approach Delay		16.1			9.2			18.1			31.4	
Approach LOS		B			A			B			C	

Intersection Summary

Cycle Length: 100
Actuated Cycle Length: 100
Offset: 79 (79%), Referenced to phase 2:EBTL and 6:WBTL, Start of Green
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 0.60
Intersection Signal Delay: 16.3 Intersection LOS: B
Intersection Capacity Utilization 70.0% ICU Level of Service C
Analysis Period (min) 15

Splits and Phases: 214: Como Lake Ave & Robinson St

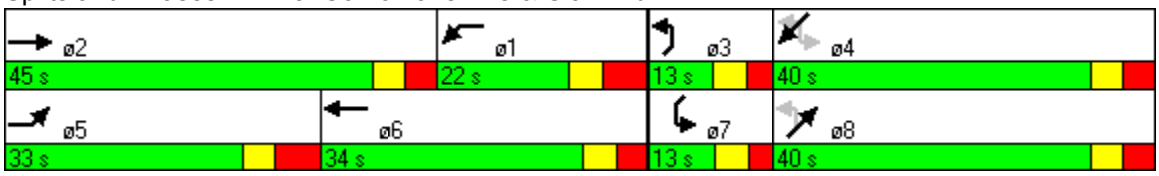


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NEL	NET	NER	SWL	SWT	SWR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	3433	3504	0	1770	3504	0	1770	3433	0	1770	3539	1583
Flt Permitted	0.950			0.950			0.389			0.254		
Satd. Flow (perm)	3433	3504	0	1770	3504	0	725	3433	0	473	3539	1583
Satd. Flow (RTOR)		7			6			27				208
Volume (vph)	547	782	58	88	283	21	1	448	114	4	396	191
Lane Group Flow (vph)	595	913	0	96	331	0	1	611	0	4	430	208
Turn Type	Prot			Prot			pm+pt			pm+pt		Perm
Protected Phases	5	2		1	6		3	8		7	4	
Permitted Phases							8			4		4
Total Split (s)	33.0	45.0	0.0	22.0	34.0	0.0	13.0	40.0	0.0	13.0	40.0	40.0
Act Effct Green (s)	27.4	37.7		15.0	25.3		54.5	52.9		54.4	52.8	52.8
Actuated g/C Ratio	0.23	0.31		0.12	0.21		0.45	0.44		0.45	0.44	0.44
v/c Ratio	0.76	0.83		0.43	0.44		0.00	0.40		0.01	0.28	0.26
Control Delay	49.9	44.7		54.1	41.7		14.0	20.6		20.8	24.1	4.6
Queue Delay	0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0	0.0
Total Delay	49.9	44.7		54.1	41.7		14.0	20.6		20.8	24.1	4.6
LOS	D	D		D	D		B	C		C	C	A
Approach Delay		46.8			44.5			20.6			17.8	
Approach LOS		D			D			C			B	

Intersection Summary

Cycle Length: 120
Actuated Cycle Length: 120
Offset: 42 (35%), Referenced to phase 4:SWTL and 8:NETL, Start of Green
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 0.83
Intersection Signal Delay: 35.6 Intersection LOS: D
Intersection Capacity Utilization 54.5% ICU Level of Service A
Analysis Period (min) 15

Splits and Phases: 215: Como Lake Ave & Clark Rd



Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	3486	0	1770	3536	0	0	1774	0	0	1733	0
Flt Permitted	0.484			0.098				0.771			0.971	
Satd. Flow (perm)	902	3486	0	183	3536	0	0	1418	0	0	1693	0
Satd. Flow (RTOR)		27			2			8			28	
Volume (vph)	84	1496	171	7	407	4	90	24	12	6	22	26
Lane Group Flow (vph)	91	1812	0	8	446	0	0	137	0	0	59	0
Turn Type	Perm			Perm			Perm			Perm		
Protected Phases		2			6			8			4	
Permitted Phases	2			6			8			4		
Total Split (s)	45.0	45.0	0.0	45.0	45.0	0.0	28.0	28.0	0.0	28.0	28.0	0.0
Act Effct Green (s)	53.3	53.3		53.3	53.3			14.3			14.3	
Actuated g/C Ratio	0.73	0.73		0.73	0.73			0.19			0.19	
v/c Ratio	0.14	0.71		0.06	0.17			0.50			0.17	
Control Delay	5.2	9.5		6.3	4.2			26.4			13.2	
Queue Delay	0.0	0.0		0.0	0.0			0.0			0.0	
Total Delay	5.2	9.5		6.3	4.2			26.4			13.2	
LOS	A	A		A	A			C			B	
Approach Delay		9.3			4.3			26.4			13.2	
Approach LOS		A			A			C			B	

Intersection Summary

Cycle Length: 73
Actuated Cycle Length: 73.5
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 0.71
Intersection Signal Delay: 9.4 Intersection LOS: A
Intersection Capacity Utilization 76.3% ICU Level of Service D
Analysis Period (min) 15

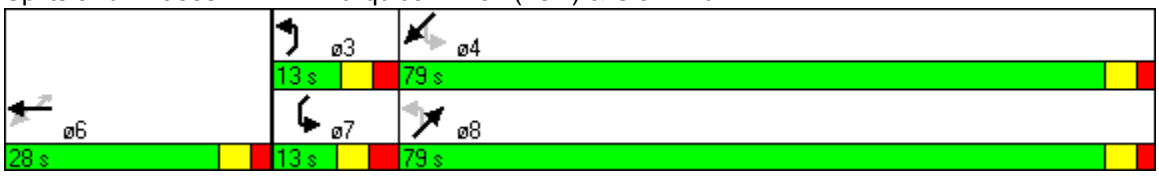
Splits and Phases: 216: Como Lake Ave & North Rd

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NEL	NET	NER	SWL	SWT	SWR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	0	0	0	0	1770	1583	1770	3433	0	1770	3529	0
Flt Permitted					0.950		0.443			0.381		
Satd. Flow (perm)	0	0	0	0	1770	1583	825	3433	0	710	3529	0
Satd. Flow (RTOR)						102		48			3	
Volume (vph)	0	0	0	72	0	94	6	462	114	63	456	8
Lane Group Flow (vph)	0	0	0	0	78	102	7	626	0	68	505	0
Turn Type				Perm		Perm	pm+pt			pm+pt		
Protected Phases					6		3	8		7	4	
Permitted Phases				6		6	8			4		
Total Split (s)	0.0	0.0	0.0	28.0	28.0	28.0	13.0	79.0	0.0	13.0	79.0	0.0
Act Effct Green (s)					12.3	12.3	96.0	89.7		99.0	97.3	
Actuated g/C Ratio					0.10	0.10	0.80	0.75		0.82	0.81	
v/c Ratio					0.43	0.40	0.01	0.24		0.10	0.18	
Control Delay					57.1	14.0	0.5	2.3		1.7	1.8	
Queue Delay					0.0	0.0	0.0	0.0		0.0	0.0	
Total Delay					57.1	14.0	0.5	2.3		1.7	1.8	
LOS					E	B	A	A		A	A	
Approach Delay					32.7			2.3			1.8	
Approach LOS					C			A			A	

Intersection Summary

Cycle Length: 120
Actuated Cycle Length: 120
Offset: 38 (32%), Referenced to phase 4:SWTL and 8:NETL, Start of Green
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 0.43
Intersection Signal Delay: 6.0 Intersection LOS: A
Intersection Capacity Utilization 37.2% ICU Level of Service A
Analysis Period (min) 15

Splits and Phases: 217: Burquitlam Mall (new) & Clark Rd



Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Satd. Flow (prot)	0	1796	0	0	1796	0	0	1809	0	0	1818	0
Flt Permitted		0.988			0.996			0.990			0.993	
Satd. Flow (perm)	0	1796	0	0	1796	0	0	1809	0	0	1818	0
Volume (vph)	46	106	32	7	57	20	29	95	20	17	91	16
Lane Group Flow (vph)	0	200	0	0	92	0	0	157	0	0	134	0
Sign Control		Stop			Stop			Stop			Stop	

Intersection Summary	
Control Type: Unsignalized	
Intersection Capacity Utilization 35.4%	ICU Level of Service A
Analysis Period (min) 15	

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NEL	NET	NER	SWL	SWT	SWR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	1822	0	1770	1805	0	1770	3479	0	1770	3525	0
Flt Permitted	0.675			0.513			0.455			0.361		
Satd. Flow (perm)	1257	1822	0	956	1805	0	848	3479	0	672	3525	0
Satd. Flow (RTOR)		7			10			22			4	
Volume (vph)	18	127	22	50	64	17	22	540	71	29	430	12
Lane Group Flow (vph)	20	162	0	54	88	0	24	664	0	32	480	0
Turn Type	Perm			Perm			pm+pt			pm+pt		
Protected Phases		2			6		3	8		7	4	
Permitted Phases	2			6			8			4		
Total Split (s)	29.0	29.0	0.0	29.0	29.0	0.0	13.0	78.0	0.0	13.0	78.0	0.0
Act Effct Green (s)	17.3	17.3		17.3	17.3		91.6	87.0		93.1	87.8	
Actuated g/C Ratio	0.14	0.14		0.14	0.14		0.76	0.72		0.78	0.73	
v/c Ratio	0.11	0.60		0.39	0.33		0.03	0.26		0.05	0.19	
Control Delay	43.8	55.0		53.7	42.8		3.7	6.9		7.2	13.6	
Queue Delay	0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0	
Total Delay	43.8	55.0		53.7	42.8		3.7	6.9		7.2	13.6	
LOS	D	D		D	D		A	A		A	B	
Approach Delay		53.8			46.9			6.8			13.2	
Approach LOS		D			D			A			B	

Intersection Summary

Cycle Length: 120
Actuated Cycle Length: 120
Offset: 25 (21%), Referenced to phase 4:SWTL and 8:NETL, Start of Green
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 0.60
Intersection Signal Delay: 18.3 Intersection LOS: B
Intersection Capacity Utilization 48.0% ICU Level of Service A
Analysis Period (min) 15

Splits and Phases: 219: Smith & Clark Rd

Lane Group	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Satd. Flow (prot)	1631	0	1785	0	0	1816
Flt Permitted	0.994					0.975
Satd. Flow (perm)	1631	0	1785	0	0	1816
Volume (vph)	9	68	50	22	122	113
Lane Group Flow (vph)	84	0	78	0	0	256
Sign Control	Stop		Free			Free

Intersection Summary	
Control Type: Unsignalized	
Intersection Capacity Utilization 30.7%	ICU Level of Service A
Analysis Period (min) 15	

Appendix A-18-5

LOUGHEED HIGHWAY ALIGNMENT
TRAFFIC IMPACT ASSESSMENT

GNEC

GREAT NORTHERN ENGINEERING CONSULTANTS INC.

Coquitlam IP Pipeline Replacement Project Lougheed Highway Alignment Traffic Impact Assessment - Draft

October 23, 2014

Submitted to: FORTIS BC

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Note to Reader

The opinions and findings expressed in this report are based on technical information and analysis available at the time of writing. These opinions and findings have not been discussed with the City of Burnaby and their response thereto has not been ascertained.

Introduction

Fortis BC is proposing to replace the existing 20km long Coquitlam IP Pipeline gas line between Coquitlam (Como Lake Avenue Avenue/Mariner Way intersection) and Vancouver (East 2nd Avenue/Woodland Drive intersection). At present a preliminary design of the gas line has been prepared by Worley Parsons and it is expected that construction will take place during the summer of 2018. For the most part, the replacement gas line will run along existing road rights of way through the Cities of Coquitlam, Burnaby and Vancouver.

Fortis BC has retained Great Northern Engineering Consultants (GNEC) to support them and their design team to assist with providing traffic management advice as they proceed forward with community and stakeholder consultation, detailed design and permit approvals. As part of the early work, GNEC was requested to assess the likely traffic impacts if the laning on sections of Lougheed Highway in Burnaby were to be reduced in the east/west directions during gas line construction. This memo documents this preliminary assessment and is intended to assist Fortis BC in deciding whether to retain the current Broadway alignment or possibly switch to the Lougheed Highway alignment in Burnaby. The focus of this memo is on assessing the ability of the Lougheed Highway corridor to accommodate traffic during gas line construction and limited attention has been given at this time to the details of how the lane reductions will actually be implemented.

It is noted that this memo provides additional updated information to that contained in GNEC's previous memo titled *"Coquitlam IP Pipeline Project Preliminary Traffic Management Review Burnaby Segment – Final"* dated August 14, 2014.

Proposed Alignment

The currently proposed alignment of the gas line within the City of Burnaby is provided in ***Appendix A***. As can be seen the alignment from east to west is generally:

- West along Broadway from North Road;
- West across Gaglardi Way;
- Southwest along the west side of Gaglardi Way to Broadway;
- West along the Broadway alignment through the BC Hydro right of way to Underhill Avenue
- West along Broadway to Springer Avenue;
- North on Springer Avenue to Halifax Street;
- West on Halifax Street to Delta Avenue;
- North on Delta Avenue to Highlawn Drive;
- West on Highlawn Drive to Midlawn Drive;
- West on Midlawn Drive to Fairlawn Drive;
- South on Fairlawn Drive to Brentlawn Drive;
- West on Brentlawn Drive across Willingdon Avenue to Gravely Street;
- West on Gravely Street to Carleton Avenue;
- Either:
    - West across the park across Gilmore Avenue/Douglas Road to Gravely Street; or

  - South on Carlton Avenue, west across vacant lot, north on Gilmore Avenue, and west on Gravely (See ***Appendix B***);
- West on Gravely Street across Boundary Road into the City of Vancouver.

This alignment described above was selected previously by Fortis BC based on preliminary opinions that construction along the Lougheed Highway corridor would probably not be acceptable to the City of Burnaby due to the impacts of construction on traffic. Fortis BC has now requested GNEC to revisit the possibility of constructing the gas line along Lougheed Highway between Bainbridge Avenue and Boundary Road.

This alternate Lougheed Highway alignment would maintain the ***Appendix A*** alignment between Gaglardi Way and Bainbridge Avenue. It would then proceed:

- South on Bainbridge Avenue;
- West on Lougheed Highway;
- North on Madison Avenue;
- Northwest on Douglas Road; and
- West on Gravely Street to Boundary Road.

Construction Approach

Based on preliminary advice from Fortis BC, it is intended that the gas line will be constructed using a combination of trenchless and open cut methods. The crossing of the following major roads/intersections on the alternate Lougheed Highway alignment is expected to be achieved using trenchless technology:

- Lougheed Highway/Kensington Avenue;
- Lougheed Highway/Holdom Avenue;
- Lougheed Highway/Springer Avenue;
- Lougheed Highway/Delta Avenue;
- Lougheed Highway/Beta Avenue; and
- Lougheed Highway/Willingdon Avenue.

Between the intersections listed above and across the minor intersections, the gas line would be constructed using an open cut approach that will require approximately 200-1000m of road space occupation at any one time depending on site conditions. Due to the nature of construction, it is expected that the road occupation will be on a full time basis limiting the ability to open/close lanes by time of day.

Based on preliminary advice from Fortis BC, the open cut work will require the closure of two westbound lanes on Lougheed Highway with a third lane being closed during non-peak hour periods to haul away excavated material and deliver pipe. This would effectively require all westbound traffic to detour to alternative routes or alternatively be accommodated on the existing eastbound lanes as discussed later in this report.

Traffic Data Collection

In order to assess the impacts of the gas line construction, current traffic count data was required. A comprehensive project specific traffic data collection program was therefore undertaken during the summer of 2014. The data from this program is to be used to support traffic modelling that would assist in assessing the impacts of any proposed lane/road closures during construction and the subsequent development of traffic management strategies to mitigate the impacts as far as possible.

Turning Movement Counts

Within the City of Burnaby, any construction work on the originally proposed Broadway route could result in traffic detouring to alternate routes, primarily the continuous parallel Lougheed Highway routes. Turning movement counts were therefore undertaken at the major intersections on both of these east/west routes along with the major north/south routes between Gaglardi Way and Delta Avenue. Surveys were not undertaken at the intersections on Lougheed between west of Delta Ave and east of Boundary Rd as, at the time, significant detouring to Lougheed Highway was not expected when the minor residential roads in the area around Brentwood Mall would be affected as per the original preferred alignment. Surveys were also undertaken on the roads around Brentwood Mall and north of Lougheed Highway along the originally proposed gas line route.

The turning movement counts were undertaken between July 29, 2014 and August 28, 2014. These counts were performed on either a Tuesday, Wednesday or Thursday between the hours of 7:00 – 9:00am, 11:00am – 1:00pm, and 3:00pm – 6:00pm. Data was collected for passenger cars, heavy vehicles, TransLink buses and pedestrians.

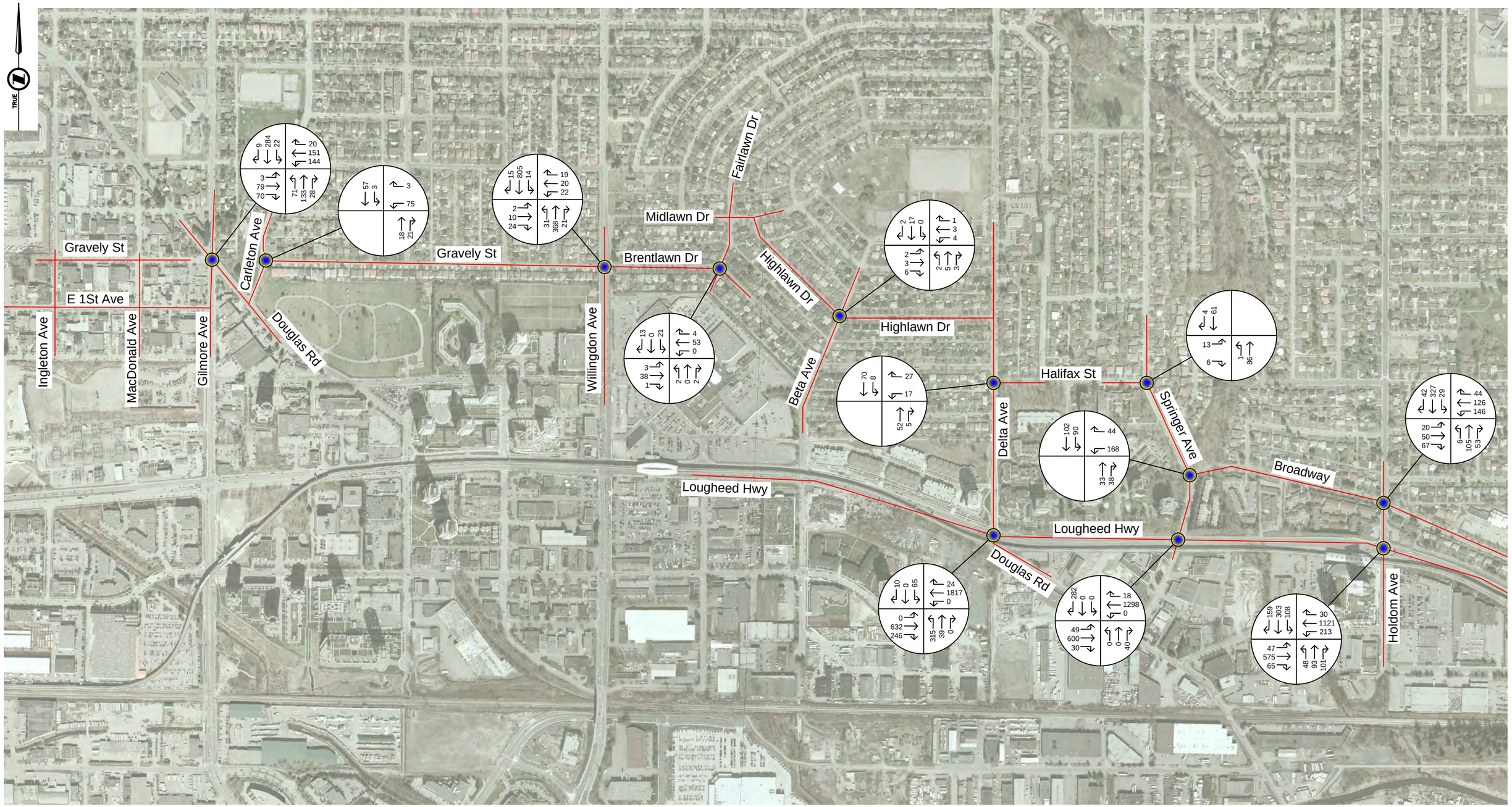
All the turning movement count data was then processed to determine the turning movement volumes at each intersection for the AM and PM peak hours. The resultant AM and PM peak hour volumes for the area under discussion are illustrated in ***Exhibits 1.1 to 1.4*** for all vehicle types combined.

Base Synchro Model Development

"Base" traffic models were developed for the AM and PM peak hours using the Synchro software. The models were coded over scaled aerial photographs to ensure correct distances between intersections. These Base models reflected existing traffic conditions and, as such, incorporated the following data:

- Existing laning geometry at all the major intersections and between intersections (excluding minor intersections and accesses – see ***Exhibit 1.1*** and ***1.2*** for model area);
- Existing traffic signal timings at all signalized intersections (as provided by City of Burnaby);
- Summer peak hour turning movement volumes from ***Exhibits 1.1*** to ***1.4***; and
- Pedestrian volumes at the intersections that have high pedestrian activity.

Note: The traffic data collection and the development of the Base Synchro models is documented in more detail in a GNEC report titled "*Coquitlam IP Pipeline Replacement Project – Base Traffic Modelling*" dated October 16, 2014.



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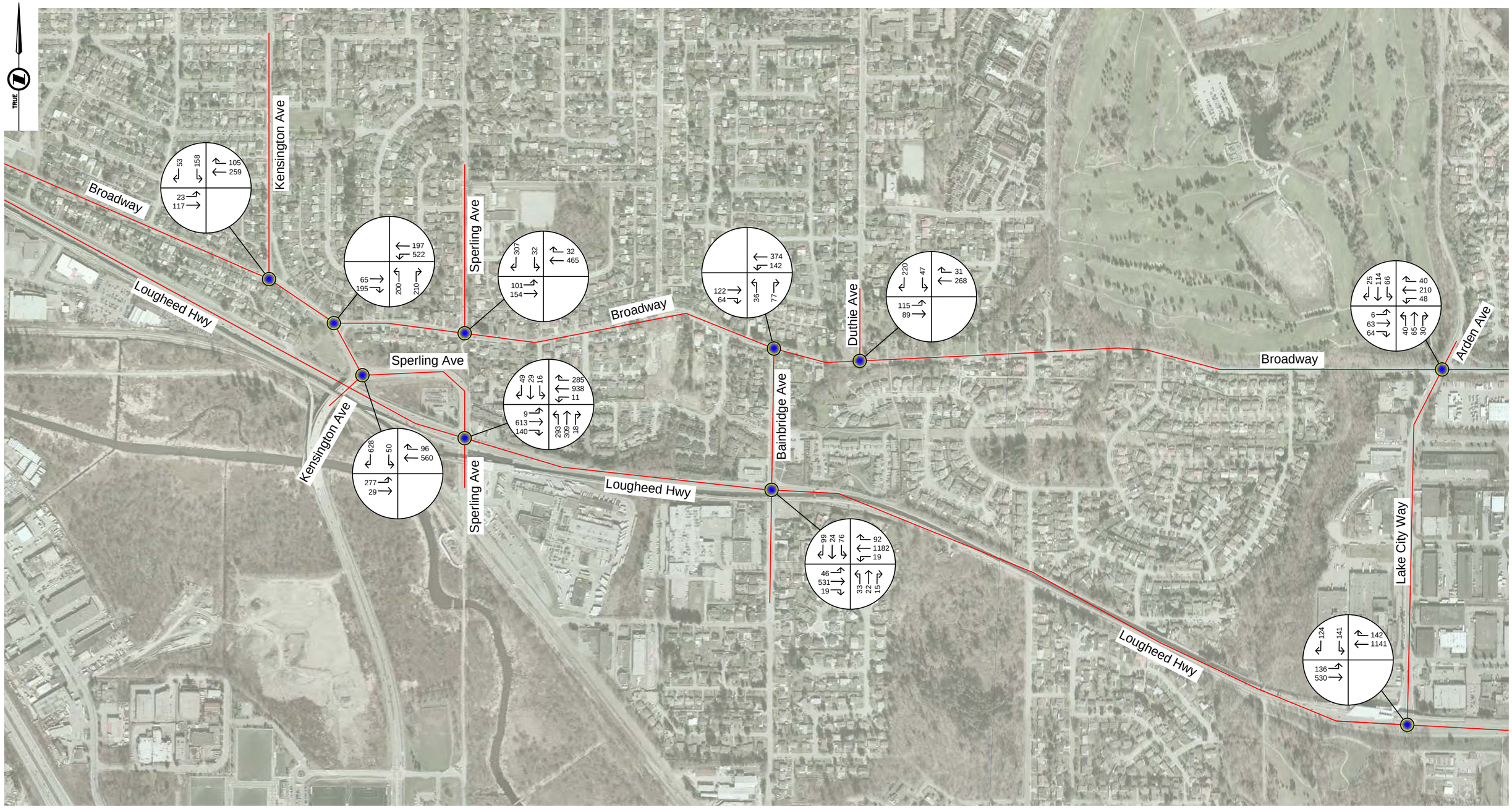
AM PEAK HOUR VOLUMES
(GILMORE AVENUE TO HOLDOM AVENUE)

(NOT TO SCALE)

EXHIBIT 1.1



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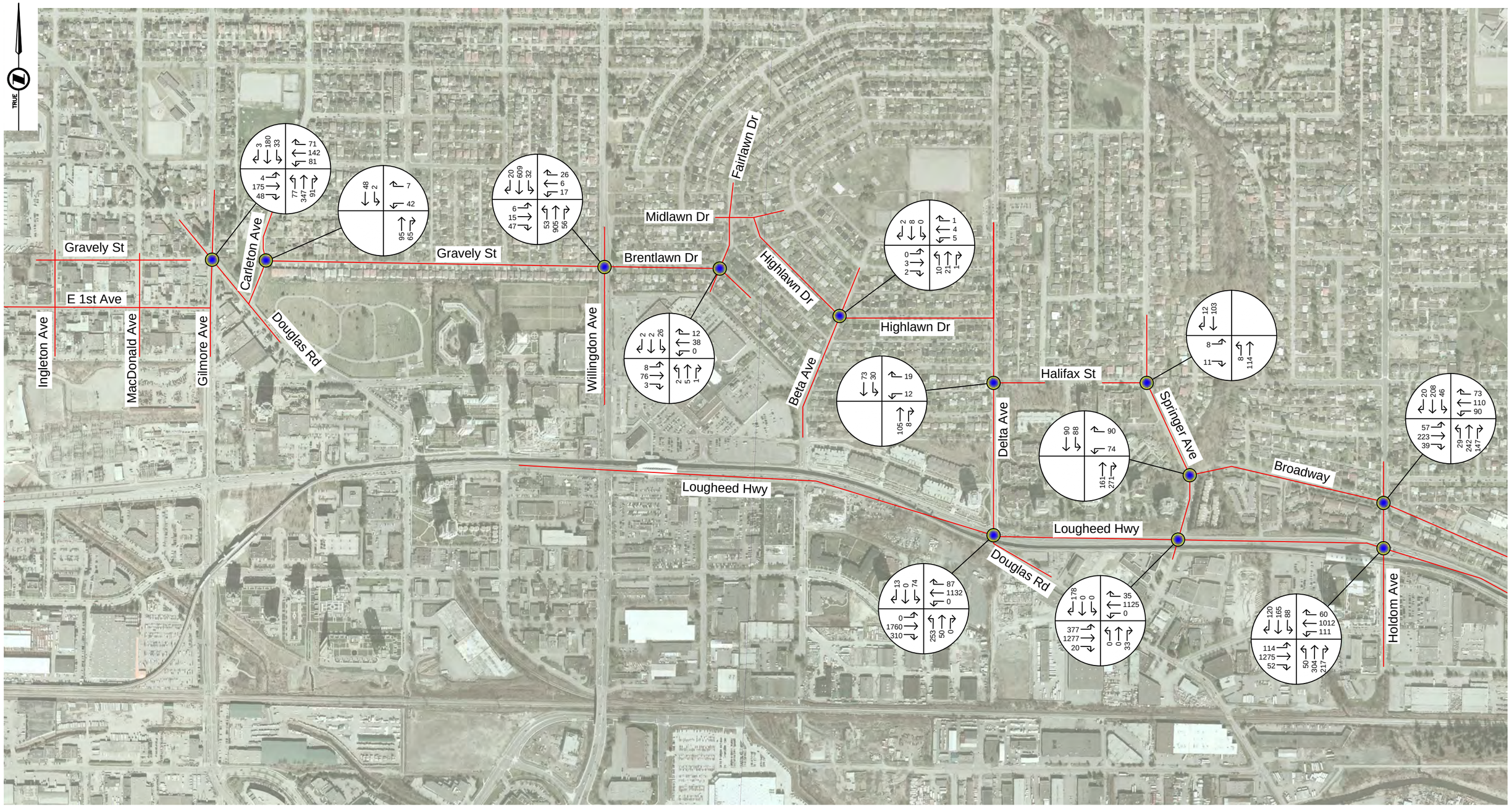
AM PEAK HOUR VOLUMES
(KENSINGTON AVENUE TO LAKE CITY WAY)

(NOT TO SCALE)

EXHIBIT 1.2



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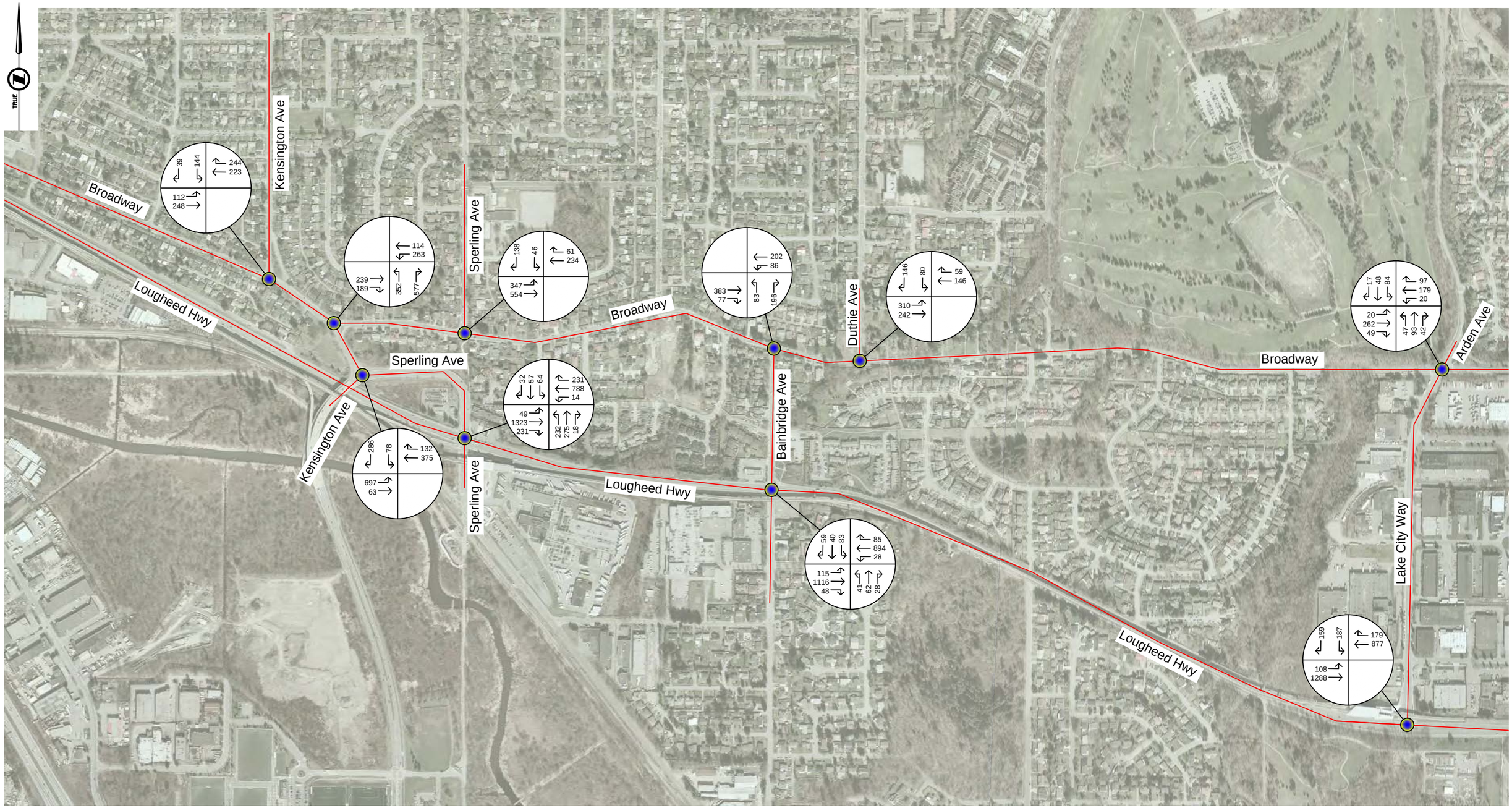
PM PEAK HOUR VOLUMES
(GILMORE AVENUE TO HOLDOM AVENUE)

(NOT TO SCALE)

EXHIBIT 1.3



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PM PEAK HOUR VOLUMES
(KENSINGTON AVENUE TO LAKE CITY WAY)

(NOT TO SCALE)

EXHIBIT 1.4

The Base performance data for the intersections was then extracted from the Base AM and PM peak hour models. These data included the following:

- Level of Service (LOS) - the Level of Service for a movement or an intersection overall is an indication of the delays due to the intersection controls. The LOS is derived by calculating the intersection or approach control delay and converting it to a letter between A and F. LOS A represents minimal delays and LOS F represents lengthy delays as per ***Table 1***. As a general rule, LOS of D or better is considered to be acceptable in an urban environment.

Table 1 - LOS/Delay

LOS	Delay (sec/veh)
A	<10
B	>10 and <20
C	>20 and <35
D	>35 and <55
E	>55 and <80
F	>80

- Volume/Capacity Ratio (v/c) - The v/c ratio indicates the amount of congestion for each lane group. Any v/c ratio greater than or equal to 1.0 indicates that the approach is operating at above capacity. As a general rule, v/c ratios less than 0.85 are considered to be acceptable in an urban environment.

The Base traffic performance of the signalized intersections on Lougheed Highway and Broadway where new traffic counts were undertaken is summarized in ***Table 2***. Note that this table only includes information for "problem" movements that have LOS D or worse, or v/c>0.85. All other movements not included in the table are considered to have acceptable performance. In this table abbreviations such as EBL (eastbound left), SBT (southbound through), WBR (westbound right), etc. have been used to describe the individual turning movements. If a movement occurs from a shared lane (e.g. a right turn movement from a shared through/right lane), the performance is recorded for the through lane. Only in cases where there are dedicated left or right turn lanes, is the performance of the applicable movement recorded under the relevant left or right turn columns.

Table 2 – Base Intersection Performance

				Turning Movements																							
				EBL		EBT		EBR		WBL		WBT		WBR		NBL		NBT		NBR		SBL		SBT		SBR	
Intersection	**Time Period**	**Int. LOS**	**Int. Avg. Delay (sec/veh)**	**LOS**	**v/c**	**LOS**	**v/c**	**LOS**	**v/c**	**LOS**	**v/c**	**LOS**	**v/c**	**LOS**	**v/c**	**LOS**	**v/c**	**LOS**	**v/c**	**LOS**	**v/c**	**LOS**	**v/c**	**LOS**	**v/c**	**LOS**	**v/c**
	Broadway																										
Broadway/Sperling	AM	B	12																								
	PM	A	8																								
Broadway/Kensington East	AM	B	11																								
	PM	B	13																								
Broadway/Holdom	AM	A	9																								
	PM	B	10																								
	Lougheed Highway																										
Lougheed/Bainbridge	AM	B	16	D						D																	
	PM	B	17	D						D																	
Lougheed/Sperling	AM	B	15	D						D																	
	PM	B	16							D																	
Lougheed/Holdom	AM	C	24	D						D																	
	PM	C	25	D						D																	
Lougheed/Delta	AM	C	24													E		E				E					
	PM	C	20													E		E				E					

As evident from the table above, there are currently no operational issues on the Broadway corridor. On Lougheed Highway, however, there are existing operational issues with the left turn movements off Lougheed Highway at Bainbridge Avenue, Sperling Avenue and Holdom Avenue, and in the northbound/southbound directions at Delta Avenue.

An assessment of the Base eastbound and westbound capacity of Broadway and Lougheed Highway was also undertaken at the signalized intersections where traffic data was available. Capacity calculations were performed for all the intersections between Bainbridge Avenue and Delta Avenue based on the following:

- The eastbound and westbound through/right turn lane group capacities (as applicable depending on lane configuration) was assessed.
- The determination of the eastbound and westbound capacities at each intersection was derived from the applicable lane group flow rates and v/c ratios.

The resultant Base eastbound and westbound lane group capacities at each affected signalized intersection are summarized in ***Table 3*** per direction and peak period.

Table 3 – Base East/West Lane Group Capacities (veh/hr)

	AM		**PM**	
	WB	**EB**	**WB**	**EB**
Intersection	**Broadway**			
Broadway/Sperling	712	1116	528	1171
Broadway/Kensington East (WBR/EBL)	882	310	781	414
Broadway/Holdom	443	403	609	580
Average Lane Grp. Cap.	679	610	639	722
	Lougheed Highway			
Lougheed/Bainbridge	1751	1834	1719	1957
Lougheed/Sperling	1391	1999	1453	2315
Lougheed/Holdom	1556	1226	1523	1563
Lougheed/Delta	2219	2224	2257	2282
Average Lane Grp. Cap.	1729	1821	1738	2029

From the above table, it can be seen that the eastbound/westbound carrying capacity of the Broadway intersections varies between a low of 310 veh/hr and a high of 1171 veh/hr. The average capacity of Broadway in this area is approximately 660 veh/hr per direction in the AM and PM peak periods.

The eastbound/westbound carrying capacity of the Lougheed Highway signalized intersections varies between a low of 1226 veh/hr and a high of 2315 veh/hr. The average capacity is approximately 1925 veh/hr eastbound and 1730 westbound.

With an understanding of the Base traffic conditions, the next step was to evaluate and model possible construction scenarios. These are discussed in the next section.

Construction Scenario Modelling

As mentioned previously, the purposes of this assignment is to assess from a traffic perspective if the possibility exists for the gas line to be constructed on Lougheed Highway instead of along the currently preferred Broadway alignment. The section of potential realignment is between Bainbridge Avenue and Madison Avenue.

On Lougheed Highway between Bainbridge Avenue and Madison Avenue the through lane configuration (excluding turn lanes) varies as follows:

Westbound:

- two westbound lanes between Bainbridge Avenue and Delta Avenue;
- three westbound lanes between Delta Avenue and Willingdon Avenue; and
- two westbound lanes just after Willingdon Avenue which then flare out to three lanes to beyond Madison Avenue.

Eastbound:

- two lanes between Maddison Avenue and Bainbridge Avenue.

With the possible Lougheed Highway gas line alignment alternative, it is expected that construction will occur in the westbound lanes requiring a full closure of these lanes as a minimum of two lanes is required for construction. This would require all westbound traffic to detour to alternative routes or alternatively be accommodated on the eastbound lanes as discussed below.

Reviewing the adjacent road network, there are considered to be no suitable continuous and nearby alternate routes which would have the ability to accommodate all the westbound traffic that would be detoured off Lougheed Highway if all the westbound lanes were closed. As shown in ***Table 3*** earlier, the westbound capacity of Broadway is approximately 660 veh/hr yet the westbound through volumes on Lougheed Highway are approximately 1100 veh/hr in the AM peak period (from ***Exhibit 1.1*** and ***1.2***). It can therefore be concluded that Broadway would not be able to accommodate a full diversion of Lougheed Highway westbound traffic if all westbound lanes were closed.

In addition to the capacity issues is the matter of diversion of westbound Lougheed Highway traffic onto streets like Broadway which is essentially a two lane road passing through residential areas. Furthermore, between Springer Avenue and Madison Avenue the detoured traffic would have to follow circuitous routes as there are no continuous east/west roads in this area. The total closure of all the westbound lanes on Lougheed Highway does not therefore appear feasible from a traffic perspective.

As an alternative to fully closing the westbound lanes on Lougheed Highway, the possibility of reducing Lougheed Highway to a single lane in each direction was considered. This could be achieved by running the two way traffic on the existing two eastbound lanes in road segments of 200m-1000m depending on site conditions during gas line construction. To assess the impacts of these lane closures a construction scenario was created and evaluated using Synchro as discussed in the subsection below.

Scenario 1

As a test of a "worst case" construction scenario, this Scenario 1 assumed the following:

- The eastbound and westbound though lanes on Lougheed Highway were reduced to single lanes at all the signalized intersections between Bainbridge Avenue and Delta Avenue;
- The existing left turn lanes on Lougheed Highway were retained where applicable as it is assumed that it will be possible to keep these lanes operational given that the major intersections are expected to be crossed using trenchless technology;
- The northbound and southbound lanes at the Lougheed Highway signalized intersections would remain as per existing;
- The Base traffic signal timings would remain; and
- The Base traffic volumes would continue to use the Lougheed Highway corridor (i.e. no detouring).

The Synchro models were adjusted to suit and the resultant intersection performance of the Lougheed Highway corridor signalized intersections is summarized in ***Table 4***.

Table 4 – Scenario 1 Intersection Performance

				Turning Movements																							
				EBL		EBT		EBR		WBL		WBT		WBR		NBL		NBT		NBR		SBL		SBT		SBR	
Intersection	**Time Period**	**Int. LOS**	**Int. Avg. Delay (sec/veh)**	**LOS**	**v/c**	**LOS**	**v/c**	**LOS**	**v/c**	**LOS**	**v/c**	**LOS**	**v/c**	**LOS**	**v/c**	**LOS**	**v/c**	**LOS**	**v/c**	**LOS**	**v/c**	**LOS**	**v/c**	**LOS**	**v/c**	**LOS**	**v/c**
	Lougheed Highway																										
Lougheed/Bainbridge	AM	E	64	D						D		F	1.15														
	PM	E	60	D		F	1.11			D		D	0.96											D			
Lougheed/Sperling	AM	C	28	D						D		D	0.97														
	PM	C	24	D						D						D		D									
Lougheed/Holdom	AM	E	79	D						D		F	1.25											D			
	PM	F	124	D		F	1.40			D		F	1.21					D									
Lougheed/Delta	AM	F	175									F	1.55			E		E				E					
	PM	F	139			F	1.46					D	1.02			E		E				E					

As is evident, the performance of all the affected signalized intersections is severely compromised by the lane reductions with the intersections LOSs being E or F in both the AM and PM peak periods except for at Sperling Avenue. In particular, the eastbound and westbound through movement performances deteriorate with many v/c ratios well in excess of 1.0 and multiple LOS E and F. At the Lougheed Highway/Sperling Avenue intersection, performance is better and this is attributed to the assumed retention of two eastbound lanes (one on Lougheed Highway and one from the Kensington ramp).

The Scenario 1 assessed above is considered a worst case with lane reductions on Lougheed Highway all the way between Bainbridge Avenue and Delta Avenue. These full corridor lane reductions are however not expected to occur, but the Scenario 1 analysis can be used to assist in the determination of the capacity of the Lougheed Highway corridor if it were to be reduced to single lanes between adjacent intersections.

Capacity calculations were therefore performed for all the signalized intersections on Lougheed Highway between Bainbridge Avenue and Delta Avenue based on the following:

- The eastbound and westbound through/right turn lane group capacities (as applicable depending on lane configuration) was assessed on the assumption that the existing left turn lanes on Lougheed Highway would be retained at the intersections; and
- The determination of the eastbound and westbound capacities at each intersection was derived from the applicable lane group flow rates and v/c ratios from Scenario 1.

The resultant calculated eastbound and westbound lane group capacities at each affected intersection are summarized in ***Table 5*** per direction and peak period.

Table 5 – Scenario 1 East/West Lane Group Capacities (veh/hr)

	AM		**PM**	
	WB	**EB**	**WB**	**EB**
Intersection	**Lougheed Highway**			
Lougheed/Bainbridge	1006	1047	931	1021
Lougheed/Sperling	909	1722	923	1846
Lougheed/Holdom	891	743	871	894
Lougheed/Delta	1167	1170	1190	1201
Average Lane Grp. Cap.	994	1171	979	1240
Average Lane Grp. Cap. (Existing)	1729	1821	1738	2029

Comparing the values in ***Table 5*** with the Base capacities in ***Table 3***, it is clear that the reductions in lanes has a significant impact on the Lougheed Highway capacities. From the above table, it can also be seen that the eastbound/westbound carrying capacity of the intersections varies between a low of 743 veh/hr and a high of 1846 veh/hr. The average capacity of Lougheed Highway is approximately 980 veh/hr

westbound and 1200 veh/hr eastbound (compared to approximately 1730 veh/hr westbound and 1925 veh/hr currently).

Knowing the volume of traffic that currently uses the Lougheed Highway corridor (from the turning movement counts) and the amount of traffic that can be processed at each intersection if the lanes were reduced to single lanes (i.e. calculated capacity), it was possible to calculate how much "excess" traffic there may be on the corridor during the lane reductions. This excess traffic (or unserviced demand) would either be queued on the corridor or would alternatively reroute to other routes. ***Table 6*** presents the excess volumes by intersection for the two peak periods. Zero values in these tables suggest that the applicable intersections can accommodate the existing volumes with single eastbound/westbound through lanes.

Table 6 – Scenario 1 East/West Lane Group Excess Demand (veh/hr)

	AM		**PM**	
	WB	**EB**	**WB**	**EB**
Intersection	**Lougheed Highway**			
Lougheed/Bainbridge	176	0	0	142
Lougheed/Sperling	29	0	0	0
Lougheed/Holdom	259	0	200	380
Lougheed/Delta	673	0	28	559

Broadly speaking, if the excess volumes in ***Table 6*** diverted to alternate routes if Lougheed Highway was reduced to single lanes, then the Lougheed Highway corridor intersections could be expected to operate at or near capacity (i.e. v/c ~ 1.0).

The above analysis suggests that the gas line could be constructed on Lougheed Highway between the Bainbridge Avenue and Sperling Avenue intersections with manageable impacts to traffic. The excess east/west volumes on Lougheed Highway in this area are not significant (<176 veh/hr) and these would either queue on the corridor or divert to the adjacent streets (e.g. Broadway) during construction.

The problem area is west of Sperling Avenue where the traffic volumes are generally higher and the excess volumes reach 673 veh/hr. Not only are excess volumes higher here, but in this area in particular, suitable alternative detour routes are not readily available. It is also noted that the above analysis did not consider the impacts at what is probably the most capacity constrained intersection in the area, Lougheed Highway/Willingdon Avenue. There is significant congestion at this intersection for many hours of the day, and any reduction in capacity due to gas line construction will result in lengthy delays and queues. It is therefore recommended that the alternative Lougheed Highway alignment not be pursued from a traffic management perspective west of Sperling Avenue.

Other Considerations

In addition to the delay and congestion impacts of constructing the gas line on Lougheed Highway discussed above, there are a number of other traffic considerations as discussed below:

- Lougheed Highway is a bus route and any reductions in capacity will increase travel times and affect bus schedules.
- Lougheed Highway is a cycle route with designated cycle lanes in both directions. The accommodation of the bi-directional traffic and cycle lanes in the existing eastbound lanes will likely be very challenging.
- There is a raised median island on Lougheed Highway and the lane crossovers will require careful design. This is exacerbated in the Delta Avenue to Madison Avenue segment where the SkyTrain guideway and piers are located in the median. This severely restricts the ability to switch the traffic lanes in this area during various phases of construction.
- The area around Brentwood Mall is currently under large scale redevelopment and it is expected that this will continue in the near future. With all the impacts to traffic associated with this construction work, it would be advisable for the gas line replacement work to be separated from Lougheed Highway to avoid overlapping traffic management issues on this busy corridor.

Conclusions

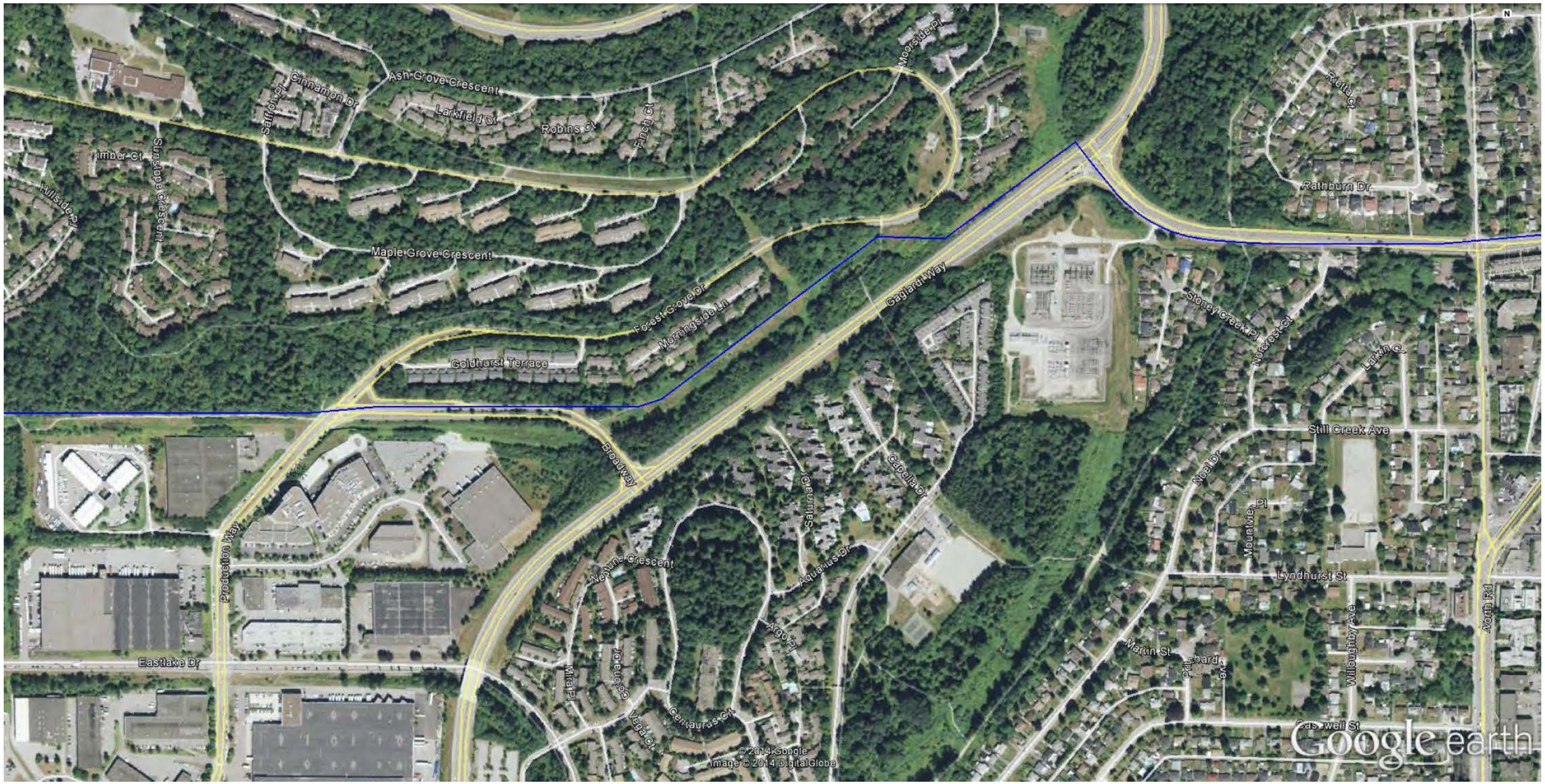
Based on the preliminary analysis work described in this report, the following conclusions can be made regarding the possible alignment of the gas line on Lougheed Highway between Bainbridge Avenue and Maddison Avenue:

- The total closure of all the westbound lanes on Lougheed Highway does not appear feasible from a traffic perspective given that there are no suitable continuous parallel routes for traffic to detour to.
- The reduction of the lanes on Lougheed Highway to single lanes in each direction during construction will result in a significant deterioration in traffic performance. The reduction in capacity will result in volume/capacity ratios exceeding 1.0 and the excess traffic will not have suitable alternate routes to detour to, especially west of Sperling Avenue.
- The accommodation of bi-directional buses and cyclists on the existing two eastbound lanes will prove challenging.
- The presence of raised medians and SkyTrain piers severely restricts the ability to switch the traffic lanes during various phases of construction.

It is therefore recommended from a traffic management perspective that Fortis BC does not pursue the Lougheed Highway alignment option.

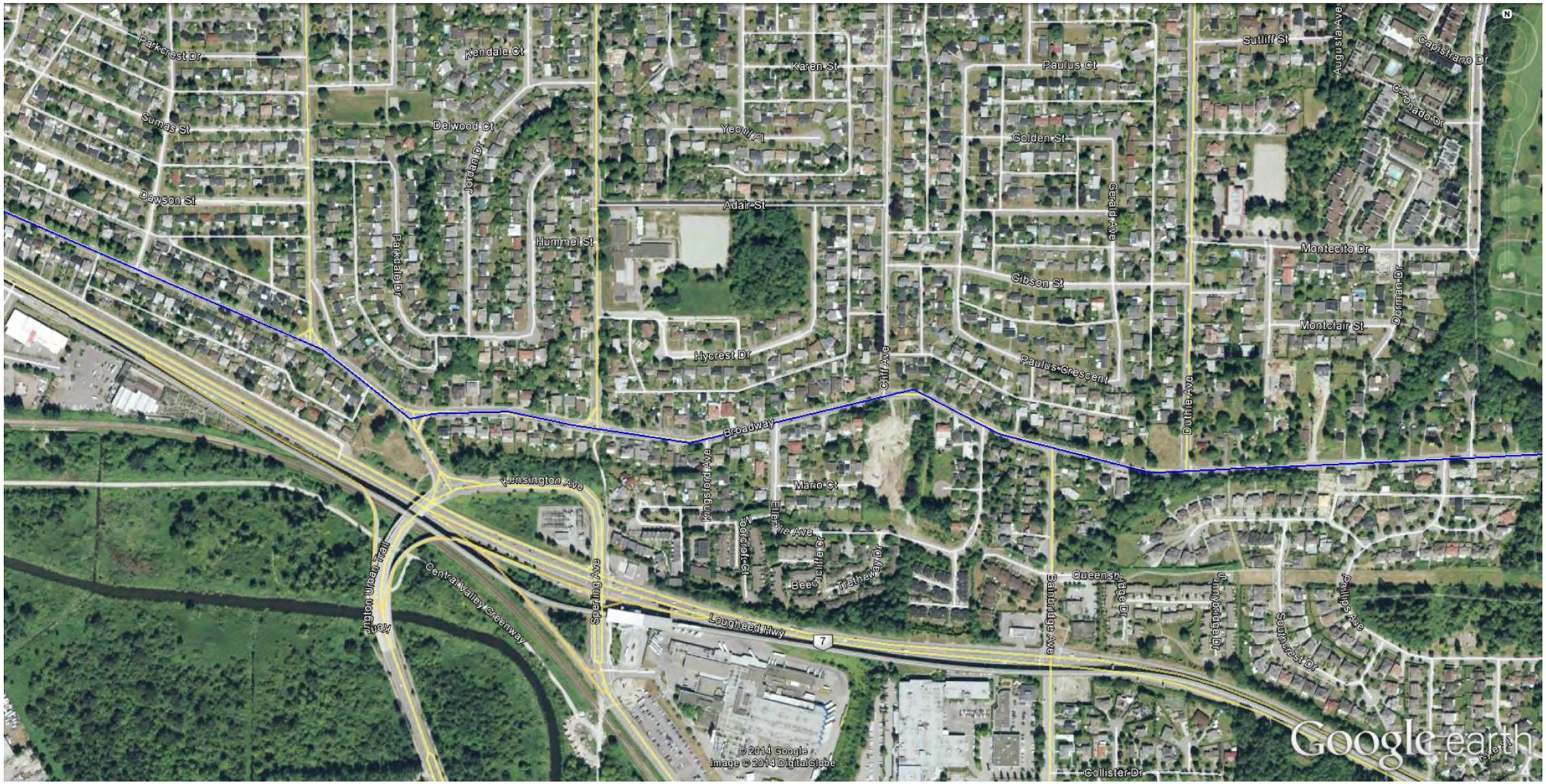
Appendix A – Preliminary Gas Line Alignment

Burnaby Alignment – Section 1

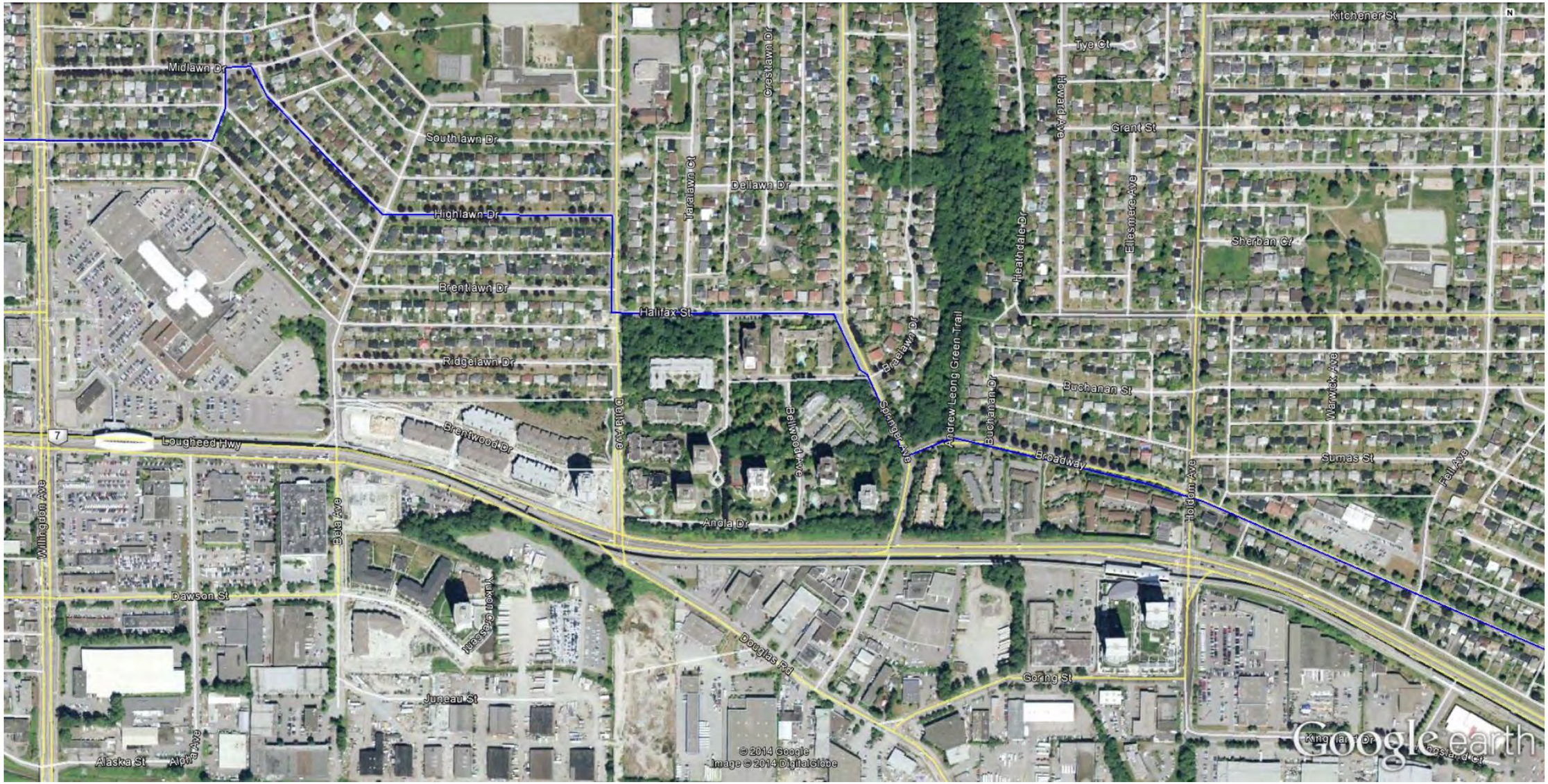


Burnaby Alignment – Section 2

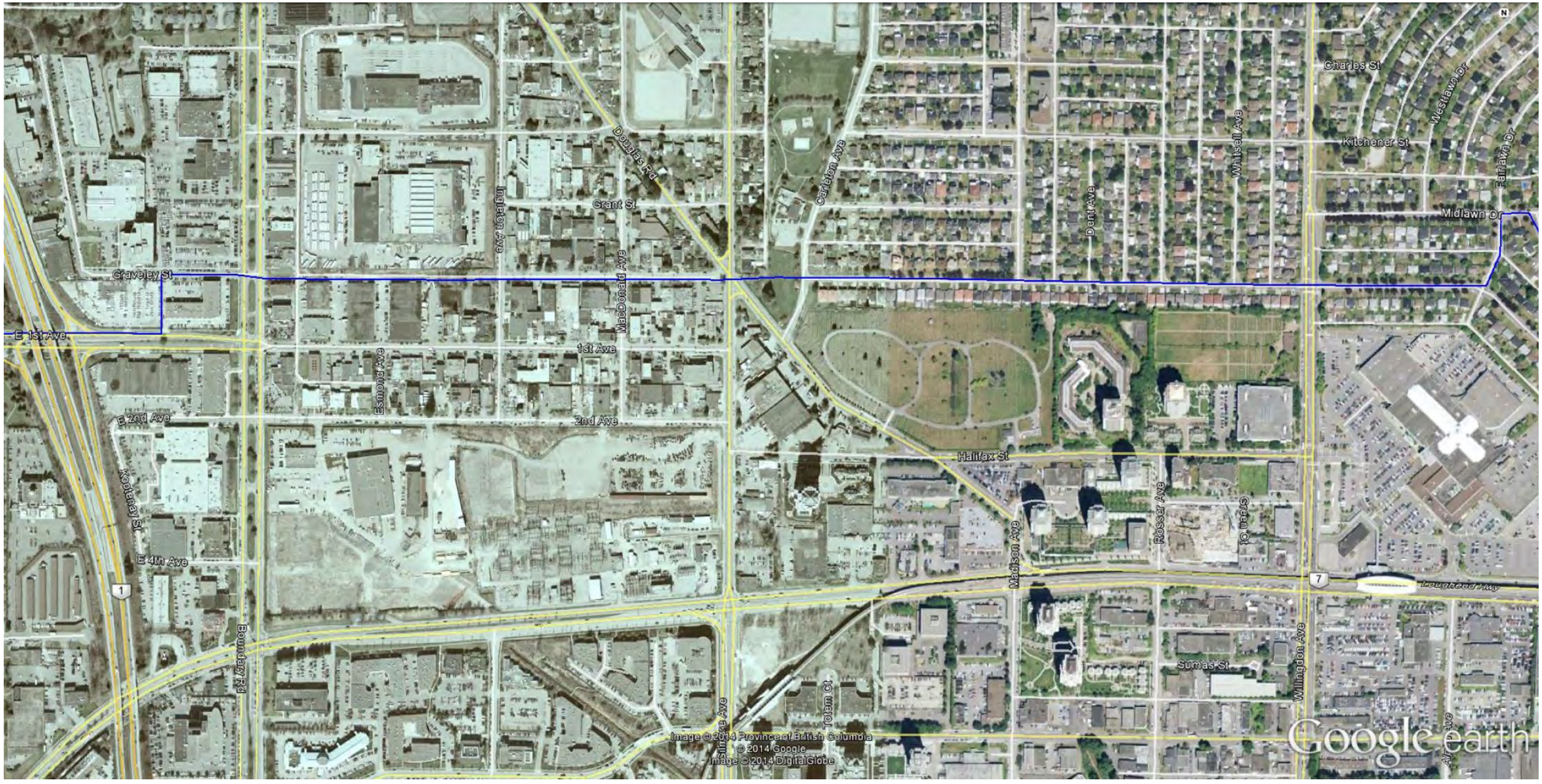
Burnaby Alignment – Section 3



Burnaby Alignment – Section 4

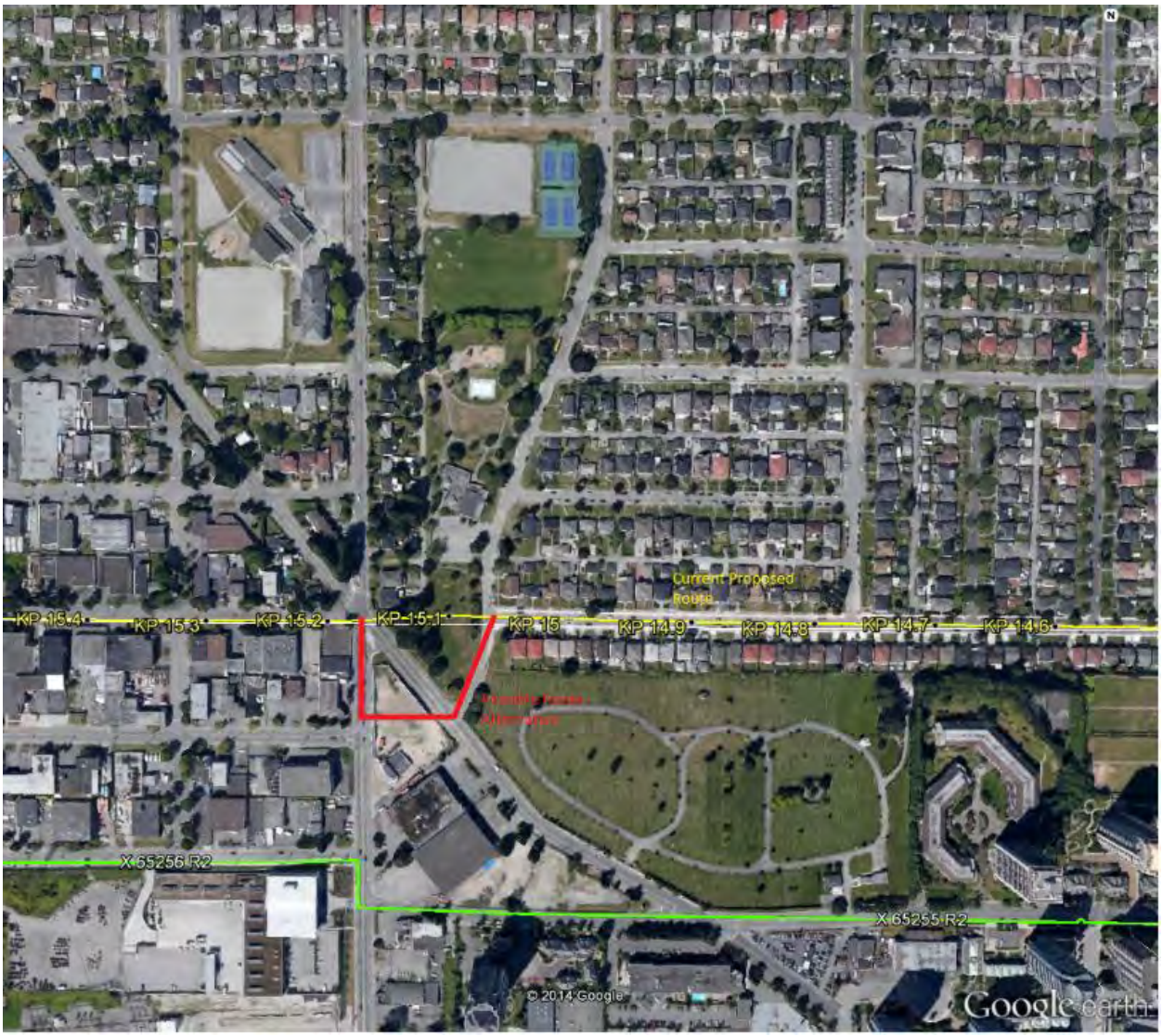


Burnaby Alignment – Section 5



Appendix B – Willingdon Park Alternative

Willingdon Park Alternative



Appendix A-18-6

EAST 1ST AVENUE ALIGNMENT TRAFFIC IMPACT ASSESSMENT

GNEC

GREAT NORTHERN ENGINEERING CONSULTANTS INC.

Coquitlam IP Pipeline Replacement Project
1st Avenue Alignment Traffic Impact Assessment - Final

October 20, 2014

Submitted to: FORTIS BC

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Note to Reader

The opinions and findings expressed in this report are based on technical information and analysis available at the time of writing. These opinions and findings have not been disclosed to the City of Vancouver and their acceptance thereof has not therefore been confirmed.

Introduction

Fortis BC is proposing to replace the existing 20km long Coquitlam IP Pipeline between Coquitlam (Como Lake Avenue Avenue/Mariner Way intersection) and Vancouver (East 2nd Avenue/Woodland Drive intersection). At present a preliminary design of the gas line has been prepared by Worley Parsons and it is expected that construction will take place during the summer of 2018. For the most part, the replacement gas line will run along existing road rights of way through the Cities of Coquitlam, Burnaby and Vancouver.

Fortis BC has retained Great Northern Engineering Consultants (GNEC) to support them and their design team to assist with providing traffic management advice as they proceed forward with community and stakeholder consultation, detailed design and permit approvals. As part of previous work, GNEC performed preliminary analysis which concluded that the originally proposed full closure of the westbound lanes on E 1st Avenue during construction would cause major issues on the parallel E Hastings Street and E Broadway corridors. A preferred solution at the time was therefore to close a lane in each direction on E 1st Avenue thus maintaining mobility as well as not overloading the parallel routes. This would entail retaining two way flow on the existing two eastbound lanes. This work, which was based on outdated or limited available traffic data, was documented in a previous GNEC report titled *"Coquitlam IP Pipeline Replacement Project – Preliminary Traffic Management Review – Vancouver Segment – Final"* dated July 29, 2014.

Subsequent to the above mentioned report a project specific traffic data collection program was initiated in summer 2014. Traffic modelling was then undertaken to quantify the existing traffic operations for the entire pipeline project area in Vancouver, Burnaby and Coquitlam. This work was documented in a GNEC report titled "*Coquitlam IP Pipeline Replacement Project – Base Traffic Modelling – Final"* dated October 16, 2014.

GNEC was then requested by Fortis BC to reassess the likely traffic impacts if sections of 1st Avenue in Vancouver were to be reduced to single though lanes in the east/west directions during gas line construction. This memo documents this preliminary assessment based on the new summer 2014 data and traffic models and is intended to assist Fortis BC in deciding whether to pursue the 1st Avenue alignment or possibly switch to an alternate alignment in Vancouver. The focus of this memo is on the ability of the E 1st Avenue corridor to accommodate traffic during gas line construction and limited attention has been given at this time to the details of how the lane reductions will actually be implemented.

Proposed Alignment

The proposed alignment of the gas line within the City of Vancouver is provided in ***Appendix A***. As can be seen the alignment from east to west is generally:

- West on Graveley Street across Boundary Road;
- South to E 1st Avenue through the Vancouver Police Department parking lot;
- West along E 1st Avenue to Woodland Drive;
- West across Woodland Drive on the north side of E 1st Avenue; and

- South on the west side of Woodland Drive across E 1st Avenue to the end point just south of E 2nd Avenue.

E 1st Avenue is a major east/west arterial connecting Vancouver and Highway 1. On E 1st Avenue between Boundary Road and Nanaimo Street, there is a raised central median (except for at intersections) with two through lanes in each direction. West of Nanaimo Street, there are two through lanes in each direction with no median. Left turn lanes have been provided on E 1st Avenue at the following locations:

- Boundary Road;
- Highway 1;
- Renfrew Street;
- Nanaimo Street; and
- Commercial Drive.

At intersections other than those listed above, left turn movements from E 1st Avenue occur from the inside lane except where left turns are prohibited as follows:

- Victoria Drive – westbound left prohibited 7:00-9:30am and 3:00-6:00pm Monday to Friday, eastbound left prohibited full time.

The following signalized intersections on E 1st Avenue may be directly or indirectly affected by the gas line works:

- Boundary Road/E 1st Avenue;
- E 1st Avenue/Highway 1 Eastbound;
- E 1st Avenue/Highway 1 West bound;
- E 1st Avenue/Rupert Street;
- E 1st Avenue/Lillooet Street (Pedestrian signal);
- E 1st Avenue/Renfrew Street;
- E 1st Avenue/Slocan Street (Pedestrian signal);
- E 1st Avenue/Nanaimo Street;
- E 1st Avenue/Templeton Drive (Pedestrian signal);
- E 1st Avenue/Lakewood Drive (Pedestrian signal);
- E 1st Avenue/Victoria Drive;
- E 1st Avenue/Commercial Drive; and
- E 1st Avenue/Woodland Drive (Pedestrian signal).

Construction Approach

Based on preliminary advice from Fortis BC, it is intended that the gas line will be constructed using a combination of trenchless and open cut methods. The crossing of the following major roads/intersections is expected to be achieved using trenchless technology:

- Graveley Street/Boundary Road;
- E 1st Avenue/Highway 1 interchange;
- E 1st Avenue/Rupert Street;

- E 1st Avenue/Renfrew Street;
- E 1st Avenue/Nanaimo Street; and
- E 1st Avenue/Commercial Drive.

Between the major intersections listed above and across the minor intersections, the gas line is expected to be constructed using an open cut approach that will require approximately 200-1000m of road space occupation at any one time depending on site conditions. Based on preliminary information provided by Fortis BC, it is proposed to construct the gas line along the north side of the center median of E 1st Avenue in the westbound lanes between Highway 1 and Nanaimo Street. The existing westbound lanes in this area would be closed between the major intersections thereby requiring closures up to 1000m at a time. West of Nanaimo Street where there is no median, both westbound lanes on E 1st Avenue would also be closed, however, the length of the closures is expected to be less than 1000m. As mentioned previously, it is expected that E 1st Avenue will be reduced to single through lanes in each direction in the vicinity of the work zones with two way flow being maintained on the existing eastbound lanes. Due to the nature of construction, it is expected that the road occupation will be on a full time basis limiting the ability to open/close lanes by time of day.

Traffic Data Collection

In order to quantify existing traffic conditions and assess the impacts of construction on traffic, current traffic data was required. A comprehensive project specific traffic data collection program was therefore undertaken in the summer of 2014. This involved two types of data collection as discussed in the following sub-sections.

Note: Additional information regarding the data collection program is provided in the GNEC report titled "*Coquitlam IP Pipeline Replacement Project – Base Traffic Modelling*".

Tube Counts

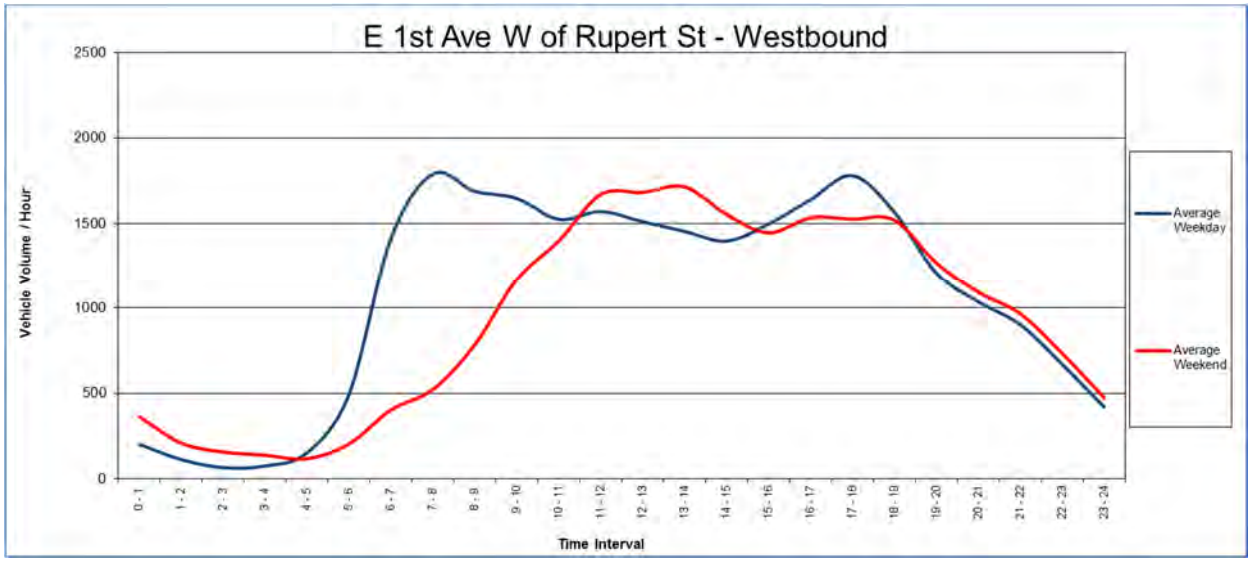
Tube counts involve placing pneumatic tubes across the road that are connected to a counter device on the side of the road. They enable the collection of directional traffic volumes by time of day and over multiple days. For the purposes of this project the tube counts were undertaken for a full week on E 1st Avenue west of Rupert Street between Friday July 25 and Thursday July 31 2014.

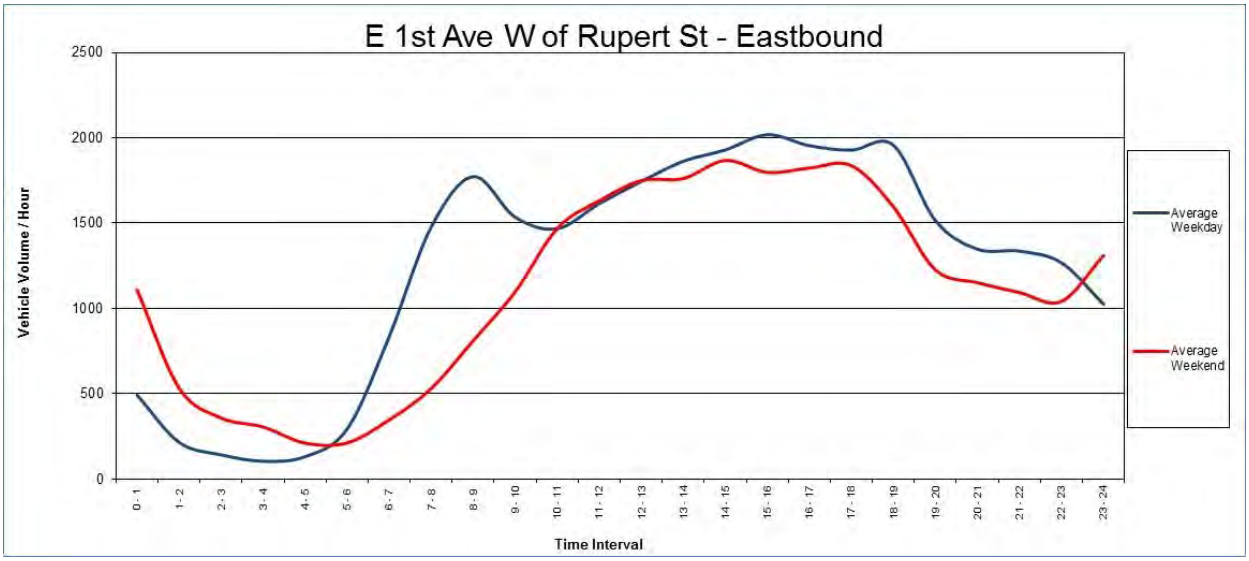
In ***Table 1*** below, the average weekday and average weekend daily volumes on E 1St Avenue are presented. As can be seen, the eastbound daily volumes exceed the westbound daily volumes. This summary also shows that weekend daily volumes are lower than the weekday volumes, but not by a significant margin.

Table 1 – Average Weekday/Weekend Daily Volumes (veh/day)

Location	Day	Westbound	Eastbound	Two Way
E 1st Avenue west of Rupert Street	Weekday	25819	29976	55795
	Weekend	22642	26877	49519

In the charts below, the average weekday and average weekend day hourly volumes are presented for the westbound and eastbound directions.





From the above charts, the following are observed:

(a) Westbound weekday volumes peak at approximately 1800 veh/hr in the AM peak period;
(b) Eastbound weekday volumes peak at approximately 2000 veh/hr in the PM peak period;
(c) Weekday midday peak volumes are 1500-1750 veh/hr per direction; and
(d) Weekend peak volumes are approximately 1700 veh/hr westbound and 1800 veh/hr eastbound.

Turning Movement Counts

Within the City of Vancouver, any construction work on the heavily trafficked E 1st Avenue route could result in traffic detouring to alternate routes, primarily the continuous parallel E Hastings Street and E Broadway routes. Turning movement counts were therefore undertaken at the major intersections on all

three of these east/west routes along with the major north/south routes between Boundary Road and Clark Drive. On E 1st Avenue all signalized intersections were surveyed while on E Hastings Street and E Broadway only the intersections with the major north/south roads were surveyed. On the major north/south roads only the intersections on E 1st Avenue, E Broadway and E Hastings Street were surveyed.

The turning movement counts were undertaken between July 29, 2014 and August 28, 2014. These counts were performed on either a Tuesday, Wednesday or Thursday between the hours of 7:00 – 9:00am, 11:00am – 1:00pm, and 3:00pm – 6:00pm. Data was collected for passenger cars, heavy vehicles, TransLink buses and pedestrians.

All the turning movement count data was then processed to determine the turning movement volumes at each intersection for the AM and PM peak hours. The resultant AM and PM peak hour volumes are illustrated in ***Exhibit 1.1*** and ***1.2*** for all vehicle types combined.

Base Synchro Model Development

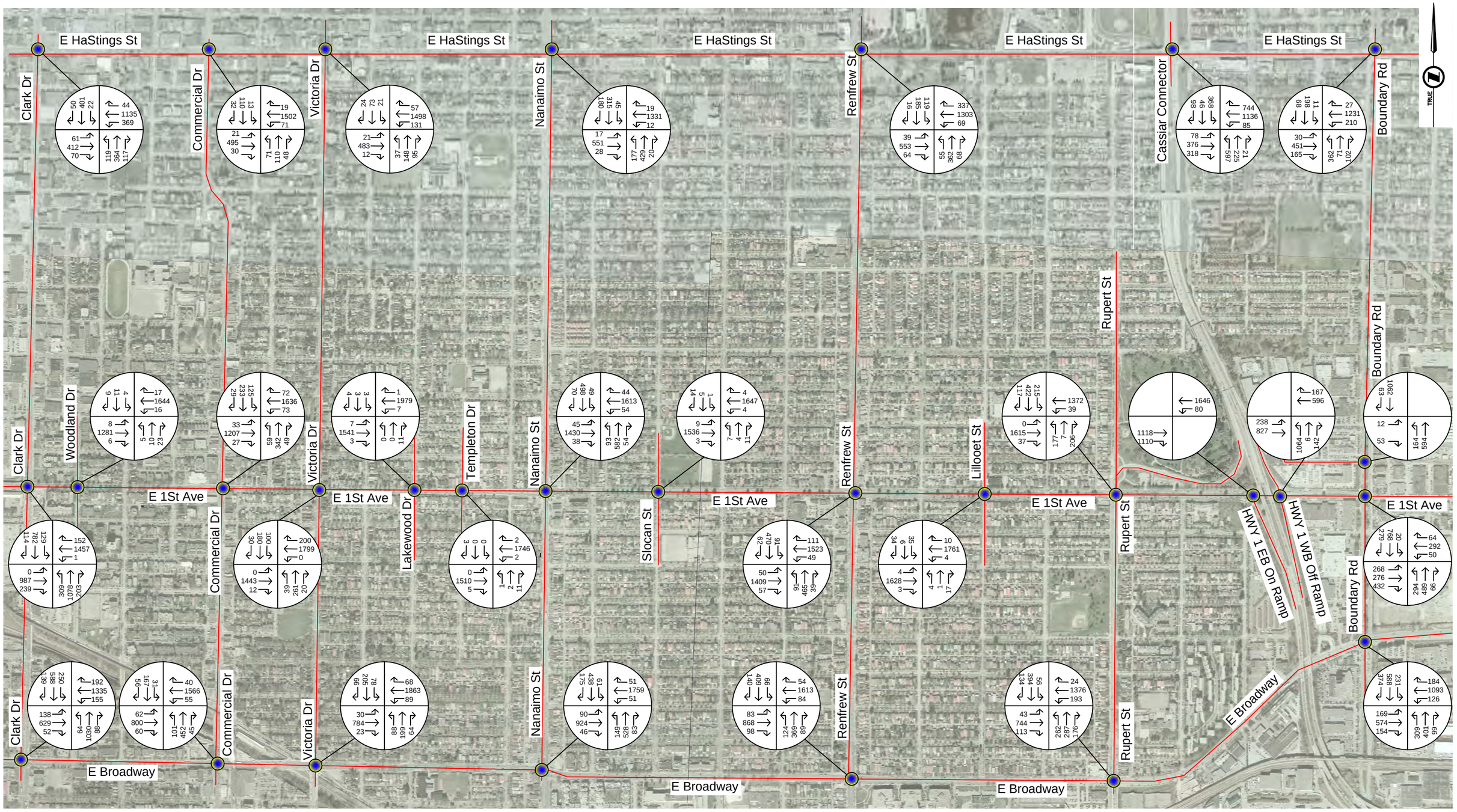
For traffic modelling purposes, the study area was divided into three sub areas covering the Cities of Coquitlam, Burnaby and Vancouver respectively. "Base" traffic models were then developed for the AM and PM peak hours for each subarea using the Synchro software. Relevant to this report, the Vancouver Synchro models covered the area, roads and intersections shown in ***Exhibit 1.1*** and ***1.2***. The models were coded over scaled aerial photographs to ensure correct distances between intersections. The resultant Base models reflected existing traffic conditions and as such, incorporated the following data:

- Existing laning geometry at all the major intersections shown and between intersections (excluding minor intersections and accesses);
- Existing traffic signal timings at all signalized intersections (as provided by the City of Vancouver);
- Existing stop controls at unsignalized intersections;
- Peak hour turning movement volumes from ***Exhibit 1.1*** to ***1.2***;
- Pedestrians volumes at the intersections that have high pedestrian activity; and
- Existing time of day parking and HOV lane restrictions where applicable.

Note: The development of the Base Synchro models is documented in more detail in the GNEC report titled "*Coquitlam IP Pipeline Replacement Project – Base Traffic Modelling*".

The Base performance data for the signalized intersections was then extracted from the Base AM and PM peak hour models. These data included the following:

- Level of Service (LOS) - the Level of Service for a movement or an intersection overall is an indication of the delays due to the intersection controls. The LOS is derived by calculating the intersection or approach control delay and converting it to a letter between A and F. LOS A represents minimal delays and LOS F represents lengthy delays as per ***Table 2***. As a general rule, LOS of D or better is considered to be acceptable in an urban environment.



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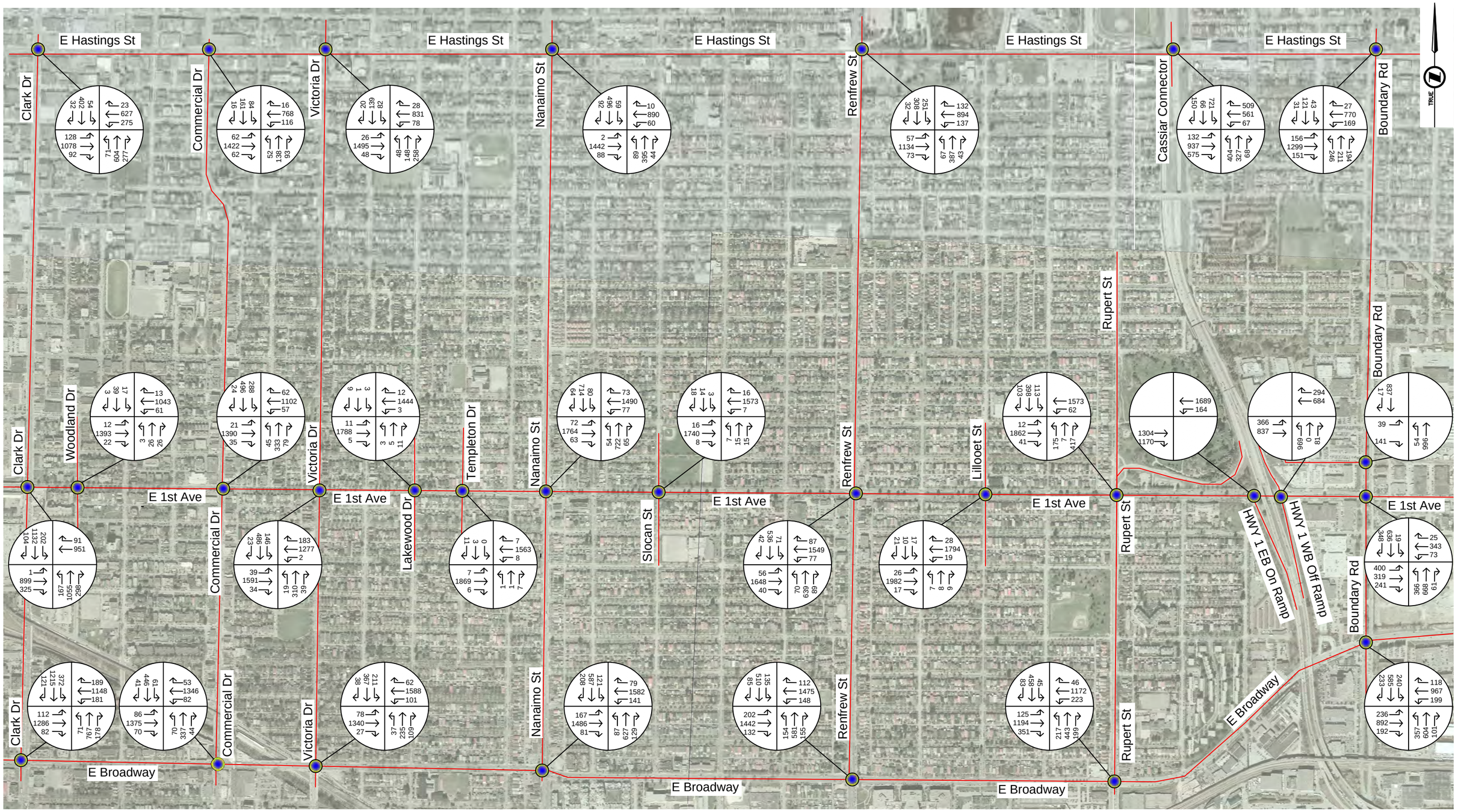
AM PEAK HOUR VOLUMES
(CLARK DRIVE TO BOUNDARY ROAD)
(NOT TO SCALE)

EXHIBIT 1.1



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PM PEAK HOUR VOLUMES
(CLARK DRIVE TO BOUNDARY ROAD)
(NOT TO SCALE)

EXHIBIT 1.2

Table 2 - LOS/Delay

LOS	Delay (sec/veh)
A	<10
B	>10 and <20
C	>20 and <35
D	>35 and <55
E	>55 and <80
F	>80

- Volume/Capacity Ratio (v/c) - The v/c ratio indicates the amount of congestion for each lane group. Any v/c ratio greater than or equal to 1.0 indicates that the approach is operating at above capacity. As a general rule, v/c ratios less than 0.85 are considered to be acceptable in an urban environment.

The Base traffic performance of the signalized intersections in the Vancouver model area is summarized in ***Table 3*** with the Synchro output files included in ***Appendix B***. Note that this table only includes information for "problem" movements that have LOS D or worse, or v/c>0.85. All other movements not included in the table are considered to have acceptable performance. In this table abbreviations such as EBL (eastbound left), SBT (southbound through), WBR (westbound right), etc. have been used to describe the individual turning movements. If a movement occurs from a shared lane (e.g. a left turn movement from a shared through/left lane), the performance is recorded for the through lane. Only in cases where there are dedicated left or right turn lanes, is the performance of the applicable movement recorded under the relevant left or right turn columns.

Table 3 – Base Intersection Performance

				Turning Movement																							
				EBL		EBT		EBR		WBL		WBT		WBR		NBL		NBT		NBR		SBL		SBT		SBR	
Intersection	Peak Period	Int. LOS	Int. Avg. Delay (sec/veh)	LOS	v/c	LOS	v/c	LOS	v/c	LOS	v/c	LOS	v/c	LOS	v/c	LOS	v/c	LOS	v/c	LOS	v/c	LOS	v/c	LOS	v/c	LOS	v/c
	E 1st Avenue																										
E 1st/Boundary	AM	C	28	D	-	-	-	-	-	-	-	D	-	-	-	-	1.45	-	-	-	-	-	-	D	-	-	-
	PM	C	34	E	1.01	-	-	-	-	D	-	D	-	-	-	-	1.71	-	-	-	-	-	-	D	-	-	-
Highway 1/E 1St (east)	AM	C	32	D	-	-	-	-	-	-	-	D	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	PM	C	35	E	-	-	-	-	-	-	-	E	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Highway 1/E 1St (west)	AM	A	6	-	-	-	-	-	0.89	D	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	PM	B	12	-	-	-	-	-	0.98	E	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
E 1st/Rupert	AM	C	25	-	-	-	-	-	-	-	-	-	0.94	-	-	E	-	-	-	-	-	-	-	-	-	-	-
	PM	E	61	-	-	-	-	-	-	-	-	F	1.28	-	-	D	-	-	-	-	-	-	-	-	-	-	-
E 1st/Lillooet	AM	C	21	-	-	-	0.86	-	-	-	-	-	0.94	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	PM	F	174	-	-	F	1.37	-	-	-	-	F	1.32	-	-	-	-	-	-	-	-	-	-	-	-	-	-
E 1st/Renfrew	AM	B	18	D	-	-	-	-	-	-	-	-	0.90	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	PM	B	20	-	-	-	0.92	-	-	D	0.90	-	0.90	-	-	-	-	-	-	-	-	D	-	-	-	-	-
E 1st/Slocan	AM	A	9	-	-	-	-	-	-	-	-	-	0.87	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	PM	B	20	-	-	-	0.97	-	-	-	-	-	0.88	-	-	-	-	-	-	-	-	-	-	-	-	-	-
E 1st/Nanaimo	AM	B	17	D	-	-	-	-	-	-	-	-	0.85	-	-	D	-	-	-	-	-	-	-	-	-	-	-
	PM	B	18	D	-	-	0.94	-	-	E	0.90	-	-	-	-	D	-	-	-	-	-	F	0.94	-	-	-	-
E 1st/Templeton	AM	A	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	PM	A	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
E 1st/Lakewood	AM	A	7	-	-	-	-	-	-	-	-	-	0.86	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	PM	A	5	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-
E 1st/Victoria	AM	B	18	-	-	-	-	-	-	-	-	-	0.99	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	PM	D	44	-	-	E	1.10	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-	E	0.90	-	-
E 1st/Commercial	AM	B	18	-	-	-	-	-	-	-	-	-	0.91	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	PM	C	24	-	-	-	0.88	-	-	D	-	-	-	-	-	-	-	-	-	-	-	D	-	-	-	-	-
E 1st/Woodland	AM	A	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	PM	B	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
E 1st/Clark	AM	D	50	-	-	-	-	-	-	-	-	D	1.07	-	-	F	1.05	F	1.08	-	-	-	-	-	-	-	-
	PM	C	30	-	-	-	0.90	-	-	-	-	-	-	-	-	D	-	-	0.87	-	-	E	0.98	-	-	-	-
	E Hastings Street																										
Hastings/Boundary	AM	C	26	-	-	-	-	-	-	-	-	-	-	-	-	D	-	-	-	-	-	D	-	-	-	-	-
	PM	C	30	-	-	-	-	-	-	D	-	-	-	-	-	D	-	-	-	-	-	D	-	D	-	-	-
Hastings/Cassiar Connector/Hwy 1 ramps	AM	C	28	D	-	-	-	-	-	D	-	-	-	-	-	-	-	D	-	-	-	D	-	D	-	-	-
	PM	C	34	E	-	-	-	-	-	E	-	D	-	-	-	D	D	-	-	-	-	D	-	D	-	-	-

				Turning Movement																							
				EBL		EBT		EBR		WBL		WBT		WBR		NBL		NBT		NBR		SBL		SBT		SBR	
Intersection	Peak Period	Int. LOS	Int. Avg. Delay (sec/veh)	LOS	v/c	LOS	v/c	LOS	v/c	LOS	v/c	LOS	v/c	LOS	v/c	LOS	v/c	LOS	v/c	LOS	v/c	LOS	v/c	LOS	v/c	LOS	v/c
Hastings/Renfrew	AM	B	15	D	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	PM	C	27	D	-	-	-	-	-	F	1.28	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hastings/Nanaimo	AM	B	13	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	PM	B	20	-	-	-	-	-	-	-	-	-	0.91	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hastings/Victoria	AM	A	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	PM	A	9	-	-	-	-	-	-	D	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hastings/Commercial	AM	B	13	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	PM	B	15	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hastings/Clark	AM	B	15	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	PM	C	25	-	-	-	-	-	-	-	-	-	-	-	-	-	-	D	-	-	-	-	-	-	-	-	-
	E Broadway																										
Boundary/Lougheed/Broadway	AM	D	38	-	-	-	-	-	-	-	-	D	0.97	-	-	D	-	D	-	-	-	E	-	D	-	-	-
	PM	D	42	D		D	-	-	-	D	-	D	0.91	-	-	-	-	E	0.91	-	-	E	-	D	-	-	-
Broadway/Rupert	AM	C	27	-	-	-	-	-	-	-	-	-	-	-	-	D	-	D	-	-	-	-	-	D	-	-	-
	PM	C	34	-	-	-	-	-	-	E	0.89	-	-	-	-	D	-	D	-	-	-	-	-	D	-	-	-
Broadway/Renfrew	AM	C	30	-	-	-	-	-	-	-	-	-	-	-	-		-	D	-	-	-	-	-	D	-	-	-
	PM	D	43	E	0.86	D	-	-	-	D	-	D	-	-	-	D	-	E	0.91	-	-	D	-	D	-	-	-
Broadway/Nanaimo	AM	C	28	-	-	-	-	-	-	-	-	-	-	-	-	-	-	D	-	-	-	-	-	D	-	-	-
	PM	C	34	D	-	-	-	-	-	D	-	-	-	-	-	-	-	D	-	-	-	-	-	D	-	-	-
Broadway/Victoria	AM	B	14	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	PM	B	19	F	0.91	-	-	-	-	E	-	-	-	-	-	-	-	-	-	-	-	E	-	D	-	-	-
Broadway/Commercial	AM	B	15	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	PM	C	21	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	D	-	-	-
Broadway/Clark	AM	D	45	D	-	-	-	-	-	-	-	D	0.87	-	-		-	E	0.91	-	-	E	0.86	-	-	-	-
	PM	D	51	D	-	D	-	-	-	E	-	D	-	-	-	D	-	E	-	-	-	F	1.12	D	-	-	-

As evident from the table above, there are currently operational issues on all three east/west corridors in one or both peak periods. On E 1st Avenue in particular, there are existing eastbound/westbound through movement operational issues depending on the time of day at:

- Boundary Road;
- Highway 1 (East);
- Rupert Street;
- Lillooet Street;
- Renfrew Street;
- Slocan Avenue;
- Nanaimo Street;
- Lakewood Drive;
- Victoria Drive;
- Commercial Drive; and
- Clark Drive.

An assessment of the Base eastbound and westbound capacity of E 1st Avenue was also undertaken. Capacity calculations were performed for all the intersections between Lillooet Street and Woodland Drive based on the following:

- The eastbound and westbound through/right turn or through/left turn/right turn or through/left turn lane group capacities (as applicable depending on lane configuration) was assessed.
- The determination of the eastbound and westbound capacities at each intersection was derived from the applicable lane group flow rates and v/c ratios.

It is noted that the Clark Drive, Highway 1 interchange, and Boundary Road intersections were not included in this assessment as the capacities of these intersections are not expected to be affected by the gas line construction as the intersections will be crossed using trenchless technology.

The resultant Base eastbound and westbound lane group capacities at each affected intersection are summarized in ***Table 4*** per direction and peak period.

Table 4 – Base East/West Lane Group Capacities (veh/hr)

Intersection	AM		PM	
	WB	EB	WB	EB
E 1st/Lillooet	1894	1893	1397	1475
E 1st/Renfrew	1812	1821	1817	1825
E 1st/Slocan	1895	1869	1815	1812
E 1st/Nanaimo	1946	1947	1940	1944
E 1st/Templeton	2329	2442	2288	2309
E 1st/Lakewood	2312	2289	2320	2294
E 1st/Victoria	2005	2032	1789	1508
E 1st/Commercial	1874	1884	1596	1618
E 1st/Woodland	2160	2173	1733	2179
Average Lane Grp Capacity	2025	2039	1855	1885

From the above table, it can be seen that the eastbound/westbound carrying capacity of the intersections varies between a low of 1397 veh/hr and a high of 2442 veh/hr. The average capacity is approximately 2030 veh/hr per direction in the AM peak and 1870 veh/hr per direction in the AM peak.

Base Arterial Travel Time data was also extracted from the SimTraffic software which is a simulation package that relies on Synchro model input. The Base average travel times for a vehicle to travel on E 1st Avenue, E Hastings Street or Broadway from west of Clark Drive to east of Boundary Road in the AM and PM peak periods is presented in ***Table 5***. As can be seen, the Base travel times on E 1st Avenue are slightly longer than the travel times on E Hastings Street and E Broadway. This is attributed to the current congestion that is more prevalent on E 1st Avenue than on the other two corridors.

Table 5 – Base East/West Travel Times (min/veh)

Peak Period	EB	WB
E 1st Avenue		
AM	9.7	13.7
PM	13.4	16.0
E Hastings Street		
AM	7.0	7.1
PM	7.1	7.7
E Broadway		
AM	7.8	8.1
PM	8.7	8.2

With an understanding of the Base traffic conditions, the next step was to evaluate and model various possible construction scenarios. These are discussed in the next section.

Construction Scenario Modelling

As mentioned previously, it is expected that parts of E 1st Avenue will be restricted to a single lane in each direction in road segments of 200-1000m during gas line construction. To assess the impacts of these lane closures a number of construction scenarios were created and evaluated using Synchro/SimTraffic. These scenarios are discussed in the subsections below.

Scenario 1

As a test of a "worst case" construction scenario, this Scenario 1 assumed the following:

- The eastbound and westbound through lanes on E 1st Avenue were reduced to single lanes at all the intersections between Lillooet Street and Woodland Avenue. It was assumed that the laning at the Clark Drive intersection (not directly affected) and the Rupert Street, Highway 1, and Boundary Road intersections (trenchless crossings) would be unaffected.
- The existing left turn lanes on E 1st Avenue were retained where applicable as it is assumed that it will be possible to keep these lanes operational given that the major intersections are expected to be crossed using trenchless technology.
- The northbound and southbound lanes at the E 1st Avenue intersections would remain as per existing.
- The Base traffic signal timings would remain.
- The Base traffic volumes would continue to use the E 1st Avenue corridor (i.e. no detouring).
- No changes were made to the E Hastings Street and E Broadway corridors.

The Synchro models were adjusted to suit and the resultant intersection performance of the E 1st Avenue corridor intersections is summarized in ***Table 6*** with the Synchro output files included in ***Appendix C.*** As is evident, the performance of all the affected intersections between Lillooet Street and Woodland Avenue is severely compromised by the lane reductions with the intersections LOSs being F in both the AM and PM peak periods. In particular, the eastbound and westbound through movement performances deteriorate with v/c ratios well in excess of 1.0 and multiple LOS Fs.

On a corridor wide basis, the travel times on E 1st Avenue are also severely affected by the lane reductions as shown in ***Table 7***.

Table 7 – Base and Scenario 1 East/West Travel Times (min/veh)

Scenario	Peak Period	EB	WB
	E 1st Avenue		
Base	AM	9.7	13.7
Scenario 1		47.1	42.9
Base	PM	13.4	16.0
Scenario 1		67.1	44.5

Table 6 – Scenario 1 Intersection Performance

				Turning Movements																							
				EBL		EBT		EBR		WBL		WBT		WBR		NBL		NBT		NBR		SBL		SBT		SBR	
Intersection	Time Period	Int. LOS	Int. Avg. Delay (sec/veh)	LOS	v/c	LOS	v/c	LOS	v/c	LOS	v/c	LOS	v/c	LOS	v/c	LOS	v/c	LOS	v/c	LOS	v/c	LOS	v/c	LOS	v/c	LOS	v/c
	E 1st Avenue																										
E 1st/Boundary	AM	C	28	D	-	-	-	-	-	-	-	D	-	-	-	-	1.45	-	-	-	-	-	-	D	-	-	-
	PM	C	34	E	1.01	-	-	-	-	D	-	D	-	-	-	-	1.71	-	-	-	-	-	-	D	-	-	-
Highway 1/E 1st (east)	AM	C	32	D	-	-	-	-	-	-	-	D	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	PM	C	35	E	-	-	-	-	-	-	-	E	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Highway 1/E 1st (west)	AM	A	6	-	-	-	-	-	0.89	D	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	PM	B	12	-	-	-	-	-	0.98	E	-	E	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
E 1st/Rupert	AM	C	24	-	-	-	-	-	-	-	-		0.94	-	-	E	-	-	-	-	-	-	-	-	-	-	-
	PM	E	61	-	-	-	-	-	-	-	-	F	1.28	-	-	D	-	-	-	-	-	-	-	-	-	-	-
E 1st/Lillooet	AM	F	300	-	-	F	1.57	-	-	-	-	F	1.70	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	PM	F	431	-	-	F	2.03	-	-	-	-	F	1.83	-	-	-	-	-	-	-	-	-	-	-	-	-	-
E 1st/Renfrew	AM	F	217	-	-	F	1.53	-	-	-	-	F	1.71	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	PM	F	245	-	-	F	1.76	-	-	-	-	F	1.71	-	-	-	-	-	-	-	-	D	-	-	-	-	-
E 1st/Slocan	AM	F	258	-	-	F	1.50	-	-	-	-	F	1.58	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	PM	F	301	-	-	F	1.73	-	-	-	-	F	1.54	-	-	-	-	-	-	-	-	-	-	-	-	-	-
E 1st/Nanaimo	AM	F	184	-	-	F	1.43	-	-	-	-	F	1.62	-	-	D	-	-	-	-	-	-	-	-	-	-	-
	PM	F	245	-	-	F	1.78	-	-	-	-	F	1.53	-	-	F	-	-	-	-	-	F	0.94	-	-	-	-
E 1st/Templeton	AM	F	351	-	-	F	1.18	-	-	-	-	F	1.69	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	PM	F	210	-	-	F	1.48	-	-	-	-	F	1.25	-	-	-	-	-	-	-	-	-	-	-	-	-	-
E 1st/Lakewood	AM	F	261	-	-	F	1.23	-	-	-	-	F	1.56	-	-	-	-	-	-	-	-	-	-	F	-	-	-
	PM	F	232	-	-	F	1.42	-	-	-	-	F	1.14	-	-	-	-	F	-	-	-	-	-	F	-	-	-
E 1st/Victoria	AM	F	272	-	-	F	1.36	-	-	-	-	F	1.88	-	-	-	-	-	-	-	-	-	-		-	-	-
	PM	F	239	-	-	F	1.77	-	-	-	-	F	1.47	-	-	-	-	-	-	-	-	-	-	D	0.90	-	-
E 1st/Commercial	AM	F	203	-	-	F	1.25	-	-	-	-	F	1.73	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	PM	F	193	-	-	F	1.70	-	-	D		F	1.41	-	-	-	-	-	-	-	-	D	0.86	-	-	-	-
E 1st/Woodland	AM	F	137	-	-	E	1.08	-	-	-	-	F	1.40	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	PM	F	85	-	-	F	1.18	-	-	-	-	E	1.09	-	-	-	-		-	-	-	-	-	-	-	-	-
E 1st/Clark	AM	D	49	-	-	-	-	-	-	-	-	D	1.07	-	-	F	1.05	F	1.08	-	-	-	-	-	-	-	-
	PM	C	32	-	-	-	0.90	-	-	-	-	-	-	-	-	D	-	-	0.87	-	-	F	0.98	-	-	-	-

The Scenario 1 assessed above is considered a worst case with lane reductions on E 1st Avenue all the way between Lillooet Street and Woodland Drive. These full corridor lane reductions are however not expected to occur, but the Scenario 1 analysis can be used to assist in the determination of the capacity of the E 1st Avenue corridor if it were to be reduced to single lanes between adjacent intersections.

Capacity calculations were therefore performed for all the intersections between Lillooet Street and Woodland Drive based on the following:

- The eastbound and westbound through/right turn or through/left turn/right turn or through/left turn lane group capacities (as applicable depending on lane configuration) was assessed on the assumption that the existing left turn lanes on E 1st Avenue would be retained at the intersections; and
- The determination of the eastbound and westbound capacities at each intersection was derived from the applicable lane group flow rates and v/c ratios from Scenario 1.

The resultant calculated eastbound and westbound through lane group capacities at each affected intersection with single eastbound/westbound lanes are summarized in ***Table 8*** per direction and peak period.

Table 8 – Scenario 1 East/West Lane Group Capacities (veh/hr)

	AM		PM	
Intersection	**WB**	**EB**	**WB**	**EB**
E 1st/Lillooet	1045	1044	1005	1000
E 1st/Renfrew	954	959	957	960
E 1st/Slocan	1045	1033	1035	1021
E 1st/Nanaimo	1024	1025	1021	1023
E 1st/Templeton	1034	1285	1264	1274
E 1st/Lakewood	1275	1265	1280	1269
E 1st/Victoria	1057	1070	988	937
E 1st/Commercial	984	990	825	837
E 1st/Woodland	1196	1201	1022	1203
Average Lane Grp Capacity	1068	1097	1044	1058

Comparing the values in ***Table 8*** with the Base capacities in ***Table 4***, it is clear that the reductions in lanes has a significant impact on the E 1st Avenue capacities. From the above table, it can also be seen that the eastbound/westbound carrying capacity of the intersections varies between a low of 825 veh/hr and a high of 1285 veh/hr. The average capacity is approximately 1070 veh/hr per direction (compared to approximately 1950 veh/hr currently). It is also noted that the intersection which consistently constrains capacity is the E 1st Avenue/Commercial Drive intersection. The reasons for this are twofold:

- There is a southbound left turn traffic signal phase on Commercial Drive which limits the amount of green time available for the east/west movements; and
- There are high pedestrian volumes particularly in the PM peak period which affect the right turn movements off E 1st Avenue and hence the through movements as the right turn movements occurs from shared through/right lanes.

Knowing the volume of traffic that currently uses the E 1st Avenue corridor (from the turning movement counts) and the amount of traffic that can be processed at each intersection if the lanes were reduced to single lanes (i.e. calculated capacity), it was possible to calculate how much "excess" traffic there may be on the corridor during the lane reductions. This excess traffic (or unserviced demand) would either be queued on the corridor or would alternatively reroute to other routes. ***Table 9*** presents the excess volumes by intersection and also the averages for all intersections for the two peak periods.

Table 9 – Scenario 1 East/West Lane Group Excess Demand (veh/hr)

	AM		PM	
Intersection	**WB**	**EB**	**WB**	**EB**
E 1st/Lillooet	730	591	835	1024
E 1st/Renfrew	677	506	677	726
E 1st/Slocan	609	515	561	742
E 1st/Nanaimo	632	442	540	801
E 1st/Templeton	716	229	315	609
E 1st/Lakewood	712	286	179	535
E 1st/Victoria	937	385	467	726
E 1st/Commercial	721	243	336	587
E 1st/Woodland	479	95	94	223
Average Lane Group Excess	**690**	**366**	**445**	**664**

Broadly speaking, if the Average Lane Group Excess volume in ***Table 9*** diverted to alternate routes if E 1st Avenue was reduced to single lanes, then the E 1st Avenue corridor intersections could be expected to operate at or near capacity (i.e. v/c ~ 1.0). This will be discussed later under Scenario 3.

Scenario 2

As mentioned previously, Scenario 1 was a worst case with lanes closed at all intersections on E 1st Avenue between Lillooet Street and Woodland Drive. Scenario 2 is a better representation of the proposed construction approach as it only assumes the lanes are closed between two major adjacent intersections. Scenario 2 assumed the following:

- Single lanes on E 1st Avenue <u>between Commercial Drive and Victoria Drive</u>, with all the lanes on the remainder of the corridor as per existing conditions. This segment of E 1st Avenue was selected

for evaluation as it has previously been shown that the E 1st Avenue/Commercial Drive intersection was a capacity constraint.

- The existing left turn lanes on E 1st Avenue were retained where applicable as it is assumed that it will be possible to keep these lanes operational given that the major intersections are expected to be crossed using trenchless technology.
- The northbound and southbound lanes at the E 1st Avenue intersections would remain as per existing.
- The Base traffic signal timings would remain.
- The Base traffic volumes would continue to use the E 1st Avenue corridor (i.e. no detouring).
- No changes were made to the E Hastings Street and E Broadway corridors.

The AM and PM Synchro models were adjusted accordingly to suit the above and the performance data for the E 1st Avenue corridor was extracted as per the Base models. The intersection performance for Scenario 2 is summarized in ***Table 10*** with the Synchro output files included in ***Appendix D.***

As expected the performance of the Commercial Drive and Victoria Drive intersections deteriorates from the Base conditions with v/c ratios well in excess of 1.0. The performance of the other intersections remains similar to the Base conditions.

The E 1st Avenue arterial travel times are presented in ***Table 11***. This table also includes the Base and Scenario 1 travel times for comparison.

Table 11 – Base and Scenario 1 and 2 East/West Travel Times (min/veh)

Scenario	Peak Period	EB	WB
	E 1st Avenue		
Base	AM	9.7	13.7
Scenario 1		47.1	42.9
Scenario 2		22.9	38.9
Base	PM	13.4	16.0
Scenario 1		67.1	44.5
Scenario 2		47.7	26.9

The Scenario 2 travel times show a marked reduction compared to Scenario 1, but are still significantly worse than the Base case. It is considered unlikely that drivers will tolerate/endure these Scenario 2 travel times on a regular basis and will likely detour to alternate routes. This led to the development of Scenario 3 as discussed below.

Table 10 – Scenario 2 Intersection Performance

				Turning Movements																							
				EBL		EBT		EBR		WBL		WBT		WBR		NBL		NBT		NBR		SBL		SBT		SBR	
Intersection	Time Period	Int. LOS	Int. Avg. Delay (sec/veh)	LOS	v/c	LOS	v/c	LOS	v/c	LOS	v/c	LOS	v/c	LOS	v/c	LOS	v/c	LOS	v/c	LOS	v/c	LOS	v/c	LOS	v/c	LOS	v/c
	E 1st Avenue																										
E 1st/Boundary	AM	C	28	D	-	-	-	-	-	-	-	D	-	-	-	-	1.45	-	-	-	-	-	-	D	-	-	-
	PM	C	34	E	1.01	-	-	-	-	D		D	-	-	-	-	1.71	-	-	-	-	-	-	D	-	-	-
Highway 1/E 1st (east)	AM	C	32	D	-	-	-	-	-	-	-	D	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	PM	C	35	E	-	-	-	-	-	-	-	E	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Highway 1/E 1St (west)	AM	A	6	-	-	-	-	-	0.89	D	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	PM	B	12	-	-	-	-	-	0.98	E	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
E 1st/Rupert	AM	C	25	-	-	-	-	-	-	-	-	-	0.94	-	-	E	-	-	-	-	-	-	-	-	-	-	-
	PM	E	61	-	-	-	-	-	-	-	-	F	1.28	-	-	D	-	-	-	-	-	-	-	-	-	-	-
E 1st/Lillooet	AM	C	21	-	-	-	0.86	-	-	-	-	-	0.94	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	PM	F	174	-	-	F	1.37		-	-	-	F	1.32	-	-	-	-	-	-	-	-	-	-	-	-	-	-
E 1st/Renfrew	AM	B	18	D	-	-	-	-	-	-	-	-	0.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	PM	B	20	-	-	-	0.92	-	-	D	0.9	-	0.9	-	-	-	-	-	-	-	-	D	-	-	-	-	-
E 1st/Slocan	AM	A	10	-	-	-		-	-	-	-	-	0.87	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	PM	B	20	-	-	-	0.97	-	-	-	-	-	0.88	-	-	-	-	-	-	-	-	-	-	-	-	-	-
E 1st/Nanaimo	AM	B	18	D	-	-	-	-	-	-	-	-	0.85	-	-	D	-	-	-	-	-	-	-	-	-	-	-
	PM	B	18	D	-	-	0.94	-	-	E	0.9	-	-	-	-	D	-	-	-	-	-	F	0.94	-	-	-	-
E 1st/Templeton	AM	A	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	PM	A	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
E 1st/Lakewood	AM	A	8	-	-	-	-	-	-	-	-	-	0.86	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	PM	A	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
E 1st/Victoria	AM	F	80	-	-	F	1.36	-	-	-	-	-	0.99	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	PM	F	237	-	-	F	2.17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	D	0.90	-	-
E 1st/Commercial	AM	F	166	-	-	-	-	-	-	-	-	F	1.73	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	PM	E	79	-	-	-	0.90	-	-	D		F	1.41	-	-	-	-	-	-	-	-	D	0.86	-	-	-	-
E 1st/Woodland	AM	A	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	PM	A	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
E 1st/Clark	AM	D	50	-	-	-	-	-	-	-	-	D	1.07	-	-	F	1.05	F	1.08	-	-	-	-	-	-	-	-
	PM	C	31	-	-	-	0.90	-	-	-	-	-	-	-	-	D	-	-	0.87	-	-	E	0.98	-	-	-	-

Scenario 3

Scenario 3 is similar to Scenario 2 except that the traffic volumes along the E 1st Avenue corridor are reduced to account for drivers avoiding the corridor and diverting to alternate routes during construction. The key consideration for this Scenario 3 is however, how much traffic will divert to other routes?

As discussed earlier under Scenario 1 and summarized in ***Table 9***, if E 1st Avenue is operating at capacity, the average excess demand on the E 1st Avenue corridor is as per ***Table 12*** if there are single lanes at the intersections. This excess demand would either wait in queues on E 1st Avenue or divert to alternate routes. Assuming that the excess demand all diverts to alternate routes, the volumes on E 1st Avenue could be reduced by the values shown in ***Table 12***. Then assuming that 50% of the diverted traffic diverts to E Hastings Street and 50% diverts to Broadway, the increased volumes on E Hastings Street and E Broadway can be estimated as shown in ***Table 12***.

Table 12 – Excess Demand on E 1st Avenue and Alternate Routing (veh/hr)

	AM		PM	
	WB	**EB**	**WB**	**EB**
Average Lane Group Excess on E 1 St Avenue	-690	-366	-445	-664
50% to E Hastings	+345	+183	+222	+332
50% to Broadway	+345	+183	+222	+332

The volumes in ***Table 12*** were therefore incorporated in the Scenario 3 Synchro models by applying the decreases/ increases to the eastbound and westbound through movements at the intersections on the three corridors. It is acknowledged that this approach is not entirely correct as some increases/decreases will affect the turning movements at some of the intersections. This methodology is however considered adequate for the purposes of this corridor wide review of traffic impacts.

The intersection performance for Scenario 3 is summarized in ***Table 13*** with the Synchro output files included in ***Appendix E.*** On E 1st Avenue, the intersection performance is generally acceptable except for at the Commercial Drive and Victoria Drive intersections (where the single lanes are introduced) and a few other locations unaffected by the lane closures.

On E Hastings Street, the notable deterioration in performance compared with the Base conditions is the westbound through movement in the PM peak period at Nanaimo Street where the LOS is now F with a v/c of 1.23 (currently 0.91). This is attributed to the additional traffic volumes that have been assigned to E Hastings Street.

Table 13 – Scenario 3 Intersection Performance

				Turning Movements																							
				EBL		EBT		EBR		WBL		WBT		WBR		NBL		NBT		NBR		SBL		SBT		SBR	
Intersection	Time Period	Int. LOS	Int. Avg. Delay (sec/veh)	LOS	v/c	LOS	v/c	LOS	v/c	LOS	v/c	LOS	v/c	LOS	v/c	LOS	v/c	LOS	v/c	LOS	v/c	LOS	v/c	LOS	v/c	LOS	v/c
	E 1st Avenue																										
E 1st/Boundary	AM	C	28	-	-	-	-	-	-	-	-	D	-	-	-	1.77	-	-	-	-	-	-	-	D	-	-	-
	PM	C	22	-	-	-	-	-	-	-	-	-	-	-	-	1.22	-	-	-	-	-	-	-	-	-	-	-
Highway 1/E 1St (east)	AM	C	29	D	-	-	-	-	-	-	-	D	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	PM	C	34	E	-	-	-	-	-	-	-	D	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Highway 1/E 1St (west)	AM	A	7	-	-	-	-	-	0.89	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	PM	B	16	-	-	-	-	-	0.98	E	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
E 1st/Rupert	AM	C	20	-	-	-	-	-	-	-	-	-	-	-	-	E	-	-	-	-	-	-	-	-	-	-	-
	PM	B	15	-	-	-	-	-	-	-	-	-	-	-	-	D	-	-	-	-	-	-	-	-	-	-	-
E 1st/Lillooet	AM	B	17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	PM	B	17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
E 1st/Renfrew	AM	B	17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	PM	B	20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	D	-	-	-	-	-
E 1st/Slocan	AM	A	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	PM	B	14	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
E 1st/Nanaimo	AM	B	18	-	-	-	-	-	-	-	-	-	-	-	-	D	-	-	-	-	-	-	-	-	-	-	-
	PM	B	17	-	-	-	-	-	-	-	-	-	-	-	-	D	-	-	-	-	-	F	0.94	-	-	-	-
E 1st/Templeton	AM	A	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	PM	A	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
E 1st/Lakewood	AM	A	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	PM	A	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
E 1st/Victoria	AM	C	26	-	-	D	1.02	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	PM	D	40	-	-	E	1.08	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	D	0.90	-	-
E 1st/Commercial	AM	C	30	-	-	-	-	-	-	-	-	D	1.04	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	PM	C	27	-	-	-	-	-	-	-	-	D	0.88	-	-	-	-	-	-	-	-	D	0.86	-	-	-	-
E 1st/Woodland	AM	A	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	PM	A	9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
E 1st/Clark	AM	D	41	-	-	-	-	-	-	-	-	-	-	-	-	F	1.05	F	1.08	-	-	-	-	-	-	-	-
	PM	C	27	-	-	-	-	-	-	-	-	-	-	-	-	D	-	-	0.86	-	-	E	0.98	-	-	-	-
	E Hastings Street																										
Hastings/Boundary	AM	C	29	-	-	-	-	-	-	-	-	-	-	-	-	D	-	D	-	-	-	D	-	D	-	-	-
	PM	C	33	-	-	-	-	-	-	D	-	-	-	-	-	E	-	D	-	-	-	D	-	D	-	-	-
	AM	C	31	D	-	-	-	-	-	D	-	-	-	-	-	D	-	D	-	-	-	D	-	D	-	-	-

				Turning Movements																							
				EBL		EBT		EBR		WBL		WBT		WBR		NBL		NBT		NBR		SBL		SBT		SBR	
Intersection	Time Period	Int. LOS	Int. Avg. Delay (sec/veh)	LOS	v/c	LOS	v/c	LOS	v/c	LOS	v/c	LOS	v/c	LOS	v/c	LOS	v/c	LOS	v/c	LOS	v/c	LOS	v/c	LOS	v/c	LOS	v/c
Hastings/Cassiar Connector/Hwy 1 ramps	PM	D	39	E	D	-	-	-	-	E	-	D	-	-	-	D	-	D	-	-	-	D	-	D	-	-	-
Hastings/Renfrew	AM	B	17	D	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	PM	C	35	D	-	-	-	-	-	F	1.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hastings/Nanaimo	AM	B	16	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	PM	D	50	-	-	-	-	-	-	-	-	F	1.21	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hastings/Victoria	AM	B	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	PM	A	8	-	-	-	-	-	-		0.91	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hastings/Commercial	AM	B	13	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	PM	B	16	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hastings/Clark	AM	B	17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	PM	C	27	-	-	-	0.88	-	-	-	-	-	-	-	-	-	-	D	-	-	-	-	-	-	-	-	-
	E Broadway																										
Boundary/Lougheed/Broadway	AM	E	71	-	-	-	-	-	-	-	-	F	1.27	-	-	D	-	D	-	-	-	E	-	D	-	-	-
	PM	E	65	D	-	F	1.10	-	-	D	-	F	1.10	-	-	E	-	E	0.91	-	-	E	-	-	-	-	-
Broadway/Rupert	AM	C	28	-	-	-	-	-	-	-	-	-	-	-	-	D	-	D	-	-	-	-	-	D	-	-	-
	PM	D	38	D	-	D	-	-	-	E	0.89	-	-	-	-	D	-	D	-	-	-	-	-	D	-	-	-
Broadway/Renfrew	AM	C	33	-	-	-	-	-	-	-	-	-	0.88	-	-	-	-	D	-	-	-	-	-	D	-	-	-
	PM	D	48	E	0.88	D	0.93	-	-	D	-	D	0.91	-	-	D	-	E	0.92	-	-	D	-	D	-	-	-
Broadway/Nanaimo	AM	C	32	-	-	-	-	-	-	-	-	-	0.93	-	-	-	-	D	-	-	-	-	-	D	-	-	-
	PM	D	38	D	-	D	0.89	-	-	D	-	D	0.90	-	-	-	-	D	-	-	-	-	-	D	-	-	-
Broadway/Victoria	AM	B	17	-	-	-	-	-	-	-	-	-	0.89	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	PM	C	21	E	0.91	-	-	-	-	F	1.18	-	-	-	-	-	-	-	-	-	-	E	-	D	-	-	-
Broadway/Commercial	AM	B	18	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	PM	C	22	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	D	-	-	-
Broadway/Clark	AM	E	57	D	-	-	-	-	-	-	-	E	1.06	-	-	-	-	E	0.91	-	-	E	0.86	-	-	-	-
	PM	E	57	D	-	E	1.00	-	-	E		D	0.87	-	-	D	-	E	-	-	-	F	1.12	D	-	-	-

On E Broadway, the performance deteriorates at some intersections compared to Base conditions. These are:

- Boundary/Lougheed/Broadway intersection – EBT and WBT movements with v/c >1.0 in the AM and PM peak periods due to the assumed increased volumes. In reality, however, the increases in volumes would be distributed between the applicable turning movements (i.e. not just on the through movements), so this deterioration is not considered problematic.
- Broadway/Victoria intersection – WBL movement in the PM peak period with v/c = 1.18. This is a relatively minor movement (101 veh/hr) so the impact is considered minor.
- Broadway/Clark – WBT movement in the AM peak period with v/c = 1.06. In reality, however, the increases in volumes would be distributed between the applicable turning movements (i.e. not just on the through movements), so this deterioration is not considered problematic.

The arterial travel times on the three east/west corridors are presented in ***Table 14***. This table also includes the Base and Scenario 1 and 2 travel times for comparison.

Table 14 – Base and Scenario 1, 2 and 3 East/West Travel Times (sec/veh)

Scenario	Peak Period	EB	WB
	E 1st Avenue		
Base	AM	9.7	13.7
Scenario 1		47.1	42.9
Scenario 2		22.9	38.9
Scenario 3		11.1	12.7
Base	PM	13.4	16.0
Scenario 1		67.1	44.5
Scenario 2		47.7	26.9
Scenario 3		17.8	10.7
	E Hastings Street		
Base	AM	7.0	7.1
Scenario 3		7.3	7.6
Existing	PM	7.1	7.7
Scenario 3		7.6	9.3
	E Broadway		
Base	AM	7.8	8.1
Scenario 3		7.9	8.6
Existing	PM	8.7	8.2
Scenario 3		10.7	9.1

The Scenario 3 travel times on E 1st Avenue show a significant reduction compared to Scenario 2 which is expected given the reduced volume assumption. Interestingly, the Scenario 3 westbound travel times on E 1st Avenue are actually lower than the Base travel times. While travel times in the vicinity of the lane

reductions increase, with the assumed reduced volumes on the remainder of the corridor and the resulting reduced congestion, the overall corridor travel time reduces.

On E Hastings Street and E Broadway, the Scenario 3 travel times are marginally higher than the Base travel times. This is attributed to the increased volumes manually reassigned from E 1st Avenue.

Scenario 3 has considered lane closures on the section of E 1st Avenue between Commercial Drive and Victoria Drive where there are identified capacity constraints. Lane closures on other less critical sections are expected to have less of an impact on E 1st Avenue traffic and hence result in less diversion to alternate routes.

Conclusions

The Scenario 3 diversions and resultant intersection performance and arterial travel times on all three east/west corridors are considered to be reasonable estimates. While the impacts of the gas line construction on E 1st Avenue will definitely be felt by drivers, they will, over time, find the path of least resistance to the point where the delays on each route would be equitable and tolerable. This suggests that the gas line construction impacts on E 1st Avenue are manageable, but in order to achieve the results outlined above, special attention will need to be given to the following:

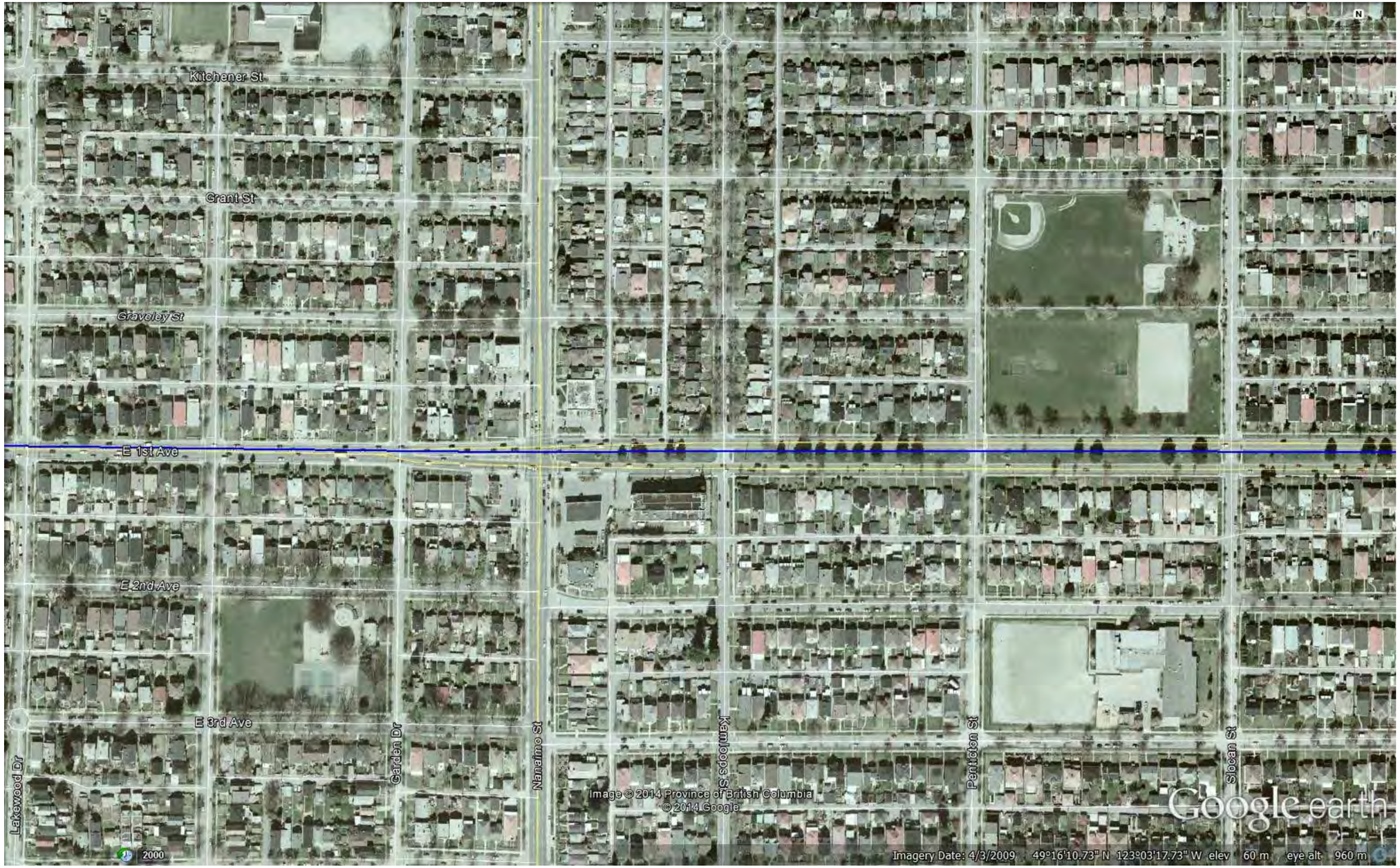
- With single lanes on E 1st Avenue, it is critical that no left turn movements be permitted from the through lanes as this will severely disrupt through traffic.
- With single lanes on E 1st Avenue, the right turn movements which conflict with major pedestrian movements should be accommodated on dedicated right turn lanes where possible such that through traffic is not delayed.
- Extensive publicity through the media, changeable message signs, static advisory signs, etc. will be required to advise drivers of the capacity reductions on E 1st Avenue and recommend the use of alternate routes.
- Notwithstanding the analysis work described in this report, it is still likely that some drivers who normally use E 1st Avenue will divert off E 1st Avenue and “rat run” through the local residential street network. While this creates a another set of issues on the side streets not discussed in this report, the management of where these rat runners turn off/onto E 1st Avenue will have to be managed to ensure that they do not delay the through traffic.

Appendix A – Preliminary Gas Line Alignment

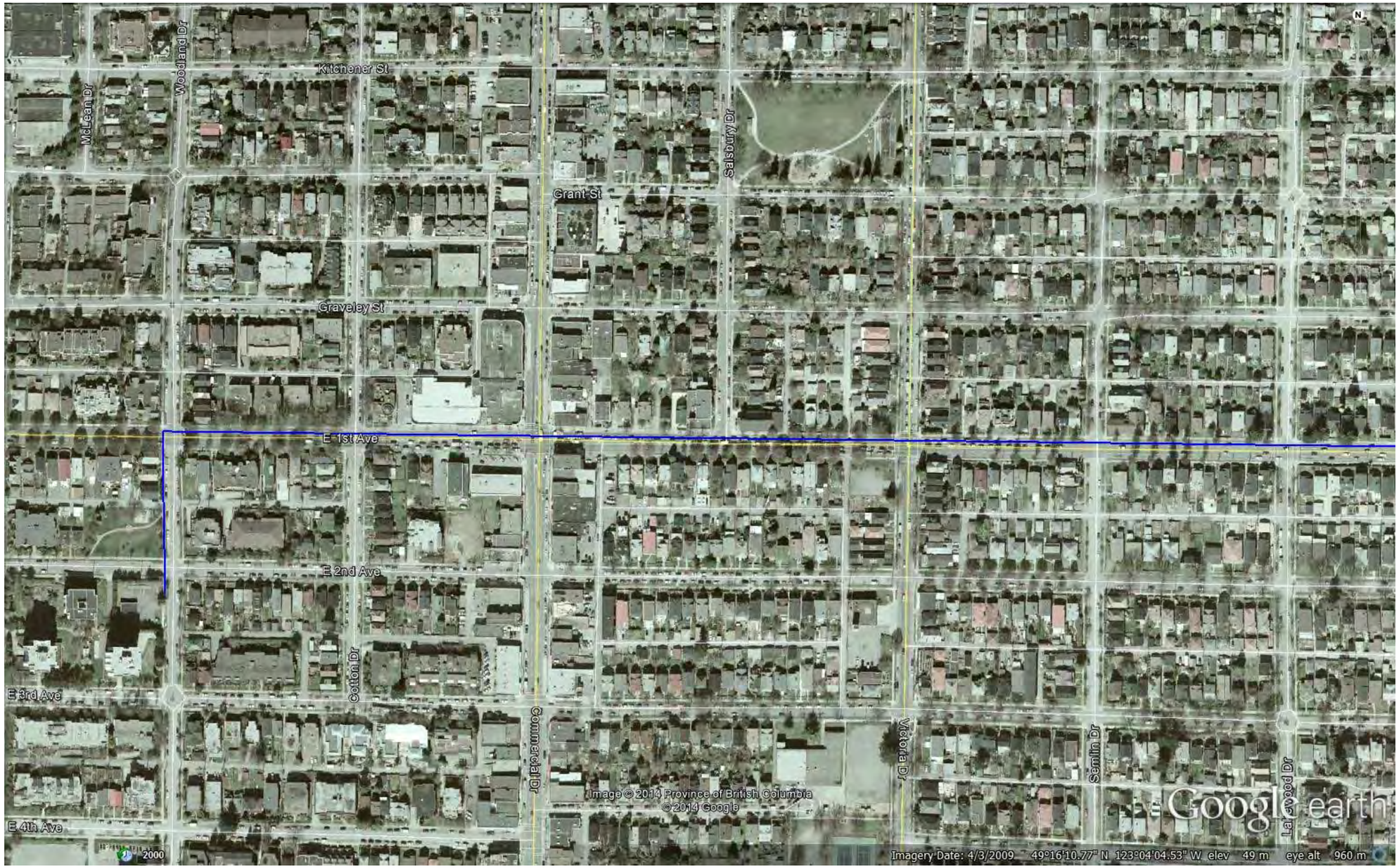
Vancouver Alignment – Section 1

Vancouver Alignment – Section 2

Vancouver Alignment – Section 3



Vancouver Alignment – Section 4



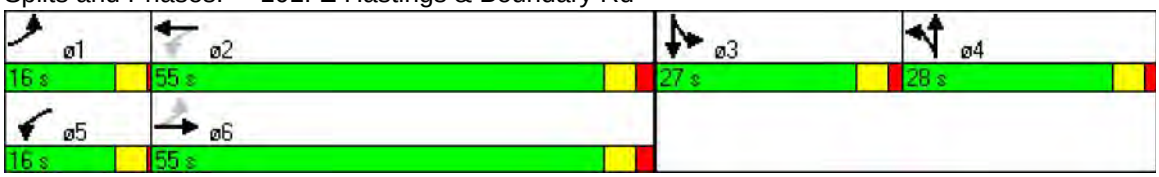
Appendix B – Base Synchro Output Files (AM and PM)

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	3398	0	1770	5070	0	1610	3163	0	1770	3405	0
Flt Permitted	0.096			0.286			0.950	0.975		0.950		
Satd. Flow (perm)	179	3398	0	533	5070	0	1610	3163	0	1770	3405	0
Satd. Flow (RTOR)		50			3			39			33	
Volume (vph)	30	451	165	210	1231	27	362	71	102	11	198	68
Lane Group Flow (vph)	33	669	0	228	1367	0	197	384	0	12	289	0
Turn Type	pm+pt			pm+pt			Split			Split		
Protected Phases	1	6		5	2		4	4		3	3	
Permitted Phases	6			2								
Total Split (s)	16.0	55.0	0.0	16.0	55.0	0.0	28.0	28.0	0.0	27.0	27.0	0.0
Act Effct Green (s)	32.1	25.6		40.7	35.1		16.8	16.8		13.1	13.1	
Actuated g/C Ratio	0.37	0.31		0.49	0.42		0.20	0.20		0.16	0.16	
v/c Ratio	0.18	0.62		0.54	0.64		0.61	0.57		0.04	0.51	
Control Delay	15.3	25.6		18.4	22.4		42.7	33.0		37.8	35.0	
Queue Delay	0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0	
Total Delay	15.3	25.6		18.4	22.4		42.7	33.0		37.8	35.0	
LOS	B	C		B	C		D	C		D	C	
Approach Delay		25.1			21.8			36.3			35.1	
Approach LOS		C			C			D			D	

Intersection Summary

Cycle Length: 126
Actuated Cycle Length: 83.5
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 0.64
Intersection Signal Delay: 26.4 Intersection LOS: C
Intersection Capacity Utilization 60.9% ICU Level of Service B
Analysis Period (min) 15

Splits and Phases: 101: E Hastings & Boundary Rd

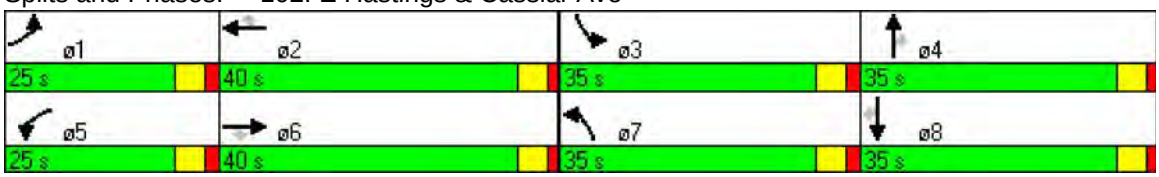


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	3539	1583	1770	5085	1583	3433	3539	1583	3433	3539	1583
Flt Permitted	0.950			0.950			0.950			0.950		
Satd. Flow (perm)	1770	3539	1583	1770	5085	1583	3433	3539	1583	3433	3539	1583
Satd. Flow (RTOR)			346			20			23			107
Volume (vph)	78	376	318	85	1136	27	597	225	21	368	46	98
Lane Group Flow (vph)	85	409	346	92	1235	29	649	245	23	400	50	107
Turn Type	Prot		Perm	Prot		Perm	Prot		Perm	Prot		Perm
Protected Phases	1	6		5	2		7	4		3	8	
Permitted Phases			6			2			4			8
Total Split (s)	25.0	40.0	40.0	25.0	40.0	40.0	35.0	35.0	35.0	35.0	35.0	35.0
Act Effct Green (s)	10.9	30.0	30.0	11.2	30.3	30.3	22.5	14.1	14.1	17.5	8.7	8.7
Actuated g/C Ratio	0.13	0.36	0.36	0.13	0.37	0.37	0.27	0.17	0.17	0.21	0.10	0.10
v/c Ratio	0.37	0.32	0.43	0.39	0.66	0.05	0.69	0.41	0.08	0.55	0.14	0.41
Control Delay	44.8	23.7	4.9	44.8	27.1	13.1	34.0	37.6	15.6	36.8	42.8	14.6
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	44.8	23.7	4.9	44.8	27.1	13.1	34.0	37.6	15.6	36.8	42.8	14.6
LOS	D	C	A	D	C	B	C	D	B	D	D	B
Approach Delay		18.1			28.0			34.5			33.1	
Approach LOS		B			C			C			C	

Intersection Summary

Cycle Length: 135
Actuated Cycle Length: 82.4
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 0.69
Intersection Signal Delay: 28.1 Intersection LOS: C
Intersection Capacity Utilization 60.8% ICU Level of Service B
Analysis Period (min) 15

Splits and Phases: 102: E Hastings & Cassiar Ave

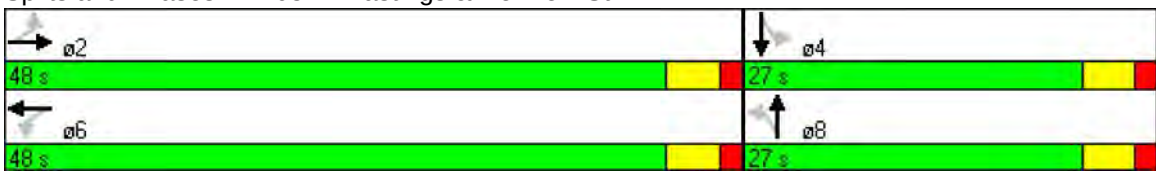


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	3483	0	1770	4928	0	0	4949	0	0	3451	0
Flt Permitted	0.091			0.364				0.858			0.631	
Satd. Flow (perm)	170	3483	0	678	4928	0	0	4272	0	0	2218	0
Satd. Flow (RTOR)		29			147			43			7	
Volume (vph)	39	553	64	69	1309	337	55	362	68	119	185	16
Lane Group Flow (vph)	42	671	0	75	1789	0	0	527	0	0	347	0
Turn Type	Perm			Perm			Perm			Perm		
Protected Phases		2			6			8			4	
Permitted Phases	2			6			8			4		
Total Split (s)	48.0	48.0	0.0	48.0	48.0	0.0	27.0	27.0	0.0	27.0	27.0	0.0
Act Effct Green (s)	44.0	44.0		44.0	44.0			23.0			23.0	
Actuated g/C Ratio	0.59	0.59		0.59	0.59			0.31			0.31	
v/c Ratio	0.42	0.33		0.19	0.61			0.39			0.51	
Control Delay	39.7	20.0		8.7	10.1			19.8			24.0	
Queue Delay	0.0	0.0		0.0	0.0			0.0			0.0	
Total Delay	39.7	20.0		8.7	10.1			19.8			24.0	
LOS	D	C		A	B			B			C	
Approach Delay		21.2			10.0			19.8			24.0	
Approach LOS		C			B			B			C	

Intersection Summary

Cycle Length: 75
Actuated Cycle Length: 75
Offset: 43 (57%), Referenced to phase 2:EBTL and 6:WBTL, Start of Green
Control Type: Pretimed
Maximum v/c Ratio: 0.61
Intersection Signal Delay: 15.2 Intersection LOS: B
Intersection Capacity Utilization 70.7% ICU Level of Service C
Analysis Period (min) 15

Splits and Phases: 103: E Hastings & Renfrew St

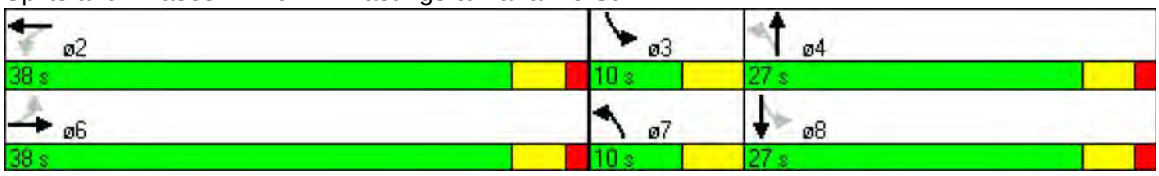


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	0	3506	0	0	5070	0	1770	5041	0	1770	4672	0
Flt Permitted		0.887			0.933		0.395			0.429		
Satd. Flow (perm)	0	3113	0	0	4730	0	714	5041	0	790	4672	0
Satd. Flow (RTOR)		8			4			10			57	
Volume (vph)	17	551	28	12	1331	19	177	429	20	45	315	180
Lane Group Flow (vph)	0	647	0	0	1481	0	192	488	0	49	538	0
Turn Type	Perm			Perm			pm+pt			pm+pt		
Protected Phases		6			2		7	4		3	8	
Permitted Phases	6			2			4			8		
Total Split (s)	38.0	38.0	0.0	38.0	38.0	0.0	10.0	27.0	0.0	10.0	27.0	0.0
Act Effct Green (s)		34.0			34.0		30.6	27.0		28.9	23.0	
Actuated g/C Ratio		0.45			0.45		0.41	0.36		0.39	0.31	
v/c Ratio		0.46			0.69		0.51	0.27		0.13	0.37	
Control Delay		5.2			12.7		19.3	18.2		13.1	18.9	
Queue Delay		0.0			0.0		0.0	0.0		0.0	0.0	
Total Delay		5.2			12.7		19.3	18.2		13.1	18.9	
LOS		A			B		B	B		B	B	
Approach Delay		5.2			12.7			18.5			18.4	
Approach LOS		A			B			B			B	

Intersection Summary

Cycle Length: 75
Actuated Cycle Length: 75
Offset: 20 (27%), Referenced to phase 2:WBTL and 6:EBTL, Start of Green
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 0.69
Intersection Signal Delay: 13.4 Intersection LOS: B
Intersection Capacity Utilization 71.8% ICU Level of Service C
Analysis Period (min) 15

Splits and Phases: 104: E Hastings & Nanaimo St

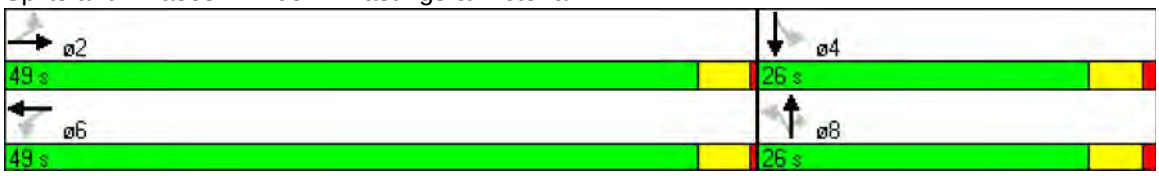


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	3525	0	1770	5055	0	0	1844	1583	0	3409	0
Flt Permitted	0.098			0.436				0.924			0.884	
Satd. Flow (perm)	183	3525	0	812	5055	0	0	1721	1583	0	3044	0
Satd. Flow (RTOR)		6			13				103		23	
Volume (vph)	21	483	12	131	1498	57	37	148	95	24	73	21
Lane Group Flow (vph)	23	538	0	142	1690	0	0	201	103	0	128	0
Turn Type	Perm			Perm			Perm		Perm	Perm		
Protected Phases		2			6			8			4	
Permitted Phases	2			6			8		8	4		
Total Split (s)	49.0	49.0	0.0	49.0	49.0	0.0	26.0	26.0	26.0	26.0	26.0	0.0
Act Effct Green (s)	45.0	45.0		45.0	45.0			22.0	22.0		22.0	
Actuated g/C Ratio	0.60	0.60		0.60	0.60			0.29	0.29		0.29	
v/c Ratio	0.21	0.25		0.29	0.56			0.40	0.19		0.14	
Control Delay	29.3	21.0		5.0	4.5			24.1	5.7		16.5	
Queue Delay	0.0	0.0		0.0	0.0			0.0	0.0		0.0	
Total Delay	29.3	21.0		5.0	4.5			24.1	5.7		16.5	
LOS	C	C		A	A			C	A		B	
Approach Delay		21.3			4.5			17.9			16.5	
Approach LOS		C			A			B			B	

Intersection Summary

Cycle Length: 75
Actuated Cycle Length: 75
Offset: 54 (72%), Referenced to phase 2:EBTL and 6:WBTL, Start of Green
Control Type: Pretimed
Maximum v/c Ratio: 0.56
Intersection Signal Delay: 9.8 Intersection LOS: A
Intersection Capacity Utilization 65.0% ICU Level of Service C
Analysis Period (min) 15

Splits and Phases: 105: E Hastings & Victoria Dr



Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	3493	0	1770	5072	0	1770	1756	0	1770	1740	0
Flt Permitted	0.129			0.327			0.643			0.619		
Satd. Flow (perm)	240	3493	0	600	5072	0	1118	1756	0	1125	1740	0
Satd. Flow (RTOR)		10			4			32			17	
Volume (vph)	21	495	30	71	1502	19	71	110	48	13	110	32
Lane Group Flow (vph)	23	571	0	77	1654	0	77	172	0	14	155	0
Turn Type	Perm			pm+pt			Perm			Perm		
Protected Phases		2		1	6			8			4	
Permitted Phases	2			6			8			4		
Total Split (s)	35.0	35.0	0.0	10.0	45.0	0.0	30.0	30.0	0.0	30.0	30.0	0.0
Act Effct Green (s)	33.0	33.0		41.0	41.0		26.0	26.0		26.0	26.0	
Actuated g/C Ratio	0.44	0.44		0.55	0.55		0.35	0.35		0.35	0.35	
v/c Ratio	0.22	0.37		0.18	0.60		0.20	0.27		0.04	0.25	
Control Delay	9.7	5.7		12.1	14.5		19.0	15.7		16.7	16.9	
Queue Delay	0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0	
Total Delay	9.7	5.7		12.1	14.5		19.0	15.7		16.7	16.9	
LOS	A	A		B	B		B	B		B	B	
Approach Delay		5.8			14.4			16.7			16.9	
Approach LOS		A			B			B			B	

Intersection Summary

Cycle Length: 75
Actuated Cycle Length: 75
Offset: 0 (0%), Referenced to phase 2:EBTL and 6:WBTL, Start of Green
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 0.60
Intersection Signal Delay: 12.9 Intersection LOS: B
Intersection Capacity Utilization 64.5% ICU Level of Service C
Analysis Period (min) 15

Splits and Phases: 106: E Hastings & Commercial Dr

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	3461	0	1770	5055	0	0	3497	1583	0	3529	1583
Flt Permitted	0.190			0.332				0.687			0.912	
Satd. Flow (perm)	354	3461	0	618	5055	0	0	2431	1583	0	3228	1583
Satd. Flow (RTOR)		25			8				127			2
Volume (vph)	61	412	70	369	1135	44	119	364	117	22	401	50
Lane Group Flow (vph)	66	524	0	401	1282	0	0	525	127	0	460	54
Turn Type	pm+pt			pm+pt			Perm		pm+ov	Perm		pm+ov
Protected Phases	1	6		5	2			4	5		8	1
Permitted Phases	6			2			4		4	8		8
Total Split (s)	21.0	25.0	0.0	21.0	25.0	0.0	29.0	29.0	21.0	29.0	29.0	21.0
Act Effct Green (s)	32.3	25.6		41.4	33.1			25.0	41.4		25.0	35.8
Actuated g/C Ratio	0.43	0.34		0.55	0.44			0.33	0.55		0.33	0.48
v/c Ratio	0.24	0.44		0.75	0.57			0.65	0.14		0.43	0.07
Control Delay	11.1	20.7		12.1	7.5			25.8	1.6		21.0	10.3
Queue Delay	0.0	0.0		0.0	0.0			0.0	0.0		0.0	0.0
Total Delay	11.1	20.7		12.1	7.5			25.8	1.6		21.0	10.3
LOS	B	C		B	A			C	A		C	B
Approach Delay		19.7			8.6			21.1			19.9	
Approach LOS		B			A			C			B	

Intersection Summary

Cycle Length: 75
Actuated Cycle Length: 75
Offset: 45 (60%), Referenced to phase 2:WBTL and 6:EBTL, Start of Green
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 0.75
Intersection Signal Delay: 14.6 Intersection LOS: B
Intersection Capacity Utilization 86.3% ICU Level of Service E
Analysis Period (min) 15

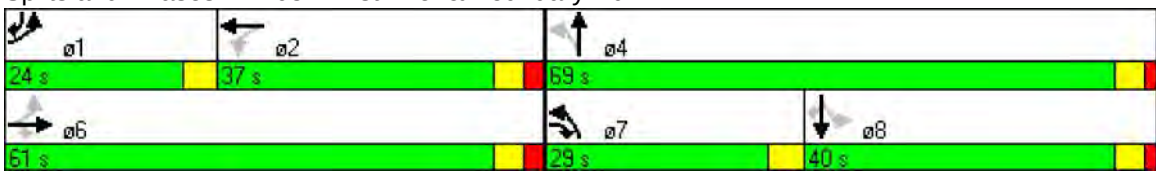
Splits and Phases: 107: E Hastings & Clark Dr

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	1863	1583	1770	1812	0	0	4939	0	0	3536	1583
Flt Permitted	0.150			0.577				0.697			0.905	
Satd. Flow (perm)	279	1863	1583	1075	1812	0	0	3502	0	0	3203	1583
Satd. Flow (RTOR)			18		8			15				207
Volume (vph)	268	276	432	50	292	64	294	489	66	20	768	279
Lane Group Flow (vph)	291	300	470	54	387	0	0	924	0	0	857	303
Turn Type	pm+pt		pm+ov	Perm			pm+pt			Perm		pm+ov
Protected Phases	1	6	7		2		7	4			8	1
Permitted Phases	6		6	2			4			8		8
Total Split (s)	24.0	61.0	29.0	37.0	37.0	0.0	29.0	69.0	0.0	40.0	40.0	24.0
Act Effct Green (s)	48.7	48.7	61.1	28.1	28.1			45.9			33.5	54.1
Actuated g/C Ratio	0.47	0.47	0.59	0.27	0.27			0.45			0.33	0.53
v/c Ratio	0.78	0.34	0.50	0.18	0.77			1.45dl			0.82	0.33
Control Delay	36.8	18.2	13.7	31.9	45.9			21.7			40.5	5.7
Queue Delay	0.0	0.0	0.0	0.0	0.0			0.0			0.0	0.0
Total Delay	36.8	18.2	13.7	31.9	45.9			21.7			40.5	5.7
LOS	D	B	B	C	D			C			D	A
Approach Delay		21.3			44.2			21.7			31.4	
Approach LOS		C			D			C			C	

Intersection Summary

Cycle Length: 130
Actuated Cycle Length: 102.8
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 0.82
Intersection Signal Delay: 27.5 Intersection LOS: C
Intersection Capacity Utilization 86.1% ICU Level of Service E
Analysis Period (min) 15
dl Defacto Left Lane. Recode with 1 though lane as a left lane.

Splits and Phases: 108: E 1st Ave. & Boundary Rd

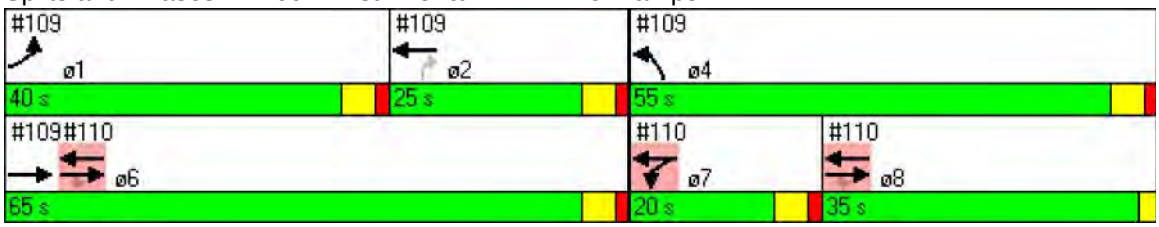


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	3539	0	0	5085	1583	3433	0	1583	0	0	0
Flt Permitted	0.950						0.950					
Satd. Flow (perm)	1770	3539	0	0	5085	1583	3433	0	1583	0	0	0
Satd. Flow (RTOR)						66			56			
Volume (vph)	238	827	0	0	596	167	1064	0	142	0	0	0
Lane Group Flow (vph)	259	899	0	0	648	182	1157	0	154	0	0	0
Turn Type	Prot					Free	Prot		custom			
Protected Phases	1	6			2		4					
Permitted Phases						Free			2			
Total Split (s)	40.0	65.0	0.0	0.0	25.0	0.0	55.0	0.0	25.0	0.0	0.0	0.0
Act Effct Green (s)	36.0	61.0			21.0	120.0	51.0		21.0			
Actuated g/C Ratio	0.30	0.51			0.18	1.00	0.42		0.18			
v/c Ratio	0.49	0.50			0.73	0.11	0.79		0.48			
Control Delay	34.9	17.4			52.3	0.1	34.9		33.5			
Queue Delay	4.3	0.6			0.0	0.0	0.0		0.0			
Total Delay	39.2	18.0			52.3	0.1	34.9		33.5			
LOS	D	B			D	A	C		C			
Approach Delay		22.8			40.8							
Approach LOS		C			D							

Intersection Summary

Cycle Length: 120
Actuated Cycle Length: 120
Offset: 0 (0%), Referenced to phase 2:WBT and 6:EBT, Start of Green
Control Type: Pretimed
Maximum v/c Ratio: 0.89
Intersection Signal Delay: 32.1 Intersection LOS: C
Intersection Capacity Utilization 120.6% ICU Level of Service H
Analysis Period (min) 15

Splits and Phases: 109: E 1st Ave. & HW1 WB on ramps



Lane Group	ø7	ø8
Lane Configurations		
Total Lost Time (s)		
Satd. Flow (prot)		
Flt Permitted		
Satd. Flow (perm)		
Satd. Flow (RTOR)		
Volume (vph)		
Lane Group Flow (vph)		
Turn Type		
Protected Phases	7	8
Permitted Phases		
Total Split (s)	20.0	35.0
Act Effct Green (s)		
Actuated g/C Ratio		
v/c Ratio		
Control Delay		
Queue Delay		
Total Delay		
LOS		
Approach Delay		
Approach LOS		

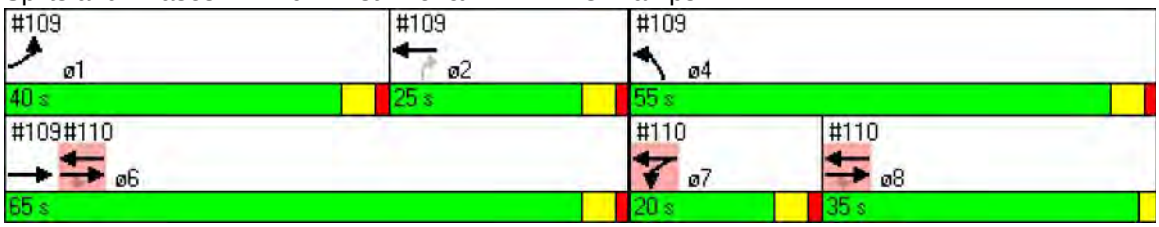
Intersection Summary

Lane Group	EBT	EBR	WBL	WBT	NBL	NBR	ø1	ø2	ø4	ø6	ø8
Lane Configurations											
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0					
Satd. Flow (prot)	5085	1583	1770	5085	0	0					
Flt Permitted			0.950								
Satd. Flow (perm)	5085	1583	1770	5085	0	0					
Satd. Flow (RTOR)		471									
Volume (vph)	1118	1110	80	1646	0	0					
Lane Group Flow (vph)	1215	1207	87	1789	0	0					
Turn Type		Perm	Prot								
Protected Phases	6 8		7	6 7 8			1	2	4	6	8
Permitted Phases		6 8									
Total Split (s)	100.0	100.0	20.0	120.0	0.0	0.0	40.0	25.0	55.0	65.0	35.0
Act Effct Green (s)	96.0	96.0	16.0	120.0							
Actuated g/C Ratio	0.80	0.80	0.13	1.00							
v/c Ratio	0.30	0.89	0.37	0.35							
Control Delay	3.4	14.6	52.1	0.2							
Queue Delay	0.0	0.0	0.0	0.0							
Total Delay	3.4	14.6	52.1	0.2							
LOS	A	B	D	A							
Approach Delay	9.0			2.6							
Approach LOS	A			A							

Intersection Summary

Cycle Length: 120
Actuated Cycle Length: 120
Offset: 0 (0%), Referenced to phase 2:WBT and 6:EBT, Start of Green
Control Type: Pretimed
Maximum v/c Ratio: 0.89
Intersection Signal Delay: 6.2 Intersection LOS: A
Intersection Capacity Utilization 120.6% ICU Level of Service H
Analysis Period (min) 15

Splits and Phases: 110: E 1st Ave. & HW1 EB On ramps

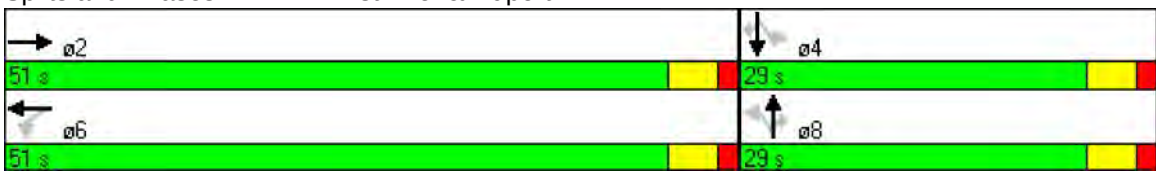


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	0	5070	0	0	3511	0	1770	1522	1504	1770	3539	1583
Flt Permitted					0.823		0.399			0.672		
Satd. Flow (perm)	0	5070	0	0	2892	0	743	1522	1504	1252	3539	1583
Satd. Flow (RTOR)		7			10			19	19			36
Volume (vph)	0	1615	37	39	1372	64	177	7	206	215	422	117
Lane Group Flow (vph)	0	1795	0	0	1603	0	192	120	112	234	459	127
Turn Type				Perm			Perm		Perm	Perm		Perm
Protected Phases		2			6			8			4	
Permitted Phases				6			8		8	4		4
Total Split (s)	0.0	51.0	0.0	51.0	51.0	0.0	29.0	29.0	29.0	29.0	29.0	29.0
Act Effct Green (s)		47.0			47.0		25.0	25.0	25.0	25.0	25.0	25.0
Actuated g/C Ratio		0.59			0.59		0.31	0.31	0.31	0.31	0.31	0.31
v/c Ratio		0.60			0.94		0.83	0.25	0.23	0.60	0.42	0.24
Control Delay		20.2			28.2		56.4	18.8	18.4	30.9	23.1	16.2
Queue Delay		0.0			0.0		0.0	0.0	0.0	0.0	0.0	0.0
Total Delay		20.2			28.2		56.4	18.8	18.4	30.9	23.1	16.2
LOS		C			C		E	B	B	C	C	B
Approach Delay		20.2			28.2			35.7			24.3	
Approach LOS		C			C			D			C	

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 80
Offset: 31 (39%), Referenced to phase 2:EBT and 6:WBTL, Start of Green
Control Type: Pretimed
Maximum v/c Ratio: 0.94
Intersection Signal Delay: 25.1 Intersection LOS: C
Intersection Capacity Utilization 99.7% ICU Level of Service F
Analysis Period (min) 15

Splits and Phases: 111: E 1st Ave. & Rupert

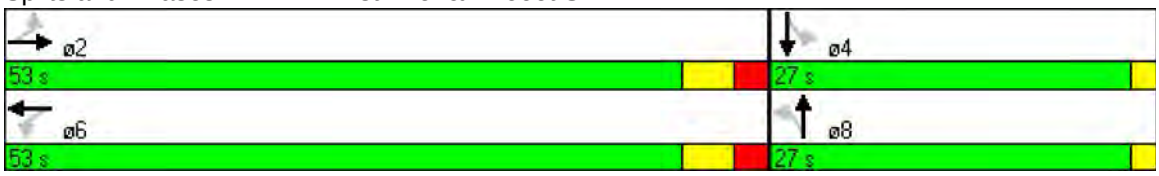


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	0	3539	0	0	3536	0	0	1650	0	0	1709	0
Flt Permitted		0.950			0.951			0.978			0.893	
Satd. Flow (perm)	0	3362	0	0	3362	0	0	1629	0	0	1562	0
Satd. Flow (RTOR)					1			18			15	
Volume (vph)	4	1628	3	4	1761	10	4	1	17	35	6	34
Lane Group Flow (vph)	0	1777	0	0	1929	0	0	23	0	0	82	0
Turn Type	Perm			Perm			Perm			Perm		
Protected Phases		2			6			8			4	
Permitted Phases	2			6			8			4		
Total Split (s)	53.0	53.0	0.0	53.0	53.0	0.0	27.0	27.0	0.0	27.0	27.0	0.0
Act Effct Green (s)		49.0			49.0			23.0			23.0	
Actuated g/C Ratio		0.61			0.61			0.29			0.29	
v/c Ratio		0.86			0.94			0.05			0.18	
Control Delay		29.0			13.4			11.6			19.2	
Queue Delay		0.0			0.0			0.0			0.0	
Total Delay		29.0			13.4			11.6			19.2	
LOS		C			B			B			B	
Approach Delay		29.0			13.4			11.6			19.2	
Approach LOS		C			B			B			B	

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 80
Offset: 56 (70%), Referenced to phase 2:EBTL and 6:WBTL, Start of Green
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 0.94
Intersection Signal Delay: 20.8 Intersection LOS: C
Intersection Capacity Utilization 67.8% ICU Level of Service C
Analysis Period (min) 15

Splits and Phases: 112: E 1st Ave. & Lillooet ST

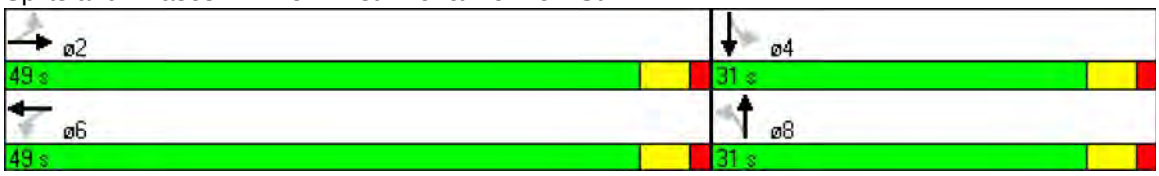


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	3518	0	1770	3504	0	1770	3497	0	1770	3479	0
Flt Permitted	0.089			0.089			0.325			0.347		
Satd. Flow (perm)	166	3518	0	166	3504	0	605	3497	0	646	3479	0
Satd. Flow (RTOR)		8			15			12			19	
Volume (vph)	50	1409	57	49	1523	111	91	465	39	91	470	62
Lane Group Flow (vph)	54	1594	0	53	1776	0	99	547	0	99	578	0
Turn Type	Perm			Perm			Perm			Perm		
Protected Phases		2			6			8			4	
Permitted Phases	2			6			8			4		
Total Split (s)	49.0	49.0	0.0	49.0	49.0	0.0	31.0	31.0	0.0	31.0	31.0	0.0
Act Effct Green (s)	45.0	45.0		45.0	45.0		27.0	27.0		27.0	27.0	
Actuated g/C Ratio	0.56	0.56		0.56	0.56		0.34	0.34		0.34	0.34	
v/c Ratio	0.58	0.80		0.57	0.90		0.49	0.46		0.45	0.49	
Control Delay	36.3	23.4		18.4	7.8		30.8	21.8		29.0	22.0	
Queue Delay	0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0	
Total Delay	36.3	23.4		18.4	7.8		30.8	21.8		29.0	22.0	
LOS	D	C		B	A		C	C		C	C	
Approach Delay		23.8			8.1			23.2			23.0	
Approach LOS		C			A			C			C	

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 80
Offset: 2 (3%), Referenced to phase 2:EBTL and 6:WBTL, Start of Green
Control Type: Pretimed
Maximum v/c Ratio: 0.90
Intersection Signal Delay: 17.6 Intersection LOS: B
Intersection Capacity Utilization 75.6% ICU Level of Service D
Analysis Period (min) 15

Splits and Phases: 113: E 1st Ave. & Renfrew St

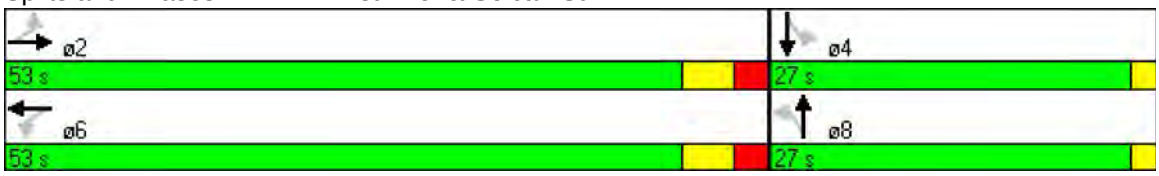


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	0	3539	0	0	3539	0	0	1708	0	0	1681	0
Flt Permitted		0.937			0.951			0.957			0.997	
Satd. Flow (perm)	0	3316	0	0	3366	0	0	1661	0	0	1679	0
Satd. Flow (RTOR)								12			15	
Volume (vph)	9	1536	3	4	1647	4	7	4	11	1	5	14
Lane Group Flow (vph)	0	1683	0	0	1798	0	0	24	0	0	21	0
Turn Type	Perm			Perm			Perm			Perm		
Protected Phases		2			6			8			4	
Permitted Phases	2			6			8			4		
Total Split (s)	53.0	53.0	0.0	53.0	53.0	0.0	27.0	27.0	0.0	27.0	27.0	0.0
Act Effct Green (s)		49.0			49.0			23.0			23.0	
Actuated g/C Ratio		0.61			0.61			0.29			0.29	
v/c Ratio		0.83			0.87			0.05			0.04	
Control Delay		10.8			8.0			14.5			12.5	
Queue Delay		0.0			0.0			0.0			0.0	
Total Delay		10.8			8.0			14.5			12.5	
LOS		B			A			B			B	
Approach Delay		10.8			8.0			14.5			12.5	
Approach LOS		B			A			B			B	

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 80
Offset: 30 (38%), Referenced to phase 2:EBTL and 6:WBTL, Start of Green
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 0.87
Intersection Signal Delay: 9.4 Intersection LOS: A
Intersection Capacity Utilization 59.5% ICU Level of Service B
Analysis Period (min) 15

Splits and Phases: 114: E 1st Ave. & Solcan St

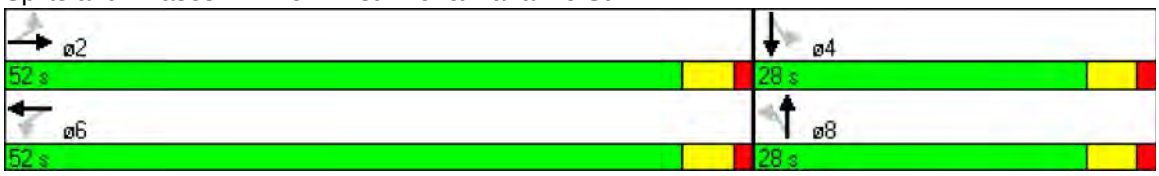


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	3525	0	1770	3525	0	1770	3493	0	1770	4994	0
Flt Permitted	0.083			0.083			0.339			0.223		
Satd. Flow (perm)	155	3525	0	155	3525	0	631	3493	0	415	4994	0
Satd. Flow (RTOR)		6			6			12			20	
Volume (vph)	45	1430	38	54	1613	44	93	582	54	49	498	70
Lane Group Flow (vph)	49	1595	0	59	1801	0	101	692	0	53	617	0
Turn Type	Perm			Perm			Perm			Perm		
Protected Phases		2			6			8			4	
Permitted Phases	2			6			8			4		
Total Split (s)	52.0	52.0	0.0	52.0	52.0	0.0	28.0	28.0	0.0	28.0	28.0	0.0
Act Effct Green (s)	48.0	48.0		48.0	48.0		24.0	24.0		24.0	24.0	
Actuated g/C Ratio	0.60	0.60		0.60	0.60		0.30	0.30		0.30	0.30	
v/c Ratio	0.53	0.75		0.63	0.85		0.53	0.66		0.42	0.41	
Control Delay	39.8	22.9		22.9	3.6		35.6	27.5		35.0	22.6	
Queue Delay	0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0	
Total Delay	39.8	22.9		22.9	3.6		35.6	27.5		35.0	22.6	
LOS	D	C		C	A		D	C		C	C	
Approach Delay		23.4			4.2			28.5			23.5	
Approach LOS		C			A			C			C	

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 80
Offset: 68 (85%), Referenced to phase 2:EBTL and 6:WBTL, Start of Green
Control Type: Pretimed
Maximum v/c Ratio: 0.85
Intersection Signal Delay: 17.0 Intersection LOS: B
Intersection Capacity Utilization 77.1% ICU Level of Service D
Analysis Period (min) 15

Splits and Phases: 115: E 1st Ave. & Nanaimo St

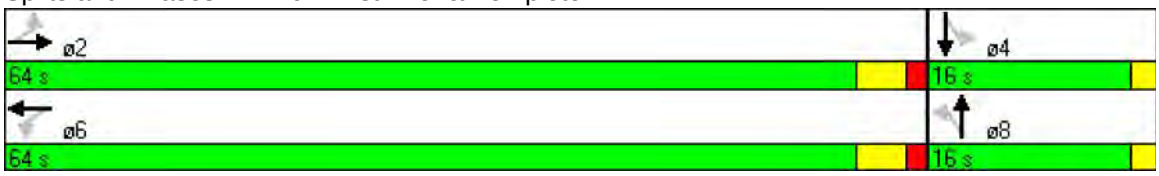


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	0	3539	0	0	3539	0	0	1657	0	0	1611	0
Flt Permitted					0.954			0.994				
Satd. Flow (perm)	0	3539	0	0	3376	0	0	1652	0	0	1611	0
Satd. Flow (RTOR)		1						12			36	
Volume (vph)	0	1510	5	2	1746	2	1	2	11	0	0	3
Lane Group Flow (vph)	0	1646	0	0	1902	0	0	15	0	0	3	0
Turn Type	Perm			Perm			Perm			Perm		
Protected Phases		2			6			8			4	
Permitted Phases	2			6			8			4		
Total Split (s)	64.0	64.0	0.0	64.0	64.0	0.0	16.0	16.0	0.0	16.0	16.0	0.0
Act Effct Green (s)		60.0			60.0			12.0			12.0	
Actuated g/C Ratio		0.75			0.75			0.15			0.15	
v/c Ratio		0.62			0.75			0.06			0.01	
Control Delay		3.7			2.5			18.1			0.0	
Queue Delay		0.1			0.0			0.0			0.0	
Total Delay		3.8			2.5			18.1			0.0	
LOS		A			A			B			A	
Approach Delay		3.8			2.5			18.1			0.0	
Approach LOS		A			A			B			A	

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 80
Offset: 76 (95%), Referenced to phase 2:EBTL and 6:WBTL, Start of Green
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 0.75
Intersection Signal Delay: 3.1 Intersection LOS: A
Intersection Capacity Utilization 59.7% ICU Level of Service B
Analysis Period (min) 15

Splits and Phases: 116: E 1st Ave. & Templeton Dr

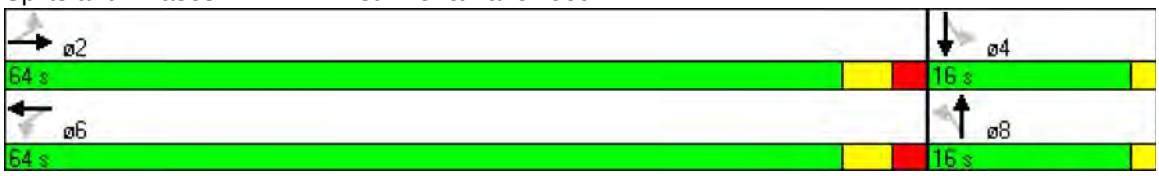


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	0	3539	0	0	3539	0	0	1611	0	0	1736	0
Flt Permitted		0.937			0.946						0.965	
Satd. Flow (perm)	0	3316	0	0	3348	0	0	1611	0	0	1700	0
Satd. Flow (RTOR)		1						55			4	
Volume (vph)	7	1541	3	7	1979	1	0	0	11	3	3	4
Lane Group Flow (vph)	0	1686	0	0	2160	0	0	12	0	0	10	0
Turn Type	Perm			Perm			Perm			Perm		
Protected Phases		2			6			8			4	
Permitted Phases	2			6			8			4		
Total Split (s)	64.0	64.0	0.0	64.0	64.0	0.0	16.0	16.0	0.0	16.0	16.0	0.0
Act Effct Green (s)		60.0			60.0			12.0			12.0	
Actuated g/C Ratio		0.75			0.75			0.15			0.15	
v/c Ratio		0.68			0.86			0.04			0.04	
Control Delay		9.3			5.4			0.3			24.4	
Queue Delay		0.0			0.1			0.0			0.0	
Total Delay		9.3			5.5			0.3			24.4	
LOS		A			A			A			C	
Approach Delay		9.3			5.5			0.3			24.4	
Approach LOS		A			A			A			C	

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 80
Offset: 7 (9%), Referenced to phase 2:EBTL and 6:WBTL, Start of Green
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 0.86
Intersection Signal Delay: 7.2 Intersection LOS: A
Intersection Capacity Utilization 69.6% ICU Level of Service C
Analysis Period (min) 15

Splits and Phases: 117: E 1st Ave. & Lakewood Dr

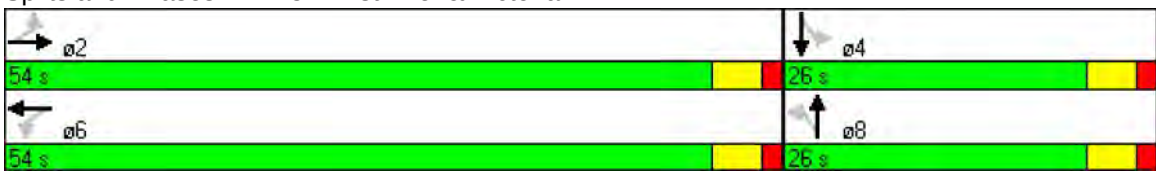


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	0	3536	0	0	3486	0	0	3486	0	0	3430	0
Flt Permitted								0.874			0.695	
Satd. Flow (perm)	0	3536	0	0	3486	0	0	3065	0	0	2423	0
Satd. Flow (RTOR)		2			28			8			14	
Volume (vph)	0	1443	12	0	1799	200	39	261	20	100	180	30
Lane Group Flow (vph)	0	1581	0	0	2172	0	0	348	0	0	338	0
Turn Type	Perm			Perm			Perm			Perm		
Protected Phases		2			6			8			4	
Permitted Phases	2			6			8			4		
Total Split (s)	54.0	54.0	0.0	54.0	54.0	0.0	26.0	26.0	0.0	26.0	26.0	0.0
Act Effct Green (s)		50.0			50.0			22.0			22.0	
Actuated g/C Ratio		0.62			0.62			0.28			0.28	
v/c Ratio		0.72			0.99			0.41			0.50	
Control Delay		13.6			18.7			24.9			26.4	
Queue Delay		0.0			0.0			0.0			0.0	
Total Delay		13.6			18.7			24.9			26.4	
LOS		B			B			C			C	
Approach Delay		13.6			18.7			24.9			26.4	
Approach LOS		B			B			C			C	

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 80
Offset: 35 (44%), Referenced to phase 2:EBTL and 6:WBTL, Start of Green
Control Type: Pretimed
Maximum v/c Ratio: 0.99
Intersection Signal Delay: 17.9 Intersection LOS: B
Intersection Capacity Utilization 83.9% ICU Level of Service E
Analysis Period (min) 15

Splits and Phases: 118: E 1st Ave. & Victoria Dr

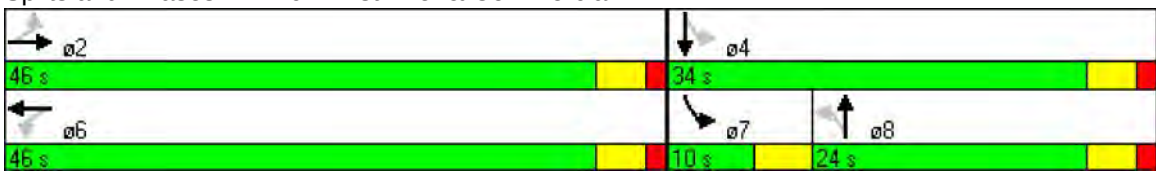


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	3525	0	1770	3506	0	1770	3394	0	1770	3417	0
Flt Permitted	0.095			0.104			0.577			0.325		
Satd. Flow (perm)	177	3525	0	194	3506	0	966	3394	0	563	3417	0
Satd. Flow (RTOR)		4			8			19			8	
Volume (vph)	33	1207	27	73	1636	72	59	342	49	125	233	29
Lane Group Flow (vph)	36	1341	0	79	1856	0	64	425	0	136	285	0
Turn Type	Perm			Perm			Perm			pm+pt		
Protected Phases		2			6			8		7	4	
Permitted Phases	2			6			8			4		
Total Split (s)	46.0	46.0	0.0	46.0	46.0	0.0	24.0	24.0	0.0	10.0	34.0	0.0
Act Effct Green (s)	46.5	46.5		46.5	46.5		15.5	15.5		25.5	25.5	
Actuated g/C Ratio	0.58	0.58		0.58	0.58		0.19	0.19		0.32	0.32	
v/c Ratio	0.35	0.65		0.70	0.91		0.34	0.63		0.50	0.26	
Control Delay	29.2	21.3		24.7	11.5		31.9	32.2		26.1	19.7	
Queue Delay	0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0	
Total Delay	29.2	21.3		24.7	11.5		31.9	32.2		26.1	19.7	
LOS	C	C		C	B		C	C		C	B	
Approach Delay		21.5			12.0			32.2			21.7	
Approach LOS		C			B			C			C	

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 80
Offset: 54 (68%), Referenced to phase 2:EBTL and 6:WBTL, Start of Green
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 0.91
Intersection Signal Delay: 18.4 Intersection LOS: B
Intersection Capacity Utilization 84.6% ICU Level of Service E
Analysis Period (min) 15

Splits and Phases: 119: E 1st Ave. & Commercial Dr

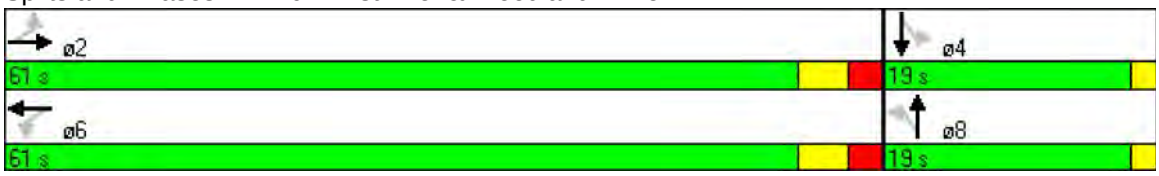


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	0	3536	0	0	3536	0	0	1700	0	0	1752	0
Flt Permitted		0.937			0.933			0.983			0.979	
Satd. Flow (perm)	0	3313	0	0	3299	0	0	1681	0	0	1729	0
Satd. Flow (RTOR)		1			3			25			10	
Volume (vph)	8	1281	6	16	1644	17	5	10	23	4	11	9
Lane Group Flow (vph)	0	1408	0	0	1822	0	0	41	0	0	26	0
Turn Type	Perm			Perm			Perm			Perm		
Protected Phases		2			6			8			4	
Permitted Phases	2			6			8			4		
Total Split (s)	61.0	61.0	0.0	61.0	61.0	0.0	19.0	19.0	0.0	19.0	19.0	0.0
Act Effct Green (s)		57.0			57.0			15.0			15.0	
Actuated g/C Ratio		0.71			0.71			0.19			0.19	
v/c Ratio		0.60			0.77			0.12			0.08	
Control Delay		10.9			3.2			16.4			20.6	
Queue Delay		0.0			0.0			0.0			0.0	
Total Delay		10.9			3.2			16.4			20.6	
LOS		B			A			B			C	
Approach Delay		10.9			3.2			16.4			20.6	
Approach LOS		B			A			B			C	

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 80
Offset: 70 (88%), Referenced to phase 2:EBTL and 6:WBTL, Start of Green
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 0.77
Intersection Signal Delay: 6.8 Intersection LOS: A
Intersection Capacity Utilization 67.2% ICU Level of Service C
Analysis Period (min) 15

Splits and Phases: 120: E 1st Ave. & Woodland Drive

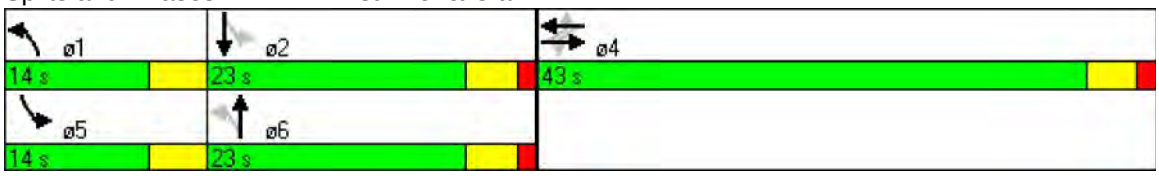


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	0	3437	0	0	3490	0	1770	4963	0	1770	4989	0
Flt Permitted					0.955		0.211			0.211		
Satd. Flow (perm)	0	3437	0	0	3333	0	393	4963	0	393	4989	0
Satd. Flow (RTOR)		52			19			45			29	
Volume (vph)	0	987	239	1	1457	152	309	1078	203	129	782	114
Lane Group Flow (vph)	0	1333	0	0	1750	0	336	1393	0	140	974	0
Turn Type	Perm			Perm			pm+pt			pm+pt		
Protected Phases		4			4		1	6		5	2	
Permitted Phases	4			4			6			2		
Total Split (s)	43.0	43.0	0.0	43.0	43.0	0.0	14.0	23.0	0.0	14.0	23.0	0.0
Act Effct Green (s)		39.0			39.0		30.2	20.2		27.8	19.0	
Actuated g/C Ratio		0.49			0.49		0.38	0.25		0.35	0.24	
v/c Ratio		0.78			1.07		1.05	1.08		0.48	0.81	
Control Delay		20.4			51.4		86.8	81.5		21.3	34.1	
Queue Delay		0.0			0.0		0.0	0.0		0.0	0.0	
Total Delay		20.4			51.4		86.8	81.5		21.3	34.1	
LOS		C			D		F	F		C	C	
Approach Delay		20.4			51.4			82.5			32.5	
Approach LOS		C			D			F			C	

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 80
Offset: 18 (23%), Referenced to phase 4:EBWB, Start of Green
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 1.08
Intersection Signal Delay: 49.9 Intersection LOS: D
Intersection Capacity Utilization 90.6% ICU Level of Service E
Analysis Period (min) 15

Splits and Phases: 121: E 1st Ave. & Clark Dr

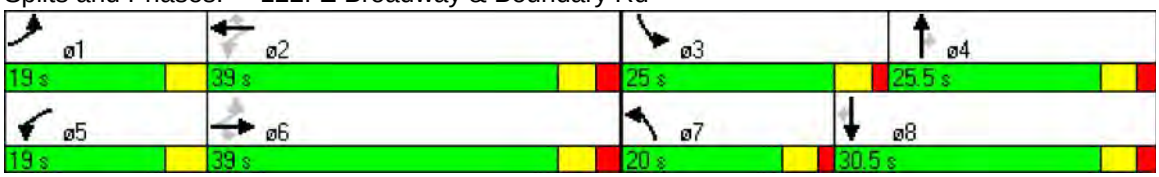


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	3539	1583	1770	3539	1583	3433	3539	1583	1770	3539	1583
Flt Permitted	0.114			0.268			0.950			0.950		
Satd. Flow (perm)	212	3539	1583	499	3539	1583	3433	3539	1583	1770	3539	1583
Satd. Flow (RTOR)			167			172			108			275
Volume (vph)	169	574	154	126	1093	184	309	401	99	231	588	374
Lane Group Flow (vph)	184	624	167	137	1188	200	336	436	108	251	639	407
Turn Type	pm+pt		Perm	pm+pt		Perm	Prot		Perm	Prot		Perm
Protected Phases	1	6		5	2		7	4		3	8	
Permitted Phases	6		6	2		2			4			8
Total Split (s)	19.0	39.0	39.0	19.0	39.0	39.0	20.0	25.5	25.5	25.0	30.5	30.5
Act Effct Green (s)	48.4	36.9	36.9	45.0	35.2	35.2	14.6	20.3	20.3	18.5	24.2	24.2
Actuated g/C Ratio	0.48	0.36	0.36	0.44	0.35	0.35	0.14	0.20	0.20	0.18	0.24	0.24
v/c Ratio	0.66	0.49	0.25	0.40	0.97	0.30	0.68	0.62	0.27	0.78	0.76	0.69
Control Delay	30.8	27.6	4.9	18.5	53.5	7.4	49.8	42.2	9.1	57.5	43.0	18.7
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	30.8	27.6	4.9	18.5	53.5	7.4	49.8	42.2	9.1	57.5	43.0	18.7
LOS	C	C	A	B	D	A	D	D	A	E	D	B
Approach Delay		24.3			44.3			41.0			38.2	
Approach LOS		C			D			D			D	

Intersection Summary

Cycle Length: 108.5
Actuated Cycle Length: 101.6
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 0.97
Intersection Signal Delay: 37.8 Intersection LOS: D
Intersection Capacity Utilization 78.2% ICU Level of Service D
Analysis Period (min) 15

Splits and Phases: 122: E Broadway & Boundary Rd

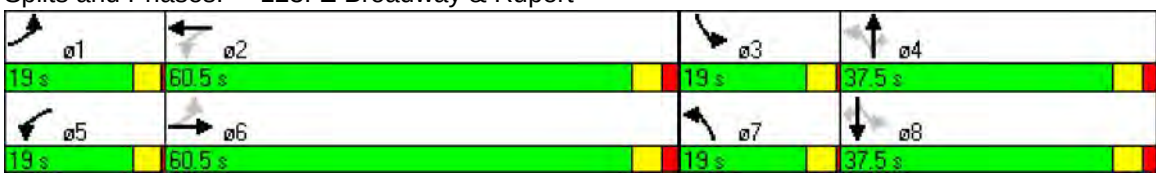


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	4984	0	1770	5070	0	1770	3539	1583	1770	3539	1583
Flt Permitted	0.071			0.218			0.343			0.457		
Satd. Flow (perm)	132	4984	0	406	5070	0	639	3539	1583	851	3539	1583
Satd. Flow (RTOR)		26			2				191			146
Volume (vph)	43	744	113	193	1376	24	262	287	176	56	394	134
Lane Group Flow (vph)	47	932	0	210	1522	0	285	312	191	61	428	146
Turn Type	pm+pt			pm+pt			pm+pt		Perm	pm+pt		Perm
Protected Phases	1	6		5	2		7	4		3	8	
Permitted Phases	6			2			4		4	8		8
Total Split (s)	19.0	60.5	0.0	19.0	60.5	0.0	19.0	37.5	37.5	19.0	37.5	37.5
Act Effct Green (s)	63.5	56.7		73.1	64.3		40.8	30.6	30.6	30.2	21.8	21.8
Actuated g/C Ratio	0.51	0.46		0.60	0.53		0.33	0.25	0.25	0.24	0.18	0.18
v/c Ratio	0.30	0.40		0.55	0.57		0.81	0.35	0.35	0.23	0.68	0.36
Control Delay	16.8	22.2		17.4	21.6		51.7	40.1	7.3	30.7	52.7	9.3
Queue Delay	0.0	0.0		0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	16.8	22.2		17.4	21.6		51.7	40.1	7.3	30.7	52.7	9.3
LOS	B	C		B	C		D	D	A	C	D	A
Approach Delay		21.9			21.1			36.4			40.6	
Approach LOS		C			C			D			D	

Intersection Summary

Cycle Length: 136
Actuated Cycle Length: 122
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 0.81
Intersection Signal Delay: 27.2 Intersection LOS: C
Intersection Capacity Utilization 71.6% ICU Level of Service C
Analysis Period (min) 15

Splits and Phases: 123: E Broadway & Rupert

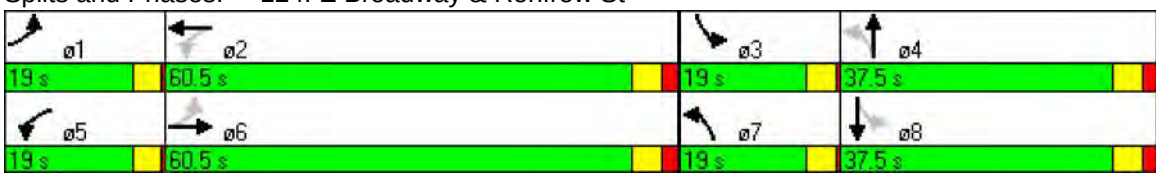


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	5009	0	1770	5060	0	1770	3437	0	1770	3405	0
Flt Permitted	0.071			0.179			0.201			0.281		
Satd. Flow (perm)	132	5009	0	333	5060	0	374	3437	0	523	3405	0
Satd. Flow (RTOR)		17			4			21			33	
Volume (vph)	83	868	98	84	1613	54	124	369	89	66	409	140
Lane Group Flow (vph)	90	1050	0	91	1812	0	135	498	0	72	597	0
Turn Type	pm+pt			pm+pt			pm+pt			pm+pt		
Protected Phases	1	6		5	2		7	4		3	8	
Permitted Phases	6			2			4			8		
Total Split (s)	19.0	60.5	0.0	19.0	60.5	0.0	19.0	37.5	0.0	19.0	37.5	0.0
Act Effct Green (s)	52.9	47.2		52.6	47.0		37.6	29.3		32.7	26.8	
Actuated g/C Ratio	0.50	0.45		0.50	0.45		0.35	0.28		0.31	0.26	
v/c Ratio	0.45	0.46		0.33	0.79		0.48	0.51		0.27	0.66	
Control Delay	23.7	22.0		16.4	29.6		31.4	36.0		27.8	41.2	
Queue Delay	0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0	
Total Delay	23.7	22.0		16.4	29.6		31.4	36.0		27.8	41.2	
LOS	C	C		B	C		C	D		C	D	
Approach Delay		22.1			29.0			35.0			39.8	
Approach LOS		C			C			D			D	

Intersection Summary

Cycle Length: 136
Actuated Cycle Length: 104.3
Control Type: Semi Act-Uncoord
Maximum v/c Ratio: 0.79
Intersection Signal Delay: 29.7 Intersection LOS: C
Intersection Capacity Utilization 72.9% ICU Level of Service C
Analysis Period (min) 15

Splits and Phases: 124: E Broadway & Renfrew St

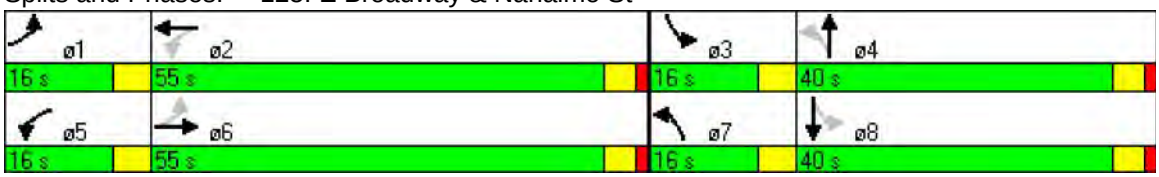


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	5050	0	1770	5065	0	1770	4984	0	1770	4867	0
Flt Permitted	0.078			0.174			0.277			0.278		
Satd. Flow (perm)	145	5050	0	324	5065	0	516	4984	0	518	4867	0
Satd. Flow (RTOR)		7			4			23			79	
Volume (vph)	90	924	46	116	1759	51	149	528	83	61	438	175
Lane Group Flow (vph)	98	1054	0	126	1967	0	162	664	0	66	666	0
Turn Type	pm+pt			pm+pt			pm+pt			pm+pt		
Protected Phases	1	6		5	2		7	4		3	8	
Permitted Phases	6			2			4			8		
Total Split (s)	16.0	55.0	0.0	16.0	55.0	0.0	16.0	40.0	0.0	16.0	40.0	0.0
Act Effct Green (s)	56.8	48.7		59.0	51.7		33.5	24.6		27.6	19.5	
Actuated g/C Ratio	0.54	0.47		0.57	0.50		0.32	0.24		0.26	0.19	
v/c Ratio	0.48	0.45		0.41	0.78		0.55	0.56		0.29	0.68	
Control Delay	21.7	20.1		14.6	26.4		33.5	37.1		28.4	38.8	
Queue Delay	0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0	
Total Delay	21.7	20.1		14.6	26.4		33.5	37.1		28.4	38.8	
LOS	C	C		B	C		C	D		C	D	
Approach Delay		20.2			25.7			36.4			37.9	
Approach LOS		C			C			D			D	

Intersection Summary

Cycle Length: 127
Actuated Cycle Length: 104.1
Control Type: Semi Act-Uncoord
Maximum v/c Ratio: 0.78
Intersection Signal Delay: 28.1 Intersection LOS: C
Intersection Capacity Utilization 74.1% ICU Level of Service D
Analysis Period (min) 15

Splits and Phases: 125: E Broadway & Nanaimo St



Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	5065	0	1770	5060	0	1770	1863	1583	1770	1794	0
Flt Permitted	0.098			0.286			0.455			0.559		
Satd. Flow (perm)	183	5065	0	533	5060	0	848	1863	1583	1041	1794	0
Satd. Flow (RTOR)		9			11				70		7	
Volume (vph)	30	784	23	89	1863	68	88	199	64	78	205	66
Lane Group Flow (vph)	33	877	0	97	2099	0	96	216	70	85	295	0
Turn Type	Perm			Perm			Perm		Perm	Perm		
Protected Phases		2			6			8			4	
Permitted Phases	2			6			8		8	4		
Total Split (s)	45.0	45.0	0.0	45.0	45.0	0.0	30.0	30.0	30.0	30.0	30.0	0.0
Act Effct Green (s)	41.0	41.0		41.0	41.0		26.0	26.0	26.0	26.0	26.0	
Actuated g/C Ratio	0.55	0.55		0.55	0.55		0.35	0.35	0.35	0.35	0.35	
v/c Ratio	0.33	0.32		0.33	0.76		0.33	0.33	0.12	0.24	0.47	
Control Delay	23.6	7.2		13.5	15.3		22.0	19.9	5.3	19.7	21.7	
Queue Delay	0.0	0.0		0.0	0.0		0.0	0.0	0.0	0.0	0.0	
Total Delay	23.6	7.2		13.5	15.3		22.0	19.9	5.3	19.7	21.7	
LOS	C	A		B	B		C	B	A	B	C	
Approach Delay		7.8			15.3			17.8			21.3	
Approach LOS		A			B			B			C	

Intersection Summary

Cycle Length: 75
Actuated Cycle Length: 75
Offset: 34 (45%), Referenced to phase 2:EBTL and 6:WBTL, Start of Green
Control Type: Pretimed
Maximum v/c Ratio: 0.76
Intersection Signal Delay: 14.3 Intersection LOS: B
Intersection Capacity Utilization 73.9% ICU Level of Service D
Analysis Period (min) 15

Splits and Phases: 126: E Broadway & Victoria Dr

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	5034	0	1770	5065	0	0	4989	0	0	4888	0
Flt Permitted	0.154			0.209				0.823			0.838	
Satd. Flow (perm)	287	5034	0	389	5065	0	0	4139	0	0	4121	0
Satd. Flow (RTOR)		17			5			19			61	
Volume (vph)	62	800	60	55	1566	40	101	452	45	31	167	56
Lane Group Flow (vph)	67	935	0	60	1745	0	0	650	0	0	277	0
Turn Type	pm+pt			pm+pt			Perm			Perm		
Protected Phases	1	6		5	2			4			4	
Permitted Phases	6			2			4			4		
Total Split (s)	15.0	30.0	0.0	15.0	30.0	0.0	30.0	30.0	0.0	30.0	30.0	0.0
Act Effct Green (s)	46.0	41.7		45.9	41.6			18.6			18.6	
Actuated g/C Ratio	0.61	0.56		0.61	0.55			0.25			0.25	
v/c Ratio	0.22	0.33		0.17	0.62			0.62			0.26	
Control Delay	8.0	11.1		9.3	13.7			26.5			17.1	
Queue Delay	0.0	0.0		0.0	0.0			0.0			0.0	
Total Delay	8.0	11.1		9.3	13.7			26.5			17.1	
LOS	A	B		A	B			C			B	
Approach Delay		10.9			13.5			26.5			17.1	
Approach LOS		B			B			C			B	

Intersection Summary

Cycle Length: 75
Actuated Cycle Length: 75
Offset: 47 (63%), Referenced to phase 2:WBTL and 6:EBTL, Start of Green
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 0.62
Intersection Signal Delay: 15.4 Intersection LOS: B
Intersection Capacity Utilization 65.5% ICU Level of Service C
Analysis Period (min) 15

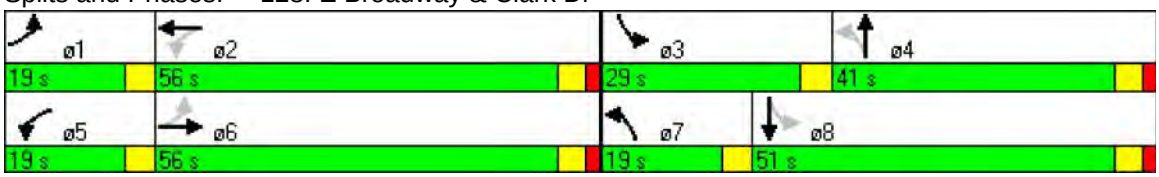
Splits and Phases: 127: E Broadway & Commercial Dr

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	5024	0	1770	4989	0	1770	5024	0	1770	4938	0
Flt Permitted	0.077			0.272			0.297			0.098		
Satd. Flow (perm)	143	5024	0	507	4989	0	553	5024	0	183	4938	0
Satd. Flow (RTOR)		10			20			9			40	
Volume (vph)	138	629	52	155	1335	192	64	1030	88	250	588	139
Lane Group Flow (vph)	150	741	0	168	1660	0	70	1216	0	272	790	0
Turn Type	pm+pt			pm+pt			pm+pt			pm+pt		
Protected Phases	1	6		5	2		7	4		3	8	
Permitted Phases	6			2			4			8		
Total Split (s)	19.0	56.0	0.0	19.0	56.0	0.0	19.0	41.0	0.0	29.0	51.0	0.0
Act Effct Green (s)	64.2	52.2		64.8	52.5		44.8	36.3		60.8	50.5	
Actuated g/C Ratio	0.47	0.38		0.47	0.38		0.32	0.26		0.44	0.37	
v/c Ratio	0.72	0.39		0.48	0.87		0.28	0.91		0.86	0.43	
Control Delay	49.0	32.2		24.8	45.4		26.7	60.1		61.2	32.5	
Queue Delay	0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0	
Total Delay	49.0	32.2		24.8	45.4		26.7	60.1		61.2	32.5	
LOS	D	C		C	D		C	E		E	C	
Approach Delay		35.0			43.5			58.3			39.9	
Approach LOS		D			D			E			D	

Intersection Summary

Cycle Length: 145
Actuated Cycle Length: 137.4
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 0.91
Intersection Signal Delay: 45.0 Intersection LOS: D
Intersection Capacity Utilization 86.8% ICU Level of Service E
Analysis Period (min) 15

Splits and Phases: 128: E Broadway & Clark Dr

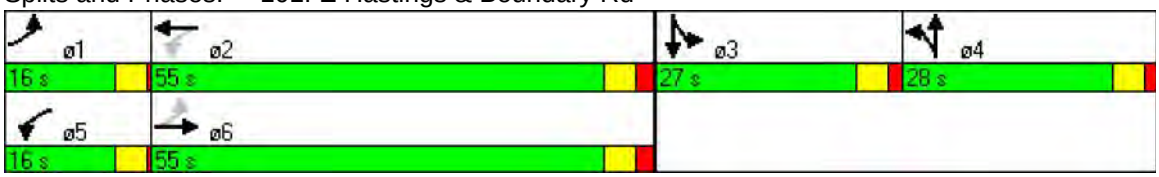


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	5004	0	1770	3522	0	1610	3157	0	1770	3429	0
Flt Permitted	0.190			0.078			0.950	0.995		0.950		
Satd. Flow (perm)	354	5004	0	145	3522	0	1610	3157	0	1770	3429	0
Satd. Flow (RTOR)		19			3			126			22	
Volume (vph)	156	1299	151	169	770	27	246	211	194	43	121	31
Lane Group Flow (vph)	170	1576	0	184	866	0	215	492	0	47	166	0
Turn Type	pm+pt			pm+pt			Split			Split		
Protected Phases	1	6		5	2		4	4		3	3	
Permitted Phases	6			2								
Total Split (s)	16.0	55.0	0.0	16.0	55.0	0.0	28.0	28.0	0.0	27.0	27.0	0.0
Act Effct Green (s)	50.2	40.6		53.3	42.1		18.7	18.7		11.1	11.1	
Actuated g/C Ratio	0.51	0.41		0.54	0.43		0.19	0.19		0.11	0.11	
v/c Ratio	0.53	0.76		0.70	0.57		0.70	0.70		0.23	0.41	
Control Delay	17.4	27.3		38.2	23.5		52.4	34.3		47.9	41.3	
Queue Delay	0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0	
Total Delay	17.4	27.3		38.2	23.5		52.4	34.3		47.9	41.3	
LOS	B	C		D	C		D	C		D	D	
Approach Delay		26.3			26.1			39.8			42.8	
Approach LOS		C			C			D			D	

Intersection Summary

Cycle Length: 126
Actuated Cycle Length: 98.2
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 0.76
Intersection Signal Delay: 29.8 Intersection LOS: C
Intersection Capacity Utilization 70.6% ICU Level of Service C
Analysis Period (min) 15

Splits and Phases: 101: E Hastings & Boundary Rd

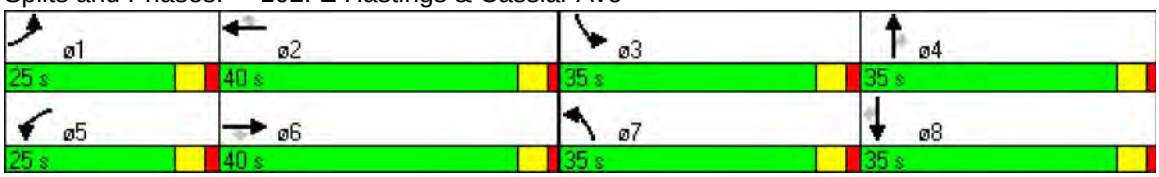


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	5085	1583	1770	3539	1583	3433	3539	1583	3433	3539	1583
Flt Permitted	0.950			0.950			0.950			0.950		
Satd. Flow (perm)	1770	5085	1583	1770	3539	1583	3433	3539	1583	3433	3539	1583
Satd. Flow (RTOR)			404			532			74			163
Volume (vph)	132	937	575	67	561	509	404	327	68	721	66	150
Lane Group Flow (vph)	143	1018	625	73	610	553	439	355	74	784	72	163
Turn Type	Prot		Perm	Prot		Perm	Prot		Perm	Prot		Perm
Protected Phases	1	6		5	2		7	4		3	8	
Permitted Phases			6			2			4			8
Total Split (s)	25.0	40.0	40.0	25.0	40.0	40.0	35.0	35.0	35.0	35.0	35.0	35.0
Act Effct Green (s)	14.5	34.3	34.3	10.7	27.6	27.6	19.5	16.9	16.9	30.2	27.5	27.5
Actuated g/C Ratio	0.14	0.32	0.32	0.10	0.26	0.26	0.18	0.16	0.16	0.29	0.26	0.26
v/c Ratio	0.59	0.62	0.80	0.41	0.66	0.69	0.69	0.63	0.23	0.80	0.08	0.31
Control Delay	56.0	33.6	20.8	56.1	39.6	8.7	47.8	48.4	11.9	44.5	35.2	7.8
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	56.0	33.6	20.8	56.1	39.6	8.7	47.8	48.4	11.9	44.5	35.2	7.8
LOS	E	C	C	E	D	A	D	D	B	D	D	A
Approach Delay		30.9			26.8			45.0			38.0	
Approach LOS		C			C			D			D	

Intersection Summary

Cycle Length: 135
Actuated Cycle Length: 105.7
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 0.80
Intersection Signal Delay: 33.8 Intersection LOS: C
Intersection Capacity Utilization 65.8% ICU Level of Service C
Analysis Period (min) 15

Splits and Phases: 102: E Hastings & Cassiar Ave

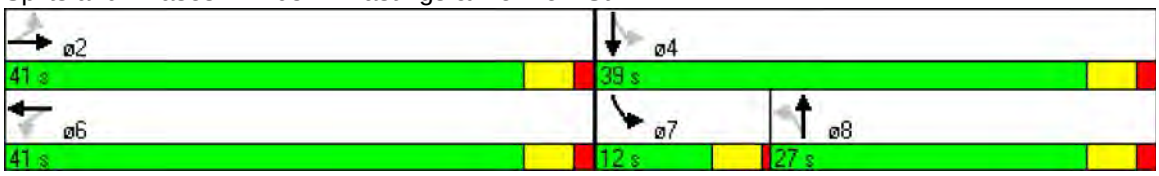


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	5040	0	1770	3472	0	0	4984	0	0	3437	0
Flt Permitted	0.140			0.135				0.790			0.575	
Satd. Flow (perm)	261	5040	0	251	3472	0	0	3965	0	0	2019	0
Satd. Flow (RTOR)		16			27			20			9	
Volume (vph)	57	1134	73	137	894	132	67	387	43	251	308	32
Lane Group Flow (vph)	62	1312	0	149	1115	0	0	541	0	0	643	0
Turn Type	Perm			Perm			Perm			pm+pt		
Protected Phases		2			6			8		7	4	
Permitted Phases	2			6			8			4		
Total Split (s)	41.0	41.0	0.0	41.0	41.0	0.0	27.0	27.0	0.0	12.0	39.0	0.0
Act Effct Green (s)	37.0	37.0		37.0	37.0			23.0			35.0	
Actuated g/C Ratio	0.46	0.46		0.46	0.46			0.29			0.44	
v/c Ratio	0.51	0.56		1.28	0.69			0.47			0.62	
Control Delay	37.5	24.9		204.5	19.2			10.2			18.8	
Queue Delay	0.0	0.0		0.0	0.0			0.0			0.0	
Total Delay	37.5	24.9		204.5	19.2			10.2			18.8	
LOS	D	C		F	B			B			B	
Approach Delay		25.5			41.1			10.2			18.8	
Approach LOS		C			D			B			B	

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 80
Offset: 60 (75%), Referenced to phase 2:EBTL and 6:WBTL, Start of Green
Control Type: Pretimed
Maximum v/c Ratio: 1.28
Intersection Signal Delay: 27.4 Intersection LOS: C
Intersection Capacity Utilization 74.7% ICU Level of Service D
Analysis Period (min) 15

Splits and Phases: 103: E Hastings & Renfrew St

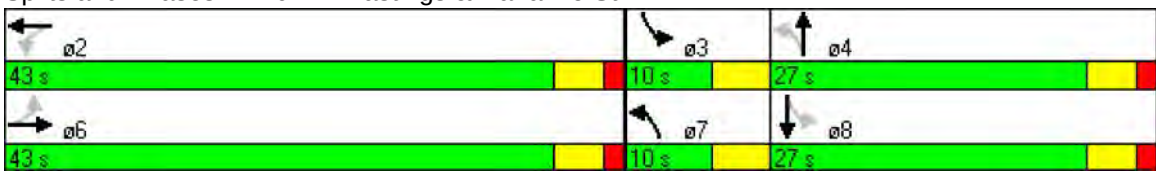


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	0	4947	0	0	3514	0	1770	4900	0	1770	4745	0
Flt Permitted		0.939			0.666		0.320			0.426		
Satd. Flow (perm)	0	4645	0	0	2344	0	535	4900	0	713	4745	0
Satd. Flow (RTOR)		16			2			24			47	
Volume (vph)	2	1442	88	60	890	10	89	395	44	59	496	92
Lane Group Flow (vph)	0	1665	0	0	1043	0	97	477	0	64	639	0
Turn Type	Perm			Perm			pm+pt			pm+pt		
Protected Phases		6			2		7	4		3	8	
Permitted Phases	6			2			4			8		
Total Split (s)	43.0	43.0	0.0	43.0	43.0	0.0	10.0	27.0	0.0	10.0	27.0	0.0
Act Effct Green (s)		39.0			39.0		29.8	25.0		29.8	25.0	
Actuated g/C Ratio		0.49			0.49		0.37	0.31		0.37	0.31	
v/c Ratio		0.73			0.91		0.33	0.31		0.19	0.42	
Control Delay		12.4			30.6		15.0	21.3		15.9	21.8	
Queue Delay		0.0			0.0		0.0	0.0		0.0	0.0	
Total Delay		12.4			30.6		15.0	21.3		15.9	21.8	
LOS		B			C		B	C		B	C	
Approach Delay		12.4			30.6			20.3			21.2	
Approach LOS		B			C			C			C	

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 80
Offset: 23 (29%), Referenced to phase 2:WBTL and 6:EBTL, Start of Green
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 0.91
Intersection Signal Delay: 19.9 Intersection LOS: B
Intersection Capacity Utilization 92.9% ICU Level of Service F
Analysis Period (min) 15

Splits and Phases: 104: E Hastings & Nanaimo St

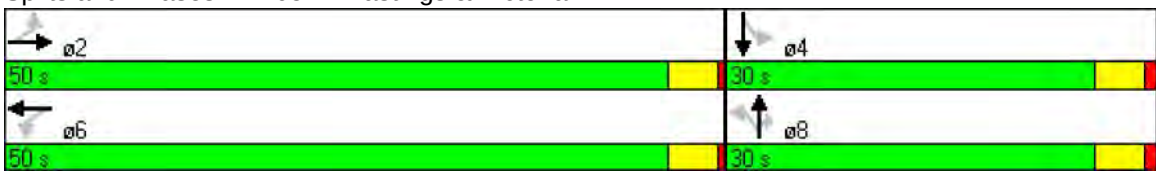


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	5060	0	1770	3522	0	0	1840	1583	0	3434	0
Flt Permitted	0.248			0.094				0.869			0.773	
Satd. Flow (perm)	462	5060	0	175	3522	0	0	1619	1583	0	2700	0
Satd. Flow (RTOR)		10			7				24		13	
Volume (vph)	26	1495	48	78	831	28	48	148	258	82	139	20
Lane Group Flow (vph)	28	1677	0	85	933	0	0	213	280	0	262	0
Turn Type	Perm			Perm			Perm		Perm	Perm		
Protected Phases		2			6			8			4	
Permitted Phases	2			6			8		8	4		
Total Split (s)	50.0	50.0	0.0	50.0	50.0	0.0	30.0	30.0	30.0	30.0	30.0	0.0
Act Effct Green (s)	46.0	46.0		46.0	46.0			26.0	26.0		26.0	
Actuated g/C Ratio	0.58	0.58		0.58	0.58			0.32	0.32		0.32	
v/c Ratio	0.11	0.58		0.84	0.46			0.40	0.53		0.30	
Control Delay	3.0	3.4		49.9	4.2			26.3	26.7		20.2	
Queue Delay	0.0	0.0		0.0	0.0			0.0	0.0		0.0	
Total Delay	3.0	3.4		49.9	4.2			26.3	26.7		20.2	
LOS	A	A		D	A			C	C		C	
Approach Delay		3.4			8.0			26.5			20.2	
Approach LOS		A			A			C			C	

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 80
Offset: 65 (81%), Referenced to phase 2:EBTL and 6:WBTL, Start of Green
Control Type: Pretimed
Maximum v/c Ratio: 0.84
Intersection Signal Delay: 9.3 Intersection LOS: A
Intersection Capacity Utilization 67.3% ICU Level of Service C
Analysis Period (min) 15

Splits and Phases: 105: E Hastings & Victoria Dr



Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	5033	0	1770	3524	0	1770	1709	0	1770	1814	0
Flt Permitted	0.332			0.100			0.577			0.493		
Satd. Flow (perm)	606	5033	0	185	3524	0	965	1709	0	890	1814	0
Satd. Flow (RTOR)		10			4			45			6	
Volume (vph)	62	1422	62	116	768	16	52	138	93	84	161	16
Lane Group Flow (vph)	67	1613	0	126	852	0	57	251	0	91	192	0
Turn Type	Perm			pm+pt			Perm			Perm		
Protected Phases		2		1	6			8			4	
Permitted Phases	2			6			8			4		
Total Split (s)	40.0	40.0	0.0	10.0	50.0	0.0	30.0	30.0	0.0	30.0	30.0	0.0
Act Effct Green (s)	38.0	38.0		46.0	46.0		26.0	26.0		26.0	26.0	
Actuated g/C Ratio	0.48	0.48		0.58	0.58		0.32	0.32		0.32	0.32	
v/c Ratio	0.23	0.67		0.56	0.42		0.18	0.43		0.31	0.32	
Control Delay	10.3	10.8		23.1	17.4		18.1	18.1		24.1	21.6	
Queue Delay	0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0	
Total Delay	10.3	10.8		23.1	17.4		18.1	18.1		24.1	21.6	
LOS	B	B		C	B		B	B		C	C	
Approach Delay		10.7			18.1			18.1			22.4	
Approach LOS		B			B			B			C	

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 80
Offset: 50 (63%), Referenced to phase 2:EBTL and 6:WBTL, Start of Green
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 0.67
Intersection Signal Delay: 14.7 Intersection LOS: B
Intersection Capacity Utilization 68.1% ICU Level of Service C
Analysis Period (min) 15

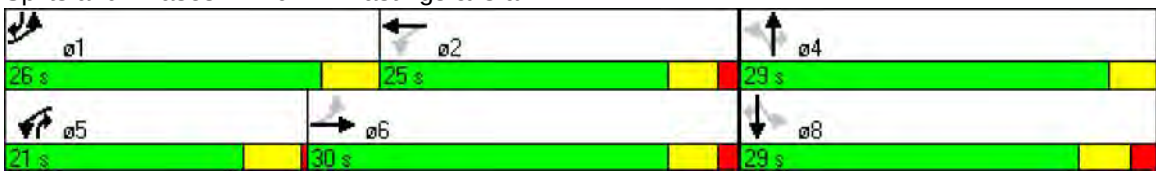
Splits and Phases: 106: E Hastings & Commercial Dr

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	5024	0	1770	3522	0	0	3522	1583	0	3518	1583
Flt Permitted	0.160			0.190				0.802			0.701	
Satd. Flow (perm)	298	5024	0	354	3522	0	0	2838	1583	0	2481	1583
Satd. Flow (RTOR)		18			4				8			33
Volume (vph)	128	1078	92	275	627	23	71	604	277	54	402	32
Lane Group Flow (vph)	139	1272	0	299	707	0	0	734	301	0	496	35
Turn Type	pm+pt			pm+pt			Perm		pm+ov	Perm		pm+ov
Protected Phases	1	6		5	2			4	5		8	1
Permitted Phases	6			2			4		4	8		8
Total Split (s)	26.0	30.0	0.0	21.0	25.0	0.0	29.0	29.0	21.0	29.0	29.0	26.0
Act Effct Green (s)	35.7	27.4		47.0	36.7			25.0	44.6		25.0	37.4
Actuated g/C Ratio	0.45	0.34		0.59	0.46			0.31	0.56		0.31	0.47
v/c Ratio	0.48	0.74		0.62	0.44			0.83	0.34		0.64	0.05
Control Delay	16.1	26.2		9.9	16.1			35.6	26.9		28.2	4.5
Queue Delay	0.0	0.0		0.0	0.0			0.0	0.0		0.0	0.0
Total Delay	16.1	26.2		9.9	16.1			35.6	26.9		28.2	4.5
LOS	B	C		A	B			D	C		C	A
Approach Delay		25.2			14.3			33.0			26.6	
Approach LOS		C			B			C			C	

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 80
Offset: 26 (33%), Referenced to phase 2:WBTL and 6:EBTL, Start of Green
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 0.83
Intersection Signal Delay: 24.7 Intersection LOS: C
Intersection Capacity Utilization 88.5% ICU Level of Service E
Analysis Period (min) 15

Splits and Phases: 107: E Hastings & Clark Dr

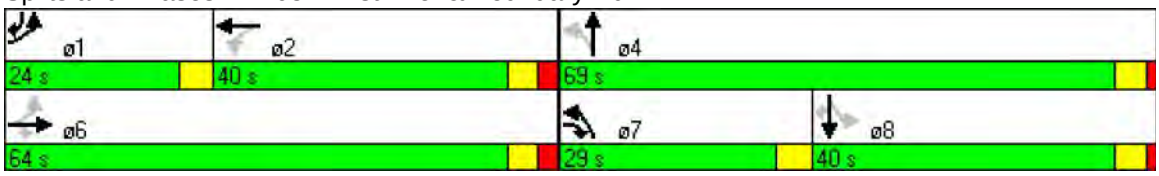


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	1863	1583	1770	1844	0	0	4964	0	0	3536	1583
Flt Permitted	0.162			0.553				0.676			0.877	
Satd. Flow (perm)	302	1863	1583	1030	1844	0	0	3410	0	0	3104	1583
Satd. Flow (RTOR)			37		3			9				228
Volume (vph)	400	319	241	73	343	25	366	668	61	19	626	348
Lane Group Flow (vph)	435	347	262	79	400	0	0	1190	0	0	701	378
Turn Type	pm+pt		pm+ov	Perm			pm+pt			Perm		pm+ov
Protected Phases	1	6	7		2		7	4			8	1
Permitted Phases	6		6	2			4			8		8
Total Split (s)	24.0	64.0	29.0	40.0	40.0	0.0	29.0	69.0	0.0	40.0	40.0	24.0
Act Effct Green (s)	53.9	53.9	66.2	29.3	29.3			45.7			33.3	58.0
Actuated g/C Ratio	0.50	0.50	0.61	0.27	0.27			0.42			0.31	0.54
v/c Ratio	1.01	0.37	0.27	0.28	0.80			1.71dl			0.73	0.39
Control Delay	74.5	19.7	10.5	36.6	50.3			28.3			37.8	6.8
Queue Delay	0.0	0.0	0.0	0.0	0.0			0.0			0.0	0.0
Total Delay	74.5	19.7	10.5	36.6	50.3			28.3			37.8	6.8
LOS	E	B	B	D	D			C			D	A
Approach Delay		40.2			48.0			28.3			27.0	
Approach LOS		D			D			C			C	

Intersection Summary

Cycle Length: 133
Actuated Cycle Length: 107.8
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 1.01
Intersection Signal Delay: 33.7 Intersection LOS: C
Intersection Capacity Utilization 94.6% ICU Level of Service F
Analysis Period (min) 15
dl Defacto Left Lane. Recode with 1 though lane as a left lane.

Splits and Phases: 108: E 1st Ave. & Boundary Rd

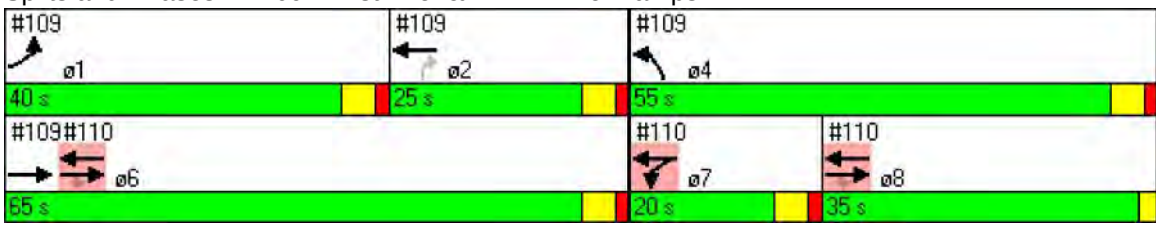


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	3539	0	0	5085	1583	3433	0	1583	0	0	0
Flt Permitted	0.950						0.950					
Satd. Flow (perm)	1770	3539	0	0	5085	1583	3433	0	1583	0	0	0
Satd. Flow (RTOR)						101			35			
Volume (vph)	366	837	0	0	684	294	969	0	81	0	0	0
Lane Group Flow (vph)	398	910	0	0	743	320	1053	0	88	0	0	0
Turn Type	Prot					Free	Prot		custom			
Protected Phases	1	6			2		4					
Permitted Phases						Free			2			
Total Split (s)	40.0	65.0	0.0	0.0	25.0	0.0	55.0	0.0	25.0	0.0	0.0	0.0
Act Effct Green (s)	36.0	61.0			21.0	120.0	51.0		21.0			
Actuated g/C Ratio	0.30	0.51			0.18	1.00	0.42		0.18			
v/c Ratio	0.75	0.51			0.83	0.20	0.72		0.29			
Control Delay	44.3	17.3			57.2	0.3	32.1		29.7			
Queue Delay	21.1	0.6			0.6	0.0	0.1		0.0			
Total Delay	65.5	17.9			57.8	0.3	32.2		29.7			
LOS	E	B			E	A	C		C			
Approach Delay		32.4			40.5							
Approach LOS		C			D							

Intersection Summary

Cycle Length: 120
Actuated Cycle Length: 120
Offset: 0 (0%), Referenced to phase 2:WBT and 6:EBT, Start of Green
Control Type: Pretimed
Maximum v/c Ratio: 0.98
Intersection Signal Delay: 34.7 Intersection LOS: C
Intersection Capacity Utilization 123.3% ICU Level of Service H
Analysis Period (min) 15

Splits and Phases: 109: E 1st Ave. & HW1 WB on ramps



Lane Group	ø7	ø8
Lane Configurations		
Total Lost Time (s)		
Satd. Flow (prot)		
Flt Permitted		
Satd. Flow (perm)		
Satd. Flow (RTOR)		
Volume (vph)		
Lane Group Flow (vph)		
Turn Type		
Protected Phases	7	8
Permitted Phases		
Total Split (s)	20.0	35.0
Act Effct Green (s)		
Actuated g/C Ratio		
v/c Ratio		
Control Delay		
Queue Delay		
Total Delay		
LOS		
Approach Delay		
Approach LOS		

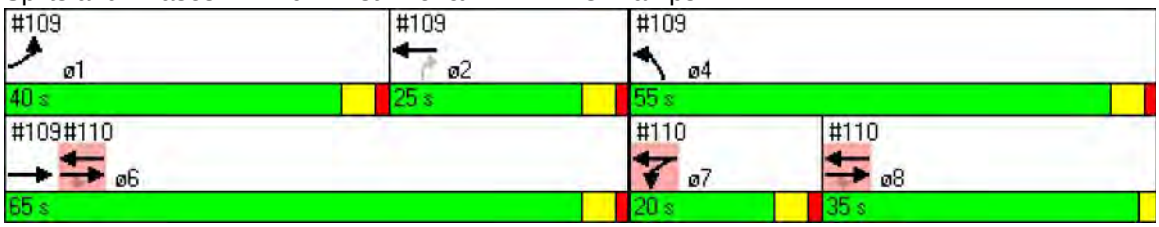
Intersection Summary

Lane Group	EBT	EBR	WBL	WBT	NBL	NBR	ø1	ø2	ø4	ø6	ø8
Lane Configurations											
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0					
Satd. Flow (prot)	5085	1583	1770	5085	0	0					
Flt Permitted			0.950								
Satd. Flow (perm)	5085	1583	1770	5085	0	0					
Satd. Flow (RTOR)		190									
Volume (vph)	1304	1170	164	1689	0	0					
Lane Group Flow (vph)	1417	1272	178	1836	0	0					
Turn Type		Perm	Prot								
Protected Phases	6 8		7	6 7 8			1	2	4	6	8
Permitted Phases		6 8									
Total Split (s)	100.0	100.0	20.0	120.0	0.0	0.0	40.0	25.0	55.0	65.0	35.0
Act Effct Green (s)	96.0	96.0	16.0	120.0							
Actuated g/C Ratio	0.80	0.80	0.13	1.00							
v/c Ratio	0.35	0.98	0.75	0.36							
Control Delay	3.6	30.5	62.8	0.2							
Queue Delay	0.0	0.0	4.0	0.0							
Total Delay	3.6	30.5	66.8	0.2							
LOS	A	C	E	A							
Approach Delay	16.3			6.1							
Approach LOS	B			A							

Intersection Summary

Cycle Length: 120
Actuated Cycle Length: 120
Offset: 0 (0%), Referenced to phase 2:WBT and 6:EBT, Start of Green
Control Type: Pretimed
Maximum v/c Ratio: 0.98
Intersection Signal Delay: 11.9 Intersection LOS: B
Intersection Capacity Utilization 123.3% ICU Level of Service H
Analysis Period (min) 15

Splits and Phases: 110: E 1st Ave. & HW1 EB On ramps

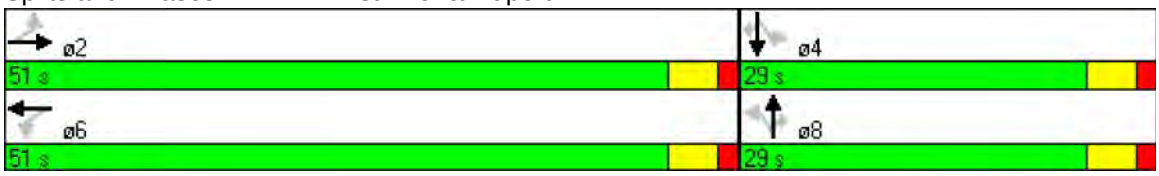


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	0	5070	0	0	3532	0	1770	1513	1504	1770	3539	1583
Flt Permitted		0.898			0.670		0.421			0.492		
Satd. Flow (perm)	0	4553	0	0	2371	0	784	1513	1504	916	3539	1583
Satd. Flow (RTOR)		7						10	10			21
Volume (vph)	12	1862	41	62	1573	0	175	7	417	113	398	103
Lane Group Flow (vph)	0	2082	0	0	1777	0	190	234	227	123	433	112
Turn Type	Perm			Perm			Perm		Perm	Perm		Perm
Protected Phases		2			6			8			4	
Permitted Phases	2			6			8		8	4		4
Total Split (s)	51.0	51.0	0.0	51.0	51.0	0.0	29.0	29.0	29.0	29.0	29.0	29.0
Act Effct Green (s)		47.0			47.0		25.0	25.0	25.0	25.0	25.0	25.0
Actuated g/C Ratio		0.59			0.59		0.31	0.31	0.31	0.31	0.31	0.31
v/c Ratio		0.78			1.28		0.78	0.49	0.48	0.43	0.39	0.22
Control Delay		5.3			150.1		48.9	25.5	25.2	27.6	22.8	17.8
Queue Delay		0.0			0.0		0.0	0.0	0.0	0.0	0.0	0.0
Total Delay		5.3			150.1		48.9	25.5	25.2	27.6	22.8	17.8
LOS		A			F		D	C	C	C	C	B
Approach Delay		5.3			150.1			32.2			22.9	
Approach LOS		A			F			C			C	

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 80
Offset: 9 (11%), Referenced to phase 2:EBTL and 6:WBTL, Start of Green
Control Type: Pretimed
Maximum v/c Ratio: 1.28
Intersection Signal Delay: 60.6 Intersection LOS: E
Intersection Capacity Utilization 116.4% ICU Level of Service H
Analysis Period (min) 15

Splits and Phases: 111: E 1st Ave. & Rupert

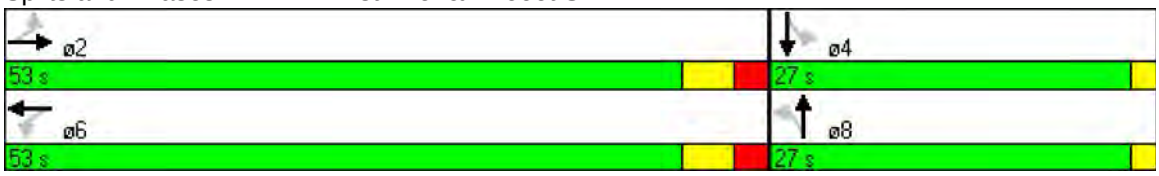


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	0	3532	0	0	3529	0	0	1743	0	0	1721	0
Flt Permitted		0.740			0.702			0.957			0.937	
Satd. Flow (perm)	0	2616	0	0	2480	0	0	1694	0	0	1641	0
Satd. Flow (RTOR)		2			3			9			14	
Volume (vph)	26	1982	17	19	1794	28	7	8	9	17	10	21
Lane Group Flow (vph)	0	2200	0	0	2001	0	0	27	0	0	52	0
Turn Type	Perm			Perm			Perm			Perm		
Protected Phases		2			6			8			4	
Permitted Phases	2			6			8			4		
Total Split (s)	53.0	53.0	0.0	53.0	53.0	0.0	27.0	27.0	0.0	27.0	27.0	0.0
Act Effct Green (s)		49.0			49.0			23.0			23.0	
Actuated g/C Ratio		0.61			0.61			0.29			0.29	
v/c Ratio		1.37			1.32			0.05			0.11	
Control Delay		184.3			169.1			16.2			17.3	
Queue Delay		0.0			0.0			0.0			0.0	
Total Delay		184.3			169.1			16.2			17.3	
LOS		F			F			B			B	
Approach Delay		184.3			169.1			16.2			17.3	
Approach LOS		F			F			B			B	

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 80
Offset: 67 (84%), Referenced to phase 2:EBTL and 6:WBTL, Start of Green
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 1.37
Intersection Signal Delay: 174.1 Intersection LOS: F
Intersection Capacity Utilization 84.3% ICU Level of Service E
Analysis Period (min) 15

Splits and Phases: 112: E 1st Ave. & Lillooet ST

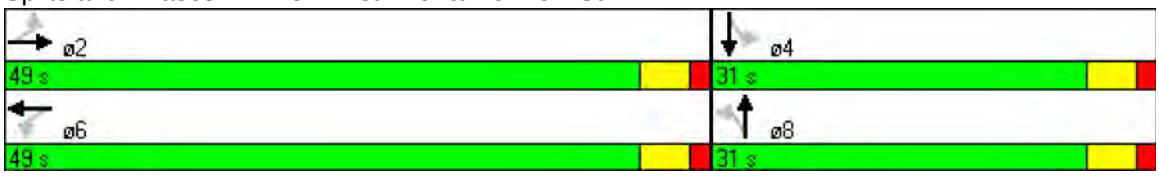


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	3525	0	1770	3511	0	1770	3476	0	1770	3500	0
Flt Permitted	0.089			0.089			0.292			0.196		
Satd. Flow (perm)	166	3525	0	166	3511	0	544	3476	0	365	3500	0
Satd. Flow (RTOR)		5			12			14			11	
Volume (vph)	56	1648	40	77	1549	87	70	639	89	71	536	42
Lane Group Flow (vph)	61	1834	0	84	1779	0	76	792	0	77	629	0
Turn Type	Perm			Perm			Perm			Perm		
Protected Phases		2			6			8			4	
Permitted Phases	2			6			8			4		
Total Split (s)	49.0	49.0	0.0	49.0	49.0	0.0	31.0	31.0	0.0	31.0	31.0	0.0
Act Effct Green (s)	45.0	45.0		45.0	45.0		27.0	27.0		27.0	27.0	
Actuated g/C Ratio	0.56	0.56		0.56	0.56		0.34	0.34		0.34	0.34	
v/c Ratio	0.66	0.92		0.90	0.90		0.41	0.67		0.63	0.53	
Control Delay	20.7	8.1		44.1	24.9		28.9	25.6		46.7	25.1	
Queue Delay	0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0	
Total Delay	20.7	8.1		44.1	24.9		28.9	25.6		46.7	25.1	
LOS	C	A		D	C		C	C		D	C	
Approach Delay		8.6			25.7			25.9			27.5	
Approach LOS		A			C			C			C	

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 80
Offset: 43 (54%), Referenced to phase 2:EBTL and 6:WBTL, Start of Green
Control Type: Pretimed
Maximum v/c Ratio: 0.92
Intersection Signal Delay: 19.9 Intersection LOS: B
Intersection Capacity Utilization 88.9% ICU Level of Service E
Analysis Period (min) 15

Splits and Phases: 113: E 1st Ave. & Renfrew St

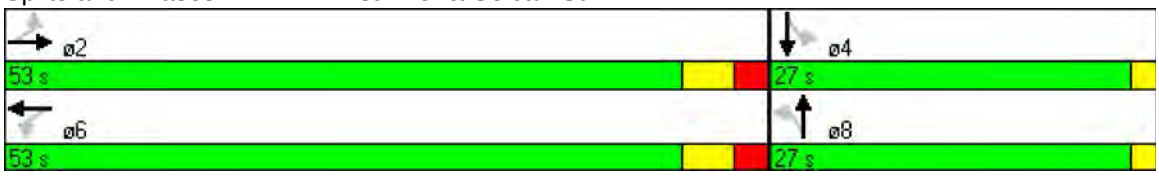


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	0	3536	0	0	3536	0	0	1745	0	0	1724	0
Flt Permitted		0.909			0.911			0.971			0.992	
Satd. Flow (perm)	0	3214	0	0	3221	0	0	1711	0	0	1717	0
Satd. Flow (RTOR)		1			2			16			20	
Volume (vph)	16	1740	8	7	1573	16	7	15	15	3	14	18
Lane Group Flow (vph)	0	1917	0	0	1735	0	0	40	0	0	38	0
Turn Type	Perm			Perm			Perm			Perm		
Protected Phases		2			6			8			4	
Permitted Phases	2			6			8			4		
Total Split (s)	53.0	53.0	0.0	53.0	53.0	0.0	27.0	27.0	0.0	27.0	27.0	0.0
Act Effct Green (s)		49.0			49.0			23.0			23.0	
Actuated g/C Ratio		0.61			0.61			0.29			0.29	
v/c Ratio		0.97			0.88			0.08			0.07	
Control Delay		12.6			27.6			15.1			13.5	
Queue Delay		0.0			0.0			0.0			0.0	
Total Delay		12.6			27.6			15.1			13.5	
LOS		B			C			B			B	
Approach Delay		12.6			27.6			15.1			13.5	
Approach LOS		B			C			B			B	

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 80
Offset: 16 (20%), Referenced to phase 2:EBTL and 6:WBTL, Start of Green
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 0.97
Intersection Signal Delay: 19.7 Intersection LOS: B
Intersection Capacity Utilization 70.0% ICU Level of Service C
Analysis Period (min) 15

Splits and Phases: 114: E 1st Ave. & Solcan St

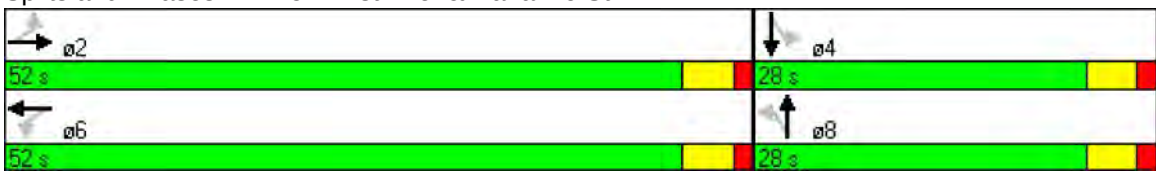


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	3522	0	1770	3514	0	1770	3497	0	1770	5024	0
Flt Permitted	0.083			0.083			0.219			0.167		
Satd. Flow (perm)	155	3522	0	155	3514	0	408	3497	0	311	5024	0
Satd. Flow (RTOR)		8			11			12			19	
Volume (vph)	72	1764	63	77	1490	73	54	722	65	80	714	64
Lane Group Flow (vph)	78	1985	0	84	1699	0	59	856	0	87	846	0
Turn Type	Perm			Perm			Perm			Perm		
Protected Phases		2			6			8			4	
Permitted Phases	2			6			8			4		
Total Split (s)	52.0	52.0	0.0	52.0	52.0	0.0	28.0	28.0	0.0	28.0	28.0	0.0
Act Effct Green (s)	48.0	48.0		48.0	48.0		24.0	24.0		24.0	24.0	
Actuated g/C Ratio	0.60	0.60		0.60	0.60		0.30	0.30		0.30	0.30	
v/c Ratio	0.84	0.94		0.90	0.80		0.48	0.81		0.94	0.56	
Control Delay	52.5	11.0		63.1	6.9		38.7	32.8		108.8	24.8	
Queue Delay	0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0	
Total Delay	52.5	11.0		63.1	6.9		38.7	32.8		108.8	24.8	
LOS	D	B		E	A		D	C		F	C	
Approach Delay		12.6			9.5			33.2			32.6	
Approach LOS		B			A			C			C	

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 80
Offset: 60 (75%), Referenced to phase 2:EBTL and 6:WBTL, Start of Green
Control Type: Pretimed
Maximum v/c Ratio: 0.94
Intersection Signal Delay: 18.2 Intersection LOS: B
Intersection Capacity Utilization 94.8% ICU Level of Service F
Analysis Period (min) 15

Splits and Phases: 115: E 1st Ave. & Nanaimo St

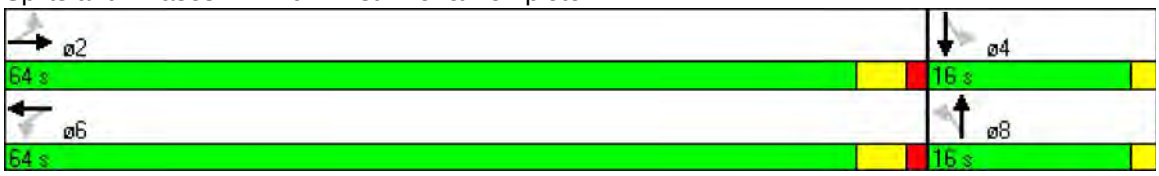


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	0	3536	0	0	3536	0	0	1653	0	0	1662	0
Flt Permitted		0.946			0.938			0.990				
Satd. Flow (perm)	0	3345	0	0	3316	0	0	1645	0	0	1662	0
Satd. Flow (RTOR)		1			2			8			12	
Volume (vph)	7	1869	6	8	1563	7	1	1	7	0	3	11
Lane Group Flow (vph)	0	2047	0	0	1716	0	0	10	0	0	15	0
Turn Type	Perm			Perm			Perm			Perm		
Protected Phases		2			6			8			4	
Permitted Phases	2			6			8			4		
Total Split (s)	64.0	64.0	0.0	64.0	64.0	0.0	16.0	16.0	0.0	16.0	16.0	0.0
Act Effct Green (s)		60.0			60.0			12.0			12.0	
Actuated g/C Ratio		0.75			0.75			0.15			0.15	
v/c Ratio		0.82			0.69			0.04			0.06	
Control Delay		3.2			11.4			19.2			18.1	
Queue Delay		0.0			0.0			0.0			0.0	
Total Delay		3.2			11.4			19.2			18.1	
LOS		A			B			B			B	
Approach Delay		3.2			11.4			19.2			18.1	
Approach LOS		A			B			B			B	

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 80
Offset: 35 (44%), Referenced to phase 2:EBTL and 6:WBTL, Start of Green
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 0.82
Intersection Signal Delay: 7.0 Intersection LOS: A
Intersection Capacity Utilization 66.7% ICU Level of Service C
Analysis Period (min) 15

Splits and Phases: 116: E 1st Ave. & Templeton Dr

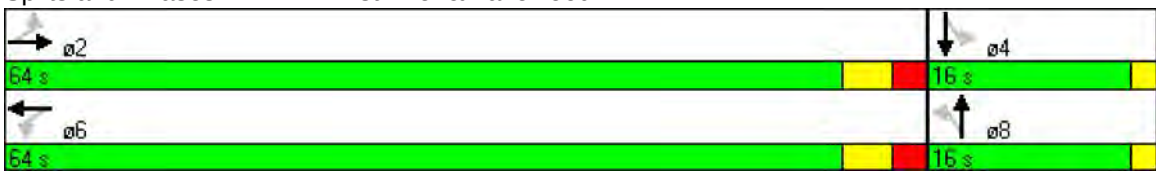


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	0	3539	0	0	3536	0	0	1700	0	0	1665	0
Flt Permitted		0.940			0.951			0.981			0.973	
Satd. Flow (perm)	0	3327	0	0	3362	0	0	1679	0	0	1638	0
Satd. Flow (RTOR)		1			3			12			10	
Volume (vph)	11	1788	5	3	1444	12	3	5	11	3	1	9
Lane Group Flow (vph)	0	1960	0	0	1586	0	0	20	0	0	14	0
Turn Type	Perm			Perm			Perm			Perm		
Protected Phases		2			6			8			4	
Permitted Phases	2			6			8			4		
Total Split (s)	64.0	64.0	0.0	64.0	64.0	0.0	16.0	16.0	0.0	16.0	16.0	0.0
Act Effct Green (s)		60.0			60.0			12.0			12.0	
Actuated g/C Ratio		0.75			0.75			0.15			0.15	
v/c Ratio		0.79			0.63			0.08			0.06	
Control Delay		2.9			7.0			20.1			19.5	
Queue Delay		0.0			0.1			0.0			0.0	
Total Delay		2.9			7.1			20.1			19.5	
LOS		A			A			C			B	
Approach Delay		2.9			7.1			20.1			19.5	
Approach LOS		A			A			C			B	

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 80
Offset: 32 (40%), Referenced to phase 2:EBTL and 6:WBTL, Start of Green
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 0.79
Intersection Signal Delay: 4.9 Intersection LOS: A
Intersection Capacity Utilization 67.3% ICU Level of Service C
Analysis Period (min) 15

Splits and Phases: 117: E 1st Ave. & Lakewood Dr

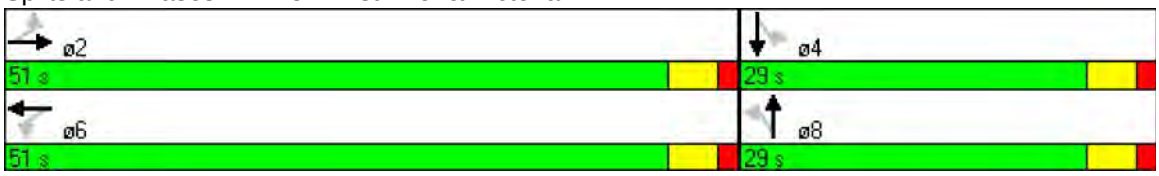


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	0	3525	0	0	3472	0	0	3472	0	0	3483	0
Flt Permitted		0.791			0.953			0.899			0.713	
Satd. Flow (perm)	0	2791	0	0	3309	0	0	3131	0	0	2511	0
Satd. Flow (RTOR)		4			34			16			5	
Volume (vph)	39	1591	34	2	1277	183	19	310	39	146	486	23
Lane Group Flow (vph)	0	1808	0	0	1589	0	0	400	0	0	712	0
Turn Type	Perm			Perm			Perm			Perm		
Protected Phases		2			6			8			4	
Permitted Phases	2			6			8			4		
Total Split (s)	51.0	51.0	0.0	51.0	51.0	0.0	29.0	29.0	0.0	29.0	29.0	0.0
Act Effct Green (s)		47.0			47.0			25.0			25.0	
Actuated g/C Ratio		0.59			0.59			0.31			0.31	
v/c Ratio		1.10			0.81			0.40			0.90	
Control Delay		65.5			26.2			14.6			44.0	
Queue Delay		0.0			0.0			0.0			0.0	
Total Delay		65.5			26.2			14.6			44.0	
LOS		E			C			B			D	
Approach Delay		65.5			26.2			14.6			44.0	
Approach LOS		E			C			B			D	

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 80
Offset: 12 (15%), Referenced to phase 2:EBTL and 6:WBTL, Start of Green
Control Type: Pretimed
Maximum v/c Ratio: 1.10
Intersection Signal Delay: 43.8 Intersection LOS: D
Intersection Capacity Utilization 111.9% ICU Level of Service H
Analysis Period (min) 15

Splits and Phases: 118: E 1st Ave. & Victoria Dr

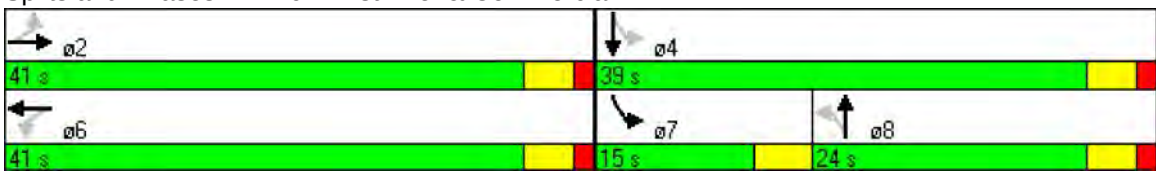


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	3508	0	1770	3461	0	1770	3205	0	1770	3450	0
Flt Permitted	0.108			0.108			0.440			0.307		
Satd. Flow (perm)	201	3508	0	201	3461	0	672	3205	0	496	3450	0
Satd. Flow (RTOR)		4			9			34			8	
Volume (vph)	21	1390	35	57	1102	62	45	333	79	288	496	24
Lane Group Flow (vph)	23	1549	0	62	1265	0	49	448	0	313	565	0
Turn Type	Perm			Perm			Perm			pm+pt		
Protected Phases		2			6			8		7	4	
Permitted Phases	2			6			8			4		
Total Split (s)	41.0	41.0	0.0	41.0	41.0	0.0	24.0	24.0	0.0	15.0	39.0	0.0
Act Effct Green (s)	40.1	40.1		40.1	40.1		16.9	16.9		31.9	31.9	
Actuated g/C Ratio	0.50	0.50		0.50	0.50		0.21	0.21		0.40	0.40	
v/c Ratio	0.23	0.88		0.61	0.73		0.35	0.64		0.84	0.41	
Control Delay	10.4	16.0		50.7	33.2		25.8	23.6		38.1	16.2	
Queue Delay	0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0	
Total Delay	10.4	16.0		50.7	33.2		25.8	23.6		38.1	16.2	
LOS	B	B		D	C		C	C		D	B	
Approach Delay		15.9			34.0			23.8			24.0	
Approach LOS		B			C			C			C	

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 80
Offset: 74 (93%), Referenced to phase 2:EBTL and 6:WBTL, Start of Green
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 0.88
Intersection Signal Delay: 24.1 Intersection LOS: C
Intersection Capacity Utilization 85.8% ICU Level of Service E
Analysis Period (min) 15

Splits and Phases: 119: E 1st Ave. & Commercial Dr

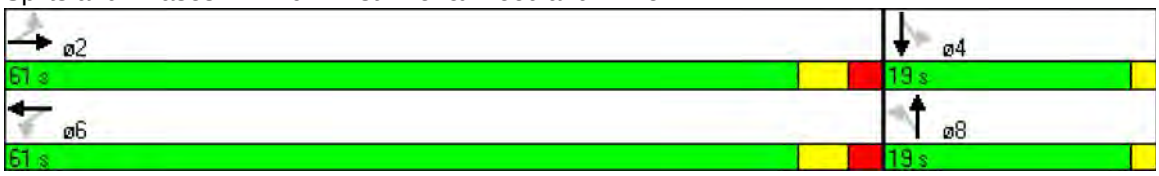


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	0	3532	0	0	3522	0	0	1738	0	0	1826	0
Flt Permitted		0.941			0.748			0.993			0.933	
Satd. Flow (perm)	0	3324	0	0	2642	0	0	1731	0	0	1728	0
Satd. Flow (RTOR)		5			4			28			3	
Volume (vph)	12	1393	22	61	1043	13	3	26	26	17	39	3
Lane Group Flow (vph)	0	1551	0	0	1214	0	0	59	0	0	63	0
Turn Type	Perm			Perm			Perm			Perm		
Protected Phases		2			6			8			4	
Permitted Phases	2			6			8			4		
Total Split (s)	61.0	61.0	0.0	61.0	61.0	0.0	19.0	19.0	0.0	19.0	19.0	0.0
Act Effct Green (s)		57.0			57.0			15.0			15.0	
Actuated g/C Ratio		0.71			0.71			0.19			0.19	
v/c Ratio		0.65			0.64			0.17			0.19	
Control Delay		6.2			14.0			18.4			28.2	
Queue Delay		0.0			0.0			0.0			0.0	
Total Delay		6.2			14.0			18.4			28.2	
LOS		A			B			B			C	
Approach Delay		6.2			14.0			18.4			28.2	
Approach LOS		A			B			B			C	

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 80
Offset: 53 (66%), Referenced to phase 2:EBTL and 6:WBTL, Start of Green
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 0.65
Intersection Signal Delay: 10.2 Intersection LOS: B
Intersection Capacity Utilization 89.5% ICU Level of Service E
Analysis Period (min) 15

Splits and Phases: 120: E 1st Ave. & Woodland Drive

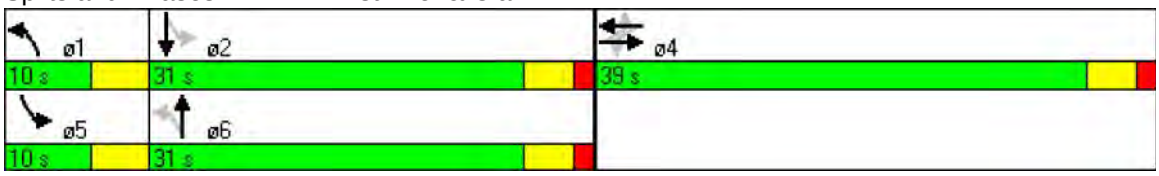


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	0	3398	0	0	3493	0	1770	4917	0	1770	5019	0
Flt Permitted		0.954					0.148			0.148		
Satd. Flow (perm)	0	3241	0	0	3493	0	276	4917	0	276	5019	0
Satd. Flow (RTOR)		81			16			63			20	
Volume (vph)	1	899	325	0	951	91	167	1055	298	202	1132	104
Lane Group Flow (vph)	0	1331	0	0	1133	0	182	1471	0	220	1343	0
Turn Type	Perm			Perm			pm+pt			pm+pt		
Protected Phases		4			4		1	6		5	2	
Permitted Phases	4			4			6			2		
Total Split (s)	39.0	39.0	0.0	39.0	39.0	0.0	10.0	31.0	0.0	10.0	31.0	0.0
Act Effct Green (s)		35.2			35.2		32.8	26.8		32.8	26.8	
Actuated g/C Ratio		0.44			0.44		0.41	0.34		0.41	0.34	
v/c Ratio		0.90			0.73		0.81	0.87		0.98	0.79	
Control Delay		30.1			27.2		43.4	30.8		71.3	23.9	
Queue Delay		0.0			0.0		0.0	0.0		0.0	0.0	
Total Delay		30.1			27.2		43.4	30.8		71.3	23.9	
LOS		C			C		D	C		E	C	
Approach Delay		30.1			27.2			32.2			30.6	
Approach LOS		C			C			C			C	

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 80
Offset: 34 (43%), Referenced to phase 4:EBWB, Start of Green
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 0.98
Intersection Signal Delay: 30.3 Intersection LOS: C
Intersection Capacity Utilization 84.2% ICU Level of Service E
Analysis Period (min) 15

Splits and Phases: 121: E 1st Ave. & Clark Dr

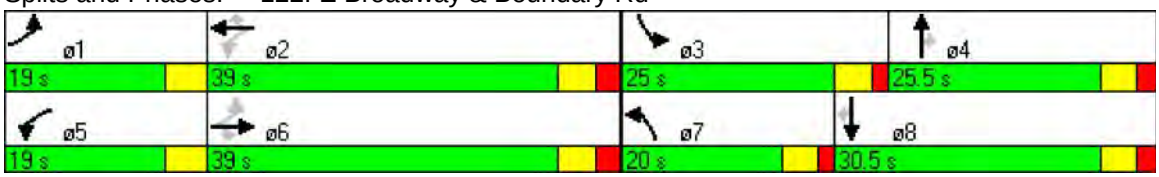


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	3539	1583	1770	3539	1583	3433	3539	1583	1770	3539	1583
Flt Permitted	0.114			0.114			0.950			0.950		
Satd. Flow (perm)	212	3539	1583	212	3539	1583	3433	3539	1583	1770	3539	1583
Satd. Flow (RTOR)			209			125			104			253
Volume (vph)	236	892	192	199	967	118	357	604	101	240	585	233
Lane Group Flow (vph)	257	970	209	216	1051	128	388	657	110	261	636	253
Turn Type	pm+pt		Perm	pm+pt		Perm	Prot		Perm	Prot		Perm
Protected Phases	1	6		5	2		7	4		3	8	
Permitted Phases	6		6	2		2			4			8
Total Split (s)	19.0	39.0	39.0	19.0	39.0	39.0	20.0	25.5	25.5	25.0	30.5	30.5
Act Effct Green (s)	48.7	34.9	34.9	46.5	33.8	33.8	15.3	21.3	21.3	19.0	25.0	25.0
Actuated g/C Ratio	0.47	0.34	0.34	0.45	0.32	0.32	0.15	0.20	0.20	0.18	0.24	0.24
v/c Ratio	0.84	0.82	0.31	0.76	0.91	0.21	0.77	0.91	0.27	0.81	0.75	0.44
Control Delay	49.1	39.1	5.1	40.1	47.2	6.1	54.7	59.2	10.2	61.0	43.3	6.9
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	49.1	39.1	5.1	40.1	47.2	6.1	54.7	59.2	10.2	61.0	43.3	6.9
LOS	D	D	A	D	D	A	D	E	B	E	D	A
Approach Delay		35.9			42.3			53.0			39.3	
Approach LOS		D			D			D			D	

Intersection Summary

Cycle Length: 108.5
Actuated Cycle Length: 104
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 0.91
Intersection Signal Delay: 42.3 Intersection LOS: D
Intersection Capacity Utilization 83.1% ICU Level of Service E
Analysis Period (min) 15

Splits and Phases: 122: E Broadway & Boundary Rd

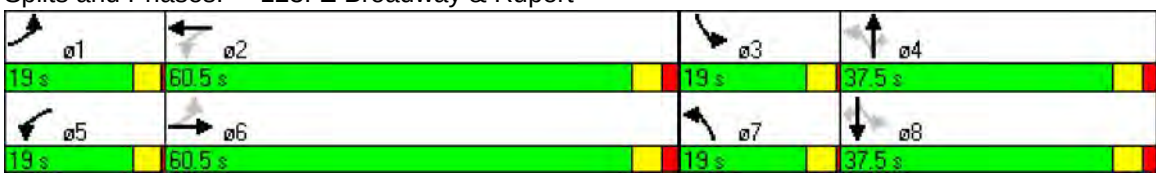


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	4912	0	1770	5055	0	1770	3539	1583	1770	3539	1583
Flt Permitted	0.108			0.071			0.281			0.294		
Satd. Flow (perm)	201	4912	0	132	5055	0	523	3539	1583	548	3539	1583
Satd. Flow (RTOR)		67			5				216			80
Volume (vph)	125	1194	351	223	1172	46	217	443	199	45	458	83
Lane Group Flow (vph)	136	1680	0	242	1324	0	236	482	216	49	498	90
Turn Type	pm+pt			pm+pt			pm+pt		Perm	pm+pt		Perm
Protected Phases	1	6		5	2		7	4		3	8	
Permitted Phases	6			2			4		4	8		8
Total Split (s)	19.0	60.5	0.0	19.0	60.5	0.0	19.0	37.5	37.5	19.0	37.5	37.5
Act Effct Green (s)	66.7	56.6		74.9	61.5		43.5	33.7	33.7	32.6	24.7	24.7
Actuated g/C Ratio	0.52	0.45		0.59	0.48		0.34	0.27	0.27	0.25	0.19	0.19
v/c Ratio	0.59	0.76		0.89	0.54		0.73	0.51	0.37	0.23	0.72	0.24
Control Delay	25.7	31.5		66.0	24.9		45.9	42.6	6.7	30.8	54.4	12.6
Queue Delay	0.0	0.0		0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	25.7	31.5		66.0	24.9		45.9	42.6	6.7	30.8	54.4	12.6
LOS	C	C		E	C		D	D	A	C	D	B
Approach Delay		31.0			31.2			35.1			46.7	
Approach LOS		C			C			D			D	

Intersection Summary

Cycle Length: 136
Actuated Cycle Length: 127.1
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 0.89
Intersection Signal Delay: 33.9 Intersection LOS: C
Intersection Capacity Utilization 81.3% ICU Level of Service D
Analysis Period (min) 15

Splits and Phases: 123: E Broadway & Rupert

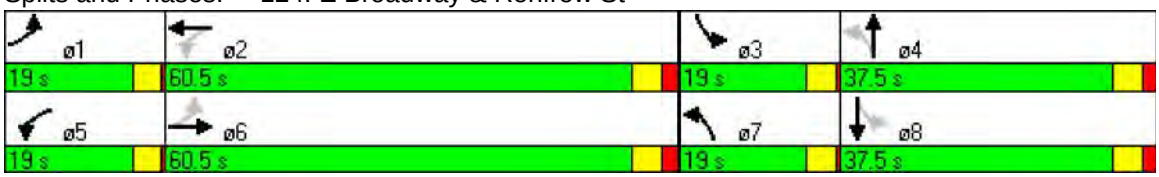


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	5019	0	1770	5029	0	1770	3429	0	1770	3465	0
Flt Permitted	0.071			0.071			0.165			0.119		
Satd. Flow (perm)	132	5019	0	132	5029	0	307	3429	0	222	3465	0
Satd. Flow (RTOR)		13			11			23			13	
Volume (vph)	202	1442	132	148	1475	112	154	581	155	135	510	85
Lane Group Flow (vph)	220	1710	0	161	1725	0	167	800	0	147	646	0
Turn Type	pm+pt			pm+pt			pm+pt			pm+pt		
Protected Phases	1	6		5	2		7	4		3	8	
Permitted Phases	6			2			4			8		
Total Split (s)	19.0	60.5	0.0	19.0	60.5	0.0	19.0	37.5	0.0	19.0	37.5	0.0
Act Effct Green (s)	67.0	53.1		62.9	51.0		44.1	31.5		43.0	31.0	
Actuated g/C Ratio	0.54	0.43		0.50	0.41		0.35	0.25		0.34	0.25	
v/c Ratio	0.86	0.80		0.72	0.84		0.65	0.91		0.65	0.74	
Control Delay	64.4	35.1		47.8	37.8		40.4	59.8		43.1	49.6	
Queue Delay	0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0	
Total Delay	64.4	35.1		47.8	37.8		40.4	59.8		43.1	49.6	
LOS	E	D		D	D		D	E		D	D	
Approach Delay		38.5			38.7			56.4			48.4	
Approach LOS		D			D			E			D	

Intersection Summary

Cycle Length: 136
Actuated Cycle Length: 124.9
Control Type: Semi Act-Uncoord
Maximum v/c Ratio: 0.91
Intersection Signal Delay: 43.1 Intersection LOS: D
Intersection Capacity Utilization 84.0% ICU Level of Service E
Analysis Period (min) 15

Splits and Phases: 124: E Broadway & Renfrew St

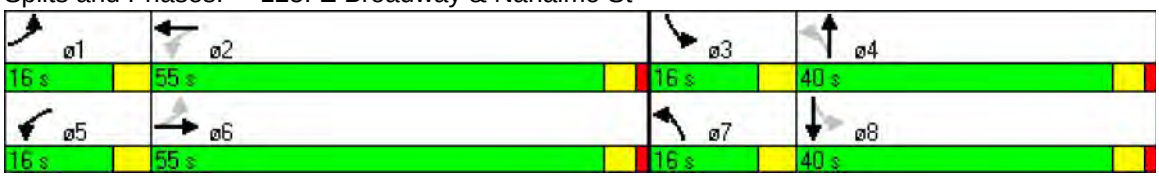


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	5045	0	1770	5050	0	1770	4953	0	1770	4887	0
Flt Permitted	0.078			0.078			0.181			0.199		
Satd. Flow (perm)	145	5045	0	145	5050	0	337	4953	0	371	4887	0
Satd. Flow (RTOR)		8			7			34			70	
Volume (vph)	167	1486	81	141	1582	79	87	627	129	121	587	208
Lane Group Flow (vph)	182	1703	0	153	1806	0	95	822	0	132	864	0
Turn Type	pm+pt			pm+pt			pm+pt			pm+pt		
Protected Phases	1	6		5	2		7	4		3	8	
Permitted Phases	6			2			4			8		
Total Split (s)	16.0	55.0	0.0	16.0	55.0	0.0	16.0	40.0	0.0	16.0	40.0	0.0
Act Effct Green (s)	63.2	52.2		61.4	51.3		34.9	25.5		37.7	28.9	
Actuated g/C Ratio	0.55	0.46		0.54	0.45		0.30	0.22		0.33	0.25	
v/c Ratio	0.77	0.74		0.69	0.80		0.44	0.73		0.53	0.67	
Control Delay	47.0	29.1		39.3	31.4		31.9	43.5		33.7	38.8	
Queue Delay	0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0	
Total Delay	47.0	29.1		39.3	31.4		31.9	43.5		33.7	38.8	
LOS	D	C		D	C		C	D		C	D	
Approach Delay		30.8			32.0			42.3			38.1	
Approach LOS		C			C			D			D	

Intersection Summary

Cycle Length: 127
Actuated Cycle Length: 114.3
Control Type: Semi Act-Uncoord
Maximum v/c Ratio: 0.80
Intersection Signal Delay: 34.3 Intersection LOS: C
Intersection Capacity Utilization 76.6% ICU Level of Service D
Analysis Period (min) 15

Splits and Phases: 125: E Broadway & Nanaimo St



Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	5070	0	1770	5055	0	1770	1863	1583	1770	1837	0
Flt Permitted	0.087			0.126			0.245			0.488		
Satd. Flow (perm)	162	5070	0	235	5055	0	456	1863	1583	909	1837	0
Satd. Flow (RTOR)		6			12				36		7	
Volume (vph)	78	1340	27	101	1588	62	37	235	109	211	367	38
Lane Group Flow (vph)	85	1486	0	110	1793	0	40	255	118	229	440	0
Turn Type	Perm			Perm			Perm		Perm	Perm		
Protected Phases		2			6			8			4	
Permitted Phases	2			6			8		8	4		
Total Split (s)	50.0	50.0	0.0	50.0	50.0	0.0	30.0	30.0	30.0	30.0	30.0	0.0
Act Effct Green (s)	46.0	46.0		46.0	46.0		26.0	26.0	26.0	26.0	26.0	
Actuated g/C Ratio	0.58	0.58		0.58	0.58		0.32	0.32	0.32	0.32	0.32	
v/c Ratio	0.91	0.51		0.81	0.62		0.27	0.42	0.22	0.78	0.73	
Control Delay	85.3	4.3		60.9	12.2		25.9	23.8	15.1	57.0	48.8	
Queue Delay	0.0	0.0		0.0	0.0		0.0	0.0	0.0	0.0	0.0	
Total Delay	85.3	4.3		60.9	12.2		25.9	23.8	15.1	57.0	48.8	
LOS	F	A		E	B		C	C	B	E	D	
Approach Delay		8.7			15.1			21.5			51.6	
Approach LOS		A			B			C			D	

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 80
Offset: 47 (59%), Referenced to phase 2:EBTL and 6:WBTL, Start of Green
Control Type: Pretimed
Maximum v/c Ratio: 0.91
Intersection Signal Delay: 18.8 Intersection LOS: B
Intersection Capacity Utilization 74.7% ICU Level of Service D
Analysis Period (min) 15

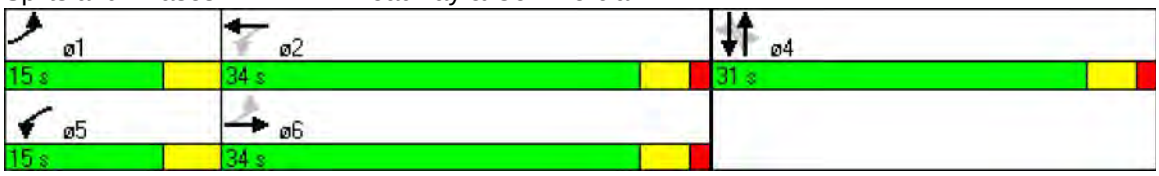
Splits and Phases: 126: E Broadway & Victoria Dr

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	5050	0	1770	5055	0	0	4969	0	0	4999	0
Flt Permitted	0.133			0.133				0.784			0.832	
Satd. Flow (perm)	248	5050	0	248	5055	0	0	3927	0	0	4184	0
Satd. Flow (RTOR)		11			8			25			18	
Volume (vph)	86	1375	70	82	1346	53	70	337	44	61	446	41
Lane Group Flow (vph)	93	1571	0	89	1521	0	0	490	0	0	596	0
Turn Type	pm+pt			pm+pt			Perm			Perm		
Protected Phases	1	6		5	2			4			4	
Permitted Phases	6			2			4			4		
Total Split (s)	15.0	34.0	0.0	15.0	34.0	0.0	31.0	31.0	0.0	31.0	31.0	0.0
Act Effct Green (s)	52.0	46.1		53.8	47.0			15.9			15.9	
Actuated g/C Ratio	0.65	0.58		0.67	0.59			0.20			0.20	
v/c Ratio	0.32	0.54		0.28	0.51			0.61			0.70	
Control Delay	7.7	12.6		12.5	17.8			30.8			42.8	
Queue Delay	0.0	0.0		0.0	0.0			0.0			0.0	
Total Delay	7.7	12.6		12.5	17.8			30.8			42.8	
LOS	A	B		B	B			C			D	
Approach Delay		12.3			17.5			30.8			42.8	
Approach LOS		B			B			C			D	

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 80
Offset: 47 (59%), Referenced to phase 2:WBTL and 6:EBTL, Start of Green
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 0.70
Intersection Signal Delay: 20.5 Intersection LOS: C
Intersection Capacity Utilization 65.7% ICU Level of Service C
Analysis Period (min) 15

Splits and Phases: 127: E Broadway & Commercial Dr

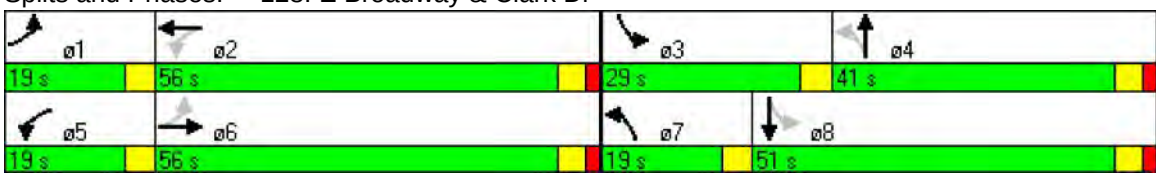


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	5040	0	1770	4979	0	1770	4943	0	1770	5014	0
Flt Permitted	0.077			0.077			0.108			0.098		
Satd. Flow (perm)	143	5040	0	143	4979	0	201	4943	0	183	5014	0
Satd. Flow (RTOR)		8			24			35			12	
Volume (vph)	112	1286	82	181	1148	189	71	767	178	372	1215	121
Lane Group Flow (vph)	122	1487	0	197	1453	0	77	1027	0	404	1453	0
Turn Type	pm+pt			pm+pt			pm+pt			pm+pt		
Protected Phases	1	6		5	2		7	4		3	8	
Permitted Phases	6			2			4			8		
Total Split (s)	19.0	56.0	0.0	19.0	56.0	0.0	19.0	41.0	0.0	29.0	51.0	0.0
Act Effct Green (s)	63.2	52.1		69.0	55.1		43.7	34.7		63.7	52.9	
Actuated g/C Ratio	0.45	0.37		0.49	0.39		0.30	0.24		0.45	0.37	
v/c Ratio	0.64	0.80		0.85	0.75		0.48	0.83		1.12	0.77	
Control Delay	41.9	44.6		65.1	40.4		35.6	56.0		122.9	43.3	
Queue Delay	0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0	
Total Delay	41.9	44.6		65.1	40.4		35.6	56.0		122.9	43.3	
LOS	D	D		E	D		D	E		F	D	
Approach Delay		44.4			43.3			54.5			60.6	
Approach LOS		D			D			D			E	

Intersection Summary

Cycle Length: 145
Actuated Cycle Length: 142
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 1.12
Intersection Signal Delay: 50.8 Intersection LOS: D
Intersection Capacity Utilization 89.4% ICU Level of Service E
Analysis Period (min) 15

Splits and Phases: 128: E Broadway & Clark Dr



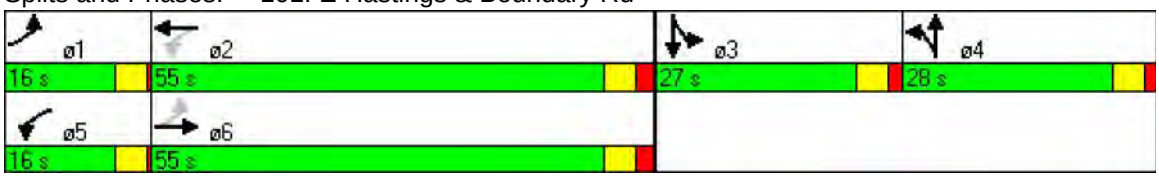
Appendix C – Scenario 1 Synchro Output Files (AM and PM)

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	3398	0	1770	5070	0	1610	3163	0	1770	3405	0
Flt Permitted	0.096			0.286			0.950	0.975		0.950		
Satd. Flow (perm)	179	3398	0	533	5070	0	1610	3163	0	1770	3405	0
Satd. Flow (RTOR)		50			3			39			33	
Volume (vph)	30	451	165	210	1231	27	362	71	102	11	198	68
Lane Group Flow (vph)	33	669	0	228	1367	0	197	384	0	12	289	0
Turn Type	pm+pt			pm+pt			Split			Split		
Protected Phases	1	6		5	2		4	4		3	3	
Permitted Phases	6			2								
Total Split (s)	16.0	55.0	0.0	16.0	55.0	0.0	28.0	28.0	0.0	27.0	27.0	0.0
Act Effct Green (s)	32.1	25.6		40.7	35.1		16.8	16.8		13.1	13.1	
Actuated g/C Ratio	0.37	0.31		0.49	0.42		0.20	0.20		0.16	0.16	
v/c Ratio	0.18	0.62		0.54	0.64		0.61	0.57		0.04	0.51	
Control Delay	15.3	25.6		18.4	22.4		42.7	33.0		37.8	35.0	
Queue Delay	0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0	
Total Delay	15.3	25.6		18.4	22.4		42.7	33.0		37.8	35.0	
LOS	B	C		B	C		D	C		D	C	
Approach Delay		25.1			21.8			36.3			35.1	
Approach LOS		C			C			D			D	

Intersection Summary

Cycle Length: 126
Actuated Cycle Length: 83.5
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 0.64
Intersection Signal Delay: 26.4 Intersection LOS: C
Intersection Capacity Utilization 60.9% ICU Level of Service B
Analysis Period (min) 15

Splits and Phases: 101: E Hastings & Boundary Rd

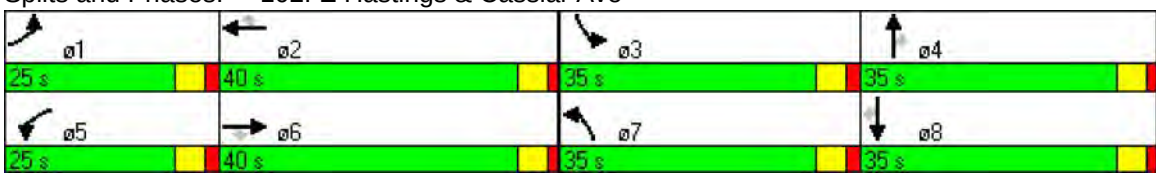


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	3539	1583	1770	5085	1583	3433	3539	1583	3433	3539	1583
Flt Permitted	0.950			0.950			0.950			0.950		
Satd. Flow (perm)	1770	3539	1583	1770	5085	1583	3433	3539	1583	3433	3539	1583
Satd. Flow (RTOR)			346			20			23			107
Volume (vph)	78	376	318	85	1136	27	597	225	21	368	46	98
Lane Group Flow (vph)	85	409	346	92	1235	29	649	245	23	400	50	107
Turn Type	Prot		Perm	Prot		Perm	Prot		Perm	Prot		Perm
Protected Phases	1	6		5	2		7	4		3	8	
Permitted Phases			6			2			4			8
Total Split (s)	25.0	40.0	40.0	25.0	40.0	40.0	35.0	35.0	35.0	35.0	35.0	35.0
Act Effct Green (s)	10.9	30.0	30.0	11.2	30.3	30.3	22.5	14.1	14.1	17.5	8.7	8.7
Actuated g/C Ratio	0.13	0.36	0.36	0.13	0.37	0.37	0.27	0.17	0.17	0.21	0.10	0.10
v/c Ratio	0.37	0.32	0.43	0.39	0.66	0.05	0.69	0.41	0.08	0.55	0.14	0.41
Control Delay	44.8	23.7	4.9	44.8	27.1	13.1	34.0	37.6	15.6	36.8	42.8	14.6
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	44.8	23.7	4.9	44.8	27.1	13.1	34.0	37.6	15.6	36.8	42.8	14.6
LOS	D	C	A	D	C	B	C	D	B	D	D	B
Approach Delay		18.1			28.0			34.5			33.1	
Approach LOS		B			C			C			C	

Intersection Summary

Cycle Length: 135
Actuated Cycle Length: 82.4
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 0.69
Intersection Signal Delay: 28.1 Intersection LOS: C
Intersection Capacity Utilization 60.8% ICU Level of Service B
Analysis Period (min) 15

Splits and Phases: 102: E Hastings & Cassiar Ave

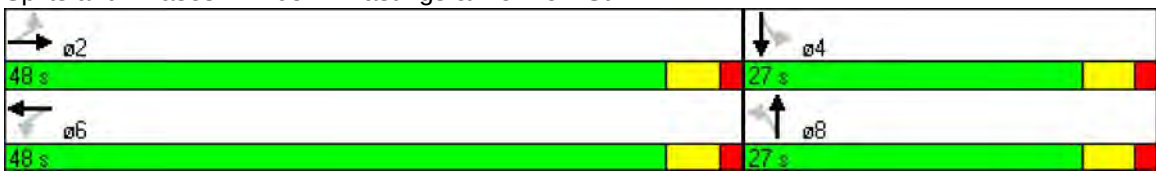


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	3483	0	1770	4928	0	0	4949	0	0	3451	0
Flt Permitted	0.091			0.364				0.858			0.631	
Satd. Flow (perm)	170	3483	0	678	4928	0	0	4272	0	0	2218	0
Satd. Flow (RTOR)		29			147			43			7	
Volume (vph)	39	553	64	69	1309	337	55	362	68	119	185	16
Lane Group Flow (vph)	42	671	0	75	1789	0	0	527	0	0	347	0
Turn Type	Perm			Perm			Perm			Perm		
Protected Phases		2			6			8			4	
Permitted Phases	2			6			8			4		
Total Split (s)	48.0	48.0	0.0	48.0	48.0	0.0	27.0	27.0	0.0	27.0	27.0	0.0
Act Effct Green (s)	44.0	44.0		44.0	44.0			23.0			23.0	
Actuated g/C Ratio	0.59	0.59		0.59	0.59			0.31			0.31	
v/c Ratio	0.42	0.33		0.19	0.61			0.39			0.51	
Control Delay	39.7	20.0		8.7	10.1			19.8			24.0	
Queue Delay	0.0	0.0		0.0	0.0			0.0			0.0	
Total Delay	39.7	20.0		8.7	10.1			19.8			24.0	
LOS	D	C		A	B			B			C	
Approach Delay		21.2			10.0			19.8			24.0	
Approach LOS		C			B			B			C	

Intersection Summary

Cycle Length: 75
Actuated Cycle Length: 75
Offset: 43 (57%), Referenced to phase 2:EBTL and 6:WBTL, Start of Green
Control Type: Pretimed
Maximum v/c Ratio: 0.61
Intersection Signal Delay: 15.2 Intersection LOS: B
Intersection Capacity Utilization 70.7% ICU Level of Service C
Analysis Period (min) 15

Splits and Phases: 103: E Hastings & Renfrew St

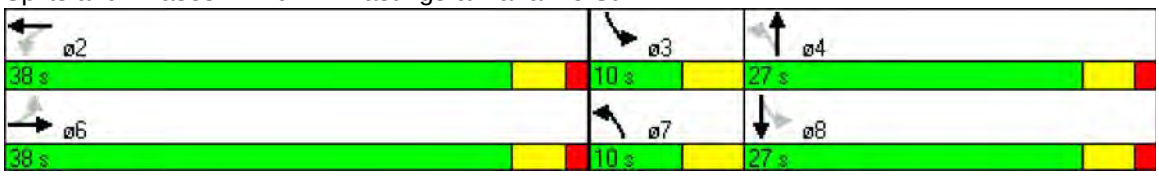


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	0	3506	0	0	5070	0	1770	5041	0	1770	4672	0
Flt Permitted		0.887			0.933		0.395			0.429		
Satd. Flow (perm)	0	3113	0	0	4730	0	714	5041	0	790	4672	0
Satd. Flow (RTOR)		8			4			10			57	
Volume (vph)	17	551	28	12	1331	19	177	429	20	45	315	180
Lane Group Flow (vph)	0	647	0	0	1481	0	192	488	0	49	538	0
Turn Type	Perm			Perm			pm+pt			pm+pt		
Protected Phases		6			2		7	4		3	8	
Permitted Phases	6			2			4			8		
Total Split (s)	38.0	38.0	0.0	38.0	38.0	0.0	10.0	27.0	0.0	10.0	27.0	0.0
Act Effct Green (s)		34.0			34.0		30.6	27.0		28.9	23.0	
Actuated g/C Ratio		0.45			0.45		0.41	0.36		0.39	0.31	
v/c Ratio		0.46			0.69		0.51	0.27		0.13	0.37	
Control Delay		5.2			12.7		19.3	18.2		13.1	18.9	
Queue Delay		0.0			0.0		0.0	0.0		0.0	0.0	
Total Delay		5.2			12.7		19.3	18.2		13.1	18.9	
LOS		A			B		B	B		B	B	
Approach Delay		5.2			12.7			18.5			18.4	
Approach LOS		A			B			B			B	

Intersection Summary

Cycle Length: 75
Actuated Cycle Length: 75
Offset: 20 (27%), Referenced to phase 2:WBTL and 6:EBTL, Start of Green
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 0.69
Intersection Signal Delay: 13.4 Intersection LOS: B
Intersection Capacity Utilization 71.8% ICU Level of Service C
Analysis Period (min) 15

Splits and Phases: 104: E Hastings & Nanaimo St

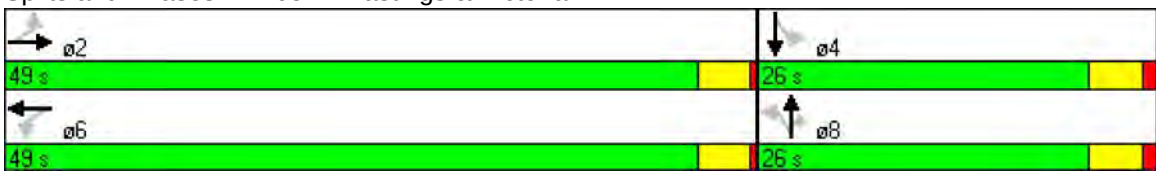


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	3525	0	1770	5055	0	0	1844	1583	0	3409	0
Flt Permitted	0.098			0.436				0.924			0.884	
Satd. Flow (perm)	183	3525	0	812	5055	0	0	1721	1583	0	3044	0
Satd. Flow (RTOR)		6			13				103		23	
Volume (vph)	21	483	12	131	1498	57	37	148	95	24	73	21
Lane Group Flow (vph)	23	538	0	142	1690	0	0	201	103	0	128	0
Turn Type	Perm			Perm			Perm		Perm	Perm		
Protected Phases		2			6			8			4	
Permitted Phases	2			6			8		8	4		
Total Split (s)	49.0	49.0	0.0	49.0	49.0	0.0	26.0	26.0	26.0	26.0	26.0	0.0
Act Effct Green (s)	45.0	45.0		45.0	45.0			22.0	22.0		22.0	
Actuated g/C Ratio	0.60	0.60		0.60	0.60			0.29	0.29		0.29	
v/c Ratio	0.21	0.25		0.29	0.56			0.40	0.19		0.14	
Control Delay	29.3	21.0		5.0	4.5			24.1	5.7		16.5	
Queue Delay	0.0	0.0		0.0	0.0			0.0	0.0		0.0	
Total Delay	29.3	21.0		5.0	4.5			24.1	5.7		16.5	
LOS	C	C		A	A			C	A		B	
Approach Delay		21.3			4.5			17.9			16.5	
Approach LOS		C			A			B			B	

Intersection Summary

Cycle Length: 75
Actuated Cycle Length: 75
Offset: 54 (72%), Referenced to phase 2:EBTL and 6:WBTL, Start of Green
Control Type: Pretimed
Maximum v/c Ratio: 0.56
Intersection Signal Delay: 9.8 Intersection LOS: A
Intersection Capacity Utilization 65.0% ICU Level of Service C
Analysis Period (min) 15

Splits and Phases: 105: E Hastings & Victoria Dr



Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	3493	0	1770	5072	0	1770	1756	0	1770	1740	0
Flt Permitted	0.129			0.327			0.643			0.619		
Satd. Flow (perm)	240	3493	0	600	5072	0	1118	1756	0	1125	1740	0
Satd. Flow (RTOR)		10			4			32			17	
Volume (vph)	21	495	30	71	1502	19	71	110	48	13	110	32
Lane Group Flow (vph)	23	571	0	77	1654	0	77	172	0	14	155	0
Turn Type	Perm			pm+pt			Perm			Perm		
Protected Phases		2		1	6			8			4	
Permitted Phases	2			6			8			4		
Total Split (s)	35.0	35.0	0.0	10.0	45.0	0.0	30.0	30.0	0.0	30.0	30.0	0.0
Act Effct Green (s)	33.0	33.0		41.0	41.0		26.0	26.0		26.0	26.0	
Actuated g/C Ratio	0.44	0.44		0.55	0.55		0.35	0.35		0.35	0.35	
v/c Ratio	0.22	0.37		0.18	0.60		0.20	0.27		0.04	0.25	
Control Delay	9.7	5.7		12.1	14.5		19.0	15.7		16.7	16.9	
Queue Delay	0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0	
Total Delay	9.7	5.7		12.1	14.5		19.0	15.7		16.7	16.9	
LOS	A	A		B	B		B	B		B	B	
Approach Delay		5.8			14.4			16.7			16.9	
Approach LOS		A			B			B			B	

Intersection Summary

Cycle Length: 75
Actuated Cycle Length: 75
Offset: 0 (0%), Referenced to phase 2:EBTL and 6:WBTL, Start of Green
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 0.60
Intersection Signal Delay: 12.9 Intersection LOS: B
Intersection Capacity Utilization 64.5% ICU Level of Service C
Analysis Period (min) 15

Splits and Phases: 106: E Hastings & Commercial Dr

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	3461	0	1770	5055	0	0	3497	1583	0	3529	1583
Flt Permitted	0.190			0.332				0.687			0.912	
Satd. Flow (perm)	354	3461	0	618	5055	0	0	2431	1583	0	3228	1583
Satd. Flow (RTOR)		25			8				127			2
Volume (vph)	61	412	70	369	1135	44	119	364	117	22	401	50
Lane Group Flow (vph)	66	524	0	401	1282	0	0	525	127	0	460	54
Turn Type	pm+pt			pm+pt			Perm		pm+ov	Perm		pm+ov
Protected Phases	1	6		5	2			4	5		8	1
Permitted Phases	6			2			4		4	8		8
Total Split (s)	21.0	25.0	0.0	21.0	25.0	0.0	29.0	29.0	21.0	29.0	29.0	21.0
Act Effct Green (s)	32.3	25.6		41.4	33.1			25.0	41.4		25.0	35.8
Actuated g/C Ratio	0.43	0.34		0.55	0.44			0.33	0.55		0.33	0.48
v/c Ratio	0.24	0.44		0.75	0.57			0.65	0.14		0.43	0.07
Control Delay	11.1	20.7		12.1	7.5			25.8	1.6		21.0	10.3
Queue Delay	0.0	0.0		0.0	0.0			0.0	0.0		0.0	0.0
Total Delay	11.1	20.7		12.1	7.5			25.8	1.6		21.0	10.3
LOS	B	C		B	A			C	A		C	B
Approach Delay		19.7			8.6			21.1			19.9	
Approach LOS		B			A			C			B	

Intersection Summary

Cycle Length: 75
Actuated Cycle Length: 75
Offset: 45 (60%), Referenced to phase 2:WBTL and 6:EBTL, Start of Green
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 0.75
Intersection Signal Delay: 14.6 Intersection LOS: B
Intersection Capacity Utilization 86.3% ICU Level of Service E
Analysis Period (min) 15

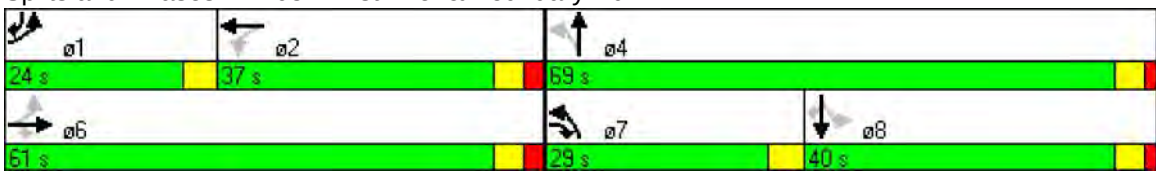
Splits and Phases: 107: E Hastings & Clark Dr

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	1863	1583	1770	1812	0	0	4939	0	0	3536	1583
Flt Permitted	0.150			0.577				0.697			0.905	
Satd. Flow (perm)	279	1863	1583	1075	1812	0	0	3502	0	0	3203	1583
Satd. Flow (RTOR)			18		8			15				207
Volume (vph)	268	276	432	50	292	64	294	489	66	20	768	279
Lane Group Flow (vph)	291	300	470	54	387	0	0	924	0	0	857	303
Turn Type	pm+pt		pm+ov	Perm			pm+pt			Perm		pm+ov
Protected Phases	1	6	7		2		7	4			8	1
Permitted Phases	6		6	2			4			8		8
Total Split (s)	24.0	61.0	29.0	37.0	37.0	0.0	29.0	69.0	0.0	40.0	40.0	24.0
Act Effct Green (s)	48.7	48.7	61.1	28.1	28.1			45.9			33.5	54.1
Actuated g/C Ratio	0.47	0.47	0.59	0.27	0.27			0.45			0.33	0.53
v/c Ratio	0.78	0.34	0.50	0.18	0.77			1.45dl			0.82	0.33
Control Delay	36.8	18.2	13.7	31.9	45.9			21.7			40.5	5.7
Queue Delay	0.0	0.0	0.0	0.0	0.0			0.0			0.0	0.0
Total Delay	36.8	18.2	13.7	31.9	45.9			21.7			40.5	5.7
LOS	D	B	B	C	D			C			D	A
Approach Delay		21.3			44.2			21.7			31.4	
Approach LOS		C			D			C			C	

Intersection Summary

Cycle Length: 130
Actuated Cycle Length: 102.8
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 0.82
Intersection Signal Delay: 27.5 Intersection LOS: C
Intersection Capacity Utilization 86.1% ICU Level of Service E
Analysis Period (min) 15
dl Defacto Left Lane. Recode with 1 though lane as a left lane.

Splits and Phases: 108: E 1st Ave. & Boundary Rd

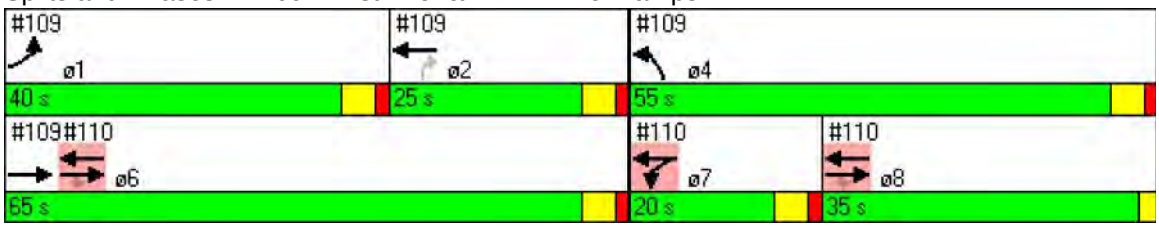


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	3539	0	0	5085	1583	3433	0	1583	0	0	0
Flt Permitted	0.950						0.950					
Satd. Flow (perm)	1770	3539	0	0	5085	1583	3433	0	1583	0	0	0
Satd. Flow (RTOR)						66			56			
Volume (vph)	238	827	0	0	596	167	1064	0	142	0	0	0
Lane Group Flow (vph)	259	899	0	0	648	182	1157	0	154	0	0	0
Turn Type	Prot					Free	Prot		custom			
Protected Phases	1	6			2		4					
Permitted Phases						Free			2			
Total Split (s)	40.0	65.0	0.0	0.0	25.0	0.0	55.0	0.0	25.0	0.0	0.0	0.0
Act Effct Green (s)	36.0	61.0			21.0	120.0	51.0		21.0			
Actuated g/C Ratio	0.30	0.51			0.18	1.00	0.42		0.18			
v/c Ratio	0.49	0.50			0.73	0.11	0.79		0.48			
Control Delay	34.9	17.4			52.3	0.1	34.9		33.5			
Queue Delay	4.3	0.6			0.0	0.0	0.0		0.0			
Total Delay	39.2	18.0			52.3	0.1	34.9		33.5			
LOS	D	B			D	A	C		C			
Approach Delay		22.8			40.8							
Approach LOS		C			D							

Intersection Summary

Cycle Length: 120
Actuated Cycle Length: 120
Offset: 0 (0%), Referenced to phase 2:WBT and 6:EBT, Start of Green
Control Type: Pretimed
Maximum v/c Ratio: 0.89
Intersection Signal Delay: 32.1 Intersection LOS: C
Intersection Capacity Utilization 120.6% ICU Level of Service H
Analysis Period (min) 15

Splits and Phases: 109: E 1st Ave. & HW1 WB on ramps



Lane Group	ø7	ø8
Lane Configurations		
Total Lost Time (s)		
Satd. Flow (prot)		
Flt Permitted		
Satd. Flow (perm)		
Satd. Flow (RTOR)		
Volume (vph)		
Lane Group Flow (vph)		
Turn Type		
Protected Phases	7	8
Permitted Phases		
Total Split (s)	20.0	35.0
Act Effct Green (s)		
Actuated g/C Ratio		
v/c Ratio		
Control Delay		
Queue Delay		
Total Delay		
LOS		
Approach Delay		
Approach LOS		

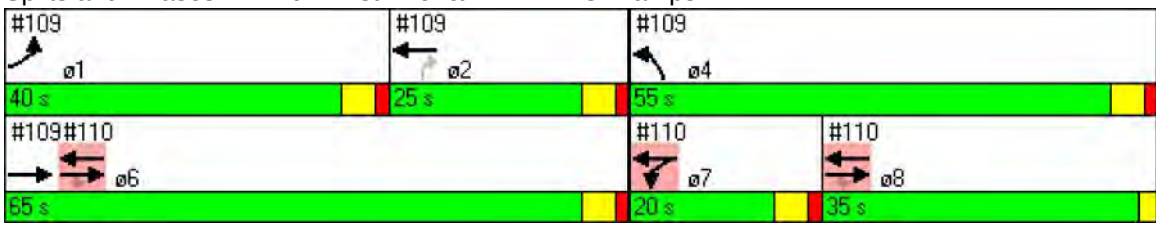
Intersection Summary

Lane Group	EBT	EBR	WBL	WBT	NBL	NBR	ø1	ø2	ø4	ø6	ø8
Lane Configurations											
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0					
Satd. Flow (prot)	5085	1583	1770	5085	0	0					
Flt Permitted			0.950								
Satd. Flow (perm)	5085	1583	1770	5085	0	0					
Satd. Flow (RTOR)		471									
Volume (vph)	1118	1110	80	1646	0	0					
Lane Group Flow (vph)	1215	1207	87	1789	0	0					
Turn Type		Perm	Prot								
Protected Phases	6 8		7	6 7 8			1	2	4	6	8
Permitted Phases		6 8									
Total Split (s)	100.0	100.0	20.0	120.0	0.0	0.0	40.0	25.0	55.0	65.0	35.0
Act Effct Green (s)	96.0	96.0	16.0	120.0							
Actuated g/C Ratio	0.80	0.80	0.13	1.00							
v/c Ratio	0.30	0.89	0.37	0.35							
Control Delay	3.4	14.6	52.1	0.2							
Queue Delay	0.0	0.0	0.0	0.0							
Total Delay	3.4	14.6	52.1	0.2							
LOS	A	B	D	A							
Approach Delay	9.0			2.6							
Approach LOS	A			A							

Intersection Summary

Cycle Length: 120
Actuated Cycle Length: 120
Offset: 0 (0%), Referenced to phase 2:WBT and 6:EBT, Start of Green
Control Type: Pretimed
Maximum v/c Ratio: 0.89
Intersection Signal Delay: 6.2 Intersection LOS: A
Intersection Capacity Utilization 120.6% ICU Level of Service H
Analysis Period (min) 15

Splits and Phases: 110: E 1st Ave. & HW1 EB On ramps

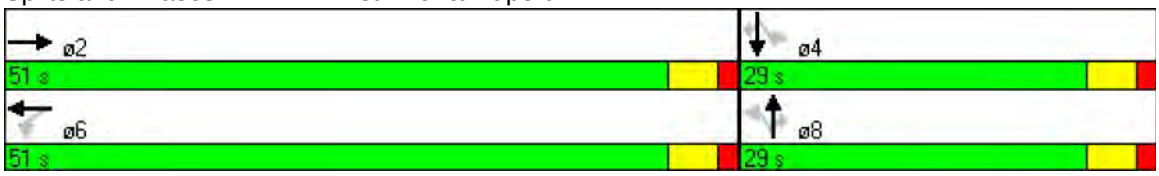


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	0	5070	0	0	3511	0	1770	1522	1504	1770	3539	1583
Flt Permitted					0.823		0.399			0.672		
Satd. Flow (perm)	0	5070	0	0	2892	0	743	1522	1504	1252	3539	1583
Satd. Flow (RTOR)		7			10			19	19			36
Volume (vph)	0	1615	37	39	1372	64	177	7	206	215	422	117
Lane Group Flow (vph)	0	1795	0	0	1603	0	192	120	112	234	459	127
Turn Type				Perm			Perm		Perm	Perm		Perm
Protected Phases		2			6			8			4	
Permitted Phases				6			8		8	4		4
Total Split (s)	0.0	51.0	0.0	51.0	51.0	0.0	29.0	29.0	29.0	29.0	29.0	29.0
Act Effct Green (s)		47.0			47.0		25.0	25.0	25.0	25.0	25.0	25.0
Actuated g/C Ratio		0.59			0.59		0.31	0.31	0.31	0.31	0.31	0.31
v/c Ratio		0.60			0.94		0.83	0.25	0.23	0.60	0.42	0.24
Control Delay		16.8			28.2		56.4	18.8	18.4	30.9	23.1	16.2
Queue Delay		0.0			0.0		0.0	0.0	0.0	0.0	0.0	0.0
Total Delay		16.8			28.2		56.4	18.8	18.4	30.9	23.1	16.2
LOS		B			C		E	B	B	C	C	B
Approach Delay		16.8			28.2			35.7			24.3	
Approach LOS		B			C			D			C	

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 80
Offset: 31 (39%), Referenced to phase 2:EBT and 6:WBTL, Start of Green
Control Type: Pretimed
Maximum v/c Ratio: 0.94
Intersection Signal Delay: 23.8 Intersection LOS: C
Intersection Capacity Utilization 99.7% ICU Level of Service F
Analysis Period (min) 15

Splits and Phases: 111: E 1st Ave. & Rupert

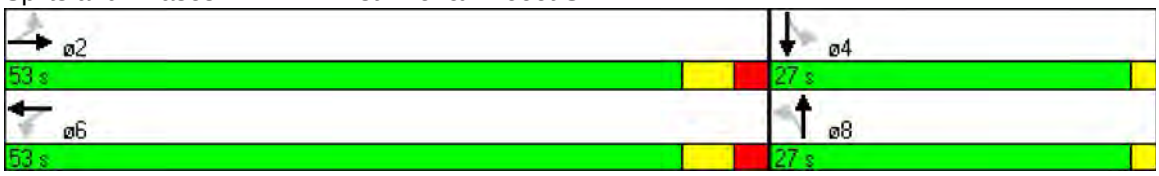


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	0	1863	0	0	1861	0	0	1650	0	0	1709	0
Flt Permitted		0.995			0.996			0.978			0.893	
Satd. Flow (perm)	0	1853	0	0	1853	0	0	1629	0	0	1562	0
Satd. Flow (RTOR)					1			18			15	
Volume (vph)	4	1628	3	4	1761	10	4	1	17	35	6	34
Lane Group Flow (vph)	0	1777	0	0	1929	0	0	23	0	0	82	0
Turn Type	Perm			Perm			Perm			Perm		
Protected Phases		2			6			8			4	
Permitted Phases	2			6			8			4		
Total Split (s)	53.0	53.0	0.0	53.0	53.0	0.0	27.0	27.0	0.0	27.0	27.0	0.0
Act Effct Green (s)		49.0			49.0			23.0			23.0	
Actuated g/C Ratio		0.61			0.61			0.29			0.29	
v/c Ratio		1.57			1.70			0.05			0.18	
Control Delay		278.9			334.1			11.6			19.2	
Queue Delay		0.0			0.0			0.0			0.0	
Total Delay		278.9			334.1			11.6			19.2	
LOS		F			F			B			B	
Approach Delay		278.9			334.1			11.6			19.2	
Approach LOS		F			F			B			B	

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 80
Offset: 56 (70%), Referenced to phase 2:EBTL and 6:WBTL, Start of Green
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 1.70
Intersection Signal Delay: 299.7 Intersection LOS: F
Intersection Capacity Utilization 112.3% ICU Level of Service H
Analysis Period (min) 15

Splits and Phases: 112: E 1st Ave. & Lillooet ST

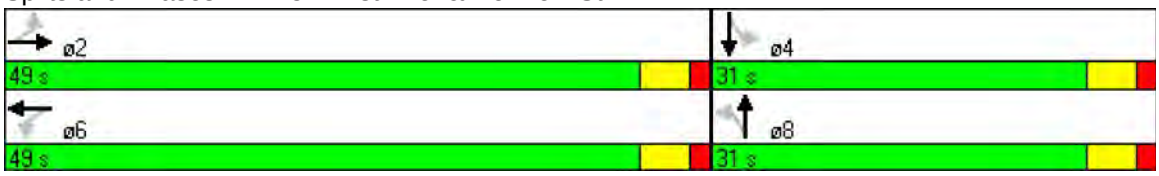


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	1852	0	1770	1844	0	1770	3497	0	1770	3479	0
Flt Permitted	0.089			0.089			0.325			0.347		
Satd. Flow (perm)	166	1852	0	166	1844	0	605	3497	0	646	3479	0
Satd. Flow (RTOR)		4			8			12			19	
Volume (vph)	50	1409	57	49	1523	111	91	465	39	91	470	62
Lane Group Flow (vph)	54	1594	0	53	1776	0	99	547	0	99	578	0
Turn Type	Perm			Perm			Perm			Perm		
Protected Phases		2			6			8			4	
Permitted Phases	2			6			8			4		
Total Split (s)	49.0	49.0	0.0	49.0	49.0	0.0	31.0	31.0	0.0	31.0	31.0	0.0
Act Effct Green (s)	45.0	45.0		45.0	45.0		27.0	27.0		27.0	27.0	
Actuated g/C Ratio	0.56	0.56		0.56	0.56		0.34	0.34		0.34	0.34	
v/c Ratio	0.58	1.53		0.57	1.71		0.49	0.46		0.45	0.49	
Control Delay	23.4	260.4		11.9	334.7		30.8	21.8		29.0	22.0	
Queue Delay	0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0	
Total Delay	23.4	260.4		11.9	334.7		30.8	21.8		29.0	22.0	
LOS	C	F		B	F		C	C		C	C	
Approach Delay		252.7			325.4			23.2			23.0	
Approach LOS		F			F			C			C	

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 80
Offset: 2 (3%), Referenced to phase 2:EBTL and 6:WBTL, Start of Green
Control Type: Pretimed
Maximum v/c Ratio: 1.71
Intersection Signal Delay: 217.1 Intersection LOS: F
Intersection Capacity Utilization 116.9% ICU Level of Service H
Analysis Period (min) 15

Splits and Phases: 113: E 1st Ave. & Renfrew St

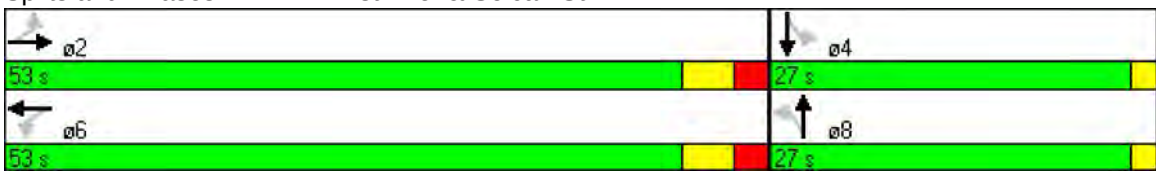


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	0	1863	0	0	1863	0	0	1708	0	0	1681	0
Flt Permitted		0.984			0.996			0.957			0.997	
Satd. Flow (perm)	0	1833	0	0	1855	0	0	1661	0	0	1679	0
Satd. Flow (RTOR)								12			15	
Volume (vph)	9	1536	3	4	1647	4	7	4	11	1	5	14
Lane Group Flow (vph)	0	1683	0	0	1798	0	0	24	0	0	21	0
Turn Type	Perm			Perm			Perm			Perm		
Protected Phases		2			6			8			4	
Permitted Phases	2			6			8			4		
Total Split (s)	53.0	53.0	0.0	53.0	53.0	0.0	27.0	27.0	0.0	27.0	27.0	0.0
Act Effct Green (s)		49.0			49.0			23.0			23.0	
Actuated g/C Ratio		0.61			0.61			0.29			0.29	
v/c Ratio		1.50			1.58			0.05			0.04	
Control Delay		241.5			279.0			14.5			12.5	
Queue Delay		0.0			0.0			0.0			0.0	
Total Delay		241.5			279.0			14.5			12.5	
LOS		F			F			B			B	
Approach Delay		241.5			279.0			14.5			12.5	
Approach LOS		F			F			B			B	

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 80
Offset: 30 (38%), Referenced to phase 2:EBTL and 6:WBTL, Start of Green
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 1.58
Intersection Signal Delay: 257.7 Intersection LOS: F
Intersection Capacity Utilization 100.3% ICU Level of Service G
Analysis Period (min) 15

Splits and Phases: 114: E 1st Ave. & Solcan St

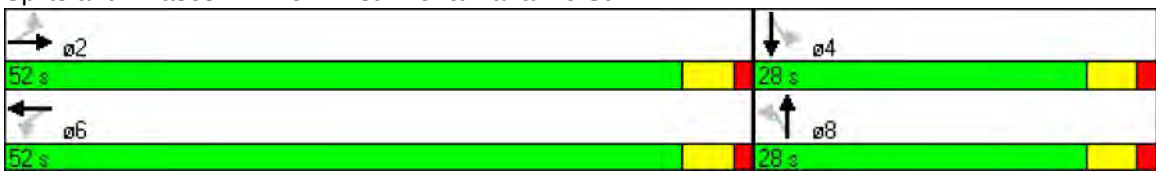


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	1855	0	1770	1855	0	1770	3493	0	1770	4994	0
Flt Permitted	0.140			0.083			0.339			0.223		
Satd. Flow (perm)	261	1855	0	155	1855	0	631	3493	0	415	4994	0
Satd. Flow (RTOR)		3			3			12			20	
Volume (vph)	45	1430	38	54	1613	44	93	582	54	49	498	70
Lane Group Flow (vph)	49	1595	0	59	1801	0	101	692	0	53	617	0
Turn Type	Perm			Perm			Perm			Perm		
Protected Phases		2			6			8			4	
Permitted Phases	2			6			8			4		
Total Split (s)	52.0	52.0	0.0	52.0	52.0	0.0	28.0	28.0	0.0	28.0	28.0	0.0
Act Effct Green (s)	48.0	48.0		48.0	48.0		24.0	24.0		24.0	24.0	
Actuated g/C Ratio	0.60	0.60		0.60	0.60		0.30	0.30		0.30	0.30	
v/c Ratio	0.31	1.43		0.63	1.62		0.53	0.66		0.42	0.41	
Control Delay	13.4	216.6		9.9	292.5		35.6	27.5		35.0	22.6	
Queue Delay	0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0	
Total Delay	13.4	216.6		9.9	292.5		35.6	27.5		35.0	22.6	
LOS	B	F		A	F		D	C		C	C	
Approach Delay		210.5			283.5			28.5			23.5	
Approach LOS		F			F			C			C	

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 80
Offset: 68 (85%), Referenced to phase 2:EBTL and 6:WBTL, Start of Green
Control Type: Pretimed
Maximum v/c Ratio: 1.62
Intersection Signal Delay: 183.6 Intersection LOS: F
Intersection Capacity Utilization 118.7% ICU Level of Service H
Analysis Period (min) 15

Splits and Phases: 115: E 1st Ave. & Nanaimo St

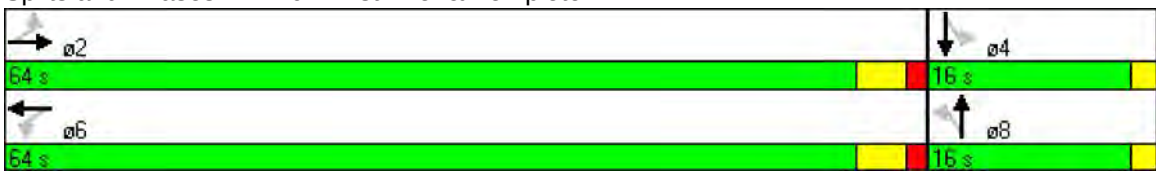


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	0	1863	0	0	1863	0	0	1657	0	0	1611	0
Flt Permitted					0.804			0.994				
Satd. Flow (perm)	0	1863	0	0	1498	0	0	1652	0	0	1611	0
Satd. Flow (RTOR)		1						12			36	
Volume (vph)	0	1510	5	2	1746	2	1	2	11	0	0	3
Lane Group Flow (vph)	0	1646	0	0	1902	0	0	15	0	0	3	0
Turn Type	Perm			Perm			Perm			Perm		
Protected Phases		2			6			8			4	
Permitted Phases	2			6			8			4		
Total Split (s)	64.0	64.0	0.0	64.0	64.0	0.0	16.0	16.0	0.0	16.0	16.0	0.0
Act Effct Green (s)		60.0			60.0			12.0			12.0	
Actuated g/C Ratio		0.75			0.75			0.15			0.15	
v/c Ratio		1.18			1.69			0.06			0.01	
Control Delay		93.8			328.4			18.1			0.0	
Queue Delay		13.0			236.0			0.1			0.0	
Total Delay		106.8			564.5			18.3			0.0	
LOS		F			F			B			A	
Approach Delay		106.8			564.5			18.3			0.0	
Approach LOS		F			F			B			A	

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 80
Offset: 76 (95%), Referenced to phase 2:EBTL and 6:WBTL, Start of Green
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 1.69
Intersection Signal Delay: 350.5 Intersection LOS: F
Intersection Capacity Utilization 103.6% ICU Level of Service G
Analysis Period (min) 15

Splits and Phases: 116: E 1st Ave. & Templeton Dr

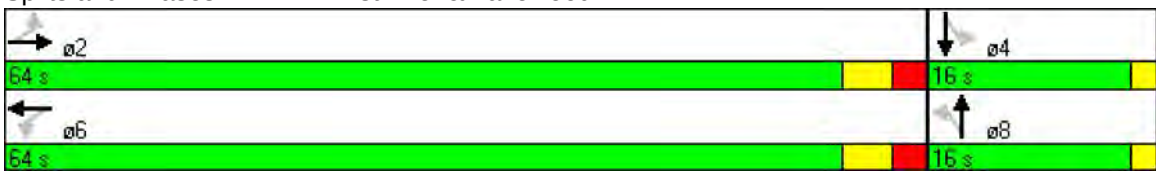


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	0	1863	0	0	1863	0	0	1611	0	0	1736	0
Flt Permitted		0.984			0.992						0.965	
Satd. Flow (perm)	0	1833	0	0	1848	0	0	1611	0	0	1700	0
Satd. Flow (RTOR)								55			4	
Volume (vph)	7	1541	3	7	1979	1	0	0	11	3	3	4
Lane Group Flow (vph)	0	1686	0	0	2160	0	0	12	0	0	10	0
Turn Type	Perm			Perm			Perm			Perm		
Protected Phases		2			6			8			4	
Permitted Phases	2			6			8			4		
Total Split (s)	64.0	64.0	0.0	64.0	64.0	0.0	16.0	16.0	0.0	16.0	16.0	0.0
Act Effct Green (s)		60.0			60.0			12.0			12.0	
Actuated g/C Ratio		0.75			0.75			0.15			0.15	
v/c Ratio		1.23			1.56			0.04			0.04	
Control Delay		123.7			266.2			0.3			24.4	
Queue Delay		98.9			25.1			7.7			674.9	
Total Delay		222.6			291.3			8.0			699.3	
LOS		F			F			A			F	
Approach Delay		222.6			291.3			8.0			699.3	
Approach LOS		F			F			A			F	

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 80
Offset: 7 (9%), Referenced to phase 2:EBTL and 6:WBTL, Start of Green
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 1.56
Intersection Signal Delay: 261.5 Intersection LOS: F
Intersection Capacity Utilization 119.1% ICU Level of Service H
Analysis Period (min) 15

Splits and Phases: 117: E 1st Ave. & Lakewood Dr

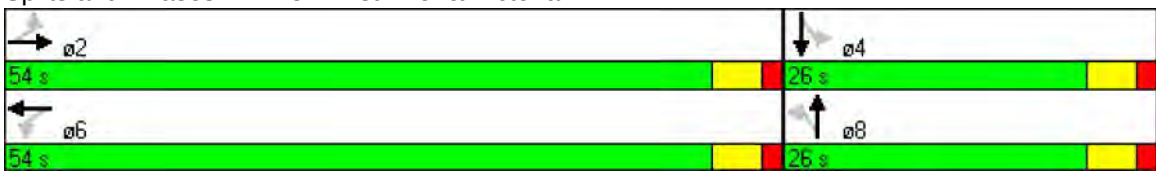


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	0	1861	0	0	1839	0	0	3486	0	0	3430	0
Flt Permitted								0.874			0.695	
Satd. Flow (perm)	0	1861	0	0	1839	0	0	3065	0	0	2423	0
Satd. Flow (RTOR)		1			13			8			14	
Volume (vph)	0	1443	12	0	1799	200	39	261	20	100	180	30
Lane Group Flow (vph)	0	1581	0	0	2172	0	0	348	0	0	338	0
Turn Type	Perm			Perm			Perm			Perm		
Protected Phases		2			6			8			4	
Permitted Phases	2			6			8			4		
Total Split (s)	54.0	54.0	0.0	54.0	54.0	0.0	26.0	26.0	0.0	26.0	26.0	0.0
Act Effct Green (s)		50.0			50.0			22.0			22.0	
Actuated g/C Ratio		0.62			0.62			0.28			0.28	
v/c Ratio		1.36			1.88			0.41			0.50	
Control Delay		183.7			413.8			24.9			26.4	
Queue Delay		0.0			0.0			0.0			0.0	
Total Delay		183.7			413.8			24.9			26.4	
LOS		F			F			C			C	
Approach Delay		183.7			413.8			24.9			26.4	
Approach LOS		F			F			C			C	

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 80
Offset: 35 (44%), Referenced to phase 2:EBTL and 6:WBTL, Start of Green
Control Type: Pretimed
Maximum v/c Ratio: 1.88
Intersection Signal Delay: 271.9 Intersection LOS: F
Intersection Capacity Utilization 134.6% ICU Level of Service H
Analysis Period (min) 15

Splits and Phases: 118: E 1st Ave. & Victoria Dr

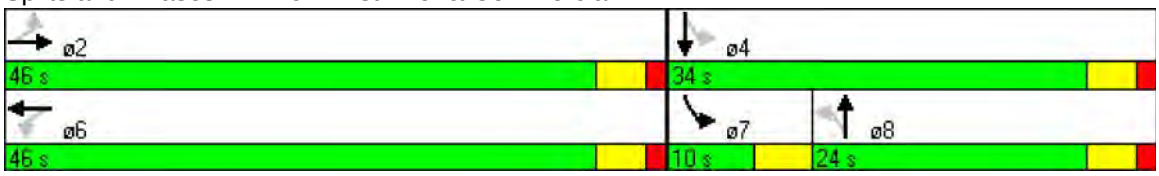


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	1855	0	1770	1845	0	1770	3341	0	1770	3376	0
Flt Permitted	0.133			0.095			0.577			0.325		
Satd. Flow (perm)	246	1855	0	177	1845	0	894	3341	0	535	3376	0
Satd. Flow (RTOR)		2			4			19			8	
Volume (vph)	33	1207	27	73	1636	72	59	342	49	125	233	29
Lane Group Flow (vph)	36	1341	0	79	1856	0	64	425	0	136	285	0
Turn Type	Perm			Perm			Perm			pm+pt		
Protected Phases		2			6			8		7	4	
Permitted Phases	2			6			8			4		
Total Split (s)	46.0	46.0	0.0	46.0	46.0	0.0	24.0	24.0	0.0	10.0	34.0	0.0
Act Effct Green (s)	46.4	46.4		46.4	46.4		15.6	15.6		25.6	25.6	
Actuated g/C Ratio	0.58	0.58		0.58	0.58		0.20	0.20		0.32	0.32	
v/c Ratio	0.25	1.25		0.77	1.73		0.37	0.64		0.52	0.26	
Control Delay	17.9	137.9		22.9	347.3		33.1	32.4		26.6	19.6	
Queue Delay	0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0	
Total Delay	17.9	137.9		22.9	347.3		33.1	32.4		26.6	19.6	
LOS	B	F		C	F		C	C		C	B	
Approach Delay		134.8			334.0			32.4			21.9	
Approach LOS		F			F			C			C	

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 80
Offset: 54 (68%), Referenced to phase 2:EBTL and 6:WBTL, Start of Green
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 1.73
Intersection Signal Delay: 203.0 Intersection LOS: F
Intersection Capacity Utilization 120.9% ICU Level of Service H
Analysis Period (min) 15

Splits and Phases: 119: E 1st Ave. & Commercial Dr

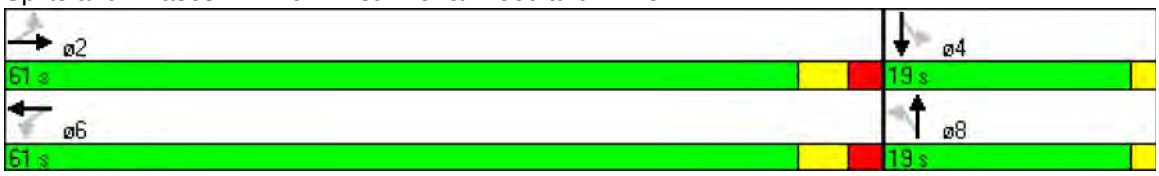


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	0	1861	0	0	1861	0	0	1700	0	0	1752	0
Flt Permitted		0.984			0.981			0.983			0.979	
Satd. Flow (perm)	0	1831	0	0	1826	0	0	1681	0	0	1729	0
Satd. Flow (RTOR)		1			2			25			10	
Volume (vph)	8	1281	6	16	1644	17	5	10	23	4	11	9
Lane Group Flow (vph)	0	1408	0	0	1822	0	0	41	0	0	26	0
Turn Type	Perm			Perm			Perm			Perm		
Protected Phases		2			6			8			4	
Permitted Phases	2			6			8			4		
Total Split (s)	61.0	61.0	0.0	61.0	61.0	0.0	19.0	19.0	0.0	19.0	19.0	0.0
Act Effct Green (s)		57.0			57.0			15.0			15.0	
Actuated g/C Ratio		0.71			0.71			0.19			0.19	
v/c Ratio		1.08			1.40			0.12			0.08	
Control Delay		65.6			195.8			16.4			20.6	
Queue Delay		0.0			0.0			0.0			0.0	
Total Delay		65.6			195.8			16.4			20.6	
LOS		E			F			B			C	
Approach Delay		65.6			195.8			16.4			20.6	
Approach LOS		E			F			B			C	

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 80
Offset: 70 (88%), Referenced to phase 2:EBTL and 6:WBTL, Start of Green
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 1.40
Intersection Signal Delay: 136.6 Intersection LOS: F
Intersection Capacity Utilization 108.3% ICU Level of Service G
Analysis Period (min) 15

Splits and Phases: 120: E 1st Ave. & Woodland Drive

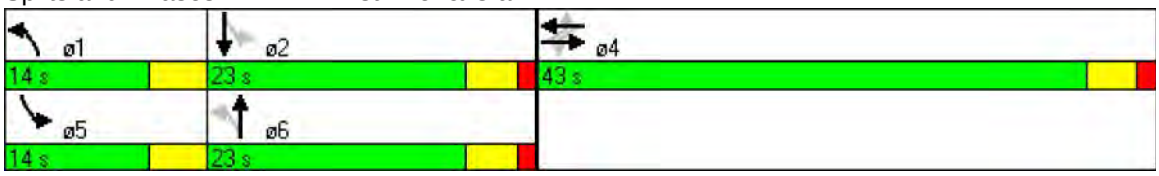


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	0	3437	0	0	3490	0	1770	4963	0	1770	4989	0
Flt Permitted					0.955		0.211			0.211		
Satd. Flow (perm)	0	3437	0	0	3333	0	393	4963	0	393	4989	0
Satd. Flow (RTOR)		52			19			45			29	
Volume (vph)	0	987	239	1	1457	152	309	1078	203	129	782	114
Lane Group Flow (vph)	0	1333	0	0	1750	0	336	1393	0	140	974	0
Turn Type	Perm			Perm			pm+pt			pm+pt		
Protected Phases		4			4		1	6		5	2	
Permitted Phases	4			4			6			2		
Total Split (s)	43.0	43.0	0.0	43.0	43.0	0.0	14.0	23.0	0.0	14.0	23.0	0.0
Act Effct Green (s)		39.0			39.0		30.2	20.2		27.8	19.0	
Actuated g/C Ratio		0.49			0.49		0.38	0.25		0.35	0.24	
v/c Ratio		0.78			1.07		1.05	1.08		0.48	0.81	
Control Delay		20.4			48.8		86.8	81.5		21.3	34.1	
Queue Delay		0.0			0.0		0.0	0.0		0.0	0.0	
Total Delay		20.4			48.8		86.8	81.5		21.3	34.1	
LOS		C			D		F	F		C	C	
Approach Delay		20.4			48.8			82.5			32.5	
Approach LOS		C			D			F			C	

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 80
Offset: 18 (23%), Referenced to phase 4:EBWB, Start of Green
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 1.08
Intersection Signal Delay: 49.2 Intersection LOS: D
Intersection Capacity Utilization 90.6% ICU Level of Service E
Analysis Period (min) 15

Splits and Phases: 121: E 1st Ave. & Clark Dr

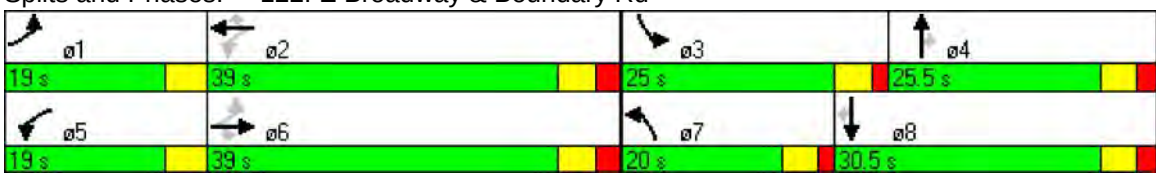


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	3539	1583	1770	3539	1583	3433	3539	1583	1770	3539	1583
Flt Permitted	0.114			0.268			0.950			0.950		
Satd. Flow (perm)	212	3539	1583	499	3539	1583	3433	3539	1583	1770	3539	1583
Satd. Flow (RTOR)			167			172			108			275
Volume (vph)	169	574	154	126	1093	184	309	401	99	231	588	374
Lane Group Flow (vph)	184	624	167	137	1188	200	336	436	108	251	639	407
Turn Type	pm+pt		Perm	pm+pt		Perm	Prot		Perm	Prot		Perm
Protected Phases	1	6		5	2		7	4		3	8	
Permitted Phases	6		6	2		2			4			8
Total Split (s)	19.0	39.0	39.0	19.0	39.0	39.0	20.0	25.5	25.5	25.0	30.5	30.5
Act Effct Green (s)	48.4	36.9	36.9	45.0	35.2	35.2	14.6	20.3	20.3	18.5	24.2	24.2
Actuated g/C Ratio	0.48	0.36	0.36	0.44	0.35	0.35	0.14	0.20	0.20	0.18	0.24	0.24
v/c Ratio	0.66	0.49	0.25	0.40	0.97	0.30	0.68	0.62	0.27	0.78	0.76	0.69
Control Delay	30.8	27.6	4.9	18.5	53.5	7.4	49.8	42.2	9.1	57.5	43.0	18.7
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	30.8	27.6	4.9	18.5	53.5	7.4	49.8	42.2	9.1	57.5	43.0	18.7
LOS	C	C	A	B	D	A	D	D	A	E	D	B
Approach Delay		24.3			44.3			41.0			38.2	
Approach LOS		C			D			D			D	

Intersection Summary

Cycle Length: 108.5
Actuated Cycle Length: 101.6
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 0.97
Intersection Signal Delay: 37.8 Intersection LOS: D
Intersection Capacity Utilization 78.2% ICU Level of Service D
Analysis Period (min) 15

Splits and Phases: 122: E Broadway & Boundary Rd

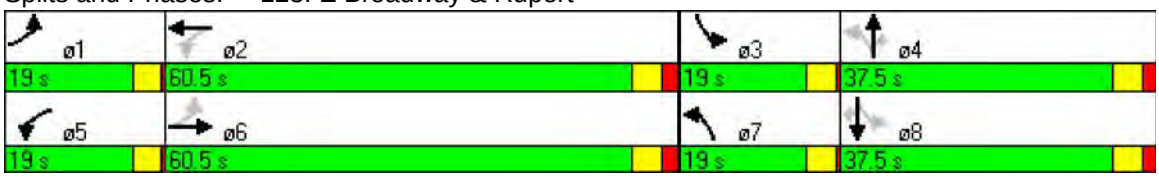


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	4984	0	1770	5070	0	1770	3539	1583	1770	3539	1583
Flt Permitted	0.071			0.218			0.343			0.457		
Satd. Flow (perm)	132	4984	0	406	5070	0	639	3539	1583	851	3539	1583
Satd. Flow (RTOR)		26			2				191			146
Volume (vph)	43	744	113	193	1376	24	262	287	176	56	394	134
Lane Group Flow (vph)	47	932	0	210	1522	0	285	312	191	61	428	146
Turn Type	pm+pt			pm+pt			pm+pt		Perm	pm+pt		Perm
Protected Phases	1	6		5	2		7	4		3	8	
Permitted Phases	6			2			4		4	8		8
Total Split (s)	19.0	60.5	0.0	19.0	60.5	0.0	19.0	37.5	37.5	19.0	37.5	37.5
Act Effct Green (s)	63.5	56.7		73.1	64.3		40.8	30.6	30.6	30.2	21.8	21.8
Actuated g/C Ratio	0.51	0.46		0.60	0.53		0.33	0.25	0.25	0.24	0.18	0.18
v/c Ratio	0.30	0.40		0.55	0.57		0.81	0.35	0.35	0.23	0.68	0.36
Control Delay	16.8	22.2		17.4	21.6		51.7	40.1	7.3	30.7	52.7	9.3
Queue Delay	0.0	0.0		0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	16.8	22.2		17.4	21.6		51.7	40.1	7.3	30.7	52.7	9.3
LOS	B	C		B	C		D	D	A	C	D	A
Approach Delay		21.9			21.1			36.4			40.6	
Approach LOS		C			C			D			D	

Intersection Summary

Cycle Length: 136
Actuated Cycle Length: 122
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 0.81
Intersection Signal Delay: 27.2 Intersection LOS: C
Intersection Capacity Utilization 71.6% ICU Level of Service C
Analysis Period (min) 15

Splits and Phases: 123: E Broadway & Rupert

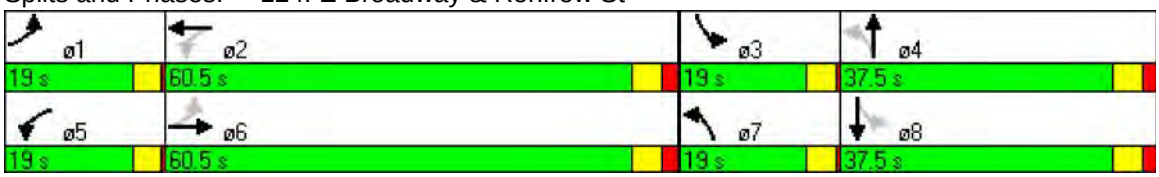


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	5009	0	1770	5060	0	1770	3437	0	1770	3405	0
Flt Permitted	0.071			0.179			0.201			0.281		
Satd. Flow (perm)	132	5009	0	333	5060	0	374	3437	0	523	3405	0
Satd. Flow (RTOR)		17			4			21			33	
Volume (vph)	83	868	98	84	1613	54	124	369	89	66	409	140
Lane Group Flow (vph)	90	1050	0	91	1812	0	135	498	0	72	597	0
Turn Type	pm+pt			pm+pt			pm+pt			pm+pt		
Protected Phases	1	6		5	2		7	4		3	8	
Permitted Phases	6			2			4			8		
Total Split (s)	19.0	60.5	0.0	19.0	60.5	0.0	19.0	37.5	0.0	19.0	37.5	0.0
Act Effct Green (s)	52.9	47.2		52.6	47.0		37.6	29.3		32.7	26.8	
Actuated g/C Ratio	0.50	0.45		0.50	0.45		0.35	0.28		0.31	0.26	
v/c Ratio	0.45	0.46		0.33	0.79		0.48	0.51		0.27	0.66	
Control Delay	23.7	22.0		16.4	29.6		31.4	36.0		27.8	41.2	
Queue Delay	0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0	
Total Delay	23.7	22.0		16.4	29.6		31.4	36.0		27.8	41.2	
LOS	C	C		B	C		C	D		C	D	
Approach Delay		22.1			29.0			35.0			39.8	
Approach LOS		C			C			D			D	

Intersection Summary

Cycle Length: 136
Actuated Cycle Length: 104.3
Control Type: Semi Act-Uncoord
Maximum v/c Ratio: 0.79
Intersection Signal Delay: 29.7 Intersection LOS: C
Intersection Capacity Utilization 72.9% ICU Level of Service C
Analysis Period (min) 15

Splits and Phases: 124: E Broadway & Renfrew St

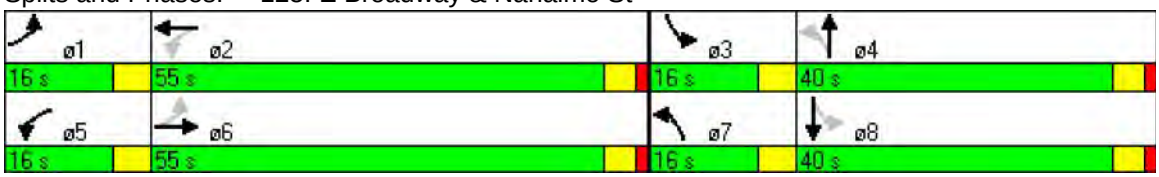


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	5050	0	1770	5065	0	1770	4984	0	1770	4867	0
Flt Permitted	0.078			0.174			0.277			0.278		
Satd. Flow (perm)	145	5050	0	324	5065	0	516	4984	0	518	4867	0
Satd. Flow (RTOR)		7			4			23			79	
Volume (vph)	90	924	46	116	1759	51	149	528	83	61	438	175
Lane Group Flow (vph)	98	1054	0	126	1967	0	162	664	0	66	666	0
Turn Type	pm+pt			pm+pt			pm+pt			pm+pt		
Protected Phases	1	6		5	2		7	4		3	8	
Permitted Phases	6			2			4			8		
Total Split (s)	16.0	55.0	0.0	16.0	55.0	0.0	16.0	40.0	0.0	16.0	40.0	0.0
Act Effct Green (s)	56.8	48.7		59.0	51.7		33.5	24.6		27.6	19.5	
Actuated g/C Ratio	0.54	0.47		0.57	0.50		0.32	0.24		0.26	0.19	
v/c Ratio	0.48	0.45		0.41	0.78		0.55	0.56		0.29	0.68	
Control Delay	21.7	20.1		14.6	26.4		33.5	37.1		28.4	38.8	
Queue Delay	0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0	
Total Delay	21.7	20.1		14.6	26.4		33.5	37.1		28.4	38.8	
LOS	C	C		B	C		C	D		C	D	
Approach Delay		20.2			25.7			36.4			37.9	
Approach LOS		C			C			D			D	

Intersection Summary

Cycle Length: 127
Actuated Cycle Length: 104.1
Control Type: Semi Act-Uncoord
Maximum v/c Ratio: 0.78
Intersection Signal Delay: 28.1 Intersection LOS: C
Intersection Capacity Utilization 74.1% ICU Level of Service D
Analysis Period (min) 15

Splits and Phases: 125: E Broadway & Nanaimo St



Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	5065	0	1770	5060	0	1770	1863	1583	1770	1794	0
Flt Permitted	0.098			0.286			0.455			0.559		
Satd. Flow (perm)	183	5065	0	533	5060	0	848	1863	1583	1041	1794	0
Satd. Flow (RTOR)		9			11				70		7	
Volume (vph)	30	784	23	89	1863	68	88	199	64	78	205	66
Lane Group Flow (vph)	33	877	0	97	2099	0	96	216	70	85	295	0
Turn Type	Perm			Perm			Perm		Perm	Perm		
Protected Phases		2			6			8			4	
Permitted Phases	2			6			8		8	4		
Total Split (s)	45.0	45.0	0.0	45.0	45.0	0.0	30.0	30.0	30.0	30.0	30.0	0.0
Act Effct Green (s)	41.0	41.0		41.0	41.0		26.0	26.0	26.0	26.0	26.0	
Actuated g/C Ratio	0.55	0.55		0.55	0.55		0.35	0.35	0.35	0.35	0.35	
v/c Ratio	0.33	0.32		0.33	0.76		0.33	0.33	0.12	0.24	0.47	
Control Delay	23.6	7.2		13.5	15.3		22.0	19.9	5.3	19.7	21.7	
Queue Delay	0.0	0.0		0.0	0.0		0.0	0.0	0.0	0.0	0.0	
Total Delay	23.6	7.2		13.5	15.3		22.0	19.9	5.3	19.7	21.7	
LOS	C	A		B	B		C	B	A	B	C	
Approach Delay		7.8			15.3			17.8			21.3	
Approach LOS		A			B			B			C	

Intersection Summary

Cycle Length: 75
Actuated Cycle Length: 75
Offset: 34 (45%), Referenced to phase 2:EBTL and 6:WBTL, Start of Green
Control Type: Pretimed
Maximum v/c Ratio: 0.76
Intersection Signal Delay: 14.3 Intersection LOS: B
Intersection Capacity Utilization 73.9% ICU Level of Service D
Analysis Period (min) 15

Splits and Phases: 126: E Broadway & Victoria Dr

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	5034	0	1770	5065	0	0	4989	0	0	4888	0
Flt Permitted	0.154			0.209				0.823			0.838	
Satd. Flow (perm)	287	5034	0	389	5065	0	0	4139	0	0	4121	0
Satd. Flow (RTOR)		17			5			19			61	
Volume (vph)	62	800	60	55	1566	40	101	452	45	31	167	56
Lane Group Flow (vph)	67	935	0	60	1745	0	0	650	0	0	277	0
Turn Type	pm+pt			pm+pt			Perm			Perm		
Protected Phases	1	6		5	2			4			4	
Permitted Phases	6			2			4			4		
Total Split (s)	15.0	30.0	0.0	15.0	30.0	0.0	30.0	30.0	0.0	30.0	30.0	0.0
Act Effct Green (s)	46.0	41.7		45.9	41.6			18.6			18.6	
Actuated g/C Ratio	0.61	0.56		0.61	0.55			0.25			0.25	
v/c Ratio	0.22	0.33		0.17	0.62			0.62			0.26	
Control Delay	8.0	11.1		9.3	13.7			26.5			17.1	
Queue Delay	0.0	0.0		0.0	0.0			0.0			0.0	
Total Delay	8.0	11.1		9.3	13.7			26.5			17.1	
LOS	A	B		A	B			C			B	
Approach Delay		10.9			13.5			26.5			17.1	
Approach LOS		B			B			C			B	

Intersection Summary

Cycle Length: 75
Actuated Cycle Length: 75
Offset: 47 (63%), Referenced to phase 2:WBTL and 6:EBTL, Start of Green
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 0.62
Intersection Signal Delay: 15.4 Intersection LOS: B
Intersection Capacity Utilization 65.5% ICU Level of Service C
Analysis Period (min) 15

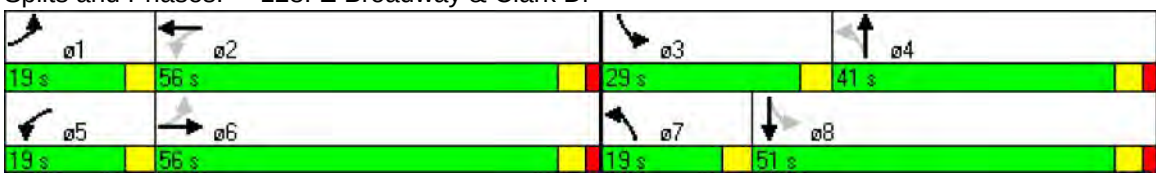
Splits and Phases: 127: E Broadway & Commercial Dr

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	5024	0	1770	4989	0	1770	5024	0	1770	4938	0
Flt Permitted	0.077			0.272			0.297			0.098		
Satd. Flow (perm)	143	5024	0	507	4989	0	553	5024	0	183	4938	0
Satd. Flow (RTOR)		10			20			9			40	
Volume (vph)	138	629	52	155	1335	192	64	1030	88	250	588	139
Lane Group Flow (vph)	150	741	0	168	1660	0	70	1216	0	272	790	0
Turn Type	pm+pt			pm+pt			pm+pt			pm+pt		
Protected Phases	1	6		5	2		7	4		3	8	
Permitted Phases	6			2			4			8		
Total Split (s)	19.0	56.0	0.0	19.0	56.0	0.0	19.0	41.0	0.0	29.0	51.0	0.0
Act Effct Green (s)	64.2	52.2		64.8	52.5		44.8	36.3		60.8	50.5	
Actuated g/C Ratio	0.47	0.38		0.47	0.38		0.32	0.26		0.44	0.37	
v/c Ratio	0.72	0.39		0.48	0.87		0.28	0.91		0.86	0.43	
Control Delay	49.0	32.2		24.8	45.4		26.7	60.1		61.2	32.5	
Queue Delay	0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0	
Total Delay	49.0	32.2		24.8	45.4		26.7	60.1		61.2	32.5	
LOS	D	C		C	D		C	E		E	C	
Approach Delay		35.0			43.5			58.3			39.9	
Approach LOS		D			D			E			D	

Intersection Summary

Cycle Length: 145
Actuated Cycle Length: 137.4
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 0.91
Intersection Signal Delay: 45.0 Intersection LOS: D
Intersection Capacity Utilization 86.8% ICU Level of Service E
Analysis Period (min) 15

Splits and Phases: 128: E Broadway & Clark Dr

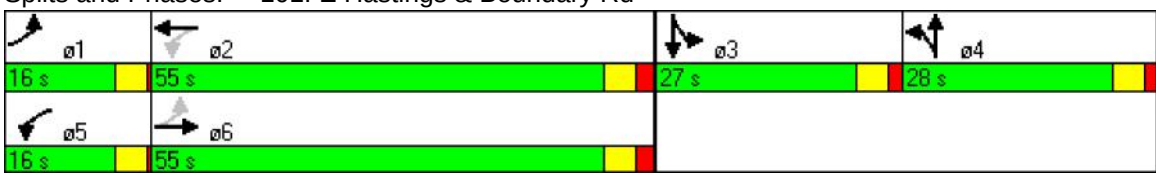


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	5004	0	1770	3522	0	1610	3157	0	1770	3429	0
Flt Permitted	0.190			0.078			0.950	0.995		0.950		
Satd. Flow (perm)	354	5004	0	145	3522	0	1610	3157	0	1770	3429	0
Satd. Flow (RTOR)		19			3			126			22	
Volume (vph)	156	1299	151	169	770	27	246	211	194	43	121	31
Lane Group Flow (vph)	170	1576	0	184	866	0	215	492	0	47	166	0
Turn Type	pm+pt			pm+pt			Split			Split		
Protected Phases	1	6		5	2		4	4		3	3	
Permitted Phases	6			2								
Total Split (s)	16.0	55.0	0.0	16.0	55.0	0.0	28.0	28.0	0.0	27.0	27.0	0.0
Act Effct Green (s)	50.2	40.6		53.3	42.1		18.7	18.7		11.1	11.1	
Actuated g/C Ratio	0.51	0.41		0.54	0.43		0.19	0.19		0.11	0.11	
v/c Ratio	0.53	0.76		0.70	0.57		0.70	0.70		0.23	0.41	
Control Delay	17.4	27.3		38.2	23.5		52.4	34.3		47.9	41.3	
Queue Delay	0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0	
Total Delay	17.4	27.3		38.2	23.5		52.4	34.3		47.9	41.3	
LOS	B	C		D	C		D	C		D	D	
Approach Delay		26.3			26.1			39.8			42.8	
Approach LOS		C			C			D			D	

Intersection Summary

Cycle Length: 126
Actuated Cycle Length: 98.2
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 0.76
Intersection Signal Delay: 29.8 Intersection LOS: C
Intersection Capacity Utilization 70.6% ICU Level of Service C
Analysis Period (min) 15

Splits and Phases: 101: E Hastings & Boundary Rd

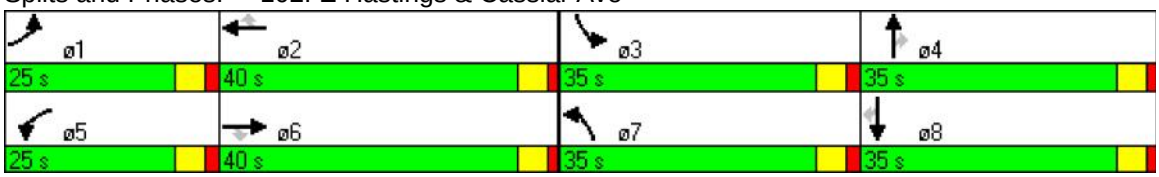


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	5085	1583	1770	3539	1583	3433	3539	1583	3433	3539	1583
Flt Permitted	0.950			0.950			0.950			0.950		
Satd. Flow (perm)	1770	5085	1583	1770	3539	1583	3433	3539	1583	3433	3539	1583
Satd. Flow (RTOR)			404			532			74			163
Volume (vph)	132	937	575	67	561	509	404	327	68	721	66	150
Lane Group Flow (vph)	143	1018	625	73	610	553	439	355	74	784	72	163
Turn Type	Prot		Perm	Prot		Perm	Prot		Perm	Prot		Perm
Protected Phases	1	6		5	2		7	4		3	8	
Permitted Phases			6			2			4			8
Total Split (s)	25.0	40.0	40.0	25.0	40.0	40.0	35.0	35.0	35.0	35.0	35.0	35.0
Act Effct Green (s)	14.5	34.3	34.3	10.7	27.6	27.6	19.5	16.9	16.9	30.2	27.5	27.5
Actuated g/C Ratio	0.14	0.32	0.32	0.10	0.26	0.26	0.18	0.16	0.16	0.29	0.26	0.26
v/c Ratio	0.59	0.62	0.80	0.41	0.66	0.69	0.69	0.63	0.23	0.80	0.08	0.31
Control Delay	56.0	33.6	20.8	56.1	39.6	8.7	47.8	48.4	11.9	44.5	35.2	7.8
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	56.0	33.6	20.8	56.1	39.6	8.7	47.8	48.4	11.9	44.5	35.2	7.8
LOS	E	C	C	E	D	A	D	D	B	D	D	A
Approach Delay		30.9			26.8			45.0			38.0	
Approach LOS		C			C			D			D	

Intersection Summary

Cycle Length: 135
Actuated Cycle Length: 105.7
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 0.80
Intersection Signal Delay: 33.8 Intersection LOS: C
Intersection Capacity Utilization 65.8% ICU Level of Service C
Analysis Period (min) 15

Splits and Phases: 102: E Hastings & Cassiar Ave

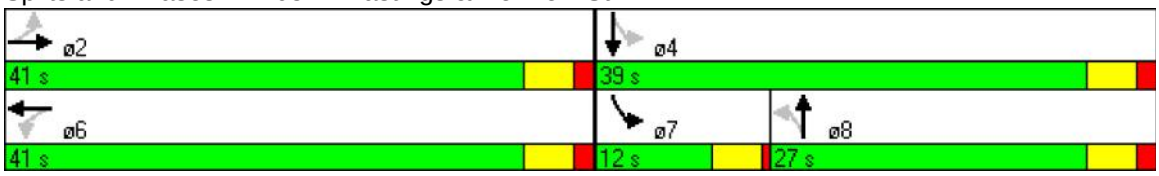


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	5040	0	1770	3472	0	0	4984	0	0	3437	0
Flt Permitted	0.140			0.135				0.790			0.575	
Satd. Flow (perm)	261	5040	0	251	3472	0	0	3965	0	0	2019	0
Satd. Flow (RTOR)		16			27			20			9	
Volume (vph)	57	1134	73	137	894	132	67	387	43	251	308	32
Lane Group Flow (vph)	62	1312	0	149	1115	0	0	541	0	0	643	0
Turn Type	Perm			Perm			Perm			pm+pt		
Protected Phases		2			6			8		7	4	
Permitted Phases	2			6			8			4		
Total Split (s)	41.0	41.0	0.0	41.0	41.0	0.0	27.0	27.0	0.0	12.0	39.0	0.0
Act Effct Green (s)	37.0	37.0		37.0	37.0			23.0			35.0	
Actuated g/C Ratio	0.46	0.46		0.46	0.46			0.29			0.44	
v/c Ratio	0.51	0.56		1.28	0.69			0.47			0.62	
Control Delay	37.5	24.8		204.5	19.2			9.8			18.8	
Queue Delay	0.0	0.0		0.0	0.0			0.0			0.0	
Total Delay	37.5	24.8		204.5	19.2			9.8			18.8	
LOS	D	C		F	B			A			B	
Approach Delay		25.4			41.1			9.8			18.8	
Approach LOS		C			D			A			B	

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 80
Offset: 60 (75%), Referenced to phase 2:EBTL and 6:WBTL, Start of Green
Control Type: Pretimed
Maximum v/c Ratio: 1.28
Intersection Signal Delay: 27.3 Intersection LOS: C
Intersection Capacity Utilization 74.7% ICU Level of Service D
Analysis Period (min) 15

Splits and Phases: 103: E Hastings & Renfrew St

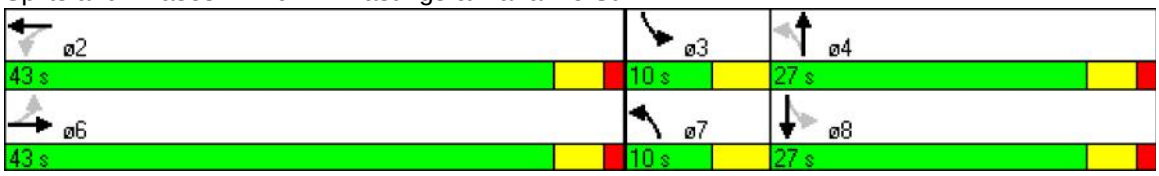


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	0	4947	0	0	3514	0	1770	4900	0	1770	4745	0
Flt Permitted		0.939			0.666		0.320			0.426		
Satd. Flow (perm)	0	4645	0	0	2344	0	535	4900	0	713	4745	0
Satd. Flow (RTOR)		16			2			24			47	
Volume (vph)	2	1442	88	60	890	10	89	395	44	59	496	92
Lane Group Flow (vph)	0	1665	0	0	1043	0	97	477	0	64	639	0
Turn Type	Perm			Perm			pm+pt			pm+pt		
Protected Phases		6			2		7	4		3	8	
Permitted Phases	6			2			4			8		
Total Split (s)	43.0	43.0	0.0	43.0	43.0	0.0	10.0	27.0	0.0	10.0	27.0	0.0
Act Effct Green (s)		39.0			39.0		29.8	25.0		29.8	25.0	
Actuated g/C Ratio		0.49			0.49		0.37	0.31		0.37	0.31	
v/c Ratio		0.73			0.91		0.33	0.31		0.19	0.42	
Control Delay		12.3			30.6		14.9	21.6		15.9	21.8	
Queue Delay		0.0			0.0		0.0	0.0		0.0	0.0	
Total Delay		12.3			30.6		14.9	21.6		15.9	21.8	
LOS		B			C		B	C		B	C	
Approach Delay		12.3			30.6			20.5			21.2	
Approach LOS		B			C			C			C	

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 80
Offset: 23 (29%), Referenced to phase 2:WBTL and 6:EBTL, Start of Green
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 0.91
Intersection Signal Delay: 19.9 Intersection LOS: B
Intersection Capacity Utilization 92.9% ICU Level of Service F
Analysis Period (min) 15

Splits and Phases: 104: E Hastings & Nanaimo St

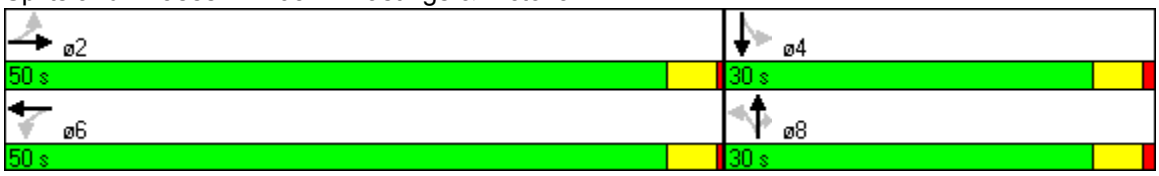


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	5060	0	1770	3522	0	0	1840	1583	0	3434	0
Flt Permitted	0.248			0.094				0.869			0.773	
Satd. Flow (perm)	462	5060	0	175	3522	0	0	1619	1583	0	2700	0
Satd. Flow (RTOR)		10			7				24		13	
Volume (vph)	26	1495	48	78	831	28	48	148	258	82	139	20
Lane Group Flow (vph)	28	1677	0	85	933	0	0	213	280	0	262	0
Turn Type	Perm			Perm			Perm		Perm	Perm		
Protected Phases		2			6			8			4	
Permitted Phases	2			6			8		8	4		
Total Split (s)	50.0	50.0	0.0	50.0	50.0	0.0	30.0	30.0	30.0	30.0	30.0	0.0
Act Effct Green (s)	46.0	46.0		46.0	46.0			26.0	26.0		26.0	
Actuated g/C Ratio	0.58	0.58		0.58	0.58			0.32	0.32		0.32	
v/c Ratio	0.11	0.58		0.84	0.46			0.40	0.53		0.30	
Control Delay	3.1	3.4		49.9	4.3			26.5	26.3		20.2	
Queue Delay	0.0	0.0		0.0	0.0			0.0	0.0		0.0	
Total Delay	3.1	3.4		49.9	4.3			26.5	26.3		20.2	
LOS	A	A		D	A			C	C		C	
Approach Delay		3.4			8.1			26.4			20.2	
Approach LOS		A			A			C			C	

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 80
Offset: 65 (81%), Referenced to phase 2:EBTL and 6:WBTL, Start of Green
Control Type: Pretimed
Maximum v/c Ratio: 0.84
Intersection Signal Delay: 9.3 Intersection LOS: A
Intersection Capacity Utilization 67.3% ICU Level of Service C
Analysis Period (min) 15

Splits and Phases: 105: E Hastings & Victoria Dr



Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	5033	0	1770	3524	0	1770	1709	0	1770	1814	0
Flt Permitted	0.332			0.100			0.577			0.493		
Satd. Flow (perm)	606	5033	0	185	3524	0	965	1709	0	890	1814	0
Satd. Flow (RTOR)		10			4			45			6	
Volume (vph)	62	1422	62	116	768	16	52	138	93	84	161	16
Lane Group Flow (vph)	67	1613	0	126	852	0	57	251	0	91	192	0
Turn Type	Perm			pm+pt			Perm			Perm		
Protected Phases		2		1	6			8			4	
Permitted Phases	2			6			8			4		
Total Split (s)	40.0	40.0	0.0	10.0	50.0	0.0	30.0	30.0	0.0	30.0	30.0	0.0
Act Effct Green (s)	38.0	38.0		46.0	46.0		26.0	26.0		26.0	26.0	
Actuated g/C Ratio	0.48	0.48		0.58	0.58		0.32	0.32		0.32	0.32	
v/c Ratio	0.23	0.67		0.56	0.42		0.18	0.43		0.31	0.32	
Control Delay	10.3	10.8		23.1	17.4		18.4	17.9		24.1	21.6	
Queue Delay	0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0	
Total Delay	10.3	10.8		23.1	17.4		18.4	17.9		24.1	21.6	
LOS	B	B		C	B		B	B		C	C	
Approach Delay		10.7			18.1			18.0			22.4	
Approach LOS		B			B			B			C	

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 80
Offset: 50 (63%), Referenced to phase 2:EBTL and 6:WBTL, Start of Green
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 0.67
Intersection Signal Delay: 14.7 Intersection LOS: B
Intersection Capacity Utilization 68.1% ICU Level of Service C
Analysis Period (min) 15

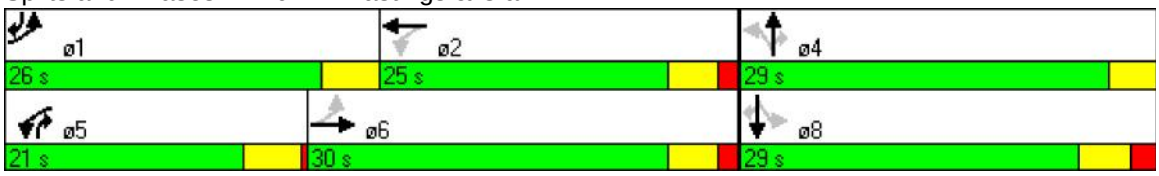
Splits and Phases: 106: E Hastings & Commercial Dr

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	5024	0	1770	3522	0	0	3522	1583	0	3518	1583
Flt Permitted	0.160			0.190				0.802			0.701	
Satd. Flow (perm)	298	5024	0	354	3522	0	0	2838	1583	0	2481	1583
Satd. Flow (RTOR)		18			4				8			33
Volume (vph)	128	1078	92	275	627	23	71	604	277	54	402	32
Lane Group Flow (vph)	139	1272	0	299	707	0	0	734	301	0	496	35
Turn Type	pm+pt			pm+pt			Perm		pm+ov	Perm		pm+ov
Protected Phases	1	6		5	2			4	5		8	1
Permitted Phases	6			2			4		4	8		8
Total Split (s)	26.0	30.0	0.0	21.0	25.0	0.0	29.0	29.0	21.0	29.0	29.0	26.0
Act Effct Green (s)	35.7	27.4		47.0	36.7			25.0	44.6		25.0	37.4
Actuated g/C Ratio	0.45	0.34		0.59	0.46			0.31	0.56		0.31	0.47
v/c Ratio	0.48	0.74		0.62	0.44			0.83	0.34		0.64	0.05
Control Delay	16.1	26.2		9.9	16.1			35.6	26.9		28.2	4.5
Queue Delay	0.0	0.0		0.0	0.0			0.0	0.0		0.0	0.0
Total Delay	16.1	26.2		9.9	16.1			35.6	26.9		28.2	4.5
LOS	B	C		A	B			D	C		C	A
Approach Delay		25.2			14.2			33.0			26.6	
Approach LOS		C			B			C			C	

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 80
Offset: 26 (33%), Referenced to phase 2:WBTL and 6:EBTL, Start of Green
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 0.83
Intersection Signal Delay: 24.7 Intersection LOS: C
Intersection Capacity Utilization 88.5% ICU Level of Service E
Analysis Period (min) 15

Splits and Phases: 107: E Hastings & Clark Dr

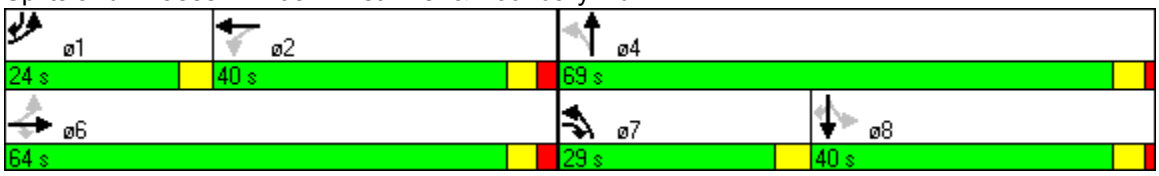


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	1863	1583	1770	1844	0	0	4964	0	0	3536	1583
Flt Permitted	0.162			0.553				0.676			0.877	
Satd. Flow (perm)	302	1863	1583	1030	1844	0	0	3410	0	0	3104	1583
Satd. Flow (RTOR)			37		3			9				228
Volume (vph)	400	319	241	73	343	25	366	668	61	19	626	348
Lane Group Flow (vph)	435	347	262	79	400	0	0	1190	0	0	701	378
Turn Type	pm+pt		pm+ov	Perm			pm+pt			Perm		pm+ov
Protected Phases	1	6	7		2		7	4			8	1
Permitted Phases	6		6	2			4			8		8
Total Split (s)	24.0	64.0	29.0	40.0	40.0	0.0	29.0	69.0	0.0	40.0	40.0	24.0
Act Effct Green (s)	53.9	53.9	66.2	29.3	29.3			45.7			33.3	58.0
Actuated g/C Ratio	0.50	0.50	0.61	0.27	0.27			0.42			0.31	0.54
v/c Ratio	1.01	0.37	0.27	0.28	0.80			1.71dl			0.73	0.39
Control Delay	74.5	19.7	10.5	36.6	50.3			28.3			37.8	6.8
Queue Delay	0.0	0.0	0.0	0.0	0.0			0.0			0.0	0.0
Total Delay	74.5	19.7	10.5	36.6	50.3			28.3			37.8	6.8
LOS	E	B	B	D	D			C			D	A
Approach Delay		40.2			48.0			28.3			27.0	
Approach LOS		D			D			C			C	

Intersection Summary

Cycle Length: 133
Actuated Cycle Length: 107.8
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 1.01
Intersection Signal Delay: 33.7 Intersection LOS: C
Intersection Capacity Utilization 94.6% ICU Level of Service F
Analysis Period (min) 15
dl Defacto Left Lane. Recode with 1 though lane as a left lane.

Splits and Phases: 108: E 1st Ave. & Boundary Rd

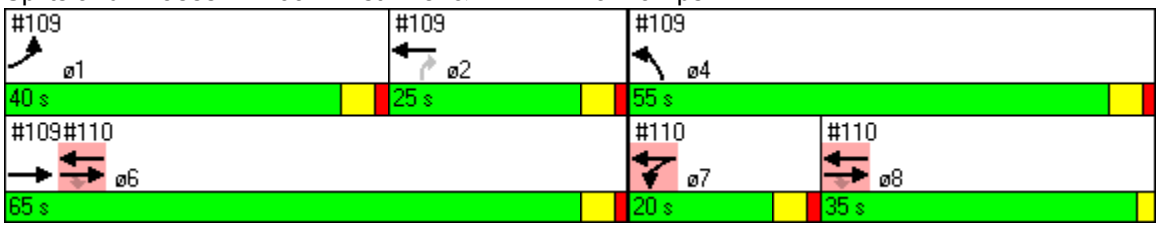


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	3539	0	0	5085	1583	3433	0	1583	0	0	0
Flt Permitted	0.950						0.950					
Satd. Flow (perm)	1770	3539	0	0	5085	1583	3433	0	1583	0	0	0
Satd. Flow (RTOR)						101			35			
Volume (vph)	366	837	0	0	684	294	969	0	81	0	0	0
Lane Group Flow (vph)	398	910	0	0	743	320	1053	0	88	0	0	0
Turn Type	Prot					Free	Prot		custom			
Protected Phases	1	6			2		4					
Permitted Phases						Free			2			
Total Split (s)	40.0	65.0	0.0	0.0	25.0	0.0	55.0	0.0	25.0	0.0	0.0	0.0
Act Effct Green (s)	36.0	61.0			21.0	120.0	51.0		21.0			
Actuated g/C Ratio	0.30	0.51			0.18	1.00	0.42		0.18			
v/c Ratio	0.75	0.51			0.83	0.20	0.72		0.29			
Control Delay	44.3	17.3			57.2	0.3	32.1		29.7			
Queue Delay	21.1	0.6			0.6	0.0	0.1		0.0			
Total Delay	65.5	17.9			57.8	0.3	32.2		29.7			
LOS	E	B			E	A	C		C			
Approach Delay		32.4			40.5							
Approach LOS		C			D							

Intersection Summary

Cycle Length: 120
Actuated Cycle Length: 120
Offset: 0 (0%), Referenced to phase 2:WBT and 6:EBT, Start of Green
Control Type: Pretimed
Maximum v/c Ratio: 0.98
Intersection Signal Delay: 34.7 Intersection LOS: C
Intersection Capacity Utilization 123.3% ICU Level of Service H
Analysis Period (min) 15

Splits and Phases: 109: E 1st Ave. & HW1 WB on ramps



Lane Group	ø7	ø8
Lane Configurations		
Total Lost Time (s)		
Satd. Flow (prot)		
Flt Permitted		
Satd. Flow (perm)		
Satd. Flow (RTOR)		
Volume (vph)		
Lane Group Flow (vph)		
Turn Type		
Protected Phases	7	8
Permitted Phases		
Total Split (s)	20.0	35.0
Act Effct Green (s)		
Actuated g/C Ratio		
v/c Ratio		
Control Delay		
Queue Delay		
Total Delay		
LOS		
Approach Delay		
Approach LOS		

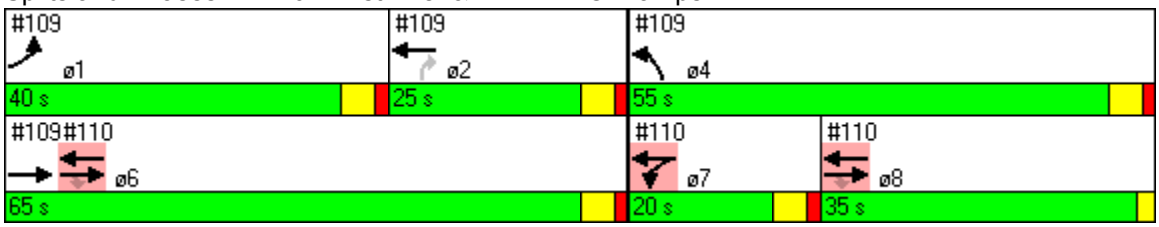
Intersection Summary

Lane Group	EBT	EBR	WBL	WBT	NBL	NBR	ø1	ø2	ø4	ø6	ø8
Lane Configurations											
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0					
Satd. Flow (prot)	5085	1583	1770	5085	0	0					
Flt Permitted			0.950								
Satd. Flow (perm)	5085	1583	1770	5085	0	0					
Satd. Flow (RTOR)		190									
Volume (vph)	1304	1170	164	1689	0	0					
Lane Group Flow (vph)	1417	1272	178	1836	0	0					
Turn Type		Perm	Prot								
Protected Phases	6 8		7	6 7 8			1	2	4	6	8
Permitted Phases		6 8									
Total Split (s)	100.0	100.0	20.0	120.0	0.0	0.0	40.0	25.0	55.0	65.0	35.0
Act Effct Green (s)	96.0	96.0	16.0	120.0							
Actuated g/C Ratio	0.80	0.80	0.13	1.00							
v/c Ratio	0.35	0.98	0.75	0.36							
Control Delay	3.6	30.5	62.8	0.2							
Queue Delay	0.0	0.0	4.0	0.0							
Total Delay	3.6	30.5	66.8	0.2							
LOS	A	C	E	A							
Approach Delay	16.3			6.1							
Approach LOS	B			A							

Intersection Summary

Cycle Length: 120
Actuated Cycle Length: 120
Offset: 0 (0%), Referenced to phase 2:WBT and 6:EBT, Start of Green
Control Type: Pretimed
Maximum v/c Ratio: 0.98
Intersection Signal Delay: 11.9 Intersection LOS: B
Intersection Capacity Utilization 123.3% ICU Level of Service H
Analysis Period (min) 15

Splits and Phases: 110: E 1st Ave. & HW1 EB On ramps

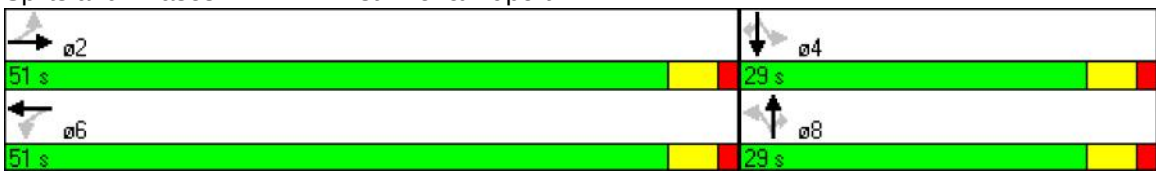


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	0	5070	0	0	3532	0	1770	1513	1504	1770	3539	1583
Flt Permitted		0.898			0.670		0.421			0.492		
Satd. Flow (perm)	0	4553	0	0	2371	0	784	1513	1504	916	3539	1583
Satd. Flow (RTOR)		7						10	10			21
Volume (vph)	12	1862	41	62	1573	0	175	7	417	113	398	103
Lane Group Flow (vph)	0	2082	0	0	1777	0	190	234	227	123	433	112
Turn Type	Perm			Perm			Perm		Perm	Perm		Perm
Protected Phases		2			6			8			4	
Permitted Phases	2			6			8		8	4		4
Total Split (s)	51.0	51.0	0.0	51.0	51.0	0.0	29.0	29.0	29.0	29.0	29.0	29.0
Act Effct Green (s)		47.0			47.0		25.0	25.0	25.0	25.0	25.0	25.0
Actuated g/C Ratio		0.59			0.59		0.31	0.31	0.31	0.31	0.31	0.31
v/c Ratio		0.78			1.28		0.78	0.49	0.48	0.43	0.39	0.22
Control Delay		5.3			150.1		48.9	25.5	25.2	27.6	22.8	17.8
Queue Delay		0.0			0.0		0.0	0.0	0.0	0.0	0.0	0.0
Total Delay		5.3			150.1		48.9	25.5	25.2	27.6	22.8	17.8
LOS		A			F		D	C	C	C	C	B
Approach Delay		5.3			150.1			32.2			22.9	
Approach LOS		A			F			C			C	

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 80
Offset: 9 (11%), Referenced to phase 2:EBTL and 6:WBTL, Start of Green
Control Type: Pretimed
Maximum v/c Ratio: 1.28
Intersection Signal Delay: 60.6 Intersection LOS: E
Intersection Capacity Utilization 116.4% ICU Level of Service H
Analysis Period (min) 15

Splits and Phases: 111: E 1st Ave. & Rupert

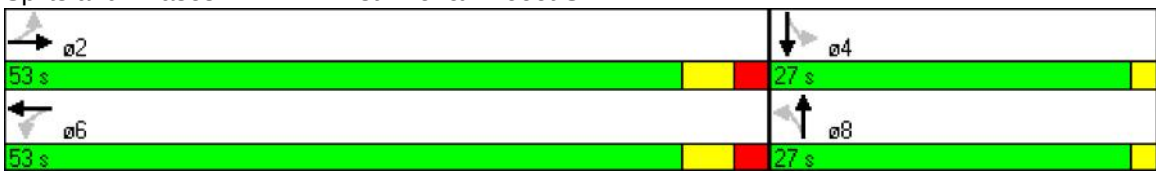


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	0	1859	0	0	1857	0	0	1743	0	0	1721	0
Flt Permitted		0.953			0.959			0.957			0.937	
Satd. Flow (perm)	0	1773	0	0	1783	0	0	1694	0	0	1641	0
Satd. Flow (RTOR)		1			2			9			14	
Volume (vph)	26	1982	17	19	1794	28	7	8	9	17	10	21
Lane Group Flow (vph)	0	2200	0	0	2001	0	0	27	0	0	52	0
Turn Type	Perm			Perm			Perm			Perm		
Protected Phases		2			6			8			4	
Permitted Phases	2			6			8			4		
Total Split (s)	53.0	53.0	0.0	53.0	53.0	0.0	27.0	27.0	0.0	27.0	27.0	0.0
Act Effct Green (s)		49.0			49.0			23.0			23.0	
Actuated g/C Ratio		0.61			0.61			0.29			0.29	
v/c Ratio		2.03			1.83			0.05			0.11	
Control Delay		477.8			396.9			16.2			17.3	
Queue Delay		0.0			0.0			0.0			0.0	
Total Delay		477.8			396.9			16.2			17.3	
LOS		F			F			B			B	
Approach Delay		477.8			396.9			16.2			17.3	
Approach LOS		F			F			B			B	

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 80
Offset: 67 (84%), Referenced to phase 2:EBTL and 6:WBTL, Start of Green
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 2.03
Intersection Signal Delay: 431.5 Intersection LOS: F
Intersection Capacity Utilization 131.9% ICU Level of Service H
Analysis Period (min) 15

Splits and Phases: 112: E 1st Ave. & Lillooet ST

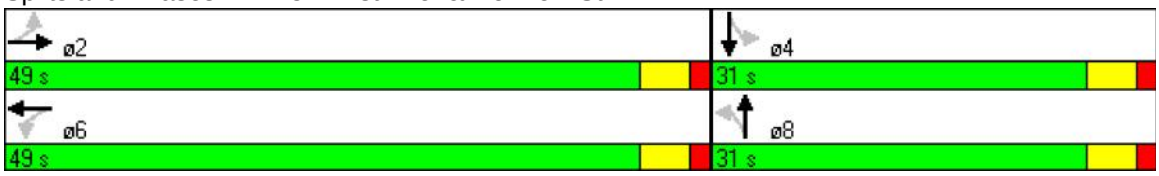


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	1855	0	1770	1848	0	1770	3476	0	1770	3500	0
Flt Permitted	0.089			0.135			0.292			0.196		
Satd. Flow (perm)	166	1855	0	251	1848	0	544	3476	0	365	3500	0
Satd. Flow (RTOR)		2			6			14			11	
Volume (vph)	56	1648	40	77	1549	87	70	639	89	71	536	42
Lane Group Flow (vph)	61	1834	0	84	1779	0	76	792	0	77	629	0
Turn Type	Perm			Perm			Perm			Perm		
Protected Phases		2			6			8			4	
Permitted Phases	2			6			8			4		
Total Split (s)	49.0	49.0	0.0	49.0	49.0	0.0	31.0	31.0	0.0	31.0	31.0	0.0
Act Effct Green (s)	45.0	45.0		45.0	45.0		27.0	27.0		27.0	27.0	
Actuated g/C Ratio	0.56	0.56		0.56	0.56		0.34	0.34		0.34	0.34	
v/c Ratio	0.66	1.76		0.60	1.71		0.41	0.67		0.63	0.53	
Control Delay	14.1	357.3		24.5	342.1		28.9	25.6		46.7	25.1	
Queue Delay	0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0	
Total Delay	14.1	357.3		24.5	342.1		28.9	25.6		46.7	25.1	
LOS	B	F		C	F		C	C		D	C	
Approach Delay		346.3			327.8			25.9			27.5	
Approach LOS		F			F			C			C	

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 80
Offset: 43 (54%), Referenced to phase 2:EBTL and 6:WBTL, Start of Green
Control Type: Pretimed
Maximum v/c Ratio: 1.76
Intersection Signal Delay: 245.4 Intersection LOS: F
Intersection Capacity Utilization 123.6% ICU Level of Service H
Analysis Period (min) 15

Splits and Phases: 113: E 1st Ave. & Renfrew St

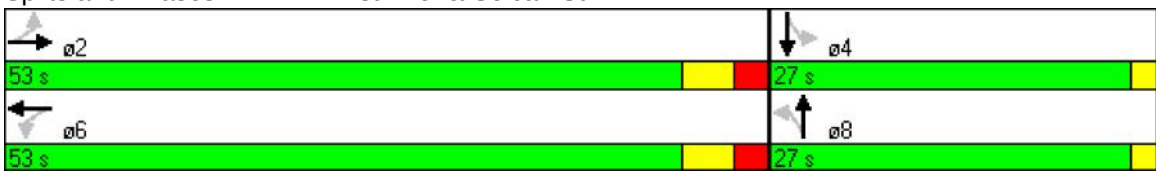


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	0	1861	0	0	1861	0	0	1745	0	0	1724	0
Flt Permitted		0.974			0.987			0.971			0.992	
Satd. Flow (perm)	0	1812	0	0	1837	0	0	1711	0	0	1717	0
Satd. Flow (RTOR)		1			1			16			20	
Volume (vph)	16	1740	8	7	1573	16	7	15	15	3	14	18
Lane Group Flow (vph)	0	1917	0	0	1735	0	0	40	0	0	38	0
Turn Type	Perm			Perm			Perm			Perm		
Protected Phases		2			6			8			4	
Permitted Phases	2			6			8			4		
Total Split (s)	53.0	53.0	0.0	53.0	53.0	0.0	27.0	27.0	0.0	27.0	27.0	0.0
Act Effct Green (s)		49.0			49.0			23.0			23.0	
Actuated g/C Ratio		0.61			0.61			0.29			0.29	
v/c Ratio		1.73			1.54			0.08			0.07	
Control Delay		343.1			268.0			15.1			13.5	
Queue Delay		0.0			0.0			0.0			0.0	
Total Delay		343.1			268.0			15.1			13.5	
LOS		F			F			B			B	
Approach Delay		343.1			268.0			15.1			13.5	
Approach LOS		F			F			B			B	

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 80
Offset: 16 (20%), Referenced to phase 2:EBTL and 6:WBTL, Start of Green
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 1.73
Intersection Signal Delay: 301.3 Intersection LOS: F
Intersection Capacity Utilization 113.7% ICU Level of Service H
Analysis Period (min) 15

Splits and Phases: 114: E 1st Ave. & Solcan St

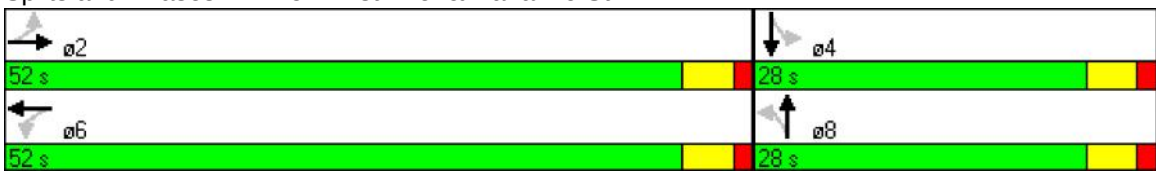


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	1853	0	1770	1850	0	1770	3497	0	1770	5024	0
Flt Permitted	0.083			0.117			0.219			0.167		
Satd. Flow (perm)	155	1853	0	218	1850	0	408	3497	0	311	5024	0
Satd. Flow (RTOR)		4			5			12			19	
Volume (vph)	72	1764	63	77	1490	73	54	722	65	80	714	64
Lane Group Flow (vph)	78	1985	0	84	1699	0	59	856	0	87	846	0
Turn Type	Perm			Perm			Perm			Perm		
Protected Phases		2			6			8			4	
Permitted Phases	2			6			8			4		
Total Split (s)	52.0	52.0	0.0	52.0	52.0	0.0	28.0	28.0	0.0	28.0	28.0	0.0
Act Effct Green (s)	48.0	48.0		48.0	48.0		24.0	24.0		24.0	24.0	
Actuated g/C Ratio	0.60	0.60		0.60	0.60		0.30	0.30		0.30	0.30	
v/c Ratio	0.84	1.78		0.64	1.53		0.48	0.81		0.94	0.56	
Control Delay	25.2	370.1		10.3	254.4		38.7	32.8		108.8	24.8	
Queue Delay	0.0	0.0		0.0	73.9		670.9	0.0		0.0	1.7	
Total Delay	25.2	370.1		10.3	328.3		709.7	32.8		108.8	26.5	
LOS	C	F		B	F		F	C		F	C	
Approach Delay		357.0			313.3			76.5			34.1	
Approach LOS		F			F			E			C	

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 80
Offset: 60 (75%), Referenced to phase 2:EBTL and 6:WBTL, Start of Green
Control Type: Pretimed
Maximum v/c Ratio: 1.78
Intersection Signal Delay: 245.3 Intersection LOS: F
Intersection Capacity Utilization 133.1% ICU Level of Service H
Analysis Period (min) 15

Splits and Phases: 115: E 1st Ave. & Nanaimo St

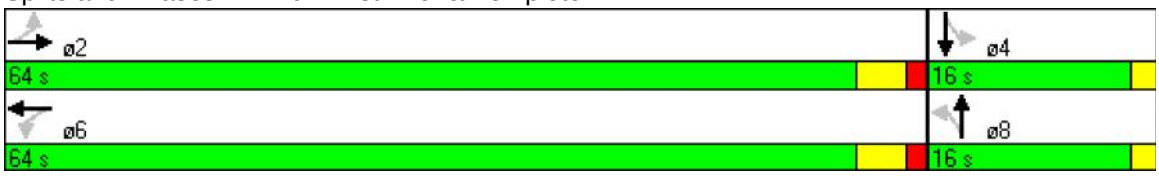


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	0	1863	0	0	1861	0	0	1653	0	0	1662	0
Flt Permitted		0.992			0.984			0.990				
Satd. Flow (perm)	0	1848	0	0	1831	0	0	1645	0	0	1662	0
Satd. Flow (RTOR)		1			1			8			12	
Volume (vph)	7	1869	6	8	1563	7	1	1	7	0	3	11
Lane Group Flow (vph)	0	2047	0	0	1716	0	0	10	0	0	15	0
Turn Type	Perm			Perm			Perm			Perm		
Protected Phases		2			6			8			4	
Permitted Phases	2			6			8			4		
Total Split (s)	64.0	64.0	0.0	64.0	64.0	0.0	16.0	16.0	0.0	16.0	16.0	0.0
Act Effct Green (s)		60.0			60.0			12.0			12.0	
Actuated g/C Ratio		0.75			0.75			0.15			0.15	
v/c Ratio		1.48			1.25			0.04			0.06	
Control Delay		229.4			133.6			19.2			18.1	
Queue Delay		0.0			55.4			0.1			0.1	
Total Delay		229.4			189.0			19.3			18.3	
LOS		F			F			B			B	
Approach Delay		229.4			189.0			19.3			18.3	
Approach LOS		F			F			B			B	

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 80
Offset: 35 (44%), Referenced to phase 2:EBTL and 6:WBTL, Start of Green
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 1.48
Intersection Signal Delay: 209.7 Intersection LOS: F
Intersection Capacity Utilization 113.6% ICU Level of Service H
Analysis Period (min) 15

Splits and Phases: 116: E 1st Ave. & Templeton Dr

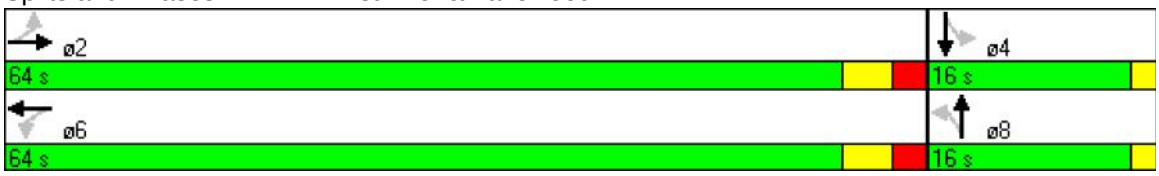


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	0	1863	0	0	1861	0	0	1700	0	0	1665	0
Flt Permitted		0.987			0.996			0.981			0.973	
Satd. Flow (perm)	0	1839	0	0	1853	0	0	1679	0	0	1638	0
Satd. Flow (RTOR)					1			12			10	
Volume (vph)	11	1788	5	3	1444	12	3	5	11	3	1	9
Lane Group Flow (vph)	0	1960	0	0	1586	0	0	20	0	0	14	0
Turn Type	Perm			Perm			Perm			Perm		
Protected Phases		2			6			8			4	
Permitted Phases	2			6			8			4		
Total Split (s)	64.0	64.0	0.0	64.0	64.0	0.0	16.0	16.0	0.0	16.0	16.0	0.0
Act Effct Green (s)		60.0			60.0			12.0			12.0	
Actuated g/C Ratio		0.75			0.75			0.15			0.15	
v/c Ratio		1.42			1.14			0.08			0.06	
Control Delay		206.0			75.2			20.1			19.5	
Queue Delay		126.5			26.2			539.8			454.3	
Total Delay		332.5			101.4			559.9			473.8	
LOS		F			F			F			F	
Approach Delay		332.5			101.4			559.9			473.8	
Approach LOS		F			F			F			F	

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 80
Offset: 32 (40%), Referenced to phase 2:EBTL and 6:WBTL, Start of Green
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 1.42
Intersection Signal Delay: 231.9 Intersection LOS: F
Intersection Capacity Utilization 112.7% ICU Level of Service H
Analysis Period (min) 15

Splits and Phases: 117: E 1st Ave. & Lakewood Dr

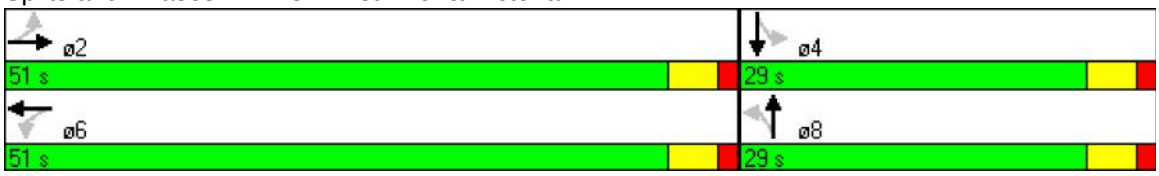


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	0	1855	0	0	1831	0	0	3472	0	0	3483	0
Flt Permitted		0.933			0.998			0.899			0.713	
Satd. Flow (perm)	0	1733	0	0	1827	0	0	3131	0	0	2511	0
Satd. Flow (RTOR)		2			16			16			5	
Volume (vph)	39	1591	34	2	1277	183	19	310	39	146	486	23
Lane Group Flow (vph)	0	1808	0	0	1589	0	0	400	0	0	712	0
Turn Type	Perm			Perm			Perm			Perm		
Protected Phases		2			6			8			4	
Permitted Phases	2			6			8			4		
Total Split (s)	51.0	51.0	0.0	51.0	51.0	0.0	29.0	29.0	0.0	29.0	29.0	0.0
Act Effct Green (s)		47.0			47.0			25.0			25.0	
Actuated g/C Ratio		0.59			0.59			0.31			0.31	
v/c Ratio		1.77			1.47			0.40			0.90	
Control Delay		366.4			236.6			14.6			44.0	
Queue Delay		0.0			0.0			0.0			0.0	
Total Delay		366.4			236.6			14.6			44.0	
LOS		F			F			B			D	
Approach Delay		366.4			236.6			14.6			44.0	
Approach LOS		F			F			B			D	

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 80
Offset: 12 (15%), Referenced to phase 2:EBTL and 6:WBTL, Start of Green
Control Type: Pretimed
Maximum v/c Ratio: 1.77
Intersection Signal Delay: 238.5 Intersection LOS: F
Intersection Capacity Utilization 154.8% ICU Level of Service H
Analysis Period (min) 15

Splits and Phases: 118: E 1st Ave. & Victoria Dr

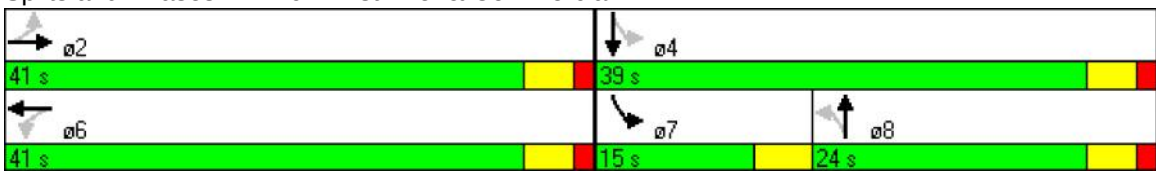


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	1846	0	1770	1822	0	1770	3051	0	1770	3407	0
Flt Permitted	0.108			0.108			0.440			0.307		
Satd. Flow (perm)	201	1846	0	201	1822	0	574	3051	0	445	3407	0
Satd. Flow (RTOR)		2			5			34			8	
Volume (vph)	21	1390	35	57	1102	62	45	333	79	288	496	24
Lane Group Flow (vph)	23	1549	0	62	1265	0	49	448	0	313	565	0
Turn Type	Perm			Perm			Perm			pm+pt		
Protected Phases		2			6			8		7	4	
Permitted Phases	2			6			8			4		
Total Split (s)	41.0	41.0	0.0	41.0	41.0	0.0	24.0	24.0	0.0	15.0	39.0	0.0
Act Effct Green (s)	39.4	39.4		39.4	39.4		17.6	17.6		32.6	32.6	
Actuated g/C Ratio	0.49	0.49		0.49	0.49		0.22	0.22		0.41	0.41	
v/c Ratio	0.23	1.70		0.63	1.41		0.39	0.64		0.86	0.41	
Control Delay	14.0	336.4		38.1	213.1		23.4	20.3		40.7	15.6	
Queue Delay	0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0	
Total Delay	14.0	336.4		38.1	213.1		23.4	20.3		40.7	15.6	
LOS	B	F		D	F		C	C		D	B	
Approach Delay		331.7			205.0			20.6			24.6	
Approach LOS		F			F			C			C	

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 80
Offset: 74 (93%), Referenced to phase 2:EBTL and 6:WBTL, Start of Green
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 1.70
Intersection Signal Delay: 193.1 Intersection LOS: F
Intersection Capacity Utilization 114.9% ICU Level of Service H
Analysis Period (min) 15

Splits and Phases: 119: E 1st Ave. & Commercial Dr

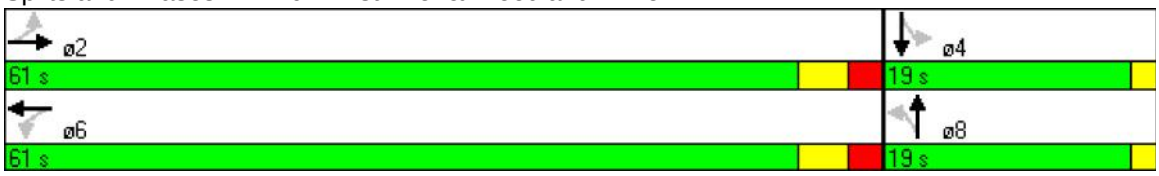


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	0	1859	0	0	1853	0	0	1738	0	0	1826	0
Flt Permitted		0.988			0.838			0.993			0.933	
Satd. Flow (perm)	0	1837	0	0	1558	0	0	1731	0	0	1728	0
Satd. Flow (RTOR)		2			2			28			3	
Volume (vph)	12	1393	22	61	1043	13	3	26	26	17	39	3
Lane Group Flow (vph)	0	1551	0	0	1214	0	0	59	0	0	63	0
Turn Type	Perm			Perm			Perm			Perm		
Protected Phases		2			6			8			4	
Permitted Phases	2			6			8			4		
Total Split (s)	61.0	61.0	0.0	61.0	61.0	0.0	19.0	19.0	0.0	19.0	19.0	0.0
Act Effct Green (s)		57.0			57.0			15.0			15.0	
Actuated g/C Ratio		0.71			0.71			0.19			0.19	
v/c Ratio		1.18			1.09			0.17			0.19	
Control Delay		103.9			67.1			18.4			28.2	
Queue Delay		0.0			0.0			0.0			0.0	
Total Delay		103.9			67.1			18.4			28.2	
LOS		F			E			B			C	
Approach Delay		103.9			67.1			18.4			28.2	
Approach LOS		F			E			B			C	

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 80
Offset: 53 (66%), Referenced to phase 2:EBTL and 6:WBTL, Start of Green
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 1.18
Intersection Signal Delay: 85.0 Intersection LOS: F
Intersection Capacity Utilization 111.6% ICU Level of Service H
Analysis Period (min) 15

Splits and Phases: 120: E 1st Ave. & Woodland Drive

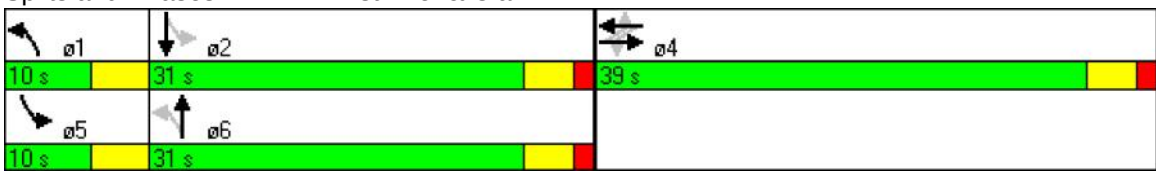


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	0	3398	0	0	3493	0	1770	4917	0	1770	5019	0
Flt Permitted		0.954					0.148			0.148		
Satd. Flow (perm)	0	3241	0	0	3493	0	276	4917	0	276	5019	0
Satd. Flow (RTOR)		81			16			63			20	
Volume (vph)	1	899	325	0	951	91	167	1055	298	202	1132	104
Lane Group Flow (vph)	0	1331	0	0	1133	0	182	1471	0	220	1343	0
Turn Type	Perm			Perm			pm+pt			pm+pt		
Protected Phases		4			4		1	6		5	2	
Permitted Phases	4			4			6			2		
Total Split (s)	39.0	39.0	0.0	39.0	39.0	0.0	10.0	31.0	0.0	10.0	31.0	0.0
Act Effct Green (s)		35.2			35.2		32.8	26.8		32.8	26.8	
Actuated g/C Ratio		0.44			0.44		0.41	0.34		0.41	0.34	
v/c Ratio		0.90			0.73		0.81	0.87		0.98	0.79	
Control Delay		30.1			26.5		43.4	30.8		71.4	23.9	
Queue Delay		3.5			0.0		0.0	0.0		17.7	0.0	
Total Delay		33.6			26.5		43.4	30.8		89.0	23.9	
LOS		C			C		D	C		F	C	
Approach Delay		33.6			26.5			32.2			33.1	
Approach LOS		C			C			C			C	

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 80
Offset: 34 (43%), Referenced to phase 4:EBWB, Start of Green
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 0.98
Intersection Signal Delay: 31.6 Intersection LOS: C
Intersection Capacity Utilization 84.2% ICU Level of Service E
Analysis Period (min) 15

Splits and Phases: 121: E 1st Ave. & Clark Dr

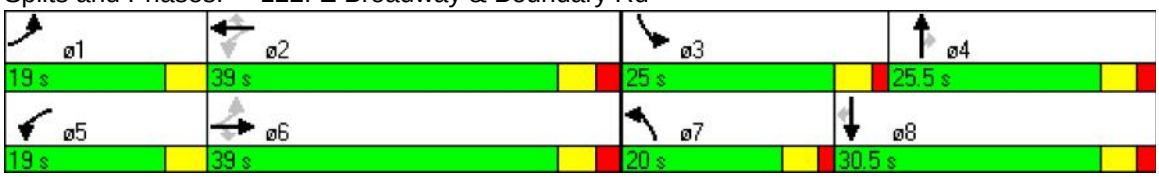


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	3539	1583	1770	3539	1583	3433	3539	1583	1770	3539	1583
Flt Permitted	0.114			0.114			0.950			0.950		
Satd. Flow (perm)	212	3539	1583	212	3539	1583	3433	3539	1583	1770	3539	1583
Satd. Flow (RTOR)			209			125			104			253
Volume (vph)	236	892	192	199	967	118	357	604	101	240	585	233
Lane Group Flow (vph)	257	970	209	216	1051	128	388	657	110	261	636	253
Turn Type	pm+pt		Perm	pm+pt		Perm	Prot		Perm	Prot		Perm
Protected Phases	1	6		5	2		7	4		3	8	
Permitted Phases	6		6	2		2			4			8
Total Split (s)	19.0	39.0	39.0	19.0	39.0	39.0	20.0	25.5	25.5	25.0	30.5	30.5
Act Effct Green (s)	48.7	34.9	34.9	46.5	33.8	33.8	15.3	21.3	21.3	19.0	25.0	25.0
Actuated g/C Ratio	0.47	0.34	0.34	0.45	0.32	0.32	0.15	0.20	0.20	0.18	0.24	0.24
v/c Ratio	0.84	0.82	0.31	0.76	0.91	0.21	0.77	0.91	0.27	0.81	0.75	0.44
Control Delay	49.1	39.1	5.1	40.1	47.2	6.1	54.7	59.2	10.2	61.0	43.3	6.9
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	49.1	39.1	5.1	40.1	47.2	6.1	54.7	59.2	10.2	61.0	43.3	6.9
LOS	D	D	A	D	D	A	D	E	B	E	D	A
Approach Delay		35.9			42.3			53.0			39.3	
Approach LOS		D			D			D			D	

Intersection Summary

Cycle Length: 108.5
Actuated Cycle Length: 104
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 0.91
Intersection Signal Delay: 42.3 Intersection LOS: D
Intersection Capacity Utilization 83.1% ICU Level of Service E
Analysis Period (min) 15

Splits and Phases: 122: E Broadway & Boundary Rd

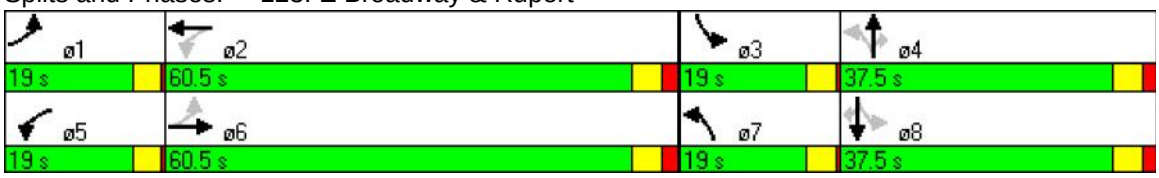


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	4912	0	1770	5055	0	1770	3539	1583	1770	3539	1583
Flt Permitted	0.108			0.071			0.281			0.294		
Satd. Flow (perm)	201	4912	0	132	5055	0	523	3539	1583	548	3539	1583
Satd. Flow (RTOR)		67			5				216			80
Volume (vph)	125	1194	351	223	1172	46	217	443	199	45	458	83
Lane Group Flow (vph)	136	1680	0	242	1324	0	236	482	216	49	498	90
Turn Type	pm+pt			pm+pt			pm+pt		Perm	pm+pt		Perm
Protected Phases	1	6		5	2		7	4		3	8	
Permitted Phases	6			2			4		4	8		8
Total Split (s)	19.0	60.5	0.0	19.0	60.5	0.0	19.0	37.5	37.5	19.0	37.5	37.5
Act Effct Green (s)	66.7	56.6		74.9	61.5		43.5	33.7	33.7	32.6	24.7	24.7
Actuated g/C Ratio	0.52	0.45		0.59	0.48		0.34	0.27	0.27	0.25	0.19	0.19
v/c Ratio	0.59	0.76		0.89	0.54		0.73	0.51	0.37	0.23	0.72	0.24
Control Delay	25.7	31.5		66.0	24.9		45.9	42.6	6.7	30.8	54.4	12.6
Queue Delay	0.0	0.0		0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	25.7	31.5		66.0	24.9		45.9	42.6	6.7	30.8	54.4	12.6
LOS	C	C		E	C		D	D	A	C	D	B
Approach Delay		31.0			31.2			35.1			46.7	
Approach LOS		C			C			D			D	

Intersection Summary

Cycle Length: 136
Actuated Cycle Length: 127.1
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 0.89
Intersection Signal Delay: 33.9 Intersection LOS: C
Intersection Capacity Utilization 81.3% ICU Level of Service D
Analysis Period (min) 15

Splits and Phases: 123: E Broadway & Rupert

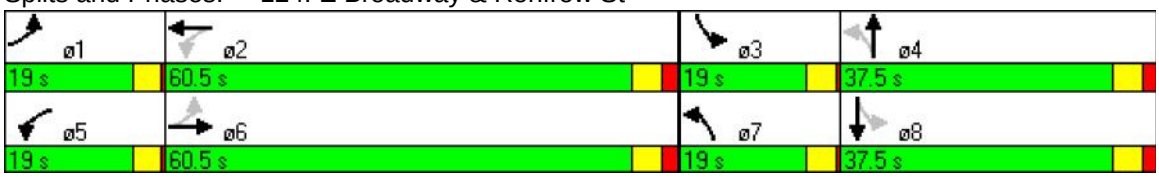


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	5019	0	1770	5029	0	1770	3429	0	1770	3465	0
Flt Permitted	0.071			0.071			0.165			0.119		
Satd. Flow (perm)	132	5019	0	132	5029	0	307	3429	0	222	3465	0
Satd. Flow (RTOR)		13			11			23			13	
Volume (vph)	202	1442	132	148	1475	112	154	581	155	135	510	85
Lane Group Flow (vph)	220	1710	0	161	1725	0	167	800	0	147	646	0
Turn Type	pm+pt			pm+pt			pm+pt			pm+pt		
Protected Phases	1	6		5	2		7	4		3	8	
Permitted Phases	6			2			4			8		
Total Split (s)	19.0	60.5	0.0	19.0	60.5	0.0	19.0	37.5	0.0	19.0	37.5	0.0
Act Effct Green (s)	67.0	53.1		62.9	51.0		44.1	31.5		43.0	31.0	
Actuated g/C Ratio	0.54	0.43		0.50	0.41		0.35	0.25		0.34	0.25	
v/c Ratio	0.86	0.80		0.72	0.84		0.65	0.91		0.65	0.74	
Control Delay	64.4	35.1		47.8	37.8		40.4	59.8		43.1	49.6	
Queue Delay	0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0	
Total Delay	64.4	35.1		47.8	37.8		40.4	59.8		43.1	49.6	
LOS	E	D		D	D		D	E		D	D	
Approach Delay		38.5			38.7			56.4			48.4	
Approach LOS		D			D			E			D	

Intersection Summary

Cycle Length: 136
Actuated Cycle Length: 124.9
Control Type: Semi Act-Uncoord
Maximum v/c Ratio: 0.91
Intersection Signal Delay: 43.1 Intersection LOS: D
Intersection Capacity Utilization 84.0% ICU Level of Service E
Analysis Period (min) 15

Splits and Phases: 124: E Broadway & Renfrew St

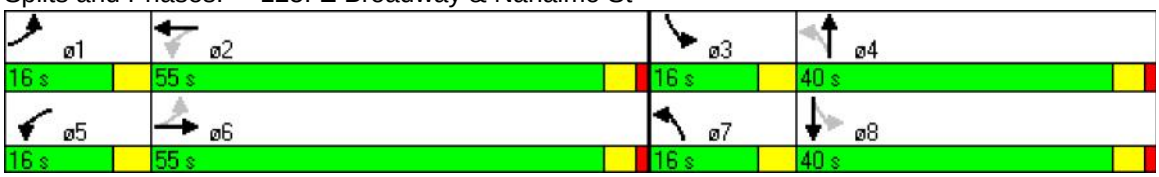


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	5045	0	1770	5050	0	1770	4953	0	1770	4887	0
Flt Permitted	0.078			0.078			0.181			0.199		
Satd. Flow (perm)	145	5045	0	145	5050	0	337	4953	0	371	4887	0
Satd. Flow (RTOR)		8			7			34			70	
Volume (vph)	167	1486	81	141	1582	79	87	627	129	121	587	208
Lane Group Flow (vph)	182	1703	0	153	1806	0	95	822	0	132	864	0
Turn Type	pm+pt			pm+pt			pm+pt			pm+pt		
Protected Phases	1	6		5	2		7	4		3	8	
Permitted Phases	6			2			4			8		
Total Split (s)	16.0	55.0	0.0	16.0	55.0	0.0	16.0	40.0	0.0	16.0	40.0	0.0
Act Effct Green (s)	63.2	52.2		61.4	51.3		34.9	25.5		37.7	28.9	
Actuated g/C Ratio	0.55	0.46		0.54	0.45		0.30	0.22		0.33	0.25	
v/c Ratio	0.77	0.74		0.69	0.80		0.44	0.73		0.53	0.67	
Control Delay	47.0	29.1		39.3	31.4		31.9	43.5		33.7	38.8	
Queue Delay	0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0	
Total Delay	47.0	29.1		39.3	31.4		31.9	43.5		33.7	38.8	
LOS	D	C		D	C		C	D		C	D	
Approach Delay		30.8			32.0			42.3			38.1	
Approach LOS		C			C			D			D	

Intersection Summary

Cycle Length: 127
Actuated Cycle Length: 114.3
Control Type: Semi Act-Uncoord
Maximum v/c Ratio: 0.80
Intersection Signal Delay: 34.3 Intersection LOS: C
Intersection Capacity Utilization 76.6% ICU Level of Service D
Analysis Period (min) 15

Splits and Phases: 125: E Broadway & Nanaimo St



Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	5070	0	1770	5055	0	1770	1863	1583	1770	1837	0
Flt Permitted	0.087			0.126			0.245			0.488		
Satd. Flow (perm)	162	5070	0	235	5055	0	456	1863	1583	909	1837	0
Satd. Flow (RTOR)		6			12				36		7	
Volume (vph)	78	1340	27	101	1588	62	37	235	109	211	367	38
Lane Group Flow (vph)	85	1486	0	110	1793	0	40	255	118	229	440	0
Turn Type	Perm			Perm			Perm		Perm	Perm		
Protected Phases		2			6			8			4	
Permitted Phases	2			6			8		8	4		
Total Split (s)	50.0	50.0	0.0	50.0	50.0	0.0	30.0	30.0	30.0	30.0	30.0	0.0
Act Effct Green (s)	46.0	46.0		46.0	46.0		26.0	26.0	26.0	26.0	26.0	
Actuated g/C Ratio	0.58	0.58		0.58	0.58		0.32	0.32	0.32	0.32	0.32	
v/c Ratio	0.91	0.51		0.81	0.62		0.27	0.42	0.22	0.78	0.73	
Control Delay	85.3	4.3		60.9	12.2		25.9	23.8	15.1	56.1	48.3	
Queue Delay	0.0	0.0		0.0	0.0		0.0	0.0	0.0	0.0	0.0	
Total Delay	85.3	4.3		60.9	12.2		25.9	23.8	15.1	56.1	48.3	
LOS	F	A		E	B		C	C	B	E	D	
Approach Delay		8.6			15.1			21.5			51.0	
Approach LOS		A			B			C			D	

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 80
Offset: 47 (59%), Referenced to phase 2:EBTL and 6:WBTL, Start of Green
Control Type: Pretimed
Maximum v/c Ratio: 0.91
Intersection Signal Delay: 18.7 Intersection LOS: B
Intersection Capacity Utilization 74.7% ICU Level of Service D
Analysis Period (min) 15

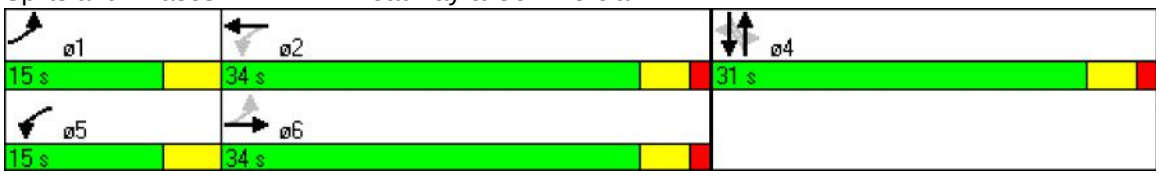
Splits and Phases: 126: E Broadway & Victoria Dr

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	5050	0	1770	5055	0	0	4969	0	0	4999	0
Flt Permitted	0.133			0.133				0.784			0.832	
Satd. Flow (perm)	248	5050	0	248	5055	0	0	3927	0	0	4184	0
Satd. Flow (RTOR)		11			8			25			18	
Volume (vph)	86	1375	70	82	1346	53	70	337	44	61	446	41
Lane Group Flow (vph)	93	1571	0	89	1521	0	0	490	0	0	596	0
Turn Type	pm+pt			pm+pt			Perm			Perm		
Protected Phases	1	6		5	2			4			4	
Permitted Phases	6			2			4			4		
Total Split (s)	15.0	34.0	0.0	15.0	34.0	0.0	31.0	31.0	0.0	31.0	31.0	0.0
Act Effct Green (s)	52.0	46.1		53.8	47.0			15.9			15.9	
Actuated g/C Ratio	0.65	0.58		0.67	0.59			0.20			0.20	
v/c Ratio	0.32	0.54		0.28	0.51			0.61			0.70	
Control Delay	7.7	12.6		12.5	17.8			30.8			42.4	
Queue Delay	0.0	0.0		0.0	0.0			0.0			0.0	
Total Delay	7.7	12.6		12.5	17.8			30.8			42.4	
LOS	A	B		B	B			C			D	
Approach Delay		12.3			17.5			30.8			42.4	
Approach LOS		B			B			C			D	

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 80
Offset: 47 (59%), Referenced to phase 2:WBTL and 6:EBTL, Start of Green
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 0.70
Intersection Signal Delay: 20.4 Intersection LOS: C
Intersection Capacity Utilization 65.7% ICU Level of Service C
Analysis Period (min) 15

Splits and Phases: 127: E Broadway & Commercial Dr

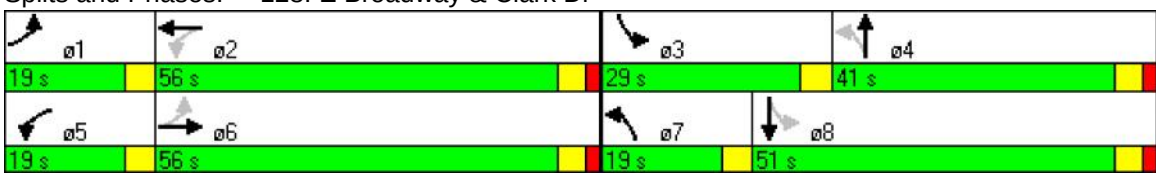


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	5040	0	1770	4979	0	1770	4943	0	1770	5014	0
Flt Permitted	0.077			0.077			0.108			0.098		
Satd. Flow (perm)	143	5040	0	143	4979	0	201	4943	0	183	5014	0
Satd. Flow (RTOR)		8			24			35			12	
Volume (vph)	112	1286	82	181	1148	189	71	767	178	372	1215	121
Lane Group Flow (vph)	122	1487	0	197	1453	0	77	1027	0	404	1453	0
Turn Type	pm+pt			pm+pt			pm+pt			pm+pt		
Protected Phases	1	6		5	2		7	4		3	8	
Permitted Phases	6			2			4			8		
Total Split (s)	19.0	56.0	0.0	19.0	56.0	0.0	19.0	41.0	0.0	29.0	51.0	0.0
Act Effct Green (s)	63.2	52.1		69.0	55.1		43.7	34.7		63.7	52.9	
Actuated g/C Ratio	0.45	0.37		0.49	0.39		0.30	0.24		0.45	0.37	
v/c Ratio	0.64	0.80		0.85	0.75		0.48	0.83		1.12	0.77	
Control Delay	41.9	44.6		65.1	40.4		35.6	56.0		122.9	43.3	
Queue Delay	0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0	
Total Delay	41.9	44.6		65.1	40.4		35.6	56.0		122.9	43.3	
LOS	D	D		E	D		D	E		F	D	
Approach Delay		44.4			43.3			54.5			60.6	
Approach LOS		D			D			D			E	

Intersection Summary

Cycle Length: 145
Actuated Cycle Length: 142
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 1.12
Intersection Signal Delay: 50.8 Intersection LOS: D
Intersection Capacity Utilization 89.4% ICU Level of Service E
Analysis Period (min) 15

Splits and Phases: 128: E Broadway & Clark Dr



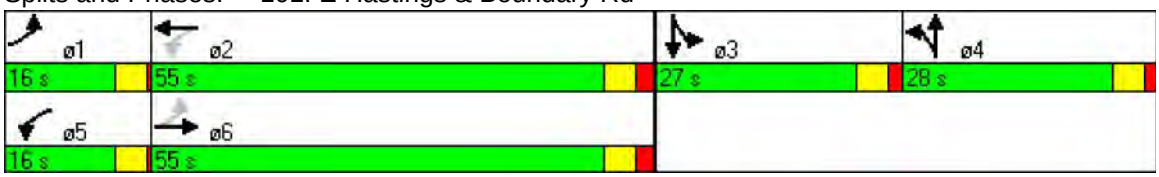
Appendix D – Scenario 2 Synchro Output Files (AM and PM)

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	3398	0	1770	5070	0	1610	3163	0	1770	3405	0
Flt Permitted	0.096			0.286			0.950	0.975		0.950		
Satd. Flow (perm)	179	3398	0	533	5070	0	1610	3163	0	1770	3405	0
Satd. Flow (RTOR)		50			3			39			33	
Volume (vph)	30	451	165	210	1231	27	362	71	102	11	198	68
Lane Group Flow (vph)	33	669	0	228	1367	0	197	384	0	12	289	0
Turn Type	pm+pt			pm+pt			Split			Split		
Protected Phases	1	6		5	2		4	4		3	3	
Permitted Phases	6			2								
Total Split (s)	16.0	55.0	0.0	16.0	55.0	0.0	28.0	28.0	0.0	27.0	27.0	0.0
Act Effct Green (s)	32.1	25.6		40.7	35.1		16.8	16.8		13.1	13.1	
Actuated g/C Ratio	0.37	0.31		0.49	0.42		0.20	0.20		0.16	0.16	
v/c Ratio	0.18	0.62		0.54	0.64		0.61	0.57		0.04	0.51	
Control Delay	15.3	25.6		18.4	22.4		42.7	33.0		37.8	35.0	
Queue Delay	0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0	
Total Delay	15.3	25.6		18.4	22.4		42.7	33.0		37.8	35.0	
LOS	B	C		B	C		D	C		D	C	
Approach Delay		25.1			21.8			36.3			35.1	
Approach LOS		C			C			D			D	

Intersection Summary

Cycle Length: 126
Actuated Cycle Length: 83.5
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 0.64
Intersection Signal Delay: 26.4 Intersection LOS: C
Intersection Capacity Utilization 60.9% ICU Level of Service B
Analysis Period (min) 15

Splits and Phases: 101: E Hastings & Boundary Rd

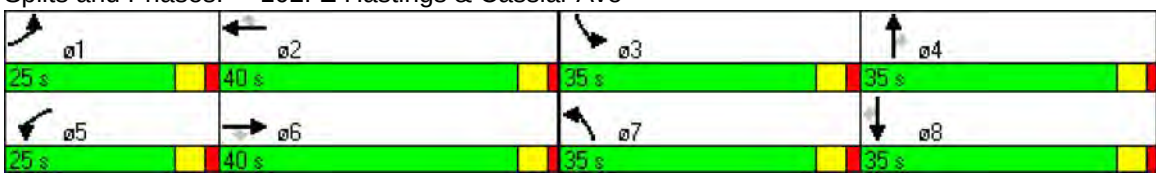


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	3539	1583	1770	5085	1583	3433	3539	1583	3433	3539	1583
Flt Permitted	0.950			0.950			0.950			0.950		
Satd. Flow (perm)	1770	3539	1583	1770	5085	1583	3433	3539	1583	3433	3539	1583
Satd. Flow (RTOR)			346			20			23			107
Volume (vph)	78	376	318	85	1136	27	597	225	21	368	46	98
Lane Group Flow (vph)	85	409	346	92	1235	29	649	245	23	400	50	107
Turn Type	Prot		Perm	Prot		Perm	Prot		Perm	Prot		Perm
Protected Phases	1	6		5	2		7	4		3	8	
Permitted Phases			6			2			4			8
Total Split (s)	25.0	40.0	40.0	25.0	40.0	40.0	35.0	35.0	35.0	35.0	35.0	35.0
Act Effct Green (s)	10.9	30.0	30.0	11.2	30.3	30.3	22.5	14.1	14.1	17.5	8.7	8.7
Actuated g/C Ratio	0.13	0.36	0.36	0.13	0.37	0.37	0.27	0.17	0.17	0.21	0.10	0.10
v/c Ratio	0.37	0.32	0.43	0.39	0.66	0.05	0.69	0.41	0.08	0.55	0.14	0.41
Control Delay	44.8	23.7	4.9	44.8	27.1	13.1	34.0	37.6	15.6	36.8	42.8	14.6
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	44.8	23.7	4.9	44.8	27.1	13.1	34.0	37.6	15.6	36.8	42.8	14.6
LOS	D	C	A	D	C	B	C	D	B	D	D	B
Approach Delay		18.1			28.0			34.5			33.1	
Approach LOS		B			C			C			C	

Intersection Summary

Cycle Length: 135
Actuated Cycle Length: 82.4
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 0.69
Intersection Signal Delay: 28.1 Intersection LOS: C
Intersection Capacity Utilization 60.8% ICU Level of Service B
Analysis Period (min) 15

Splits and Phases: 102: E Hastings & Cassiar Ave

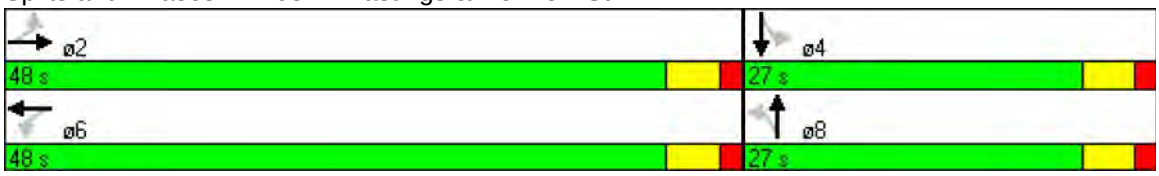


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	3483	0	1770	4928	0	0	4949	0	0	3451	0
Flt Permitted	0.091			0.364				0.858			0.631	
Satd. Flow (perm)	170	3483	0	678	4928	0	0	4272	0	0	2218	0
Satd. Flow (RTOR)		29			147			43			7	
Volume (vph)	39	553	64	69	1309	337	55	362	68	119	185	16
Lane Group Flow (vph)	42	671	0	75	1789	0	0	527	0	0	347	0
Turn Type	Perm			Perm			Perm			Perm		
Protected Phases		2			6			8			4	
Permitted Phases	2			6			8			4		
Total Split (s)	48.0	48.0	0.0	48.0	48.0	0.0	27.0	27.0	0.0	27.0	27.0	0.0
Act Effct Green (s)	44.0	44.0		44.0	44.0			23.0			23.0	
Actuated g/C Ratio	0.59	0.59		0.59	0.59			0.31			0.31	
v/c Ratio	0.42	0.33		0.19	0.61			0.39			0.51	
Control Delay	39.7	20.0		8.7	10.1			19.8			24.0	
Queue Delay	0.0	0.0		0.0	0.0			0.0			0.0	
Total Delay	39.7	20.0		8.7	10.1			19.8			24.0	
LOS	D	C		A	B			B			C	
Approach Delay		21.2			10.0			19.8			24.0	
Approach LOS		C			B			B			C	

Intersection Summary

Cycle Length: 75
Actuated Cycle Length: 75
Offset: 43 (57%), Referenced to phase 2:EBTL and 6:WBTL, Start of Green
Control Type: Pretimed
Maximum v/c Ratio: 0.61
Intersection Signal Delay: 15.2 Intersection LOS: B
Intersection Capacity Utilization 70.7% ICU Level of Service C
Analysis Period (min) 15

Splits and Phases: 103: E Hastings & Renfrew St

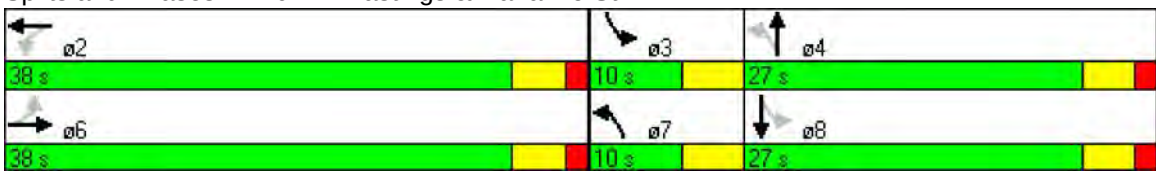


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	0	3506	0	0	5070	0	1770	5041	0	1770	4672	0
Flt Permitted		0.887			0.933		0.395			0.429		
Satd. Flow (perm)	0	3113	0	0	4730	0	714	5041	0	790	4672	0
Satd. Flow (RTOR)		8			4			10			57	
Volume (vph)	17	551	28	12	1331	19	177	429	20	45	315	180
Lane Group Flow (vph)	0	647	0	0	1481	0	192	488	0	49	538	0
Turn Type	Perm			Perm			pm+pt			pm+pt		
Protected Phases		6			2		7	4		3	8	
Permitted Phases	6			2			4			8		
Total Split (s)	38.0	38.0	0.0	38.0	38.0	0.0	10.0	27.0	0.0	10.0	27.0	0.0
Act Effct Green (s)		34.0			34.0		30.6	27.0		28.9	23.0	
Actuated g/C Ratio		0.45			0.45		0.41	0.36		0.39	0.31	
v/c Ratio		0.46			0.69		0.51	0.27		0.13	0.37	
Control Delay		5.2			12.7		19.3	18.2		13.1	18.9	
Queue Delay		0.0			0.0		0.0	0.0		0.0	0.0	
Total Delay		5.2			12.7		19.3	18.2		13.1	18.9	
LOS		A			B		B	B		B	B	
Approach Delay		5.2			12.7			18.5			18.4	
Approach LOS		A			B			B			B	

Intersection Summary

Cycle Length: 75
Actuated Cycle Length: 75
Offset: 20 (27%), Referenced to phase 2:WBTL and 6:EBTL, Start of Green
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 0.69
Intersection Signal Delay: 13.4 Intersection LOS: B
Intersection Capacity Utilization 71.8% ICU Level of Service C
Analysis Period (min) 15

Splits and Phases: 104: E Hastings & Nanaimo St

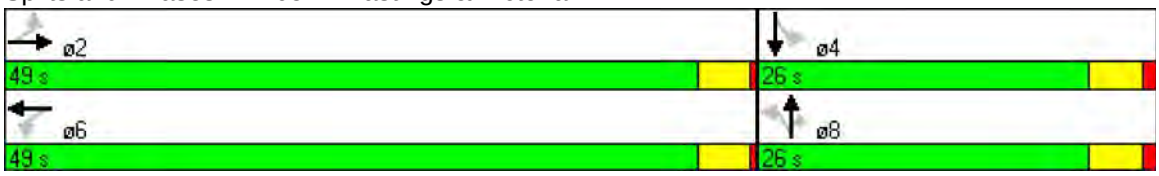


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	3525	0	1770	5055	0	0	1844	1583	0	3409	0
Flt Permitted	0.098			0.436				0.924			0.884	
Satd. Flow (perm)	183	3525	0	812	5055	0	0	1721	1583	0	3044	0
Satd. Flow (RTOR)		6			13				103		23	
Volume (vph)	21	483	12	131	1498	57	37	148	95	24	73	21
Lane Group Flow (vph)	23	538	0	142	1690	0	0	201	103	0	128	0
Turn Type	Perm			Perm			Perm		Perm	Perm		
Protected Phases		2			6			8			4	
Permitted Phases	2			6			8		8	4		
Total Split (s)	49.0	49.0	0.0	49.0	49.0	0.0	26.0	26.0	26.0	26.0	26.0	0.0
Act Effct Green (s)	45.0	45.0		45.0	45.0			22.0	22.0		22.0	
Actuated g/C Ratio	0.60	0.60		0.60	0.60			0.29	0.29		0.29	
v/c Ratio	0.21	0.25		0.29	0.56			0.40	0.19		0.14	
Control Delay	29.3	21.0		5.0	4.5			24.1	5.7		16.5	
Queue Delay	0.0	0.0		0.0	0.0			0.0	0.0		0.0	
Total Delay	29.3	21.0		5.0	4.5			24.1	5.7		16.5	
LOS	C	C		A	A			C	A		B	
Approach Delay		21.3			4.5			17.9			16.5	
Approach LOS		C			A			B			B	

Intersection Summary

Cycle Length: 75
Actuated Cycle Length: 75
Offset: 54 (72%), Referenced to phase 2:EBTL and 6:WBTL, Start of Green
Control Type: Pretimed
Maximum v/c Ratio: 0.56
Intersection Signal Delay: 9.8 Intersection LOS: A
Intersection Capacity Utilization 65.0% ICU Level of Service C
Analysis Period (min) 15

Splits and Phases: 105: E Hastings & Victoria Dr



Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	3493	0	1770	5072	0	1770	1756	0	1770	1740	0
Flt Permitted	0.129			0.327			0.643			0.619		
Satd. Flow (perm)	240	3493	0	600	5072	0	1118	1756	0	1125	1740	0
Satd. Flow (RTOR)		10			4			32			17	
Volume (vph)	21	495	30	71	1502	19	71	110	48	13	110	32
Lane Group Flow (vph)	23	571	0	77	1654	0	77	172	0	14	155	0
Turn Type	Perm			pm+pt			Perm			Perm		
Protected Phases		2		1	6			8			4	
Permitted Phases	2			6			8			4		
Total Split (s)	35.0	35.0	0.0	10.0	45.0	0.0	30.0	30.0	0.0	30.0	30.0	0.0
Act Effct Green (s)	33.0	33.0		41.0	41.0		26.0	26.0		26.0	26.0	
Actuated g/C Ratio	0.44	0.44		0.55	0.55		0.35	0.35		0.35	0.35	
v/c Ratio	0.22	0.37		0.18	0.60		0.20	0.27		0.04	0.25	
Control Delay	9.7	5.7		12.1	14.5		19.0	15.7		16.7	16.9	
Queue Delay	0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0	
Total Delay	9.7	5.7		12.1	14.5		19.0	15.7		16.7	16.9	
LOS	A	A		B	B		B	B		B	B	
Approach Delay		5.8			14.4			16.7			16.9	
Approach LOS		A			B			B			B	

Intersection Summary

Cycle Length: 75
Actuated Cycle Length: 75
Offset: 0 (0%), Referenced to phase 2:EBTL and 6:WBTL, Start of Green
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 0.60
Intersection Signal Delay: 12.9 Intersection LOS: B
Intersection Capacity Utilization 64.5% ICU Level of Service C
Analysis Period (min) 15

Splits and Phases: 106: E Hastings & Commercial Dr

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	3461	0	1770	5055	0	0	3497	1583	0	3529	1583
Flt Permitted	0.190			0.332				0.687			0.912	
Satd. Flow (perm)	354	3461	0	618	5055	0	0	2431	1583	0	3228	1583
Satd. Flow (RTOR)		25			8				127			2
Volume (vph)	61	412	70	369	1135	44	119	364	117	22	401	50
Lane Group Flow (vph)	66	524	0	401	1282	0	0	525	127	0	460	54
Turn Type	pm+pt			pm+pt			Perm		pm+ov	Perm		pm+ov
Protected Phases	1	6		5	2			4	5		8	1
Permitted Phases	6			2			4		4	8		8
Total Split (s)	21.0	25.0	0.0	21.0	25.0	0.0	29.0	29.0	21.0	29.0	29.0	21.0
Act Effct Green (s)	32.3	25.6		41.4	33.1			25.0	41.4		25.0	35.8
Actuated g/C Ratio	0.43	0.34		0.55	0.44			0.33	0.55		0.33	0.48
v/c Ratio	0.24	0.44		0.75	0.57			0.65	0.14		0.43	0.07
Control Delay	11.1	20.7		12.1	7.5			25.8	1.6		21.0	10.3
Queue Delay	0.0	0.0		0.0	0.0			0.0	0.0		0.0	0.0
Total Delay	11.1	20.7		12.1	7.5			25.8	1.6		21.0	10.3
LOS	B	C		B	A			C	A		C	B
Approach Delay		19.7			8.6			21.1			19.9	
Approach LOS		B			A			C			B	

Intersection Summary

Cycle Length: 75
Actuated Cycle Length: 75
Offset: 45 (60%), Referenced to phase 2:WBTL and 6:EBTL, Start of Green
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 0.75
Intersection Signal Delay: 14.6 Intersection LOS: B
Intersection Capacity Utilization 86.3% ICU Level of Service E
Analysis Period (min) 15

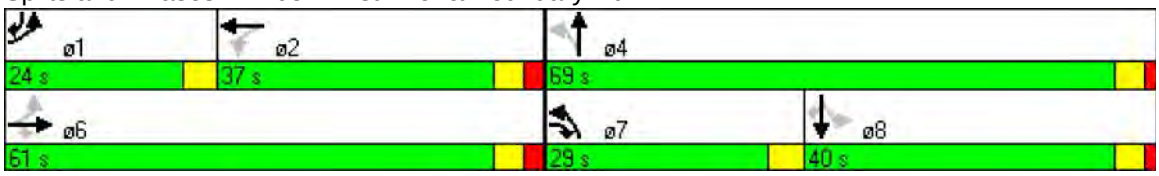
Splits and Phases: 107: E Hastings & Clark Dr

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	1863	1583	1770	1812	0	0	4939	0	0	3536	1583
Flt Permitted	0.150			0.577				0.697			0.905	
Satd. Flow (perm)	279	1863	1583	1075	1812	0	0	3502	0	0	3203	1583
Satd. Flow (RTOR)			18		8			15				207
Volume (vph)	268	276	432	50	292	64	294	489	66	20	768	279
Lane Group Flow (vph)	291	300	470	54	387	0	0	924	0	0	857	303
Turn Type	pm+pt		pm+ov	Perm			pm+pt			Perm		pm+ov
Protected Phases	1	6	7		2		7	4			8	1
Permitted Phases	6		6	2			4			8		8
Total Split (s)	24.0	61.0	29.0	37.0	37.0	0.0	29.0	69.0	0.0	40.0	40.0	24.0
Act Effct Green (s)	48.7	48.7	61.1	28.1	28.1			45.9			33.5	54.1
Actuated g/C Ratio	0.47	0.47	0.59	0.27	0.27			0.45			0.33	0.53
v/c Ratio	0.78	0.34	0.50	0.18	0.77			1.45dl			0.82	0.33
Control Delay	36.8	18.2	13.7	31.9	45.9			21.7			40.5	5.7
Queue Delay	0.0	0.0	0.0	0.0	0.0			0.0			0.0	0.0
Total Delay	36.8	18.2	13.7	31.9	45.9			21.7			40.5	5.7
LOS	D	B	B	C	D			C			D	A
Approach Delay		21.3			44.2			21.7			31.4	
Approach LOS		C			D			C			C	

Intersection Summary

Cycle Length: 130
Actuated Cycle Length: 102.8
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 0.82
Intersection Signal Delay: 27.5 Intersection LOS: C
Intersection Capacity Utilization 86.1% ICU Level of Service E
Analysis Period (min) 15
dl Defacto Left Lane. Recode with 1 though lane as a left lane.

Splits and Phases: 108: E 1st Ave. & Boundary Rd

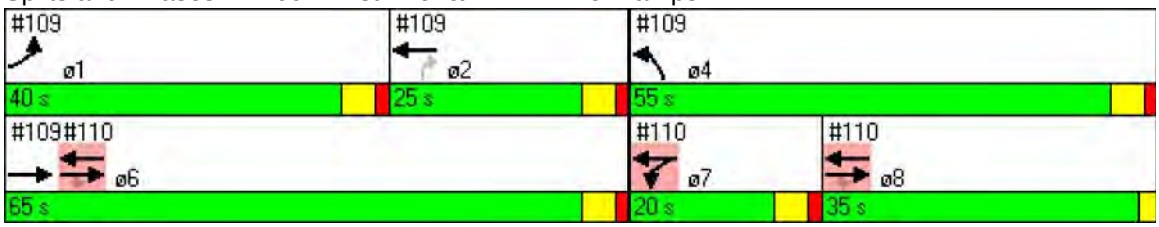


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	3539	0	0	5085	1583	3433	0	1583	0	0	0
Flt Permitted	0.950						0.950					
Satd. Flow (perm)	1770	3539	0	0	5085	1583	3433	0	1583	0	0	0
Satd. Flow (RTOR)						66			56			
Volume (vph)	238	827	0	0	596	167	1064	0	142	0	0	0
Lane Group Flow (vph)	259	899	0	0	648	182	1157	0	154	0	0	0
Turn Type	Prot					Free	Prot		custom			
Protected Phases	1	6			2		4					
Permitted Phases						Free			2			
Total Split (s)	40.0	65.0	0.0	0.0	25.0	0.0	55.0	0.0	25.0	0.0	0.0	0.0
Act Effct Green (s)	36.0	61.0			21.0	120.0	51.0		21.0			
Actuated g/C Ratio	0.30	0.51			0.18	1.00	0.42		0.18			
v/c Ratio	0.49	0.50			0.73	0.11	0.79		0.48			
Control Delay	34.9	17.4			52.3	0.1	34.9		33.5			
Queue Delay	4.3	0.6			0.0	0.0	0.0		0.0			
Total Delay	39.2	18.0			52.3	0.1	34.9		33.5			
LOS	D	B			D	A	C		C			
Approach Delay		22.8			40.8							
Approach LOS		C			D							

Intersection Summary

Cycle Length: 120
Actuated Cycle Length: 120
Offset: 0 (0%), Referenced to phase 2:WBT and 6:EBT, Start of Green
Control Type: Pretimed
Maximum v/c Ratio: 0.89
Intersection Signal Delay: 32.1 Intersection LOS: C
Intersection Capacity Utilization 120.6% ICU Level of Service H
Analysis Period (min) 15

Splits and Phases: 109: E 1st Ave. & HW1 WB on ramps



Lane Group	ø7	ø8
Lane Configurations		
Total Lost Time (s)		
Satd. Flow (prot)		
Flt Permitted		
Satd. Flow (perm)		
Satd. Flow (RTOR)		
Volume (vph)		
Lane Group Flow (vph)		
Turn Type		
Protected Phases	7	8
Permitted Phases		
Total Split (s)	20.0	35.0
Act Effct Green (s)		
Actuated g/C Ratio		
v/c Ratio		
Control Delay		
Queue Delay		
Total Delay		
LOS		
Approach Delay		
Approach LOS		

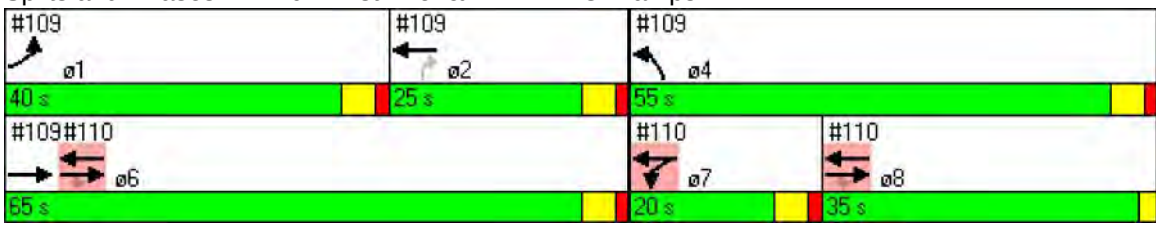
Intersection Summary

Lane Group	EBT	EBR	WBL	WBT	NBL	NBR	ø1	ø2	ø4	ø6	ø8
Lane Configurations											
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0					
Satd. Flow (prot)	5085	1583	1770	5085	0	0					
Flt Permitted			0.950								
Satd. Flow (perm)	5085	1583	1770	5085	0	0					
Satd. Flow (RTOR)		471									
Volume (vph)	1118	1110	80	1646	0	0					
Lane Group Flow (vph)	1215	1207	87	1789	0	0					
Turn Type		Perm	Prot								
Protected Phases	6 8		7	6 7 8			1	2	4	6	8
Permitted Phases		6 8									
Total Split (s)	100.0	100.0	20.0	120.0	0.0	0.0	40.0	25.0	55.0	65.0	35.0
Act Effct Green (s)	96.0	96.0	16.0	120.0							
Actuated g/C Ratio	0.80	0.80	0.13	1.00							
v/c Ratio	0.30	0.89	0.37	0.35							
Control Delay	3.4	14.6	52.1	0.2							
Queue Delay	0.0	0.0	0.0	0.0							
Total Delay	3.4	14.6	52.1	0.2							
LOS	A	B	D	A							
Approach Delay	9.0			2.6							
Approach LOS	A			A							

Intersection Summary

Cycle Length: 120
Actuated Cycle Length: 120
Offset: 0 (0%), Referenced to phase 2:WBT and 6:EBT, Start of Green
Control Type: Pretimed
Maximum v/c Ratio: 0.89
Intersection Signal Delay: 6.2 Intersection LOS: A
Intersection Capacity Utilization 120.6% ICU Level of Service H
Analysis Period (min) 15

Splits and Phases: 110: E 1st Ave. & HW1 EB On ramps

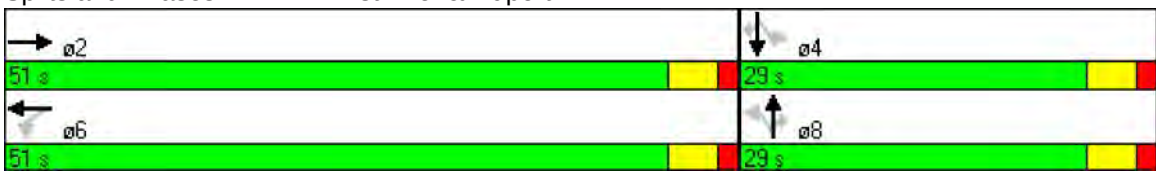


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	0	5070	0	0	3511	0	1770	1522	1504	1770	3539	1583
Flt Permitted					0.823		0.399			0.672		
Satd. Flow (perm)	0	5070	0	0	2892	0	743	1522	1504	1252	3539	1583
Satd. Flow (RTOR)		7			10			19	19			36
Volume (vph)	0	1615	37	39	1372	64	177	7	206	215	422	117
Lane Group Flow (vph)	0	1795	0	0	1603	0	192	120	112	234	459	127
Turn Type				Perm			Perm		Perm	Perm		Perm
Protected Phases		2			6			8			4	
Permitted Phases				6			8		8	4		4
Total Split (s)	0.0	51.0	0.0	51.0	51.0	0.0	29.0	29.0	29.0	29.0	29.0	29.0
Act Effct Green (s)		47.0			47.0		25.0	25.0	25.0	25.0	25.0	25.0
Actuated g/C Ratio		0.59			0.59		0.31	0.31	0.31	0.31	0.31	0.31
v/c Ratio		0.60			0.94		0.83	0.25	0.23	0.60	0.42	0.24
Control Delay		20.2			28.2		56.4	18.8	18.4	30.9	23.1	16.2
Queue Delay		0.0			0.0		0.0	0.0	0.0	0.0	0.0	0.0
Total Delay		20.2			28.2		56.4	18.8	18.4	30.9	23.1	16.2
LOS		C			C		E	B	B	C	C	B
Approach Delay		20.2			28.2			35.7			24.3	
Approach LOS		C			C			D			C	

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 80
Offset: 31 (39%), Referenced to phase 2:EBT and 6:WBTL, Start of Green
Control Type: Pretimed
Maximum v/c Ratio: 0.94
Intersection Signal Delay: 25.1 Intersection LOS: C
Intersection Capacity Utilization 99.7% ICU Level of Service F
Analysis Period (min) 15

Splits and Phases: 111: E 1st Ave. & Rupert

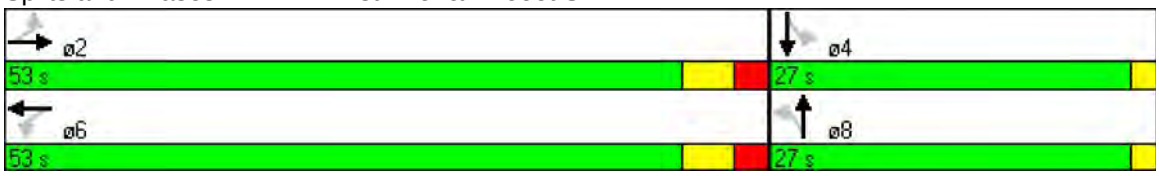


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	0	3539	0	0	3536	0	0	1650	0	0	1709	0
Flt Permitted		0.950			0.951			0.978			0.893	
Satd. Flow (perm)	0	3362	0	0	3362	0	0	1629	0	0	1562	0
Satd. Flow (RTOR)					1			18			15	
Volume (vph)	4	1628	3	4	1761	10	4	1	17	35	6	34
Lane Group Flow (vph)	0	1777	0	0	1929	0	0	23	0	0	82	0
Turn Type	Perm			Perm			Perm			Perm		
Protected Phases		2			6			8			4	
Permitted Phases	2			6			8			4		
Total Split (s)	53.0	53.0	0.0	53.0	53.0	0.0	27.0	27.0	0.0	27.0	27.0	0.0
Act Effct Green (s)		49.0			49.0			23.0			23.0	
Actuated g/C Ratio		0.61			0.61			0.29			0.29	
v/c Ratio		0.86			0.94			0.05			0.18	
Control Delay		29.0			13.4			11.6			19.2	
Queue Delay		0.0			0.0			0.0			0.0	
Total Delay		29.0			13.4			11.6			19.2	
LOS		C			B			B			B	
Approach Delay		29.0			13.4			11.6			19.2	
Approach LOS		C			B			B			B	

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 80
Offset: 56 (70%), Referenced to phase 2:EBTL and 6:WBTL, Start of Green
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 0.94
Intersection Signal Delay: 20.8 Intersection LOS: C
Intersection Capacity Utilization 67.8% ICU Level of Service C
Analysis Period (min) 15

Splits and Phases: 112: E 1st Ave. & Lillooet ST

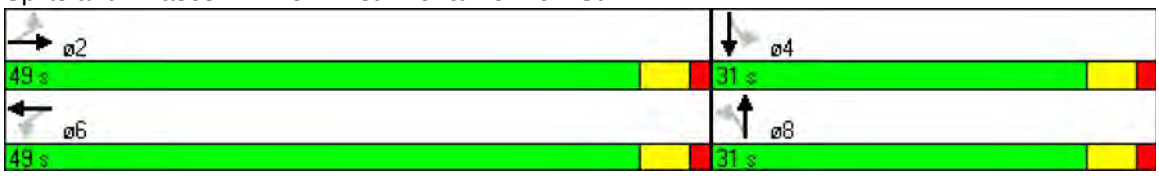


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	3518	0	1770	3504	0	1770	3497	0	1770	3479	0
Flt Permitted	0.089			0.089			0.325			0.347		
Satd. Flow (perm)	166	3518	0	166	3504	0	605	3497	0	646	3479	0
Satd. Flow (RTOR)		8			15			12			19	
Volume (vph)	50	1409	57	49	1523	111	91	465	39	91	470	62
Lane Group Flow (vph)	54	1594	0	53	1776	0	99	547	0	99	578	0
Turn Type	Perm			Perm			Perm			Perm		
Protected Phases		2			6			8			4	
Permitted Phases	2			6			8			4		
Total Split (s)	49.0	49.0	0.0	49.0	49.0	0.0	31.0	31.0	0.0	31.0	31.0	0.0
Act Effct Green (s)	45.0	45.0		45.0	45.0		27.0	27.0		27.0	27.0	
Actuated g/C Ratio	0.56	0.56		0.56	0.56		0.34	0.34		0.34	0.34	
v/c Ratio	0.58	0.80		0.57	0.90		0.49	0.46		0.45	0.49	
Control Delay	36.3	23.4		18.4	7.8		30.8	21.8		29.0	22.0	
Queue Delay	0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0	
Total Delay	36.3	23.4		18.4	7.8		30.8	21.8		29.0	22.0	
LOS	D	C		B	A		C	C		C	C	
Approach Delay		23.8			8.1			23.2			23.0	
Approach LOS		C			A			C			C	

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 80
Offset: 2 (3%), Referenced to phase 2:EBTL and 6:WBTL, Start of Green
Control Type: Pretimed
Maximum v/c Ratio: 0.90
Intersection Signal Delay: 17.6 Intersection LOS: B
Intersection Capacity Utilization 75.6% ICU Level of Service D
Analysis Period (min) 15

Splits and Phases: 113: E 1st Ave. & Renfrew St

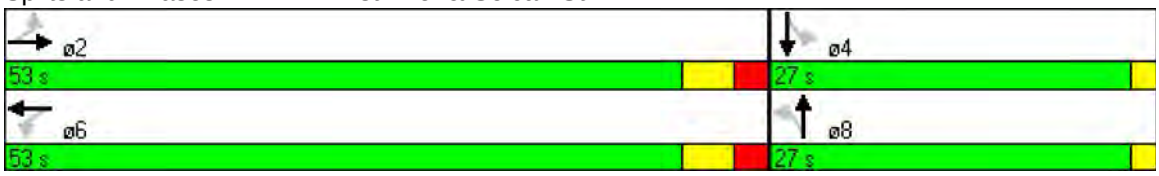


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	0	3539	0	0	3539	0	0	1708	0	0	1681	0
Flt Permitted		0.937			0.951			0.957			0.997	
Satd. Flow (perm)	0	3316	0	0	3366	0	0	1661	0	0	1679	0
Satd. Flow (RTOR)								12			15	
Volume (vph)	9	1536	3	4	1647	4	7	4	11	1	5	14
Lane Group Flow (vph)	0	1683	0	0	1798	0	0	24	0	0	21	0
Turn Type	Perm			Perm			Perm			Perm		
Protected Phases		2			6			8			4	
Permitted Phases	2			6			8			4		
Total Split (s)	53.0	53.0	0.0	53.0	53.0	0.0	27.0	27.0	0.0	27.0	27.0	0.0
Act Effct Green (s)		49.0			49.0			23.0			23.0	
Actuated g/C Ratio		0.61			0.61			0.29			0.29	
v/c Ratio		0.83			0.87			0.05			0.04	
Control Delay		11.3			8.0			14.5			12.5	
Queue Delay		0.0			0.0			0.0			0.0	
Total Delay		11.3			8.0			14.5			12.5	
LOS		B			A			B			B	
Approach Delay		11.3			8.0			14.5			12.5	
Approach LOS		B			A			B			B	

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 80
Offset: 30 (38%), Referenced to phase 2:EBTL and 6:WBTL, Start of Green
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 0.87
Intersection Signal Delay: 9.6 Intersection LOS: A
Intersection Capacity Utilization 59.5% ICU Level of Service B
Analysis Period (min) 15

Splits and Phases: 114: E 1st Ave. & Solcan St

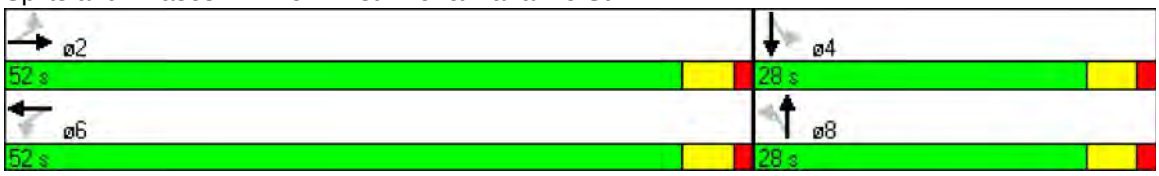


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	3525	0	1770	3525	0	1770	3493	0	1770	4994	0
Flt Permitted	0.083			0.083			0.339			0.223		
Satd. Flow (perm)	155	3525	0	155	3525	0	631	3493	0	415	4994	0
Satd. Flow (RTOR)		6			6			12			20	
Volume (vph)	45	1430	38	54	1613	44	93	582	54	49	498	70
Lane Group Flow (vph)	49	1595	0	59	1801	0	101	692	0	53	617	0
Turn Type	Perm			Perm			Perm			Perm		
Protected Phases		2			6			8			4	
Permitted Phases	2			6			8			4		
Total Split (s)	52.0	52.0	0.0	52.0	52.0	0.0	28.0	28.0	0.0	28.0	28.0	0.0
Act Effct Green (s)	48.0	48.0		48.0	48.0		24.0	24.0		24.0	24.0	
Actuated g/C Ratio	0.60	0.60		0.60	0.60		0.30	0.30		0.30	0.30	
v/c Ratio	0.53	0.75		0.63	0.85		0.53	0.66		0.42	0.41	
Control Delay	40.9	25.2		22.9	3.6		35.6	27.5		35.0	22.6	
Queue Delay	0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0	
Total Delay	40.9	25.2		22.9	3.6		35.6	27.5		35.0	22.6	
LOS	D	C		C	A		D	C		C	C	
Approach Delay		25.6			4.2			28.5			23.5	
Approach LOS		C			A			C			C	

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 80
Offset: 68 (85%), Referenced to phase 2:EBTL and 6:WBTL, Start of Green
Control Type: Pretimed
Maximum v/c Ratio: 0.85
Intersection Signal Delay: 17.8 Intersection LOS: B
Intersection Capacity Utilization 77.1% ICU Level of Service D
Analysis Period (min) 15

Splits and Phases: 115: E 1st Ave. & Nanaimo St

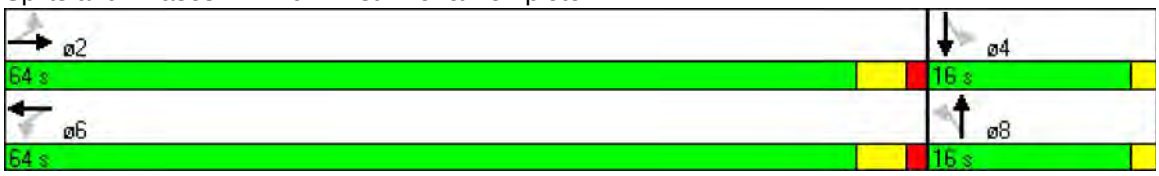


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	0	3539	0	0	3539	0	0	1657	0	0	1611	0
Flt Permitted					0.954			0.994				
Satd. Flow (perm)	0	3539	0	0	3376	0	0	1652	0	0	1611	0
Satd. Flow (RTOR)		1						12			36	
Volume (vph)	0	1510	5	2	1746	2	1	2	11	0	0	3
Lane Group Flow (vph)	0	1646	0	0	1902	0	0	15	0	0	3	0
Turn Type	Perm			Perm			Perm			Perm		
Protected Phases		2			6			8			4	
Permitted Phases	2			6			8			4		
Total Split (s)	64.0	64.0	0.0	64.0	64.0	0.0	16.0	16.0	0.0	16.0	16.0	0.0
Act Effct Green (s)		60.0			60.0			12.0			12.0	
Actuated g/C Ratio		0.75			0.75			0.15			0.15	
v/c Ratio		0.62			0.75			0.06			0.01	
Control Delay		2.9			2.5			18.1			0.0	
Queue Delay		0.1			0.0			0.0			0.0	
Total Delay		2.9			2.5			18.1			0.0	
LOS		A			A			B			A	
Approach Delay		2.9			2.5			18.1			0.0	
Approach LOS		A			A			B			A	

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 80
Offset: 76 (95%), Referenced to phase 2:EBTL and 6:WBTL, Start of Green
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 0.75
Intersection Signal Delay: 2.7 Intersection LOS: A
Intersection Capacity Utilization 59.7% ICU Level of Service B
Analysis Period (min) 15

Splits and Phases: 116: E 1st Ave. & Templeton Dr

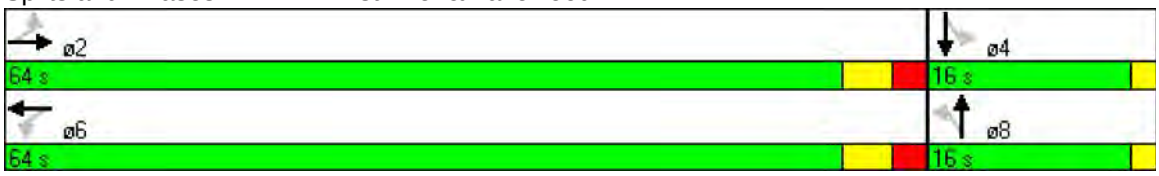


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	0	3539	0	0	3539	0	0	1611	0	0	1736	0
Flt Permitted		0.937			0.946						0.965	
Satd. Flow (perm)	0	3316	0	0	3348	0	0	1611	0	0	1700	0
Satd. Flow (RTOR)		1						55			4	
Volume (vph)	7	1541	3	7	1979	1	0	0	11	3	3	4
Lane Group Flow (vph)	0	1686	0	0	2160	0	0	12	0	0	10	0
Turn Type	Perm			Perm			Perm			Perm		
Protected Phases		2			6			8			4	
Permitted Phases	2			6			8			4		
Total Split (s)	64.0	64.0	0.0	64.0	64.0	0.0	16.0	16.0	0.0	16.0	16.0	0.0
Act Effct Green (s)		60.0			60.0			12.0			12.0	
Actuated g/C Ratio		0.75			0.75			0.15			0.15	
v/c Ratio		0.68			0.86			0.04			0.04	
Control Delay		11.4			5.4			0.3			24.4	
Queue Delay		0.0			0.1			0.0			0.0	
Total Delay		11.4			5.5			0.3			24.4	
LOS		B			A			A			C	
Approach Delay		11.4			5.5			0.3			24.4	
Approach LOS		B			A			A			C	

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 80
Offset: 7 (9%), Referenced to phase 2:EBTL and 6:WBTL, Start of Green
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 0.86
Intersection Signal Delay: 8.1 Intersection LOS: A
Intersection Capacity Utilization 69.6% ICU Level of Service C
Analysis Period (min) 15

Splits and Phases: 117: E 1st Ave. & Lakewood Dr

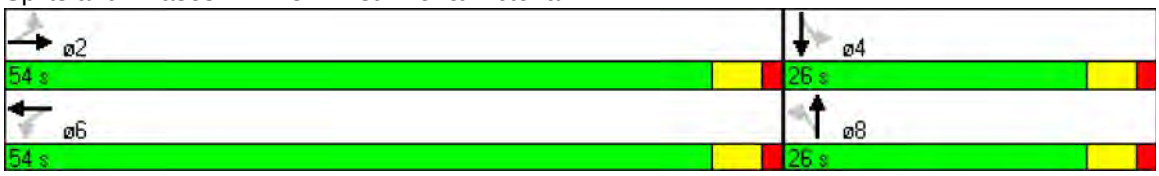


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	0	1861	0	0	3486	0	0	3486	0	0	3430	0
Flt Permitted								0.874			0.695	
Satd. Flow (perm)	0	1861	0	0	3486	0	0	3065	0	0	2423	0
Satd. Flow (RTOR)		1			28			8			14	
Volume (vph)	0	1443	12	0	1799	200	39	261	20	100	180	30
Lane Group Flow (vph)	0	1581	0	0	2172	0	0	348	0	0	338	0
Turn Type	Perm			Perm			Perm			Perm		
Protected Phases		2			6			8			4	
Permitted Phases	2			6			8			4		
Total Split (s)	54.0	54.0	0.0	54.0	54.0	0.0	26.0	26.0	0.0	26.0	26.0	0.0
Act Effct Green (s)		50.0			50.0			22.0			22.0	
Actuated g/C Ratio		0.62			0.62			0.28			0.28	
v/c Ratio		1.36			0.99			0.41			0.50	
Control Delay		189.1			18.7			24.9			26.4	
Queue Delay		0.0			0.0			0.0			0.0	
Total Delay		189.1			18.7			24.9			26.4	
LOS		F			B			C			C	
Approach Delay		189.1			18.7			24.9			26.4	
Approach LOS		F			B			C			C	

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 80
Offset: 35 (44%), Referenced to phase 2:EBTL and 6:WBTL, Start of Green
Control Type: Pretimed
Maximum v/c Ratio: 1.36
Intersection Signal Delay: 80.4 Intersection LOS: F
Intersection Capacity Utilization 104.5% ICU Level of Service G
Analysis Period (min) 15

Splits and Phases: 118: E 1st Ave. & Victoria Dr

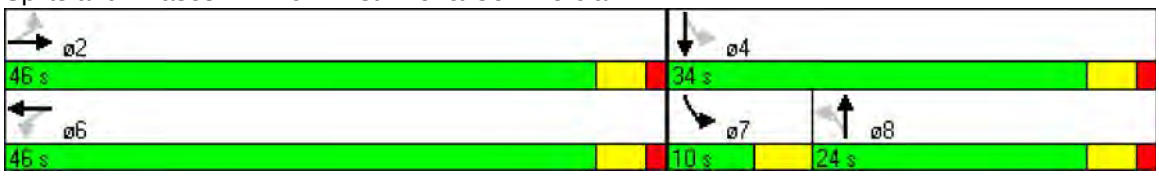


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	3525	0	1770	1845	0	1770	3341	0	1770	3417	0
Flt Permitted	0.133			0.104			0.577			0.325		
Satd. Flow (perm)	246	3525	0	194	1845	0	966	3341	0	535	3417	0
Satd. Flow (RTOR)		4			4			19			8	
Volume (vph)	33	1207	27	73	1636	72	59	342	49	125	233	29
Lane Group Flow (vph)	36	1341	0	79	1856	0	64	425	0	136	285	0
Turn Type	Perm			Perm			Perm			pm+pt		
Protected Phases		2			6			8		7	4	
Permitted Phases	2			6			8			4		
Total Split (s)	46.0	46.0	0.0	46.0	46.0	0.0	24.0	24.0	0.0	10.0	34.0	0.0
Act Effct Green (s)	46.4	46.4		46.4	46.4		15.6	15.6		25.6	25.6	
Actuated g/C Ratio	0.58	0.58		0.58	0.58		0.20	0.20		0.32	0.32	
v/c Ratio	0.25	0.66		0.70	1.73		0.34	0.64		0.52	0.26	
Control Delay	22.5	21.3		24.8	347.9		31.8	32.4		26.6	19.6	
Queue Delay	0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0	
Total Delay	22.5	21.3		24.8	347.9		31.8	32.4		26.6	19.6	
LOS	C	C		C	F		C	C		C	B	
Approach Delay		21.4			334.7			32.3			21.9	
Approach LOS		C			F			C			C	

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 80
Offset: 54 (68%), Referenced to phase 2:EBTL and 6:WBTL, Start of Green
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 1.73
Intersection Signal Delay: 166.3 Intersection LOS: F
Intersection Capacity Utilization 120.9% ICU Level of Service H
Analysis Period (min) 15

Splits and Phases: 119: E 1st Ave. & Commercial Dr

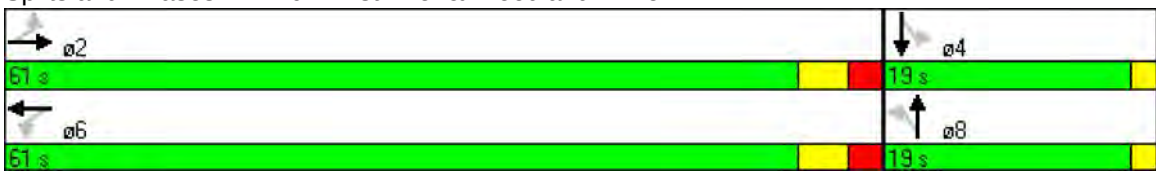


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	0	3536	0	0	3536	0	0	1700	0	0	1752	0
Flt Permitted		0.937			0.933			0.983			0.979	
Satd. Flow (perm)	0	3313	0	0	3299	0	0	1681	0	0	1729	0
Satd. Flow (RTOR)		1			3			25			10	
Volume (vph)	8	1281	6	16	1644	17	5	10	23	4	11	9
Lane Group Flow (vph)	0	1408	0	0	1822	0	0	41	0	0	26	0
Turn Type	Perm			Perm			Perm			Perm		
Protected Phases		2			6			8			4	
Permitted Phases	2			6			8			4		
Total Split (s)	61.0	61.0	0.0	61.0	61.0	0.0	19.0	19.0	0.0	19.0	19.0	0.0
Act Effct Green (s)		57.0			57.0			15.0			15.0	
Actuated g/C Ratio		0.71			0.71			0.19			0.19	
v/c Ratio		0.60			0.77			0.12			0.08	
Control Delay		10.9			2.1			16.4			20.6	
Queue Delay		0.0			0.0			0.0			0.0	
Total Delay		10.9			2.1			16.4			20.6	
LOS		B			A			B			C	
Approach Delay		10.9			2.1			16.4			20.6	
Approach LOS		B			A			B			C	

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 80
Offset: 70 (88%), Referenced to phase 2:EBTL and 6:WBTL, Start of Green
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 0.77
Intersection Signal Delay: 6.2 Intersection LOS: A
Intersection Capacity Utilization 67.2% ICU Level of Service C
Analysis Period (min) 15

Splits and Phases: 120: E 1st Ave. & Woodland Drive

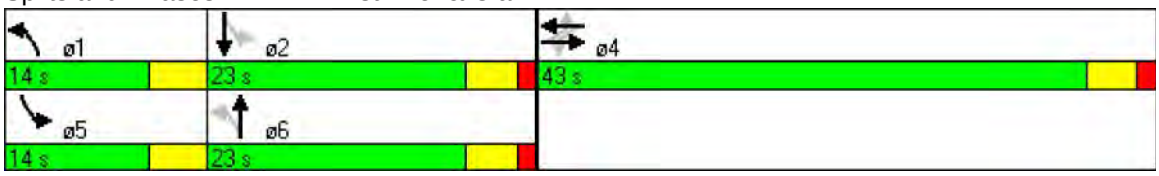


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	0	3437	0	0	3490	0	1770	4963	0	1770	4989	0
Flt Permitted					0.955		0.211			0.211		
Satd. Flow (perm)	0	3437	0	0	3333	0	393	4963	0	393	4989	0
Satd. Flow (RTOR)		52			19			45			29	
Volume (vph)	0	987	239	1	1457	152	309	1078	203	129	782	114
Lane Group Flow (vph)	0	1333	0	0	1750	0	336	1393	0	140	974	0
Turn Type	Perm			Perm			pm+pt			pm+pt		
Protected Phases		4			4		1	6		5	2	
Permitted Phases	4			4			6			2		
Total Split (s)	43.0	43.0	0.0	43.0	43.0	0.0	14.0	23.0	0.0	14.0	23.0	0.0
Act Effct Green (s)		39.0			39.0		30.2	20.2		27.8	19.0	
Actuated g/C Ratio		0.49			0.49		0.38	0.25		0.35	0.24	
v/c Ratio		0.78			1.07		1.05	1.08		0.48	0.81	
Control Delay		20.4			51.2		86.8	81.5		21.3	34.1	
Queue Delay		0.0			0.0		0.0	0.0		0.0	0.0	
Total Delay		20.4			51.2		86.8	81.5		21.3	34.1	
LOS		C			D		F	F		C	C	
Approach Delay		20.4			51.2			82.5			32.5	
Approach LOS		C			D			F			C	

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 80
Offset: 18 (23%), Referenced to phase 4:EBWB, Start of Green
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 1.08
Intersection Signal Delay: 49.9 Intersection LOS: D
Intersection Capacity Utilization 90.6% ICU Level of Service E
Analysis Period (min) 15

Splits and Phases: 121: E 1st Ave. & Clark Dr

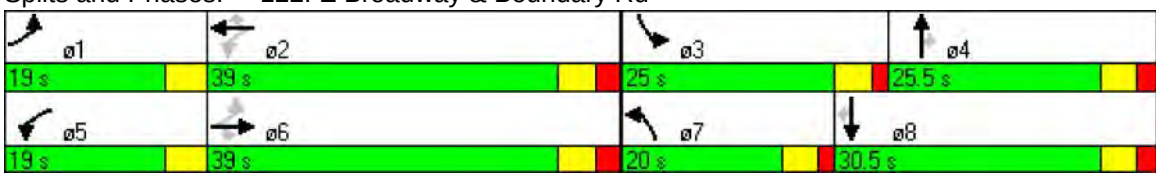


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	3539	1583	1770	3539	1583	3433	3539	1583	1770	3539	1583
Flt Permitted	0.114			0.268			0.950			0.950		
Satd. Flow (perm)	212	3539	1583	499	3539	1583	3433	3539	1583	1770	3539	1583
Satd. Flow (RTOR)			167			172			108			275
Volume (vph)	169	574	154	126	1093	184	309	401	99	231	588	374
Lane Group Flow (vph)	184	624	167	137	1188	200	336	436	108	251	639	407
Turn Type	pm+pt		Perm	pm+pt		Perm	Prot		Perm	Prot		Perm
Protected Phases	1	6		5	2		7	4		3	8	
Permitted Phases	6		6	2		2			4			8
Total Split (s)	19.0	39.0	39.0	19.0	39.0	39.0	20.0	25.5	25.5	25.0	30.5	30.5
Act Effct Green (s)	48.4	36.9	36.9	45.0	35.2	35.2	14.6	20.3	20.3	18.5	24.2	24.2
Actuated g/C Ratio	0.48	0.36	0.36	0.44	0.35	0.35	0.14	0.20	0.20	0.18	0.24	0.24
v/c Ratio	0.66	0.49	0.25	0.40	0.97	0.30	0.68	0.62	0.27	0.78	0.76	0.69
Control Delay	30.8	27.6	4.9	18.5	53.5	7.4	49.8	42.2	9.1	57.5	43.0	18.7
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	30.8	27.6	4.9	18.5	53.5	7.4	49.8	42.2	9.1	57.5	43.0	18.7
LOS	C	C	A	B	D	A	D	D	A	E	D	B
Approach Delay		24.3			44.3			41.0			38.2	
Approach LOS		C			D			D			D	

Intersection Summary

Cycle Length: 108.5
Actuated Cycle Length: 101.6
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 0.97
Intersection Signal Delay: 37.8 Intersection LOS: D
Intersection Capacity Utilization 78.2% ICU Level of Service D
Analysis Period (min) 15

Splits and Phases: 122: E Broadway & Boundary Rd

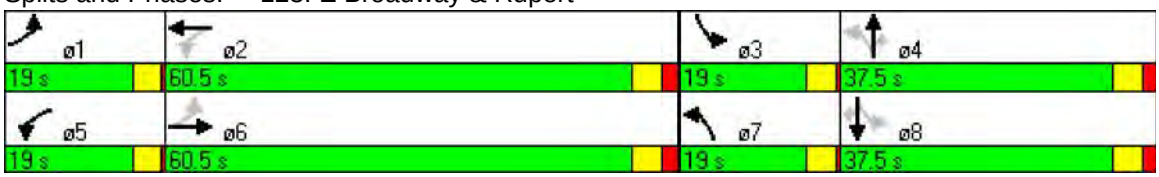


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	4984	0	1770	5070	0	1770	3539	1583	1770	3539	1583
Flt Permitted	0.071			0.218			0.343			0.457		
Satd. Flow (perm)	132	4984	0	406	5070	0	639	3539	1583	851	3539	1583
Satd. Flow (RTOR)		26			2				191			146
Volume (vph)	43	744	113	193	1376	24	262	287	176	56	394	134
Lane Group Flow (vph)	47	932	0	210	1522	0	285	312	191	61	428	146
Turn Type	pm+pt			pm+pt			pm+pt		Perm	pm+pt		Perm
Protected Phases	1	6		5	2		7	4		3	8	
Permitted Phases	6			2			4		4	8		8
Total Split (s)	19.0	60.5	0.0	19.0	60.5	0.0	19.0	37.5	37.5	19.0	37.5	37.5
Act Effct Green (s)	63.5	56.7		73.1	64.3		40.8	30.6	30.6	30.2	21.8	21.8
Actuated g/C Ratio	0.51	0.46		0.60	0.53		0.33	0.25	0.25	0.24	0.18	0.18
v/c Ratio	0.30	0.40		0.55	0.57		0.81	0.35	0.35	0.23	0.68	0.36
Control Delay	16.8	22.2		17.4	21.6		51.7	40.1	7.3	30.7	52.7	9.3
Queue Delay	0.0	0.0		0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	16.8	22.2		17.4	21.6		51.7	40.1	7.3	30.7	52.7	9.3
LOS	B	C		B	C		D	D	A	C	D	A
Approach Delay		21.9			21.1			36.4			40.6	
Approach LOS		C			C			D			D	

Intersection Summary

Cycle Length: 136
Actuated Cycle Length: 122
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 0.81
Intersection Signal Delay: 27.2 Intersection LOS: C
Intersection Capacity Utilization 71.6% ICU Level of Service C
Analysis Period (min) 15

Splits and Phases: 123: E Broadway & Rupert

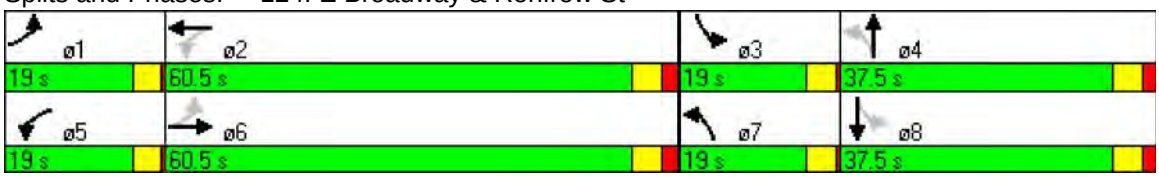


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	5009	0	1770	5060	0	1770	3437	0	1770	3405	0
Flt Permitted	0.071			0.179			0.201			0.281		
Satd. Flow (perm)	132	5009	0	333	5060	0	374	3437	0	523	3405	0
Satd. Flow (RTOR)		17			4			21			33	
Volume (vph)	83	868	98	84	1613	54	124	369	89	66	409	140
Lane Group Flow (vph)	90	1050	0	91	1812	0	135	498	0	72	597	0
Turn Type	pm+pt			pm+pt			pm+pt			pm+pt		
Protected Phases	1	6		5	2		7	4		3	8	
Permitted Phases	6			2			4			8		
Total Split (s)	19.0	60.5	0.0	19.0	60.5	0.0	19.0	37.5	0.0	19.0	37.5	0.0
Act Effct Green (s)	52.9	47.2		52.6	47.0		37.6	29.3		32.7	26.8	
Actuated g/C Ratio	0.50	0.45		0.50	0.45		0.35	0.28		0.31	0.26	
v/c Ratio	0.45	0.46		0.33	0.79		0.48	0.51		0.27	0.66	
Control Delay	23.7	22.0		16.4	29.6		31.4	36.0		27.8	41.2	
Queue Delay	0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0	
Total Delay	23.7	22.0		16.4	29.6		31.4	36.0		27.8	41.2	
LOS	C	C		B	C		C	D		C	D	
Approach Delay		22.1			29.0			35.0			39.8	
Approach LOS		C			C			D			D	

Intersection Summary

Cycle Length: 136
Actuated Cycle Length: 104.3
Control Type: Semi Act-Uncoord
Maximum v/c Ratio: 0.79
Intersection Signal Delay: 29.7 Intersection LOS: C
Intersection Capacity Utilization 72.9% ICU Level of Service C
Analysis Period (min) 15

Splits and Phases: 124: E Broadway & Renfrew St

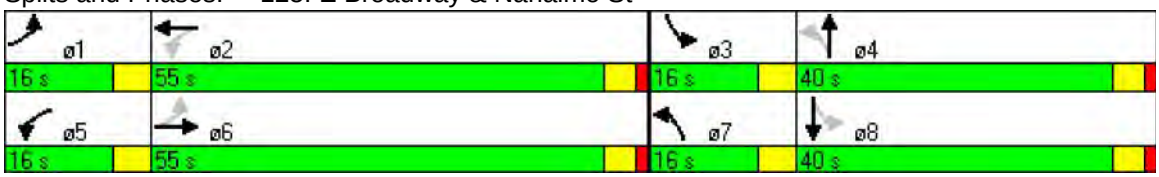


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	5050	0	1770	5065	0	1770	4984	0	1770	4867	0
Flt Permitted	0.078			0.174			0.277			0.278		
Satd. Flow (perm)	145	5050	0	324	5065	0	516	4984	0	518	4867	0
Satd. Flow (RTOR)		7			4			23			79	
Volume (vph)	90	924	46	116	1759	51	149	528	83	61	438	175
Lane Group Flow (vph)	98	1054	0	126	1967	0	162	664	0	66	666	0
Turn Type	pm+pt			pm+pt			pm+pt			pm+pt		
Protected Phases	1	6		5	2		7	4		3	8	
Permitted Phases	6			2			4			8		
Total Split (s)	16.0	55.0	0.0	16.0	55.0	0.0	16.0	40.0	0.0	16.0	40.0	0.0
Act Effct Green (s)	56.8	48.7		59.0	51.7		33.5	24.6		27.6	19.5	
Actuated g/C Ratio	0.54	0.47		0.57	0.50		0.32	0.24		0.26	0.19	
v/c Ratio	0.48	0.45		0.41	0.78		0.55	0.56		0.29	0.68	
Control Delay	21.7	20.1		14.6	26.4		33.5	37.1		28.4	38.8	
Queue Delay	0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0	
Total Delay	21.7	20.1		14.6	26.4		33.5	37.1		28.4	38.8	
LOS	C	C		B	C		C	D		C	D	
Approach Delay		20.2			25.7			36.4			37.9	
Approach LOS		C			C			D			D	

Intersection Summary

Cycle Length: 127
Actuated Cycle Length: 104.1
Control Type: Semi Act-Uncoord
Maximum v/c Ratio: 0.78
Intersection Signal Delay: 28.1 Intersection LOS: C
Intersection Capacity Utilization 74.1% ICU Level of Service D
Analysis Period (min) 15

Splits and Phases: 125: E Broadway & Nanaimo St



Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	5065	0	1770	5060	0	1770	1863	1583	1770	1794	0
Flt Permitted	0.098			0.286			0.455			0.559		
Satd. Flow (perm)	183	5065	0	533	5060	0	848	1863	1583	1041	1794	0
Satd. Flow (RTOR)		9			11				70		7	
Volume (vph)	30	784	23	89	1863	68	88	199	64	78	205	66
Lane Group Flow (vph)	33	877	0	97	2099	0	96	216	70	85	295	0
Turn Type	Perm			Perm			Perm		Perm	Perm		
Protected Phases		2			6			8			4	
Permitted Phases	2			6			8		8	4		
Total Split (s)	45.0	45.0	0.0	45.0	45.0	0.0	30.0	30.0	30.0	30.0	30.0	0.0
Act Effct Green (s)	41.0	41.0		41.0	41.0		26.0	26.0	26.0	26.0	26.0	
Actuated g/C Ratio	0.55	0.55		0.55	0.55		0.35	0.35	0.35	0.35	0.35	
v/c Ratio	0.33	0.32		0.33	0.76		0.33	0.33	0.12	0.24	0.47	
Control Delay	23.6	7.2		13.5	15.3		22.0	19.9	5.3	19.7	21.7	
Queue Delay	0.0	0.0		0.0	0.0		0.0	0.0	0.0	0.0	0.0	
Total Delay	23.6	7.2		13.5	15.3		22.0	19.9	5.3	19.7	21.7	
LOS	C	A		B	B		C	B	A	B	C	
Approach Delay		7.8			15.3			17.8			21.3	
Approach LOS		A			B			B			C	

Intersection Summary

Cycle Length: 75
Actuated Cycle Length: 75
Offset: 34 (45%), Referenced to phase 2:EBTL and 6:WBTL, Start of Green
Control Type: Pretimed
Maximum v/c Ratio: 0.76
Intersection Signal Delay: 14.3 Intersection LOS: B
Intersection Capacity Utilization 73.9% ICU Level of Service D
Analysis Period (min) 15

Splits and Phases: 126: E Broadway & Victoria Dr

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	5034	0	1770	5065	0	0	4989	0	0	4888	0
Flt Permitted	0.154			0.209				0.823			0.838	
Satd. Flow (perm)	287	5034	0	389	5065	0	0	4139	0	0	4121	0
Satd. Flow (RTOR)		17			5			19			61	
Volume (vph)	62	800	60	55	1566	40	101	452	45	31	167	56
Lane Group Flow (vph)	67	935	0	60	1745	0	0	650	0	0	277	0
Turn Type	pm+pt			pm+pt			Perm			Perm		
Protected Phases	1	6		5	2			4			4	
Permitted Phases	6			2			4			4		
Total Split (s)	15.0	30.0	0.0	15.0	30.0	0.0	30.0	30.0	0.0	30.0	30.0	0.0
Act Effct Green (s)	46.0	41.7		45.9	41.6			18.6			18.6	
Actuated g/C Ratio	0.61	0.56		0.61	0.55			0.25			0.25	
v/c Ratio	0.22	0.33		0.17	0.62			0.62			0.26	
Control Delay	8.0	11.1		9.3	13.7			26.5			17.1	
Queue Delay	0.0	0.0		0.0	0.0			0.0			0.0	
Total Delay	8.0	11.1		9.3	13.7			26.5			17.1	
LOS	A	B		A	B			C			B	
Approach Delay		10.9			13.5			26.5			17.1	
Approach LOS		B			B			C			B	

Intersection Summary

Cycle Length: 75
Actuated Cycle Length: 75
Offset: 47 (63%), Referenced to phase 2:WBTL and 6:EBTL, Start of Green
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 0.62
Intersection Signal Delay: 15.4 Intersection LOS: B
Intersection Capacity Utilization 65.5% ICU Level of Service C
Analysis Period (min) 15

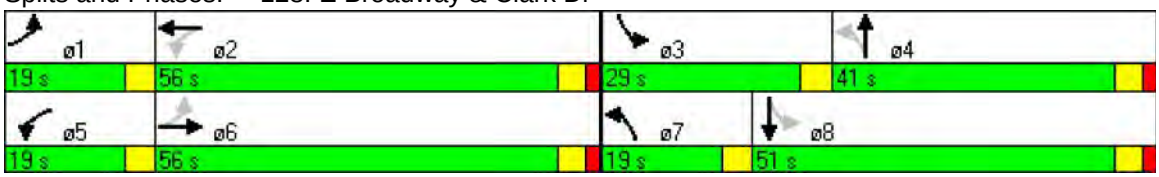
Splits and Phases: 127: E Broadway & Commercial Dr

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	5024	0	1770	4989	0	1770	5024	0	1770	4938	0
Flt Permitted	0.077			0.272			0.297			0.098		
Satd. Flow (perm)	143	5024	0	507	4989	0	553	5024	0	183	4938	0
Satd. Flow (RTOR)		10			20			9			40	
Volume (vph)	138	629	52	155	1335	192	64	1030	88	250	588	139
Lane Group Flow (vph)	150	741	0	168	1660	0	70	1216	0	272	790	0
Turn Type	pm+pt			pm+pt			pm+pt			pm+pt		
Protected Phases	1	6		5	2		7	4		3	8	
Permitted Phases	6			2			4			8		
Total Split (s)	19.0	56.0	0.0	19.0	56.0	0.0	19.0	41.0	0.0	29.0	51.0	0.0
Act Effct Green (s)	64.2	52.2		64.8	52.5		44.8	36.3		60.8	50.5	
Actuated g/C Ratio	0.47	0.38		0.47	0.38		0.32	0.26		0.44	0.37	
v/c Ratio	0.72	0.39		0.48	0.87		0.28	0.91		0.86	0.43	
Control Delay	49.0	32.2		24.8	45.4		26.7	60.1		61.2	32.5	
Queue Delay	0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0	
Total Delay	49.0	32.2		24.8	45.4		26.7	60.1		61.2	32.5	
LOS	D	C		C	D		C	E		E	C	
Approach Delay		35.0			43.5			58.3			39.9	
Approach LOS		D			D			E			D	

Intersection Summary

Cycle Length: 145
Actuated Cycle Length: 137.4
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 0.91
Intersection Signal Delay: 45.0 Intersection LOS: D
Intersection Capacity Utilization 86.8% ICU Level of Service E
Analysis Period (min) 15

Splits and Phases: 128: E Broadway & Clark Dr

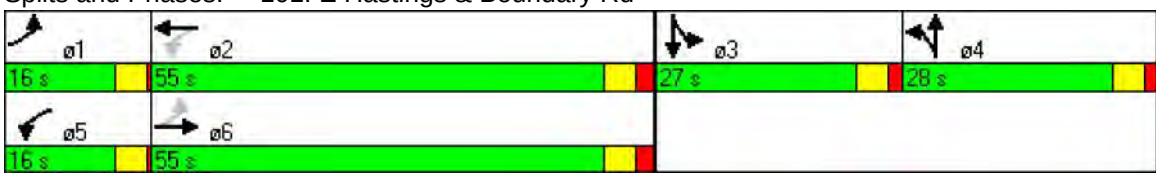


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	5004	0	1770	3522	0	1610	3157	0	1770	3429	0
Flt Permitted	0.190			0.078			0.950	0.995		0.950		
Satd. Flow (perm)	354	5004	0	145	3522	0	1610	3157	0	1770	3429	0
Satd. Flow (RTOR)		19			3			126			22	
Volume (vph)	156	1299	151	169	770	27	246	211	194	43	121	31
Lane Group Flow (vph)	170	1576	0	184	866	0	215	492	0	47	166	0
Turn Type	pm+pt			pm+pt			Split			Split		
Protected Phases	1	6		5	2		4	4		3	3	
Permitted Phases	6			2								
Total Split (s)	16.0	55.0	0.0	16.0	55.0	0.0	28.0	28.0	0.0	27.0	27.0	0.0
Act Effct Green (s)	50.2	40.6		53.3	42.1		18.7	18.7		11.1	11.1	
Actuated g/C Ratio	0.51	0.41		0.54	0.43		0.19	0.19		0.11	0.11	
v/c Ratio	0.53	0.76		0.70	0.57		0.70	0.70		0.23	0.41	
Control Delay	17.4	27.3		38.2	23.5		52.4	34.3		47.9	41.3	
Queue Delay	0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0	
Total Delay	17.4	27.3		38.2	23.5		52.4	34.3		47.9	41.3	
LOS	B	C		D	C		D	C		D	D	
Approach Delay		26.3			26.1			39.8			42.8	
Approach LOS		C			C			D			D	

Intersection Summary

Cycle Length: 126
Actuated Cycle Length: 98.2
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 0.76
Intersection Signal Delay: 29.8 Intersection LOS: C
Intersection Capacity Utilization 70.6% ICU Level of Service C
Analysis Period (min) 15

Splits and Phases: 101: E Hastings & Boundary Rd

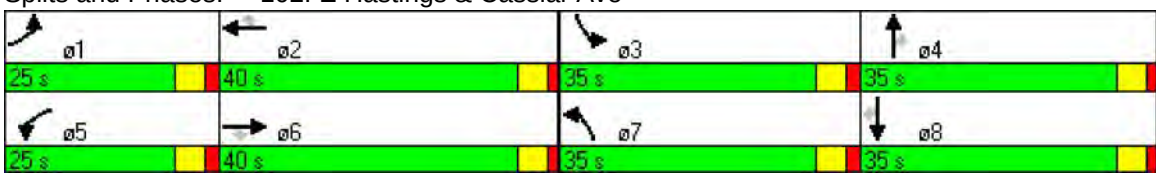


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	5085	1583	1770	3539	1583	3433	3539	1583	3433	3539	1583
Flt Permitted	0.950			0.950			0.950			0.950		
Satd. Flow (perm)	1770	5085	1583	1770	3539	1583	3433	3539	1583	3433	3539	1583
Satd. Flow (RTOR)			404			532			74			163
Volume (vph)	132	937	575	67	561	509	404	327	68	721	66	150
Lane Group Flow (vph)	143	1018	625	73	610	553	439	355	74	784	72	163
Turn Type	Prot		Perm	Prot		Perm	Prot		Perm	Prot		Perm
Protected Phases	1	6		5	2		7	4		3	8	
Permitted Phases			6			2			4			8
Total Split (s)	25.0	40.0	40.0	25.0	40.0	40.0	35.0	35.0	35.0	35.0	35.0	35.0
Act Effct Green (s)	14.5	34.3	34.3	10.7	27.6	27.6	19.5	16.9	16.9	30.2	27.5	27.5
Actuated g/C Ratio	0.14	0.32	0.32	0.10	0.26	0.26	0.18	0.16	0.16	0.29	0.26	0.26
v/c Ratio	0.59	0.62	0.80	0.41	0.66	0.69	0.69	0.63	0.23	0.80	0.08	0.31
Control Delay	56.0	33.6	20.8	56.1	39.6	8.7	47.8	48.4	11.9	44.5	35.2	7.8
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	56.0	33.6	20.8	56.1	39.6	8.7	47.8	48.4	11.9	44.5	35.2	7.8
LOS	E	C	C	E	D	A	D	D	B	D	D	A
Approach Delay		30.9			26.8			45.0			38.0	
Approach LOS		C			C			D			D	

Intersection Summary

Cycle Length: 135
Actuated Cycle Length: 105.7
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 0.80
Intersection Signal Delay: 33.8 Intersection LOS: C
Intersection Capacity Utilization 65.8% ICU Level of Service C
Analysis Period (min) 15

Splits and Phases: 102: E Hastings & Cassiar Ave

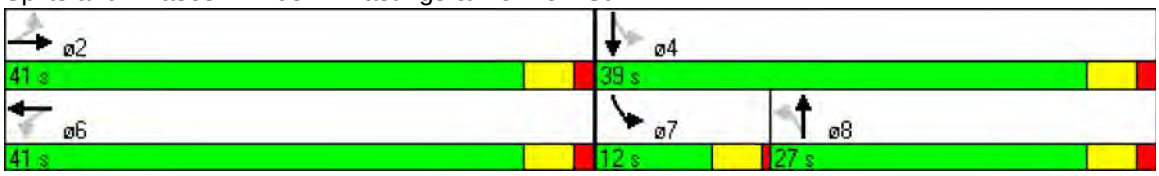


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	5040	0	1770	3472	0	0	4984	0	0	3437	0
Flt Permitted	0.140			0.135				0.790			0.575	
Satd. Flow (perm)	261	5040	0	251	3472	0	0	3965	0	0	2019	0
Satd. Flow (RTOR)		16			27			20			9	
Volume (vph)	57	1134	73	137	894	132	67	387	43	251	308	32
Lane Group Flow (vph)	62	1312	0	149	1115	0	0	541	0	0	643	0
Turn Type	Perm			Perm			Perm			pm+pt		
Protected Phases		2			6			8		7	4	
Permitted Phases	2			6			8			4		
Total Split (s)	41.0	41.0	0.0	41.0	41.0	0.0	27.0	27.0	0.0	12.0	39.0	0.0
Act Effct Green (s)	37.0	37.0		37.0	37.0			23.0			35.0	
Actuated g/C Ratio	0.46	0.46		0.46	0.46			0.29			0.44	
v/c Ratio	0.51	0.56		1.28	0.69			0.47			0.62	
Control Delay	37.5	24.9		204.5	19.2			10.2			18.8	
Queue Delay	0.0	0.0		0.0	0.0			0.0			0.0	
Total Delay	37.5	24.9		204.5	19.2			10.2			18.8	
LOS	D	C		F	B			B			B	
Approach Delay		25.4			41.1			10.2			18.8	
Approach LOS		C			D			B			B	

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 80
Offset: 60 (75%), Referenced to phase 2:EBTL and 6:WBTL, Start of Green
Control Type: Pretimed
Maximum v/c Ratio: 1.28
Intersection Signal Delay: 27.3 Intersection LOS: C
Intersection Capacity Utilization 74.7% ICU Level of Service D
Analysis Period (min) 15

Splits and Phases: 103: E Hastings & Renfrew St

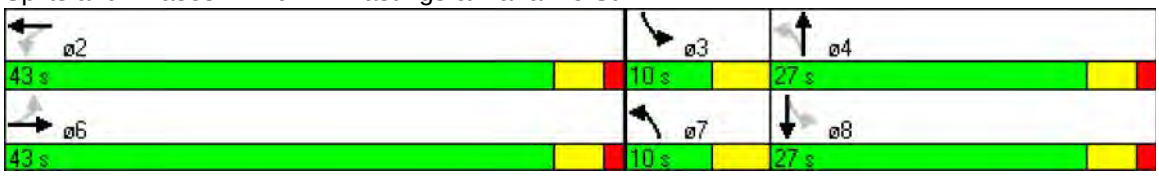


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	0	4947	0	0	3514	0	1770	4900	0	1770	4745	0
Flt Permitted		0.939			0.666		0.320			0.426		
Satd. Flow (perm)	0	4645	0	0	2344	0	535	4900	0	713	4745	0
Satd. Flow (RTOR)		16			2			24			47	
Volume (vph)	2	1442	88	60	890	10	89	395	44	59	496	92
Lane Group Flow (vph)	0	1665	0	0	1043	0	97	477	0	64	639	0
Turn Type	Perm			Perm			pm+pt			pm+pt		
Protected Phases		6			2		7	4		3	8	
Permitted Phases	6			2			4			8		
Total Split (s)	43.0	43.0	0.0	43.0	43.0	0.0	10.0	27.0	0.0	10.0	27.0	0.0
Act Effct Green (s)		39.0			39.0		29.8	25.0		29.8	25.0	
Actuated g/C Ratio		0.49			0.49		0.37	0.31		0.37	0.31	
v/c Ratio		0.73			0.91		0.33	0.31		0.19	0.42	
Control Delay		12.4			30.6		15.0	21.4		15.9	21.8	
Queue Delay		0.0			0.0		0.0	0.0		0.0	0.0	
Total Delay		12.4			30.6		15.0	21.4		15.9	21.8	
LOS		B			C		B	C		B	C	
Approach Delay		12.4			30.6			20.3			21.2	
Approach LOS		B			C			C			C	

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 80
Offset: 23 (29%), Referenced to phase 2:WBTL and 6:EBTL, Start of Green
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 0.91
Intersection Signal Delay: 19.9 Intersection LOS: B
Intersection Capacity Utilization 92.9% ICU Level of Service F
Analysis Period (min) 15

Splits and Phases: 104: E Hastings & Nanaimo St

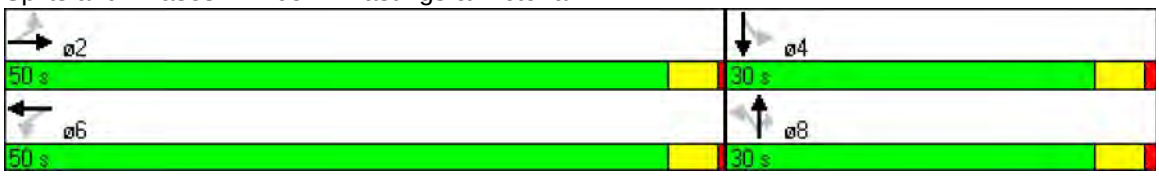


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	5060	0	1770	3522	0	0	1840	1583	0	3434	0
Flt Permitted	0.248			0.094				0.869			0.773	
Satd. Flow (perm)	462	5060	0	175	3522	0	0	1619	1583	0	2700	0
Satd. Flow (RTOR)		10			7				24		13	
Volume (vph)	26	1495	48	78	831	28	48	148	258	82	139	20
Lane Group Flow (vph)	28	1677	0	85	933	0	0	213	280	0	262	0
Turn Type	Perm			Perm			Perm		Perm	Perm		
Protected Phases		2			6			8			4	
Permitted Phases	2			6			8		8	4		
Total Split (s)	50.0	50.0	0.0	50.0	50.0	0.0	30.0	30.0	30.0	30.0	30.0	0.0
Act Effct Green (s)	46.0	46.0		46.0	46.0			26.0	26.0		26.0	
Actuated g/C Ratio	0.58	0.58		0.58	0.58			0.32	0.32		0.32	
v/c Ratio	0.11	0.58		0.84	0.46			0.40	0.53		0.30	
Control Delay	3.0	3.4		49.9	4.2			26.2	26.4		20.2	
Queue Delay	0.0	0.0		0.0	0.0			0.0	0.0		0.0	
Total Delay	3.0	3.4		49.9	4.2			26.2	26.4		20.2	
LOS	A	A		D	A			C	C		C	
Approach Delay		3.4			8.0			26.3			20.2	
Approach LOS		A			A			C			C	

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 80
Offset: 65 (81%), Referenced to phase 2:EBTL and 6:WBTL, Start of Green
Control Type: Pretimed
Maximum v/c Ratio: 0.84
Intersection Signal Delay: 9.3 Intersection LOS: A
Intersection Capacity Utilization 67.3% ICU Level of Service C
Analysis Period (min) 15

Splits and Phases: 105: E Hastings & Victoria Dr



Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	5033	0	1770	3524	0	1770	1709	0	1770	1814	0
Flt Permitted	0.332			0.100			0.577			0.493		
Satd. Flow (perm)	606	5033	0	185	3524	0	965	1709	0	890	1814	0
Satd. Flow (RTOR)		10			4			45			6	
Volume (vph)	62	1422	62	116	768	16	52	138	93	84	161	16
Lane Group Flow (vph)	67	1613	0	126	852	0	57	251	0	91	192	0
Turn Type	Perm			pm+pt			Perm			Perm		
Protected Phases		2		1	6			8			4	
Permitted Phases	2			6			8			4		
Total Split (s)	40.0	40.0	0.0	10.0	50.0	0.0	30.0	30.0	0.0	30.0	30.0	0.0
Act Effct Green (s)	38.0	38.0		46.0	46.0		26.0	26.0		26.0	26.0	
Actuated g/C Ratio	0.48	0.48		0.58	0.58		0.32	0.32		0.32	0.32	
v/c Ratio	0.23	0.67		0.56	0.42		0.18	0.43		0.31	0.32	
Control Delay	10.3	10.8		23.1	17.4		18.3	17.8		24.1	21.6	
Queue Delay	0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0	
Total Delay	10.3	10.8		23.1	17.4		18.3	17.8		24.1	21.6	
LOS	B	B		C	B		B	B		C	C	
Approach Delay		10.7			18.1			17.9			22.4	
Approach LOS		B			B			B			C	

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 80
Offset: 50 (63%), Referenced to phase 2:EBTL and 6:WBTL, Start of Green
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 0.67
Intersection Signal Delay: 14.6 Intersection LOS: B
Intersection Capacity Utilization 68.1% ICU Level of Service C
Analysis Period (min) 15

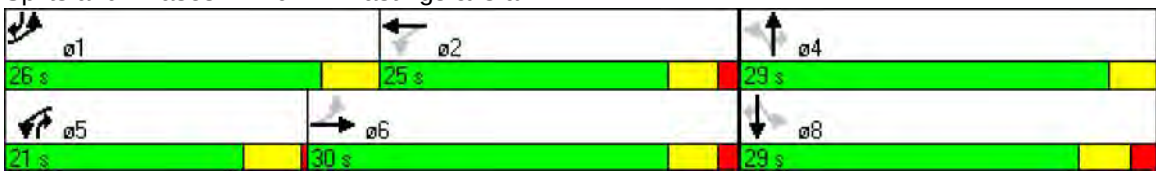
Splits and Phases: 106: E Hastings & Commercial Dr

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	5024	0	1770	3522	0	0	3522	1583	0	3518	1583
Flt Permitted	0.160			0.190				0.802			0.701	
Satd. Flow (perm)	298	5024	0	354	3522	0	0	2838	1583	0	2481	1583
Satd. Flow (RTOR)		18			4				8			33
Volume (vph)	128	1078	92	275	627	23	71	604	277	54	402	32
Lane Group Flow (vph)	139	1272	0	299	707	0	0	734	301	0	496	35
Turn Type	pm+pt			pm+pt			Perm		pm+ov	Perm		pm+ov
Protected Phases	1	6		5	2			4	5		8	1
Permitted Phases	6			2			4		4	8		8
Total Split (s)	26.0	30.0	0.0	21.0	25.0	0.0	29.0	29.0	21.0	29.0	29.0	26.0
Act Effct Green (s)	35.7	27.4		47.0	36.7			25.0	44.6		25.0	37.4
Actuated g/C Ratio	0.45	0.34		0.59	0.46			0.31	0.56		0.31	0.47
v/c Ratio	0.48	0.74		0.62	0.44			0.83	0.34		0.64	0.05
Control Delay	16.1	26.2		9.9	16.1			35.6	26.9		28.2	4.5
Queue Delay	0.0	0.0		0.0	0.0			0.0	0.0		0.0	0.0
Total Delay	16.1	26.2		9.9	16.1			35.6	26.9		28.2	4.5
LOS	B	C		A	B			D	C		C	A
Approach Delay		25.2			14.2			33.1			26.6	
Approach LOS		C			B			C			C	

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 80
Offset: 26 (33%), Referenced to phase 2:WBTL and 6:EBTL, Start of Green
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 0.83
Intersection Signal Delay: 24.7 Intersection LOS: C
Intersection Capacity Utilization 88.5% ICU Level of Service E
Analysis Period (min) 15

Splits and Phases: 107: E Hastings & Clark Dr

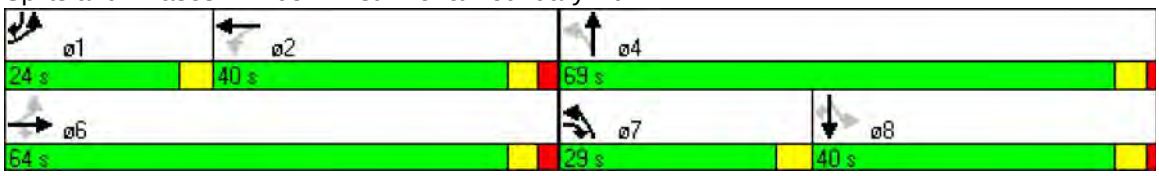


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	1863	1583	1770	1844	0	0	4964	0	0	3536	1583
Flt Permitted	0.162			0.553				0.676			0.877	
Satd. Flow (perm)	302	1863	1583	1030	1844	0	0	3410	0	0	3104	1583
Satd. Flow (RTOR)			37		3			9				228
Volume (vph)	400	319	241	73	343	25	366	668	61	19	626	348
Lane Group Flow (vph)	435	347	262	79	400	0	0	1190	0	0	701	378
Turn Type	pm+pt		pm+ov	Perm			pm+pt			Perm		pm+ov
Protected Phases	1	6	7		2		7	4			8	1
Permitted Phases	6		6	2			4			8		8
Total Split (s)	24.0	64.0	29.0	40.0	40.0	0.0	29.0	69.0	0.0	40.0	40.0	24.0
Act Effct Green (s)	53.9	53.9	66.2	29.3	29.3			45.7			33.3	58.0
Actuated g/C Ratio	0.50	0.50	0.61	0.27	0.27			0.42			0.31	0.54
v/c Ratio	1.01	0.37	0.27	0.28	0.80			1.71dl			0.73	0.39
Control Delay	74.5	19.7	10.5	36.6	50.3			28.3			37.8	6.8
Queue Delay	0.0	0.0	0.0	0.0	0.0			0.0			0.0	0.0
Total Delay	74.5	19.7	10.5	36.6	50.3			28.3			37.8	6.8
LOS	E	B	B	D	D			C			D	A
Approach Delay		40.2			48.0			28.3			27.0	
Approach LOS		D			D			C			C	

Intersection Summary

Cycle Length: 133
Actuated Cycle Length: 107.8
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 1.01
Intersection Signal Delay: 33.7 Intersection LOS: C
Intersection Capacity Utilization 94.6% ICU Level of Service F
Analysis Period (min) 15
dl Defacto Left Lane. Recode with 1 though lane as a left lane.

Splits and Phases: 108: E 1st Ave. & Boundary Rd

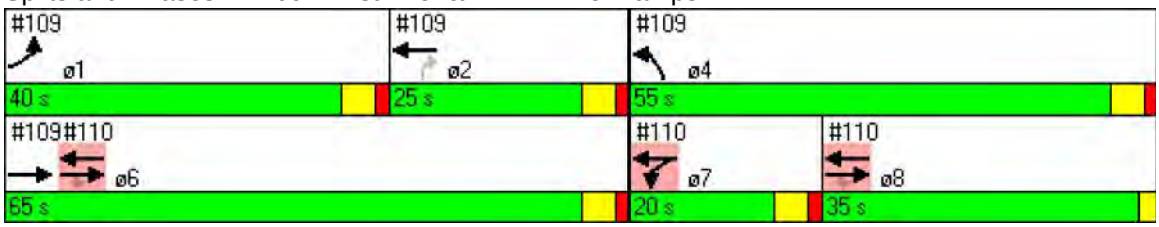


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	3539	0	0	5085	1583	3433	0	1583	0	0	0
Flt Permitted	0.950						0.950					
Satd. Flow (perm)	1770	3539	0	0	5085	1583	3433	0	1583	0	0	0
Satd. Flow (RTOR)						101			35			
Volume (vph)	366	837	0	0	684	294	969	0	81	0	0	0
Lane Group Flow (vph)	398	910	0	0	743	320	1053	0	88	0	0	0
Turn Type	Prot					Free	Prot		custom			
Protected Phases	1	6			2		4					
Permitted Phases						Free			2			
Total Split (s)	40.0	65.0	0.0	0.0	25.0	0.0	55.0	0.0	25.0	0.0	0.0	0.0
Act Effct Green (s)	36.0	61.0			21.0	120.0	51.0		21.0			
Actuated g/C Ratio	0.30	0.51			0.18	1.00	0.42		0.18			
v/c Ratio	0.75	0.51			0.83	0.20	0.72		0.29			
Control Delay	44.3	17.3			57.2	0.3	32.1		29.7			
Queue Delay	21.1	0.6			0.6	0.0	0.1		0.0			
Total Delay	65.5	17.9			57.8	0.3	32.2		29.7			
LOS	E	B			E	A	C		C			
Approach Delay		32.4			40.5							
Approach LOS		C			D							

Intersection Summary

Cycle Length: 120
Actuated Cycle Length: 120
Offset: 0 (0%), Referenced to phase 2:WBT and 6:EBT, Start of Green
Control Type: Pretimed
Maximum v/c Ratio: 0.98
Intersection Signal Delay: 34.7 Intersection LOS: C
Intersection Capacity Utilization 123.3% ICU Level of Service H
Analysis Period (min) 15

Splits and Phases: 109: E 1st Ave. & HW1 WB on ramps



Lane Group	ø7	ø8
Lane Configurations		
Total Lost Time (s)		
Satd. Flow (prot)		
Flt Permitted		
Satd. Flow (perm)		
Satd. Flow (RTOR)		
Volume (vph)		
Lane Group Flow (vph)		
Turn Type		
Protected Phases	7	8
Permitted Phases		
Total Split (s)	20.0	35.0
Act Effct Green (s)		
Actuated g/C Ratio		
v/c Ratio		
Control Delay		
Queue Delay		
Total Delay		
LOS		
Approach Delay		
Approach LOS		

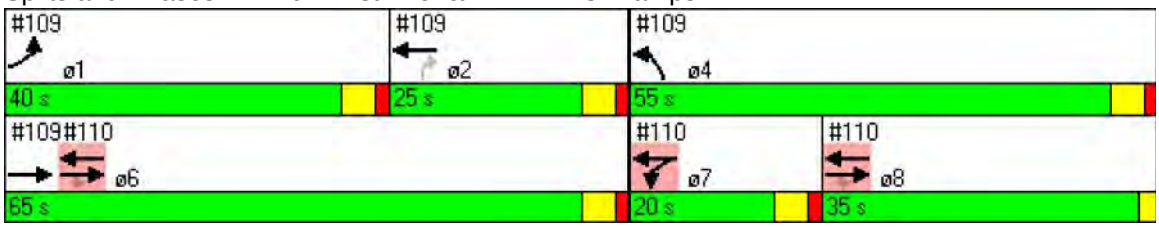
Intersection Summary

Lane Group	EBT	EBR	WBL	WBT	NBL	NBR	ø1	ø2	ø4	ø6	ø8
Lane Configurations											
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0					
Satd. Flow (prot)	5085	1583	1770	5085	0	0					
Flt Permitted			0.950								
Satd. Flow (perm)	5085	1583	1770	5085	0	0					
Satd. Flow (RTOR)		190									
Volume (vph)	1304	1170	164	1689	0	0					
Lane Group Flow (vph)	1417	1272	178	1836	0	0					
Turn Type		Perm	Prot								
Protected Phases	6 8		7	6 7 8			1	2	4	6	8
Permitted Phases		6 8									
Total Split (s)	100.0	100.0	20.0	120.0	0.0	0.0	40.0	25.0	55.0	65.0	35.0
Act Effct Green (s)	96.0	96.0	16.0	120.0							
Actuated g/C Ratio	0.80	0.80	0.13	1.00							
v/c Ratio	0.35	0.98	0.75	0.36							
Control Delay	3.6	30.5	62.8	0.2							
Queue Delay	0.0	0.0	4.0	0.0							
Total Delay	3.6	30.5	66.8	0.2							
LOS	A	C	E	A							
Approach Delay	16.3			6.1							
Approach LOS	B			A							

Intersection Summary

Cycle Length: 120
Actuated Cycle Length: 120
Offset: 0 (0%), Referenced to phase 2:WBT and 6:EBT, Start of Green
Control Type: Pretimed
Maximum v/c Ratio: 0.98
Intersection Signal Delay: 11.9 Intersection LOS: B
Intersection Capacity Utilization 123.3% ICU Level of Service H
Analysis Period (min) 15

Splits and Phases: 110: E 1st Ave. & HW1 EB On ramps

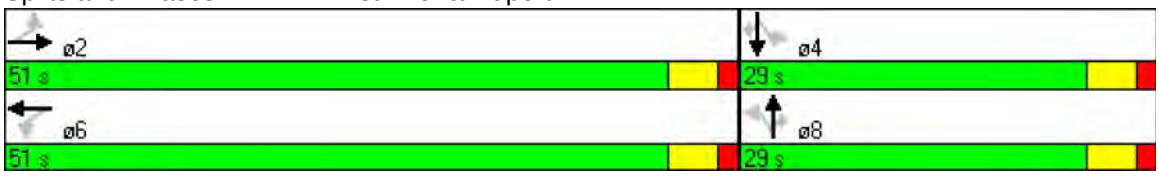


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	0	5070	0	0	3532	0	1770	1513	1504	1770	3539	1583
Flt Permitted		0.898			0.670		0.421			0.492		
Satd. Flow (perm)	0	4553	0	0	2371	0	784	1513	1504	916	3539	1583
Satd. Flow (RTOR)		7						10	10			21
Volume (vph)	12	1862	41	62	1573	0	175	7	417	113	398	103
Lane Group Flow (vph)	0	2082	0	0	1777	0	190	234	227	123	433	112
Turn Type	Perm			Perm			Perm		Perm	Perm		Perm
Protected Phases		2			6			8			4	
Permitted Phases	2			6			8		8	4		4
Total Split (s)	51.0	51.0	0.0	51.0	51.0	0.0	29.0	29.0	29.0	29.0	29.0	29.0
Act Effct Green (s)		47.0			47.0		25.0	25.0	25.0	25.0	25.0	25.0
Actuated g/C Ratio		0.59			0.59		0.31	0.31	0.31	0.31	0.31	0.31
v/c Ratio		0.78			1.28		0.78	0.49	0.48	0.43	0.39	0.22
Control Delay		5.3			150.1		48.9	25.5	25.2	27.6	22.8	17.8
Queue Delay		0.0			0.0		0.0	0.0	0.0	0.0	0.0	0.0
Total Delay		5.3			150.1		48.9	25.5	25.2	27.6	22.8	17.8
LOS		A			F		D	C	C	C	C	B
Approach Delay		5.3			150.1			32.2			22.9	
Approach LOS		A			F			C			C	

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 80
Offset: 9 (11%), Referenced to phase 2:EBTL and 6:WBTL, Start of Green
Control Type: Pretimed
Maximum v/c Ratio: 1.28
Intersection Signal Delay: 60.6 Intersection LOS: E
Intersection Capacity Utilization 116.4% ICU Level of Service H
Analysis Period (min) 15

Splits and Phases: 111: E 1st Ave. & Rupert

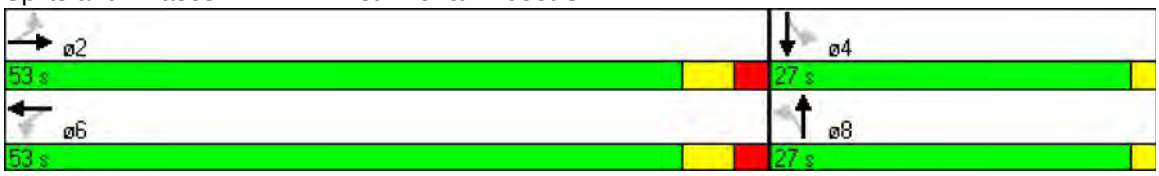


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	0	3532	0	0	3529	0	0	1743	0	0	1721	0
Flt Permitted		0.740			0.702			0.957			0.937	
Satd. Flow (perm)	0	2616	0	0	2480	0	0	1694	0	0	1641	0
Satd. Flow (RTOR)		2			3			9			14	
Volume (vph)	26	1982	17	19	1794	28	7	8	9	17	10	21
Lane Group Flow (vph)	0	2200	0	0	2001	0	0	27	0	0	52	0
Turn Type	Perm			Perm			Perm			Perm		
Protected Phases		2			6			8			4	
Permitted Phases	2			6			8			4		
Total Split (s)	53.0	53.0	0.0	53.0	53.0	0.0	27.0	27.0	0.0	27.0	27.0	0.0
Act Effct Green (s)		49.0			49.0			23.0			23.0	
Actuated g/C Ratio		0.61			0.61			0.29			0.29	
v/c Ratio		1.37			1.32			0.05			0.11	
Control Delay		184.3			169.1			16.2			17.3	
Queue Delay		0.0			0.0			0.0			0.0	
Total Delay		184.3			169.1			16.2			17.3	
LOS		F			F			B			B	
Approach Delay		184.3			169.1			16.2			17.3	
Approach LOS		F			F			B			B	

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 80
Offset: 67 (84%), Referenced to phase 2:EBTL and 6:WBTL, Start of Green
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 1.37
Intersection Signal Delay: 174.1 Intersection LOS: F
Intersection Capacity Utilization 84.3% ICU Level of Service E
Analysis Period (min) 15

Splits and Phases: 112: E 1st Ave. & Lillooet ST

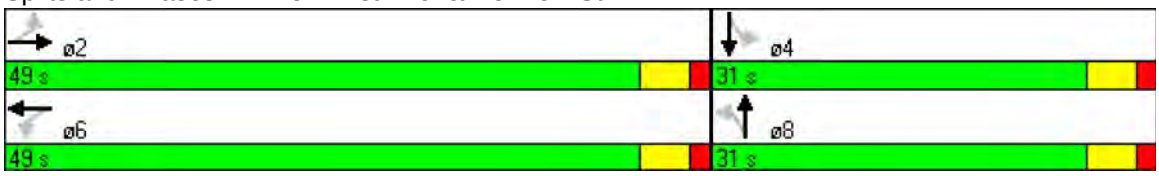


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	3525	0	1770	3511	0	1770	3476	0	1770	3500	0
Flt Permitted	0.089			0.089			0.292			0.196		
Satd. Flow (perm)	166	3525	0	166	3511	0	544	3476	0	365	3500	0
Satd. Flow (RTOR)		5			12			14			11	
Volume (vph)	56	1648	40	77	1549	87	70	639	89	71	536	42
Lane Group Flow (vph)	61	1834	0	84	1779	0	76	792	0	77	629	0
Turn Type	Perm			Perm			Perm			Perm		
Protected Phases		2			6			8			4	
Permitted Phases	2			6			8			4		
Total Split (s)	49.0	49.0	0.0	49.0	49.0	0.0	31.0	31.0	0.0	31.0	31.0	0.0
Act Effct Green (s)	45.0	45.0		45.0	45.0		27.0	27.0		27.0	27.0	
Actuated g/C Ratio	0.56	0.56		0.56	0.56		0.34	0.34		0.34	0.34	
v/c Ratio	0.66	0.92		0.90	0.90		0.41	0.67		0.63	0.53	
Control Delay	20.7	8.1		44.1	24.9		28.9	25.6		46.7	25.1	
Queue Delay	0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0	
Total Delay	20.7	8.1		44.1	24.9		28.9	25.6		46.7	25.1	
LOS	C	A		D	C		C	C		D	C	
Approach Delay		8.6			25.7			25.9			27.5	
Approach LOS		A			C			C			C	

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 80
Offset: 43 (54%), Referenced to phase 2:EBTL and 6:WBTL, Start of Green
Control Type: Pretimed
Maximum v/c Ratio: 0.92
Intersection Signal Delay: 19.9 Intersection LOS: B
Intersection Capacity Utilization 88.9% ICU Level of Service E
Analysis Period (min) 15

Splits and Phases: 113: E 1st Ave. & Renfrew St

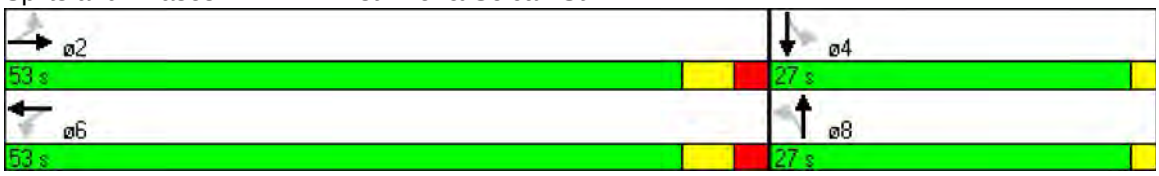


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	0	3536	0	0	3536	0	0	1745	0	0	1724	0
Flt Permitted		0.909			0.911			0.971			0.992	
Satd. Flow (perm)	0	3214	0	0	3221	0	0	1711	0	0	1717	0
Satd. Flow (RTOR)		1			2			16			20	
Volume (vph)	16	1740	8	7	1573	16	7	15	15	3	14	18
Lane Group Flow (vph)	0	1917	0	0	1735	0	0	40	0	0	38	0
Turn Type	Perm			Perm			Perm			Perm		
Protected Phases		2			6			8			4	
Permitted Phases	2			6			8			4		
Total Split (s)	53.0	53.0	0.0	53.0	53.0	0.0	27.0	27.0	0.0	27.0	27.0	0.0
Act Effct Green (s)		49.0			49.0			23.0			23.0	
Actuated g/C Ratio		0.61			0.61			0.29			0.29	
v/c Ratio		0.97			0.88			0.08			0.07	
Control Delay		12.6			27.6			15.1			13.5	
Queue Delay		0.0			0.0			0.0			0.0	
Total Delay		12.6			27.6			15.1			13.5	
LOS		B			C			B			B	
Approach Delay		12.6			27.6			15.1			13.5	
Approach LOS		B			C			B			B	

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 80
Offset: 16 (20%), Referenced to phase 2:EBTL and 6:WBTL, Start of Green
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 0.97
Intersection Signal Delay: 19.6 Intersection LOS: B
Intersection Capacity Utilization 70.0% ICU Level of Service C
Analysis Period (min) 15

Splits and Phases: 114: E 1st Ave. & Solcan St

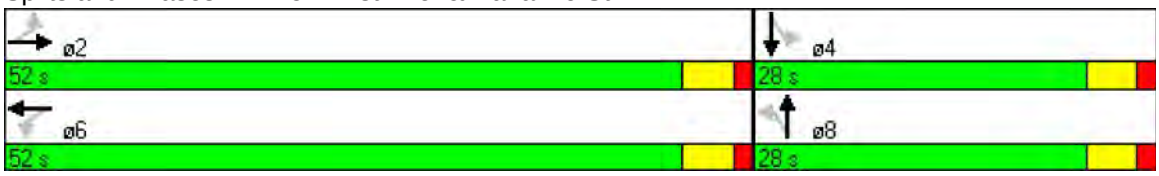


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	3522	0	1770	3514	0	1770	3497	0	1770	5024	0
Flt Permitted	0.083			0.083			0.219			0.167		
Satd. Flow (perm)	155	3522	0	155	3514	0	408	3497	0	311	5024	0
Satd. Flow (RTOR)		8			11			12			19	
Volume (vph)	72	1764	63	77	1490	73	54	722	65	80	714	64
Lane Group Flow (vph)	78	1985	0	84	1699	0	59	856	0	87	846	0
Turn Type	Perm			Perm			Perm			Perm		
Protected Phases		2			6			8			4	
Permitted Phases	2			6			8			4		
Total Split (s)	52.0	52.0	0.0	52.0	52.0	0.0	28.0	28.0	0.0	28.0	28.0	0.0
Act Effct Green (s)	48.0	48.0		48.0	48.0		24.0	24.0		24.0	24.0	
Actuated g/C Ratio	0.60	0.60		0.60	0.60		0.30	0.30		0.30	0.30	
v/c Ratio	0.84	0.94		0.90	0.80		0.48	0.81		0.94	0.56	
Control Delay	52.5	11.0		63.1	6.9		38.7	32.8		108.8	24.8	
Queue Delay	0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0	
Total Delay	52.5	11.0		63.1	6.9		38.7	32.8		108.8	24.8	
LOS	D	B		E	A		D	C		F	C	
Approach Delay		12.5			9.5			33.2			32.6	
Approach LOS		B			A			C			C	

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 80
Offset: 60 (75%), Referenced to phase 2:EBTL and 6:WBTL, Start of Green
Control Type: Pretimed
Maximum v/c Ratio: 0.94
Intersection Signal Delay: 18.2 Intersection LOS: B
Intersection Capacity Utilization 94.8% ICU Level of Service F
Analysis Period (min) 15

Splits and Phases: 115: E 1st Ave. & Nanaimo St

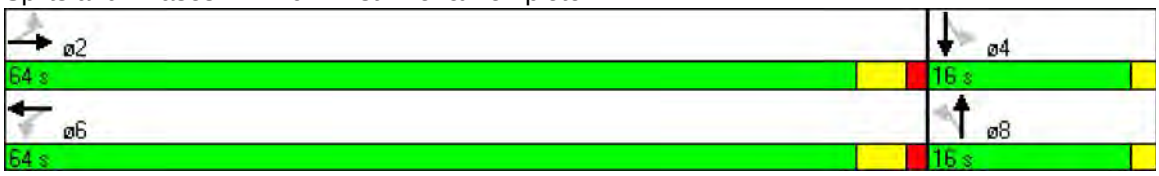


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	0	3536	0	0	3536	0	0	1653	0	0	1662	0
Flt Permitted		0.946			0.938			0.990				
Satd. Flow (perm)	0	3345	0	0	3316	0	0	1645	0	0	1662	0
Satd. Flow (RTOR)		1			2			8			12	
Volume (vph)	7	1869	6	8	1563	7	1	1	7	0	3	11
Lane Group Flow (vph)	0	2047	0	0	1716	0	0	10	0	0	15	0
Turn Type	Perm			Perm			Perm			Perm		
Protected Phases		2			6			8			4	
Permitted Phases	2			6			8			4		
Total Split (s)	64.0	64.0	0.0	64.0	64.0	0.0	16.0	16.0	0.0	16.0	16.0	0.0
Act Effct Green (s)		60.0			60.0			12.0			12.0	
Actuated g/C Ratio		0.75			0.75			0.15			0.15	
v/c Ratio		0.82			0.69			0.04			0.06	
Control Delay		3.2			11.4			19.2			18.1	
Queue Delay		0.0			0.0			0.0			0.0	
Total Delay		3.2			11.4			19.2			18.1	
LOS		A			B			B			B	
Approach Delay		3.2			11.4			19.2			18.1	
Approach LOS		A			B			B			B	

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 80
Offset: 35 (44%), Referenced to phase 2:EBTL and 6:WBTL, Start of Green
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 0.82
Intersection Signal Delay: 7.0 Intersection LOS: A
Intersection Capacity Utilization 66.7% ICU Level of Service C
Analysis Period (min) 15

Splits and Phases: 116: E 1st Ave. & Templeton Dr

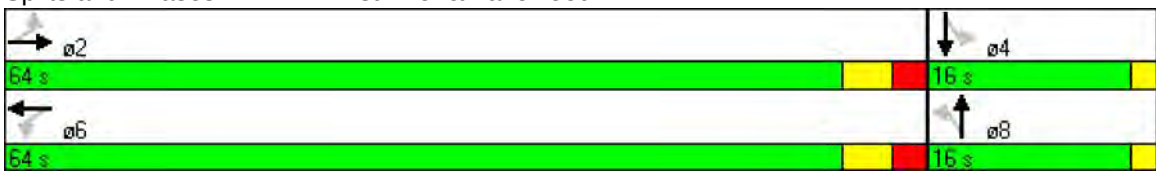


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	0	3539	0	0	3536	0	0	1700	0	0	1665	0
Flt Permitted		0.940			0.951			0.981			0.973	
Satd. Flow (perm)	0	3327	0	0	3362	0	0	1679	0	0	1638	0
Satd. Flow (RTOR)		1			3			12			10	
Volume (vph)	11	1788	5	3	1444	12	3	5	11	3	1	9
Lane Group Flow (vph)	0	1960	0	0	1586	0	0	20	0	0	14	0
Turn Type	Perm			Perm			Perm			Perm		
Protected Phases		2			6			8			4	
Permitted Phases	2			6			8			4		
Total Split (s)	64.0	64.0	0.0	64.0	64.0	0.0	16.0	16.0	0.0	16.0	16.0	0.0
Act Effct Green (s)		60.0			60.0			12.0			12.0	
Actuated g/C Ratio		0.75			0.75			0.15			0.15	
v/c Ratio		0.79			0.63			0.08			0.06	
Control Delay		2.8			7.0			20.1			19.5	
Queue Delay		0.0			0.1			0.0			0.0	
Total Delay		2.8			7.1			20.1			19.5	
LOS		A			A			C			B	
Approach Delay		2.8			7.1			20.1			19.5	
Approach LOS		A			A			C			B	

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 80
Offset: 32 (40%), Referenced to phase 2:EBTL and 6:WBTL, Start of Green
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 0.79
Intersection Signal Delay: 4.9 Intersection LOS: A
Intersection Capacity Utilization 67.3% ICU Level of Service C
Analysis Period (min) 15

Splits and Phases: 117: E 1st Ave. & Lakewood Dr

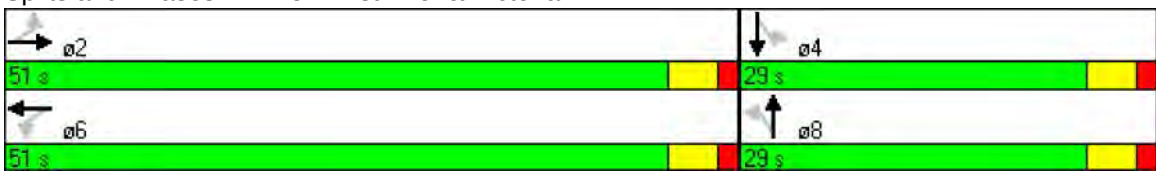


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	0	1855	0	0	3472	0	0	3472	0	0	3483	0
Flt Permitted		0.762			0.953			0.899			0.713	
Satd. Flow (perm)	0	1415	0	0	3309	0	0	3131	0	0	2511	0
Satd. Flow (RTOR)		2			34			16			5	
Volume (vph)	39	1591	34	2	1277	183	19	310	39	146	486	23
Lane Group Flow (vph)	0	1808	0	0	1589	0	0	400	0	0	712	0
Turn Type	Perm			Perm			Perm			Perm		
Protected Phases		2			6			8			4	
Permitted Phases	2			6			8			4		
Total Split (s)	51.0	51.0	0.0	51.0	51.0	0.0	29.0	29.0	0.0	29.0	29.0	0.0
Act Effct Green (s)		47.0			47.0			25.0			25.0	
Actuated g/C Ratio		0.59			0.59			0.31			0.31	
v/c Ratio		2.17			0.81			0.40			0.90	
Control Delay		547.0			26.2			14.6			44.0	
Queue Delay		0.0			0.0			0.0			0.0	
Total Delay		547.0			26.2			14.6			44.0	
LOS		F			C			B			D	
Approach Delay		547.0			26.2			14.6			44.0	
Approach LOS		F			C			B			D	

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 80
Offset: 12 (15%), Referenced to phase 2:EBTL and 6:WBTL, Start of Green
Control Type: Pretimed
Maximum v/c Ratio: 2.17
Intersection Signal Delay: 236.8 Intersection LOS: F
Intersection Capacity Utilization 156.0% ICU Level of Service H
Analysis Period (min) 15

Splits and Phases: 118: E 1st Ave. & Victoria Dr

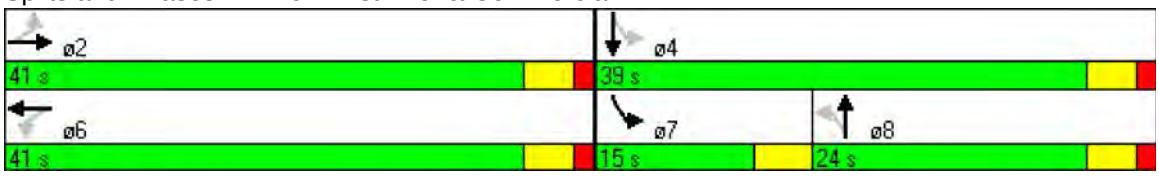


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	3508	0	1770	1822	0	1770	3051	0	1770	3450	0
Flt Permitted	0.108			0.108			0.440			0.307		
Satd. Flow (perm)	201	3508	0	201	1822	0	672	3051	0	445	3450	0
Satd. Flow (RTOR)		4			5			34			8	
Volume (vph)	21	1390	35	57	1102	62	45	333	79	288	496	24
Lane Group Flow (vph)	23	1549	0	62	1265	0	49	448	0	313	565	0
Turn Type	Perm			Perm			Perm			pm+pt		
Protected Phases		2			6			8		7	4	
Permitted Phases	2			6			8			4		
Total Split (s)	41.0	41.0	0.0	41.0	41.0	0.0	24.0	24.0	0.0	15.0	39.0	0.0
Act Effct Green (s)	39.4	39.4		39.4	39.4		17.6	17.6		32.6	32.6	
Actuated g/C Ratio	0.49	0.49		0.49	0.49		0.22	0.22		0.41	0.41	
v/c Ratio	0.23	0.90		0.63	1.41		0.33	0.64		0.86	0.40	
Control Delay	11.1	18.0		52.6	217.6		20.9	20.3		40.7	15.6	
Queue Delay	0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0	
Total Delay	11.1	18.0		52.6	217.6		20.9	20.3		40.7	15.6	
LOS	B	B		D	F		C	C		D	B	
Approach Delay		17.9			209.9			20.4			24.5	
Approach LOS		B			F			C			C	

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 80
Offset: 74 (93%), Referenced to phase 2:EBTL and 6:WBTL, Start of Green
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 1.41
Intersection Signal Delay: 79.2 Intersection LOS: E
Intersection Capacity Utilization 101.6% ICU Level of Service G
Analysis Period (min) 15

Splits and Phases: 119: E 1st Ave. & Commercial Dr

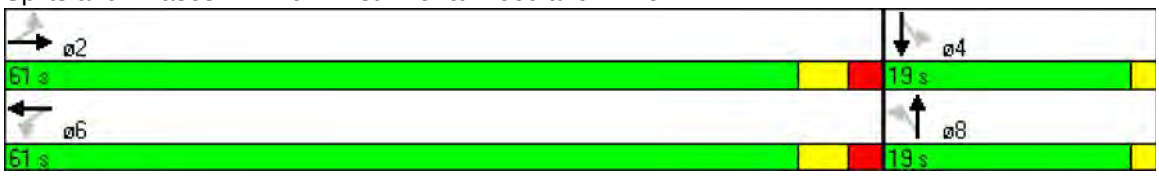


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	0	3532	0	0	3522	0	0	1738	0	0	1826	0
Flt Permitted		0.941			0.748			0.993			0.933	
Satd. Flow (perm)	0	3324	0	0	2642	0	0	1731	0	0	1728	0
Satd. Flow (RTOR)		5			4			28			3	
Volume (vph)	12	1393	22	61	1043	13	3	26	26	17	39	3
Lane Group Flow (vph)	0	1551	0	0	1214	0	0	59	0	0	63	0
Turn Type	Perm			Perm			Perm			Perm		
Protected Phases		2			6			8			4	
Permitted Phases	2			6			8			4		
Total Split (s)	61.0	61.0	0.0	61.0	61.0	0.0	19.0	19.0	0.0	19.0	19.0	0.0
Act Effct Green (s)		57.0			57.0			15.0			15.0	
Actuated g/C Ratio		0.71			0.71			0.19			0.19	
v/c Ratio		0.65			0.64			0.17			0.19	
Control Delay		6.2			13.0			18.4			28.2	
Queue Delay		0.0			0.0			0.0			0.0	
Total Delay		6.2			13.0			18.4			28.2	
LOS		A			B			B			C	
Approach Delay		6.2			13.0			18.4			28.2	
Approach LOS		A			B			B			C	

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 80
Offset: 53 (66%), Referenced to phase 2:EBTL and 6:WBTL, Start of Green
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 0.65
Intersection Signal Delay: 9.8 Intersection LOS: A
Intersection Capacity Utilization 89.5% ICU Level of Service E
Analysis Period (min) 15

Splits and Phases: 120: E 1st Ave. & Woodland Drive

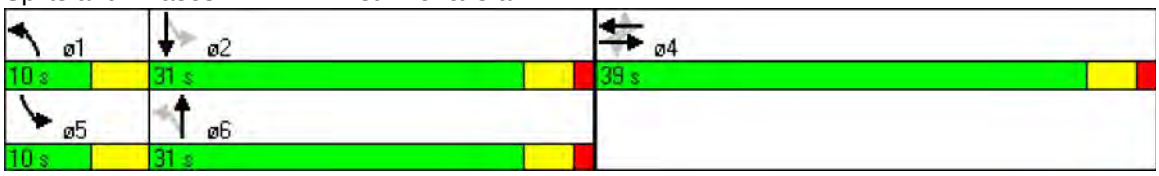


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	0	3398	0	0	3493	0	1770	4917	0	1770	5019	0
Flt Permitted		0.954					0.148			0.148		
Satd. Flow (perm)	0	3241	0	0	3493	0	276	4917	0	276	5019	0
Satd. Flow (RTOR)		81			16			63			20	
Volume (vph)	1	899	325	0	951	91	167	1055	298	202	1132	104
Lane Group Flow (vph)	0	1331	0	0	1133	0	182	1471	0	220	1343	0
Turn Type	Perm			Perm			pm+pt			pm+pt		
Protected Phases		4			4		1	6		5	2	
Permitted Phases	4			4			6			2		
Total Split (s)	39.0	39.0	0.0	39.0	39.0	0.0	10.0	31.0	0.0	10.0	31.0	0.0
Act Effct Green (s)		35.2			35.2		32.8	26.8		32.8	26.8	
Actuated g/C Ratio		0.44			0.44		0.41	0.34		0.41	0.34	
v/c Ratio		0.90			0.73		0.81	0.87		0.98	0.79	
Control Delay		30.1			30.3		43.4	30.8		71.4	23.9	
Queue Delay		0.0			0.0		0.0	0.0		0.0	0.0	
Total Delay		30.1			30.3		43.4	30.8		71.4	23.9	
LOS		C			C		D	C		E	C	
Approach Delay		30.1			30.3			32.2			30.6	
Approach LOS		C			C			C			C	

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 80
Offset: 34 (43%), Referenced to phase 4:EBWB, Start of Green
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 0.98
Intersection Signal Delay: 30.9 Intersection LOS: C
Intersection Capacity Utilization 84.2% ICU Level of Service E
Analysis Period (min) 15

Splits and Phases: 121: E 1st Ave. & Clark Dr

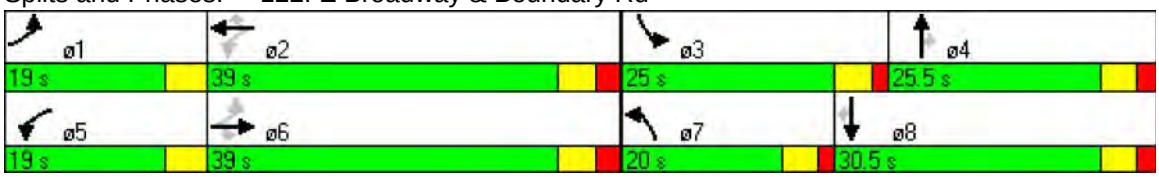


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	3539	1583	1770	3539	1583	3433	3539	1583	1770	3539	1583
Flt Permitted	0.114			0.114			0.950			0.950		
Satd. Flow (perm)	212	3539	1583	212	3539	1583	3433	3539	1583	1770	3539	1583
Satd. Flow (RTOR)			209			125			104			253
Volume (vph)	236	892	192	199	967	118	357	604	101	240	585	233
Lane Group Flow (vph)	257	970	209	216	1051	128	388	657	110	261	636	253
Turn Type	pm+pt		Perm	pm+pt		Perm	Prot		Perm	Prot		Perm
Protected Phases	1	6		5	2		7	4		3	8	
Permitted Phases	6		6	2		2			4			8
Total Split (s)	19.0	39.0	39.0	19.0	39.0	39.0	20.0	25.5	25.5	25.0	30.5	30.5
Act Effct Green (s)	48.7	34.9	34.9	46.5	33.8	33.8	15.3	21.3	21.3	19.0	25.0	25.0
Actuated g/C Ratio	0.47	0.34	0.34	0.45	0.32	0.32	0.15	0.20	0.20	0.18	0.24	0.24
v/c Ratio	0.84	0.82	0.31	0.76	0.91	0.21	0.77	0.91	0.27	0.81	0.75	0.44
Control Delay	49.1	39.1	5.1	40.1	47.2	6.1	54.7	59.2	10.2	61.0	43.3	6.9
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	49.1	39.1	5.1	40.1	47.2	6.1	54.7	59.2	10.2	61.0	43.3	6.9
LOS	D	D	A	D	D	A	D	E	B	E	D	A
Approach Delay		35.9			42.3			53.0			39.3	
Approach LOS		D			D			D			D	

Intersection Summary

Cycle Length: 108.5
Actuated Cycle Length: 104
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 0.91
Intersection Signal Delay: 42.3 Intersection LOS: D
Intersection Capacity Utilization 83.1% ICU Level of Service E
Analysis Period (min) 15

Splits and Phases: 122: E Broadway & Boundary Rd

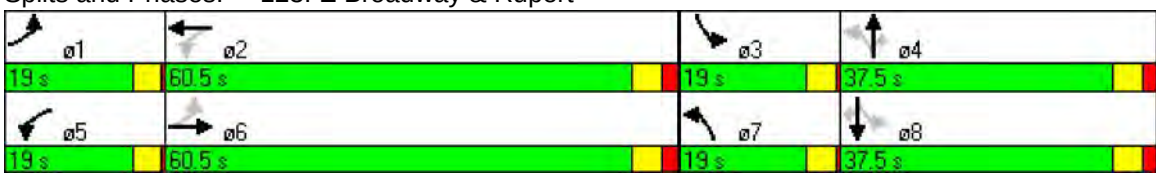


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	4912	0	1770	5055	0	1770	3539	1583	1770	3539	1583
Flt Permitted	0.108			0.071			0.281			0.294		
Satd. Flow (perm)	201	4912	0	132	5055	0	523	3539	1583	548	3539	1583
Satd. Flow (RTOR)		67			5				216			80
Volume (vph)	125	1194	351	223	1172	46	217	443	199	45	458	83
Lane Group Flow (vph)	136	1680	0	242	1324	0	236	482	216	49	498	90
Turn Type	pm+pt			pm+pt			pm+pt		Perm	pm+pt		Perm
Protected Phases	1	6		5	2		7	4		3	8	
Permitted Phases	6			2			4		4	8		8
Total Split (s)	19.0	60.5	0.0	19.0	60.5	0.0	19.0	37.5	37.5	19.0	37.5	37.5
Act Effct Green (s)	66.7	56.6		74.9	61.5		43.5	33.7	33.7	32.6	24.7	24.7
Actuated g/C Ratio	0.52	0.45		0.59	0.48		0.34	0.27	0.27	0.25	0.19	0.19
v/c Ratio	0.59	0.76		0.89	0.54		0.73	0.51	0.37	0.23	0.72	0.24
Control Delay	25.7	31.5		66.0	24.9		45.9	42.6	6.7	30.8	54.4	12.6
Queue Delay	0.0	0.0		0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	25.7	31.5		66.0	24.9		45.9	42.6	6.7	30.8	54.4	12.6
LOS	C	C		E	C		D	D	A	C	D	B
Approach Delay		31.0			31.2			35.1			46.7	
Approach LOS		C			C			D			D	

Intersection Summary

Cycle Length: 136
Actuated Cycle Length: 127.1
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 0.89
Intersection Signal Delay: 33.9 Intersection LOS: C
Intersection Capacity Utilization 81.3% ICU Level of Service D
Analysis Period (min) 15

Splits and Phases: 123: E Broadway & Rupert

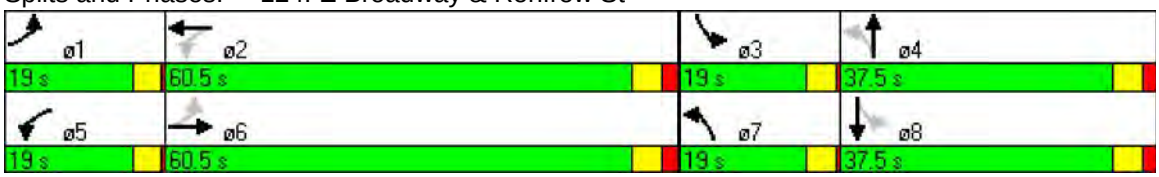


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	5019	0	1770	5029	0	1770	3429	0	1770	3465	0
Flt Permitted	0.071			0.071			0.165			0.119		
Satd. Flow (perm)	132	5019	0	132	5029	0	307	3429	0	222	3465	0
Satd. Flow (RTOR)		13			11			23			13	
Volume (vph)	202	1442	132	148	1475	112	154	581	155	135	510	85
Lane Group Flow (vph)	220	1710	0	161	1725	0	167	800	0	147	646	0
Turn Type	pm+pt			pm+pt			pm+pt			pm+pt		
Protected Phases	1	6		5	2		7	4		3	8	
Permitted Phases	6			2			4			8		
Total Split (s)	19.0	60.5	0.0	19.0	60.5	0.0	19.0	37.5	0.0	19.0	37.5	0.0
Act Effct Green (s)	67.0	53.1		62.9	51.0		44.1	31.5		43.0	31.0	
Actuated g/C Ratio	0.54	0.43		0.50	0.41		0.35	0.25		0.34	0.25	
v/c Ratio	0.86	0.80		0.72	0.84		0.65	0.91		0.65	0.74	
Control Delay	64.4	35.1		47.8	37.8		40.4	59.8		43.1	49.6	
Queue Delay	0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0	
Total Delay	64.4	35.1		47.8	37.8		40.4	59.8		43.1	49.6	
LOS	E	D		D	D		D	E		D	D	
Approach Delay		38.5			38.7			56.4			48.4	
Approach LOS		D			D			E			D	

Intersection Summary

Cycle Length: 136
Actuated Cycle Length: 124.9
Control Type: Semi Act-Uncoord
Maximum v/c Ratio: 0.91
Intersection Signal Delay: 43.1 Intersection LOS: D
Intersection Capacity Utilization 84.0% ICU Level of Service E
Analysis Period (min) 15

Splits and Phases: 124: E Broadway & Renfrew St

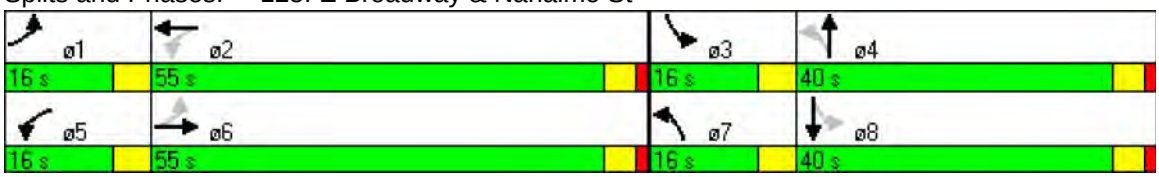


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	5045	0	1770	5050	0	1770	4953	0	1770	4887	0
Flt Permitted	0.078			0.078			0.181			0.199		
Satd. Flow (perm)	145	5045	0	145	5050	0	337	4953	0	371	4887	0
Satd. Flow (RTOR)		8			7			34			70	
Volume (vph)	167	1486	81	141	1582	79	87	627	129	121	587	208
Lane Group Flow (vph)	182	1703	0	153	1806	0	95	822	0	132	864	0
Turn Type	pm+pt			pm+pt			pm+pt			pm+pt		
Protected Phases	1	6		5	2		7	4		3	8	
Permitted Phases	6			2			4			8		
Total Split (s)	16.0	55.0	0.0	16.0	55.0	0.0	16.0	40.0	0.0	16.0	40.0	0.0
Act Effct Green (s)	63.2	52.2		61.4	51.3		34.9	25.5		37.7	28.9	
Actuated g/C Ratio	0.55	0.46		0.54	0.45		0.30	0.22		0.33	0.25	
v/c Ratio	0.77	0.74		0.69	0.80		0.44	0.73		0.53	0.67	
Control Delay	47.0	29.1		39.3	31.4		31.9	43.5		33.7	38.8	
Queue Delay	0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0	
Total Delay	47.0	29.1		39.3	31.4		31.9	43.5		33.7	38.8	
LOS	D	C		D	C		C	D		C	D	
Approach Delay		30.8			32.0			42.3			38.1	
Approach LOS		C			C			D			D	

Intersection Summary

Cycle Length: 127
Actuated Cycle Length: 114.3
Control Type: Semi Act-Uncoord
Maximum v/c Ratio: 0.80
Intersection Signal Delay: 34.3 Intersection LOS: C
Intersection Capacity Utilization 76.6% ICU Level of Service D
Analysis Period (min) 15

Splits and Phases: 125: E Broadway & Nanaimo St



Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	5070	0	1770	5055	0	1770	1863	1583	1770	1837	0
Flt Permitted	0.087			0.126			0.245			0.488		
Satd. Flow (perm)	162	5070	0	235	5055	0	456	1863	1583	909	1837	0
Satd. Flow (RTOR)		6			12				36		7	
Volume (vph)	78	1340	27	101	1588	62	37	235	109	211	367	38
Lane Group Flow (vph)	85	1486	0	110	1793	0	40	255	118	229	440	0
Turn Type	Perm			Perm			Perm		Perm	Perm		
Protected Phases		2			6			8			4	
Permitted Phases	2			6			8		8	4		
Total Split (s)	50.0	50.0	0.0	50.0	50.0	0.0	30.0	30.0	30.0	30.0	30.0	0.0
Act Effct Green (s)	46.0	46.0		46.0	46.0		26.0	26.0	26.0	26.0	26.0	
Actuated g/C Ratio	0.58	0.58		0.58	0.58		0.32	0.32	0.32	0.32	0.32	
v/c Ratio	0.91	0.51		0.81	0.62		0.27	0.42	0.22	0.78	0.73	
Control Delay	85.3	4.3		60.9	12.2		25.9	23.8	15.1	55.5	48.1	
Queue Delay	0.0	0.0		0.0	0.0		0.0	0.0	0.0	0.0	0.0	
Total Delay	85.3	4.3		60.9	12.2		25.9	23.8	15.1	55.5	48.1	
LOS	F	A		E	B		C	C	B	E	D	
Approach Delay		8.7			15.1			21.5			50.7	
Approach LOS		A			B			C			D	

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 80
Offset: 47 (59%), Referenced to phase 2:EBTL and 6:WBTL, Start of Green
Control Type: Pretimed
Maximum v/c Ratio: 0.91
Intersection Signal Delay: 18.7 Intersection LOS: B
Intersection Capacity Utilization 74.7% ICU Level of Service D
Analysis Period (min) 15

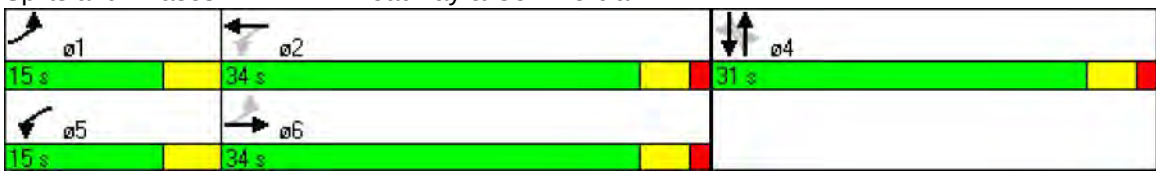
Splits and Phases: 126: E Broadway & Victoria Dr

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	5050	0	1770	5055	0	0	4969	0	0	4999	0
Flt Permitted	0.133			0.133				0.784			0.832	
Satd. Flow (perm)	248	5050	0	248	5055	0	0	3927	0	0	4184	0
Satd. Flow (RTOR)		11			8			25			18	
Volume (vph)	86	1375	70	82	1346	53	70	337	44	61	446	41
Lane Group Flow (vph)	93	1571	0	89	1521	0	0	490	0	0	596	0
Turn Type	pm+pt			pm+pt			Perm			Perm		
Protected Phases	1	6		5	2			4			4	
Permitted Phases	6			2			4			4		
Total Split (s)	15.0	34.0	0.0	15.0	34.0	0.0	31.0	31.0	0.0	31.0	31.0	0.0
Act Effct Green (s)	52.0	46.1		53.8	47.0			15.9			15.9	
Actuated g/C Ratio	0.65	0.58		0.67	0.59			0.20			0.20	
v/c Ratio	0.32	0.54		0.28	0.51			0.61			0.70	
Control Delay	7.7	12.6		12.5	17.8			30.8			42.6	
Queue Delay	0.0	0.0		0.0	0.0			0.0			0.0	
Total Delay	7.7	12.6		12.5	17.8			30.8			42.6	
LOS	A	B		B	B			C			D	
Approach Delay		12.3			17.5			30.8			42.6	
Approach LOS		B			B			C			D	

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 80
Offset: 47 (59%), Referenced to phase 2:WBTL and 6:EBTL, Start of Green
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 0.70
Intersection Signal Delay: 20.5 Intersection LOS: C
Intersection Capacity Utilization 65.7% ICU Level of Service C
Analysis Period (min) 15

Splits and Phases: 127: E Broadway & Commercial Dr

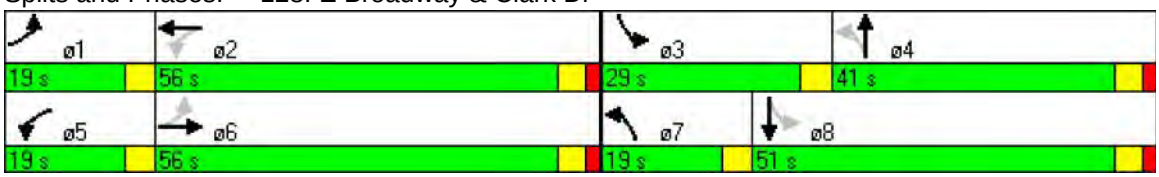


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	5040	0	1770	4979	0	1770	4943	0	1770	5014	0
Flt Permitted	0.077			0.077			0.108			0.098		
Satd. Flow (perm)	143	5040	0	143	4979	0	201	4943	0	183	5014	0
Satd. Flow (RTOR)		8			24			35			12	
Volume (vph)	112	1286	82	181	1148	189	71	767	178	372	1215	121
Lane Group Flow (vph)	122	1487	0	197	1453	0	77	1027	0	404	1453	0
Turn Type	pm+pt			pm+pt			pm+pt			pm+pt		
Protected Phases	1	6		5	2		7	4		3	8	
Permitted Phases	6			2			4			8		
Total Split (s)	19.0	56.0	0.0	19.0	56.0	0.0	19.0	41.0	0.0	29.0	51.0	0.0
Act Effct Green (s)	63.2	52.1		69.0	55.1		43.7	34.7		63.7	52.9	
Actuated g/C Ratio	0.45	0.37		0.49	0.39		0.30	0.24		0.45	0.37	
v/c Ratio	0.64	0.80		0.85	0.75		0.48	0.83		1.12	0.77	
Control Delay	41.9	44.6		65.1	40.4		35.6	56.0		122.9	43.3	
Queue Delay	0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0	
Total Delay	41.9	44.6		65.1	40.4		35.6	56.0		122.9	43.3	
LOS	D	D		E	D		D	E		F	D	
Approach Delay		44.4			43.3			54.5			60.6	
Approach LOS		D			D			D			E	

Intersection Summary

Cycle Length: 145
Actuated Cycle Length: 142
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 1.12
Intersection Signal Delay: 50.8 Intersection LOS: D
Intersection Capacity Utilization 89.4% ICU Level of Service E
Analysis Period (min) 15

Splits and Phases: 128: E Broadway & Clark Dr



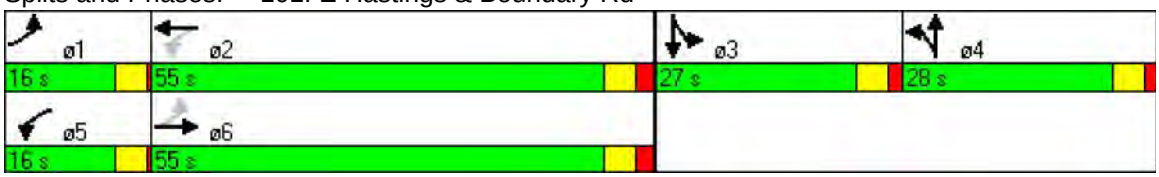
Appendix E – Scenario 3 Synchro Output Files (AM and PM)

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	3429	0	1770	5075	0	1610	3163	0	1770	3405	0
Flt Permitted	0.078			0.189			0.950	0.975		0.950		
Satd. Flow (perm)	145	3429	0	352	5075	0	1610	3163	0	1770	3405	0
Satd. Flow (RTOR)		31			2			39			33	
Volume (vph)	30	634	165	210	1576	27	362	71	102	11	198	68
Lane Group Flow (vph)	33	868	0	228	1742	0	197	384	0	12	289	0
Turn Type	pm+pt			pm+pt			Split			Split		
Protected Phases	1	6		5	2		4	4		3	3	
Permitted Phases	6			2								
Total Split (s)	16.0	55.0	0.0	16.0	55.0	0.0	28.0	28.0	0.0	27.0	27.0	0.0
Act Effct Green (s)	39.9	33.4		48.7	43.2		17.8	17.8		13.8	13.8	
Actuated g/C Ratio	0.41	0.36		0.52	0.46		0.19	0.19		0.15	0.15	
v/c Ratio	0.19	0.70		0.65	0.74		0.64	0.60		0.05	0.54	
Control Delay	15.5	27.9		22.3	24.5		48.7	37.6		41.9	39.6	
Queue Delay	0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0	
Total Delay	15.5	27.9		22.3	24.5		48.7	37.6		41.9	39.6	
LOS	B	C		C	C		D	D		D	D	
Approach Delay		27.5			24.2			41.4			39.7	
Approach LOS		C			C			D			D	

Intersection Summary

Cycle Length: 126
Actuated Cycle Length: 93.3
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 0.74
Intersection Signal Delay: 28.9 Intersection LOS: C
Intersection Capacity Utilization 66.7% ICU Level of Service C
Analysis Period (min) 15

Splits and Phases: 101: E Hastings & Boundary Rd

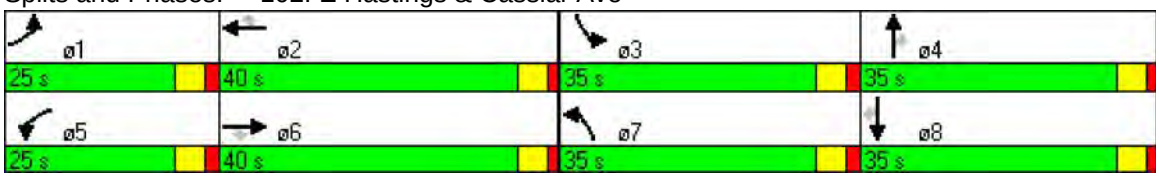


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	3539	1583	1770	5085	1583	3433	3539	1583	3433	3539	1583
Flt Permitted	0.950			0.950			0.950			0.950		
Satd. Flow (perm)	1770	3539	1583	1770	5085	1583	3433	3539	1583	3433	3539	1583
Satd. Flow (RTOR)			260			15			23			107
Volume (vph)	78	559	318	85	1481	27	597	225	21	368	46	98
Lane Group Flow (vph)	85	608	346	92	1610	29	649	245	23	400	50	107
Turn Type	Prot		Perm	Prot		Perm	Prot		Perm	Prot		Perm
Protected Phases	1	6		5	2		7	4		3	8	
Permitted Phases			6			2			4			8
Total Split (s)	25.0	40.0	40.0	25.0	40.0	40.0	35.0	35.0	35.0	35.0	35.0	35.0
Act Effct Green (s)	10.8	36.8	36.8	11.1	37.1	37.1	26.0	14.5	14.5	16.9	8.3	8.3
Actuated g/C Ratio	0.11	0.40	0.40	0.12	0.40	0.40	0.28	0.16	0.16	0.18	0.09	0.09
v/c Ratio	0.42	0.43	0.44	0.44	0.79	0.05	0.68	0.44	0.09	0.64	0.16	0.45
Control Delay	48.0	24.8	9.2	48.0	31.1	15.2	35.6	39.8	15.6	41.5	44.3	15.7
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	48.0	24.8	9.2	48.0	31.1	15.2	35.6	39.8	15.6	41.5	44.3	15.7
LOS	D	C	A	D	C	B	D	D	B	D	D	B
Approach Delay		21.5			31.7			36.2			36.8	
Approach LOS		C			C			D			D	

Intersection Summary

Cycle Length: 135
Actuated Cycle Length: 92.9
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 0.79
Intersection Signal Delay: 30.9 Intersection LOS: C
Intersection Capacity Utilization 67.5% ICU Level of Service C
Analysis Period (min) 15

Splits and Phases: 102: E Hastings & Cassiar Ave

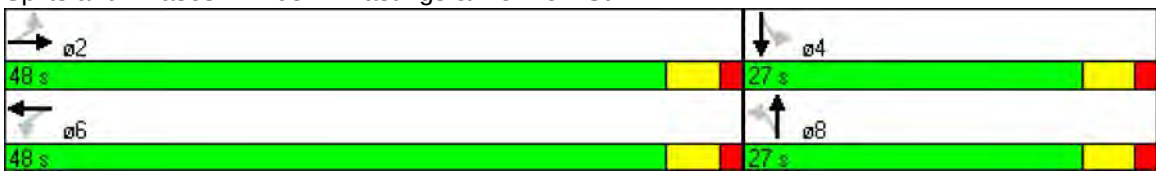


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	3497	0	1770	4958	0	0	4949	0	0	3451	0
Flt Permitted	0.091			0.277				0.858			0.631	
Satd. Flow (perm)	170	3497	0	516	4958	0	0	4272	0	0	2218	0
Satd. Flow (RTOR)		21			100			43			7	
Volume (vph)	39	736	64	69	1654	337	55	362	68	119	185	16
Lane Group Flow (vph)	42	870	0	75	2164	0	0	527	0	0	347	0
Turn Type	Perm			Perm			Perm			Perm		
Protected Phases		2			6			8			4	
Permitted Phases	2			6			8			4		
Total Split (s)	48.0	48.0	0.0	48.0	48.0	0.0	27.0	27.0	0.0	27.0	27.0	0.0
Act Effct Green (s)	44.0	44.0		44.0	44.0			23.0			23.0	
Actuated g/C Ratio	0.59	0.59		0.59	0.59			0.31			0.31	
v/c Ratio	0.42	0.42		0.25	0.73			0.39			0.51	
Control Delay	37.1	21.5		10.2	12.5			19.8			24.0	
Queue Delay	0.0	0.0		0.0	0.0			0.0			0.0	
Total Delay	37.1	21.5		10.2	12.5			19.8			24.0	
LOS	D	C		B	B			B			C	
Approach Delay		22.2			12.5			19.8			24.0	
Approach LOS		C			B			B			C	

Intersection Summary

Cycle Length: 75
Actuated Cycle Length: 75
Offset: 43 (57%), Referenced to phase 2:EBTL and 6:WBTL, Start of Green
Control Type: Pretimed
Maximum v/c Ratio: 0.73
Intersection Signal Delay: 16.6 Intersection LOS: B
Intersection Capacity Utilization 77.3% ICU Level of Service D
Analysis Period (min) 15

Splits and Phases: 103: E Hastings & Renfrew St

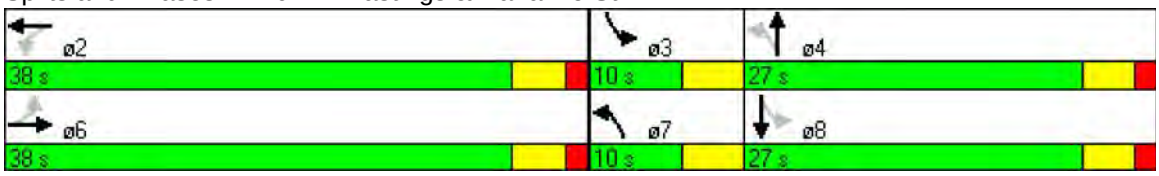


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	0	3514	0	0	5071	0	1770	5041	0	1770	4672	0
Flt Permitted		0.841			0.932		0.395			0.429		
Satd. Flow (perm)	0	2958	0	0	4726	0	714	5041	0	790	4672	0
Satd. Flow (RTOR)		6			3			10			52	
Volume (vph)	17	734	28	12	1676	19	177	429	20	45	315	180
Lane Group Flow (vph)	0	846	0	0	1856	0	192	488	0	49	538	0
Turn Type	Perm			Perm			pm+pt			pm+pt		
Protected Phases		6			2		7	4		3	8	
Permitted Phases	6			2			4			8		
Total Split (s)	38.0	38.0	0.0	38.0	38.0	0.0	10.0	27.0	0.0	10.0	27.0	0.0
Act Effct Green (s)		34.0			34.0		30.6	27.0		28.9	23.0	
Actuated g/C Ratio		0.45			0.45		0.41	0.36		0.39	0.31	
v/c Ratio		0.63			0.87		0.51	0.27		0.13	0.37	
Control Delay		6.1			17.9		19.3	18.2		13.1	19.1	
Queue Delay		0.0			0.0		0.0	0.0		0.0	0.0	
Total Delay		6.1			17.9		19.3	18.2		13.1	19.1	
LOS		A			B		B	B		B	B	
Approach Delay		6.1			17.9			18.5			18.6	
Approach LOS		A			B			B			B	

Intersection Summary

Cycle Length: 75
Actuated Cycle Length: 75
Offset: 20 (27%), Referenced to phase 2:WBTL and 6:EBTL, Start of Green
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 0.87
Intersection Signal Delay: 15.6 Intersection LOS: B
Intersection Capacity Utilization 78.4% ICU Level of Service D
Analysis Period (min) 15

Splits and Phases: 104: E Hastings & Nanaimo St

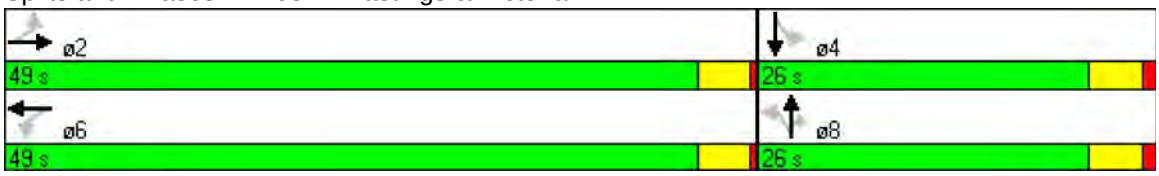


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	3529	0	1770	5060	0	0	1844	1583	0	3409	0
Flt Permitted	0.089			0.337				0.924			0.884	
Satd. Flow (perm)	166	3529	0	628	5060	0	0	1721	1583	0	3044	0
Satd. Flow (RTOR)		4			11				103		11	
Volume (vph)	21	666	12	131	1843	57	37	148	95	24	73	21
Lane Group Flow (vph)	23	737	0	142	2065	0	0	201	103	0	128	0
Turn Type	Perm			Perm			Perm		Perm	Perm		
Protected Phases		2			6			8			4	
Permitted Phases	2			6			8		8	4		
Total Split (s)	49.0	49.0	0.0	49.0	49.0	0.0	26.0	26.0	26.0	26.0	26.0	0.0
Act Effct Green (s)	45.0	45.0		45.0	45.0			22.0	22.0		22.0	
Actuated g/C Ratio	0.60	0.60		0.60	0.60			0.29	0.29		0.29	
v/c Ratio	0.23	0.35		0.38	0.68			0.40	0.19		0.14	
Control Delay	30.3	23.1		5.7	4.8			24.1	5.7		18.4	
Queue Delay	0.0	0.0		0.0	0.0			0.0	0.0		0.0	
Total Delay	30.3	23.1		5.7	4.8			24.1	5.7		18.4	
LOS	C	C		A	A			C	A		B	
Approach Delay		23.3			4.9			17.9			18.4	
Approach LOS		C			A			B			B	

Intersection Summary

Cycle Length: 75
Actuated Cycle Length: 75
Offset: 54 (72%), Referenced to phase 2:EBTL and 6:WBTL, Start of Green
Control Type: Pretimed
Maximum v/c Ratio: 0.68
Intersection Signal Delay: 10.7 Intersection LOS: B
Intersection Capacity Utilization 71.7% ICU Level of Service C
Analysis Period (min) 15

Splits and Phases: 105: E Hastings & Victoria Dr



Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	3508	0	1770	5072	0	1770	1756	0	1770	1740	0
Flt Permitted	0.129			0.228			0.643			0.619		
Satd. Flow (perm)	240	3508	0	420	5072	0	1118	1756	0	1125	1740	0
Satd. Flow (RTOR)		7			3			32			6	
Volume (vph)	21	678	30	71	1847	19	71	110	48	13	110	32
Lane Group Flow (vph)	23	770	0	77	2029	0	77	172	0	14	155	0
Turn Type	Perm			pm+pt			Perm			Perm		
Protected Phases		2		1	6			8			4	
Permitted Phases	2			6			8			4		
Total Split (s)	35.0	35.0	0.0	10.0	45.0	0.0	30.0	30.0	0.0	30.0	30.0	0.0
Act Effct Green (s)	33.0	33.0		41.0	41.0		26.0	26.0		26.0	26.0	
Actuated g/C Ratio	0.44	0.44		0.55	0.55		0.35	0.35		0.35	0.35	
v/c Ratio	0.22	0.50		0.23	0.73		0.20	0.27		0.04	0.26	
Control Delay	8.4	4.8		12.3	15.6		19.0	15.7		16.7	18.3	
Queue Delay	0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0	
Total Delay	8.4	4.8		12.3	15.6		19.0	15.7		16.7	18.3	
LOS	A	A		B	B		B	B		B	B	
Approach Delay		4.9			15.5			16.7			18.2	
Approach LOS		A			B			B			B	

Intersection Summary

Cycle Length: 75
Actuated Cycle Length: 75
Offset: 0 (0%), Referenced to phase 2:EBTL and 6:WBTL, Start of Green
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 0.73
Intersection Signal Delay: 13.2 Intersection LOS: B
Intersection Capacity Utilization 71.1% ICU Level of Service C
Analysis Period (min) 15

Splits and Phases: 106: E Hastings & Commercial Dr

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	3483	0	1770	5065	0	0	3497	1583	0	3529	1583
Flt Permitted	0.190			0.190				0.687			0.912	
Satd. Flow (perm)	354	3483	0	354	5065	0	0	2431	1583	0	3228	1583
Satd. Flow (RTOR)		17			6				49			
Volume (vph)	61	595	70	369	1480	44	119	364	117	22	401	50
Lane Group Flow (vph)	66	723	0	401	1657	0	0	525	127	0	460	54
Turn Type	pm+pt			pm+pt			Perm		pm+ov	Perm		pm+ov
Protected Phases	1	6		5	2			4	5		8	1
Permitted Phases	6			2			4		4	8		8
Total Split (s)	21.0	25.0	0.0	21.0	25.0	0.0	29.0	29.0	21.0	29.0	29.0	21.0
Act Effct Green (s)	29.7	22.9		42.0	33.1			25.0	44.1		25.0	35.8
Actuated g/C Ratio	0.40	0.31		0.56	0.44			0.33	0.59		0.33	0.48
v/c Ratio	0.25	0.67		0.83	0.74			0.65	0.13		0.43	0.07
Control Delay	11.6	26.5		23.3	8.4			25.8	4.3		21.0	10.6
Queue Delay	0.0	0.0		0.0	0.0			0.0	0.0		0.0	0.0
Total Delay	11.6	26.5		23.3	8.4			25.8	4.3		21.0	10.6
LOS	B	C		C	A			C	A		C	B
Approach Delay		25.3			11.3			21.6			19.9	
Approach LOS		C			B			C			B	

Intersection Summary

Cycle Length: 75
Actuated Cycle Length: 75
Offset: 45 (60%), Referenced to phase 2:WBTL and 6:EBTL, Start of Green
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 0.83
Intersection Signal Delay: 16.8 Intersection LOS: B
Intersection Capacity Utilization 89.1% ICU Level of Service E
Analysis Period (min) 15

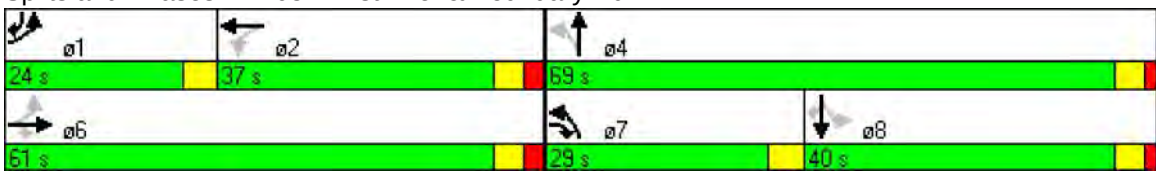
Splits and Phases: 107: E Hastings & Clark Dr

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	1863	1583	1770	1812	0	0	4939	0	0	3536	1583
Flt Permitted	0.150			0.577				0.697			0.905	
Satd. Flow (perm)	279	1863	1583	1075	1812	0	0	3502	0	0	3203	1583
Satd. Flow (RTOR)			18		8			15				207
Volume (vph)	268	276	66	50	292	64	294	489	66	20	768	279
Lane Group Flow (vph)	291	300	72	54	387	0	0	924	0	0	857	303
Turn Type	pm+pt		pm+ov	Perm			pm+pt			Perm		pm+ov
Protected Phases	1	6	7		2		7	4			8	1
Permitted Phases	6		6	2			4			8		8
Total Split (s)	24.0	61.0	29.0	37.0	37.0	0.0	29.0	69.0	0.0	40.0	40.0	24.0
Act Effct Green (s)	48.9	48.9	60.7	28.6	28.6			41.4			32.6	53.0
Actuated g/C Ratio	0.49	0.49	0.60	0.29	0.29			0.42			0.33	0.54
v/c Ratio	0.76	0.33	0.08	0.17	0.73			1.77dl			0.81	0.32
Control Delay	34.5	17.4	7.4	31.5	42.5			22.7			39.1	5.7
Queue Delay	0.0	0.0	0.0	0.0	0.0			0.0			0.0	0.0
Total Delay	34.5	17.4	7.4	31.5	42.5			22.7			39.1	5.7
LOS	C	B	A	C	D			C			D	A
Approach Delay		23.8			41.1			22.7			30.4	
Approach LOS		C			D			C			C	

Intersection Summary

Cycle Length: 130
Actuated Cycle Length: 98.8
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 0.81
Intersection Signal Delay: 28.3 Intersection LOS: C
Intersection Capacity Utilization 86.1% ICU Level of Service E
Analysis Period (min) 15
dl Defacto Left Lane. Recode with 1 though lane as a left lane.

Splits and Phases: 108: E 1st Ave. & Boundary Rd

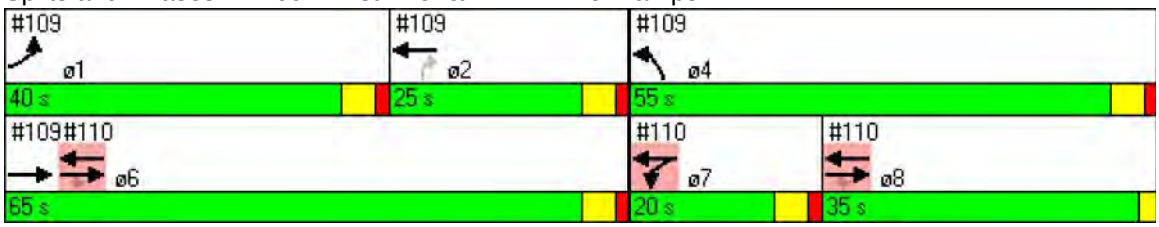


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	3539	0	0	5085	1583	3433	0	1583	0	0	0
Flt Permitted	0.950						0.950					
Satd. Flow (perm)	1770	3539	0	0	5085	1583	3433	0	1583	0	0	0
Satd. Flow (RTOR)						66			154			
Volume (vph)	238	461	0	0	596	167	374	0	142	0	0	0
Lane Group Flow (vph)	259	501	0	0	648	182	407	0	154	0	0	0
Turn Type	Prot					Free	Prot		custom			
Protected Phases	1	6			2		4					
Permitted Phases						Free			2			
Total Split (s)	40.0	65.0	0.0	0.0	25.0	0.0	55.0	0.0	25.0	0.0	0.0	0.0
Act Effct Green (s)	36.0	61.0			21.0	120.0	51.0		21.0			
Actuated g/C Ratio	0.30	0.51			0.18	1.00	0.42		0.18			
v/c Ratio	0.49	0.28			0.73	0.11	0.28		0.38			
Control Delay	35.3	14.5			52.3	0.1	23.2		9.6			
Queue Delay	4.4	0.6			0.0	0.0	0.0		0.0			
Total Delay	39.7	15.1			52.3	0.1	23.2		9.6			
LOS	D	B			D	A	C		A			
Approach Delay		23.5			40.8							
Approach LOS		C			D							

Intersection Summary

Cycle Length: 120
Actuated Cycle Length: 120
Offset: 0 (0%), Referenced to phase 2:WBT and 6:EBT, Start of Green
Control Type: Pretimed
Maximum v/c Ratio: 0.89
Intersection Signal Delay: 29.1 Intersection LOS: C
Intersection Capacity Utilization 79.8% ICU Level of Service D
Analysis Period (min) 15

Splits and Phases: 109: E 1st Ave. & HW1 WB on ramps



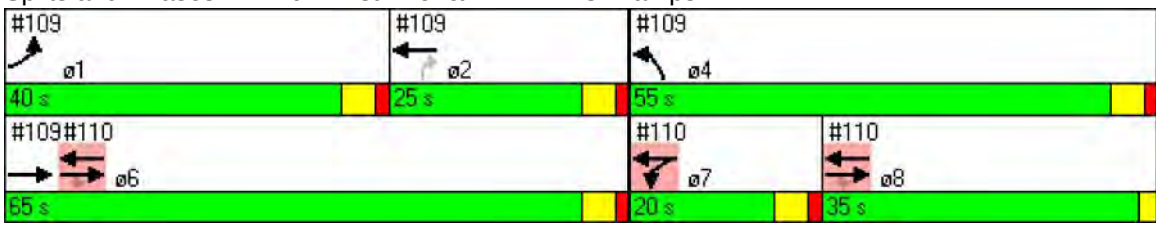
Lane Group	ø7	ø8
Lane Configurations		
Total Lost Time (s)		
Satd. Flow (prot)		
Flt Permitted		
Satd. Flow (perm)		
Satd. Flow (RTOR)		
Volume (vph)		
Lane Group Flow (vph)		
Turn Type		
Protected Phases	7	8
Permitted Phases		
Total Split (s)	20.0	35.0
Act Effct Green (s)		
Actuated g/C Ratio		
v/c Ratio		
Control Delay		
Queue Delay		
Total Delay		
LOS		
Approach Delay		
Approach LOS		

Intersection Summary

Lane Group	EBT	EBR	WBL	WBT	NBL	NBR	ø1	ø2	ø4	ø6	ø8
Lane Configurations											
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0					
Satd. Flow (prot)	5085	1583	1770	5085	0	0					
Flt Permitted			0.950								
Satd. Flow (perm)	5085	1583	1770	5085	0	0					
Satd. Flow (RTOR)		471									
Volume (vph)	752	1110	80	956	0	0					
Lane Group Flow (vph)	817	1207	87	1039	0	0					
Turn Type		Perm	Prot								
Protected Phases	6 8		7	6 7 8			1	2	4	6	8
Permitted Phases		6 8									
Total Split (s)	100.0	100.0	20.0	120.0	0.0	0.0	40.0	25.0	55.0	65.0	35.0
Act Effct Green (s)	96.0	96.0	16.0	120.0							
Actuated g/C Ratio	0.80	0.80	0.13	1.00							
v/c Ratio	0.20	0.89	0.37	0.20							
Control Delay	3.0	14.6	27.6	0.1							
Queue Delay	0.0	0.0	0.0	0.0							
Total Delay	3.0	14.6	27.6	0.1							
LOS	A	B	C	A							
Approach Delay	9.9			2.2							
Approach LOS	A			A							

Intersection Summary	
Cycle Length: 120	
Actuated Cycle Length: 120	
Offset: 0 (0%), Referenced to phase 2:WBT and 6:EBT, Start of Green	
Control Type: Pretimed	
Maximum v/c Ratio: 0.89	
Intersection Signal Delay: 7.2	Intersection LOS: A
Intersection Capacity Utilization 79.8%	ICU Level of Service D
Analysis Period (min) 15	

Splits and Phases: 110: E 1st Ave. & HW1 EB On ramps

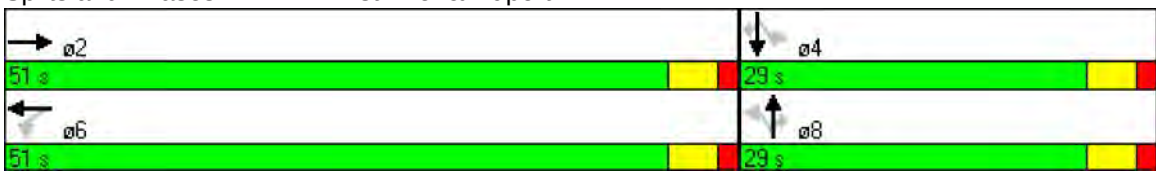


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	0	5065	0	0	3490	0	1770	1522	1504	1770	3539	1583
Flt Permitted					0.815		0.399			0.672		
Satd. Flow (perm)	0	5065	0	0	2850	0	743	1522	1504	1252	3539	1583
Satd. Flow (RTOR)		9			20			49	49			127
Volume (vph)	0	1249	37	39	682	64	177	7	206	215	422	117
Lane Group Flow (vph)	0	1398	0	0	853	0	192	120	112	234	459	127
Turn Type				Perm			Perm		Perm	Perm		Perm
Protected Phases		2			6			8			4	
Permitted Phases				6			8		8	4		4
Total Split (s)	0.0	51.0	0.0	51.0	51.0	0.0	29.0	29.0	29.0	29.0	29.0	29.0
Act Effct Green (s)		47.0			47.0		25.0	25.0	25.0	25.0	25.0	25.0
Actuated g/C Ratio		0.59			0.59		0.31	0.31	0.31	0.31	0.31	0.31
v/c Ratio		0.47			0.51		0.83	0.24	0.22	0.60	0.42	0.22
Control Delay		21.1			10.7		56.4	14.1	13.6	30.9	23.1	5.2
Queue Delay		0.0			0.0		0.0	0.0	0.0	0.0	0.0	0.0
Total Delay		21.1			10.7		56.4	14.1	13.6	30.9	23.1	5.2
LOS		C			B		E	B	B	C	C	A
Approach Delay		21.1			10.7			33.1			22.6	
Approach LOS		C			B			C			C	

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 80
Offset: 31 (39%), Referenced to phase 2:EBT and 6:WBTL, Start of Green
Control Type: Pretimed
Maximum v/c Ratio: 0.83
Intersection Signal Delay: 20.4 Intersection LOS: C
Intersection Capacity Utilization 81.7% ICU Level of Service D
Analysis Period (min) 15

Splits and Phases: 111: E 1st Ave. & Rupert

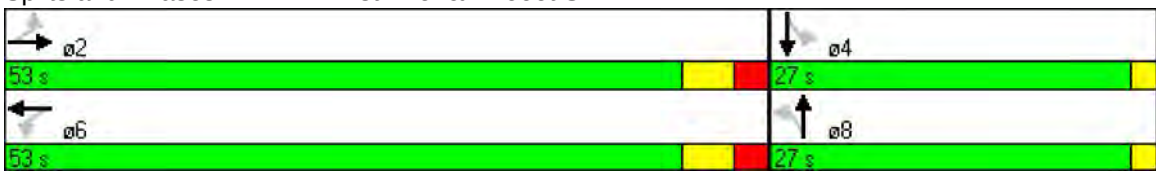


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	0	3539	0	0	3536	0	0	1650	0	0	1709	0
Flt Permitted		0.952			0.951			0.978			0.893	
Satd. Flow (perm)	0	3369	0	0	3362	0	0	1629	0	0	1562	0
Satd. Flow (RTOR)					2			18			37	
Volume (vph)	4	1262	3	4	1071	10	4	1	17	35	6	34
Lane Group Flow (vph)	0	1379	0	0	1179	0	0	23	0	0	82	0
Turn Type	Perm			Perm			Perm			Perm		
Protected Phases		2			6			8			4	
Permitted Phases	2			6			8			4		
Total Split (s)	53.0	53.0	0.0	53.0	53.0	0.0	27.0	27.0	0.0	27.0	27.0	0.0
Act Effct Green (s)		49.0			49.0			23.0			23.0	
Actuated g/C Ratio		0.61			0.61			0.29			0.29	
v/c Ratio		0.67			0.57			0.05			0.17	
Control Delay		24.9			8.1			11.6			14.4	
Queue Delay		0.0			0.0			0.0			0.0	
Total Delay		24.9			8.1			11.6			14.4	
LOS		C			A			B			B	
Approach Delay		24.9			8.1			11.6			14.4	
Approach LOS		C			A			B			B	

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 80
Offset: 56 (70%), Referenced to phase 2:EBTL and 6:WBTL, Start of Green
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 0.67
Intersection Signal Delay: 17.0 Intersection LOS: B
Intersection Capacity Utilization 53.8% ICU Level of Service A
Analysis Period (min) 15

Splits and Phases: 112: E 1st Ave. & Lillooet ST

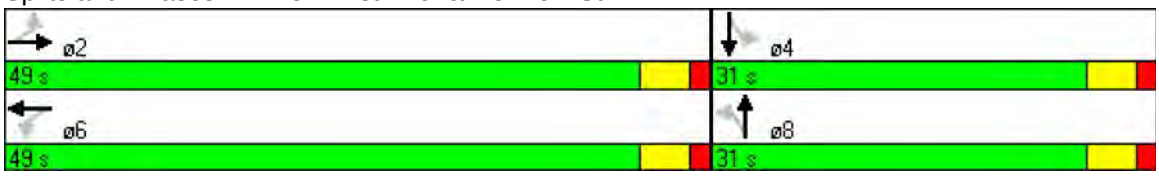


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	3511	0	1770	3476	0	1770	3497	0	1770	3479	0
Flt Permitted	0.211			0.158			0.325			0.347		
Satd. Flow (perm)	393	3511	0	294	3476	0	605	3497	0	646	3479	0
Satd. Flow (RTOR)		11			30			12			19	
Volume (vph)	50	1043	57	49	833	111	91	465	39	91	470	62
Lane Group Flow (vph)	54	1196	0	53	1026	0	99	547	0	99	578	0
Turn Type	Perm			Perm			Perm			Perm		
Protected Phases		2			6			8			4	
Permitted Phases	2			6			8			4		
Total Split (s)	49.0	49.0	0.0	49.0	49.0	0.0	31.0	31.0	0.0	31.0	31.0	0.0
Act Effct Green (s)	45.0	45.0		45.0	45.0		27.0	27.0		27.0	27.0	
Actuated g/C Ratio	0.56	0.56		0.56	0.56		0.34	0.34		0.34	0.34	
v/c Ratio	0.24	0.60		0.32	0.52		0.49	0.46		0.45	0.49	
Control Delay	17.1	22.1		6.7	3.0		30.8	21.8		29.0	22.0	
Queue Delay	0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0	
Total Delay	17.1	22.1		6.7	3.0		30.8	21.8		29.0	22.0	
LOS	B	C		A	A		C	C		C	C	
Approach Delay		21.8			3.2			23.2			23.0	
Approach LOS		C			A			C			C	

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 80
Offset: 2 (3%), Referenced to phase 2:EBTL and 6:WBTL, Start of Green
Control Type: Pretimed
Maximum v/c Ratio: 0.60
Intersection Signal Delay: 16.8 Intersection LOS: B
Intersection Capacity Utilization 67.3% ICU Level of Service C
Analysis Period (min) 15

Splits and Phases: 113: E 1st Ave. & Renfrew St

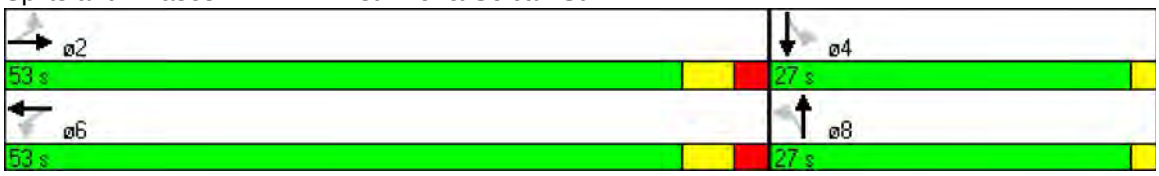


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	0	3539	0	0	3536	0	0	1708	0	0	1681	0
Flt Permitted		0.945			0.951			0.957			0.997	
Satd. Flow (perm)	0	3345	0	0	3362	0	0	1661	0	0	1679	0
Satd. Flow (RTOR)		1			1			12			15	
Volume (vph)	9	1170	3	4	957	4	7	4	11	1	5	14
Lane Group Flow (vph)	0	1285	0	0	1048	0	0	24	0	0	21	0
Turn Type	Perm			Perm			Perm			Perm		
Protected Phases		2			6			8			4	
Permitted Phases	2			6			8			4		
Total Split (s)	53.0	53.0	0.0	53.0	53.0	0.0	27.0	27.0	0.0	27.0	27.0	0.0
Act Effct Green (s)		49.0			49.0			23.0			23.0	
Actuated g/C Ratio		0.61			0.61			0.29			0.29	
v/c Ratio		0.63			0.51			0.05			0.04	
Control Delay		8.8			5.8			14.5			12.5	
Queue Delay		0.0			0.0			0.0			0.0	
Total Delay		8.8			5.8			14.5			12.5	
LOS		A			A			B			B	
Approach Delay		8.8			5.8			14.5			12.5	
Approach LOS		A			A			B			B	

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 80
Offset: 30 (38%), Referenced to phase 2:EBTL and 6:WBTL, Start of Green
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 0.63
Intersection Signal Delay: 7.5 Intersection LOS: A
Intersection Capacity Utilization 49.4% ICU Level of Service A
Analysis Period (min) 15

Splits and Phases: 114: E 1st Ave. & Solcan St

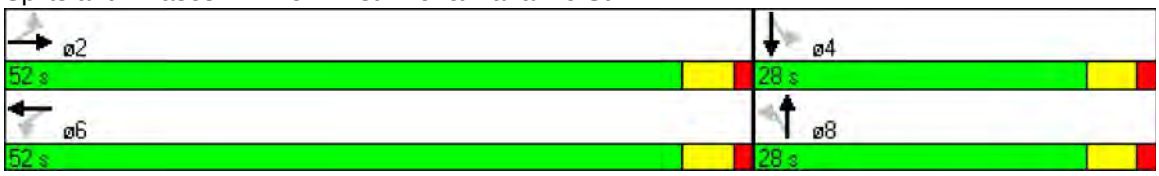


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	3522	0	1770	3514	0	1770	3493	0	1770	4994	0
Flt Permitted	0.215			0.170			0.339			0.223		
Satd. Flow (perm)	400	3522	0	317	3514	0	631	3493	0	415	4994	0
Satd. Flow (RTOR)		8			11			12			33	
Volume (vph)	45	1064	38	54	923	44	93	582	54	49	498	70
Lane Group Flow (vph)	49	1198	0	59	1051	0	101	692	0	53	617	0
Turn Type	Perm			Perm			Perm			Perm		
Protected Phases		2			6			8			4	
Permitted Phases	2			6			8			4		
Total Split (s)	52.0	52.0	0.0	52.0	52.0	0.0	28.0	28.0	0.0	28.0	28.0	0.0
Act Effct Green (s)	48.0	48.0		48.0	48.0		24.0	24.0		24.0	24.0	
Actuated g/C Ratio	0.60	0.60		0.60	0.60		0.30	0.30		0.30	0.30	
v/c Ratio	0.20	0.57		0.31	0.50		0.53	0.66		0.42	0.41	
Control Delay	19.8	22.7		4.8	1.8		35.6	27.5		35.0	22.0	
Queue Delay	0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0	
Total Delay	19.8	22.7		4.8	1.8		35.6	27.5		35.0	22.0	
LOS	B	C		A	A		D	C		C	C	
Approach Delay		22.6			1.9			28.5			23.0	
Approach LOS		C			A			C			C	

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 80
Offset: 68 (85%), Referenced to phase 2:EBTL and 6:WBTL, Start of Green
Control Type: Pretimed
Maximum v/c Ratio: 0.66
Intersection Signal Delay: 17.9 Intersection LOS: B
Intersection Capacity Utilization 68.4% ICU Level of Service C
Analysis Period (min) 15

Splits and Phases: 115: E 1st Ave. & Nanaimo St

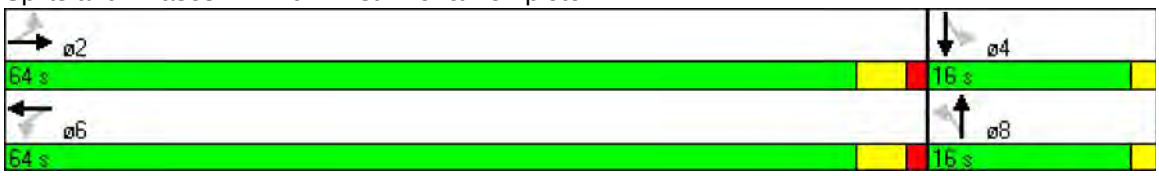


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	0	3536	0	0	3539	0	0	1657	0	0	1611	0
Flt Permitted					0.954			0.994				
Satd. Flow (perm)	0	3536	0	0	3376	0	0	1652	0	0	1611	0
Satd. Flow (RTOR)		1			1			12			145	
Volume (vph)	0	1144	5	2	1056	2	1	2	11	0	0	3
Lane Group Flow (vph)	0	1248	0	0	1152	0	0	15	0	0	3	0
Turn Type	Perm			Perm			Perm			Perm		
Protected Phases		2			6			8			4	
Permitted Phases	2			6			8			4		
Total Split (s)	64.0	64.0	0.0	64.0	64.0	0.0	16.0	16.0	0.0	16.0	16.0	0.0
Act Effct Green (s)		60.0			60.0			12.0			12.0	
Actuated g/C Ratio		0.75			0.75			0.15			0.15	
v/c Ratio		0.47			0.45			0.06			0.01	
Control Delay		2.5			2.4			18.1			0.0	
Queue Delay		0.0			0.0			0.0			0.0	
Total Delay		2.5			2.4			18.1			0.0	
LOS		A			A			B			A	
Approach Delay		2.5			2.4			18.1			0.0	
Approach LOS		A			A			B			A	

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 80
Offset: 76 (95%), Referenced to phase 2:EBTL and 6:WBTL, Start of Green
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 0.47
Intersection Signal Delay: 2.6 Intersection LOS: A
Intersection Capacity Utilization 41.8% ICU Level of Service A
Analysis Period (min) 15

Splits and Phases: 116: E 1st Ave. & Templeton Dr

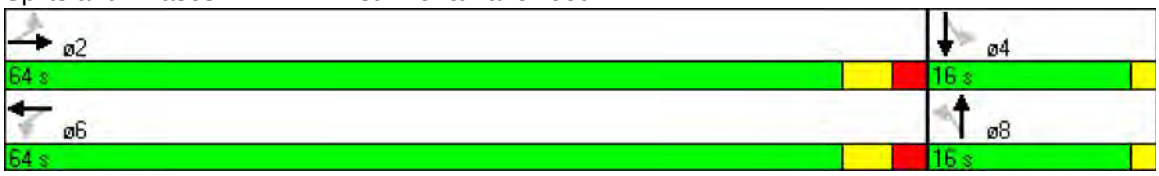


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	0	3539	0	0	3539	0	0	1611	0	0	1736	0
Flt Permitted		0.945			0.947						0.965	
Satd. Flow (perm)	0	3345	0	0	3352	0	0	1611	0	0	1700	0
Satd. Flow (RTOR)		1						115			4	
Volume (vph)	7	1175	3	7	1289	1	0	0	11	3	3	4
Lane Group Flow (vph)	0	1288	0	0	1410	0	0	12	0	0	10	0
Turn Type	Perm			Perm			Perm			Perm		
Protected Phases		2			6			8			4	
Permitted Phases	2			6			8			4		
Total Split (s)	64.0	64.0	0.0	64.0	64.0	0.0	16.0	16.0	0.0	16.0	16.0	0.0
Act Effct Green (s)		60.0			60.0			12.0			12.0	
Actuated g/C Ratio		0.75			0.75			0.15			0.15	
v/c Ratio		0.51			0.56			0.04			0.04	
Control Delay		7.9			2.0			0.2			24.4	
Queue Delay		0.0			0.0			0.0			0.0	
Total Delay		7.9			2.0			0.2			24.4	
LOS		A			A			A			C	
Approach Delay		7.9			2.0			0.2			24.4	
Approach LOS		A			A			A			C	

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 80
Offset: 7 (9%), Referenced to phase 2:EBTL and 6:WBTL, Start of Green
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 0.56
Intersection Signal Delay: 4.9 Intersection LOS: A
Intersection Capacity Utilization 50.5% ICU Level of Service A
Analysis Period (min) 15

Splits and Phases: 117: E 1st Ave. & Lakewood Dr

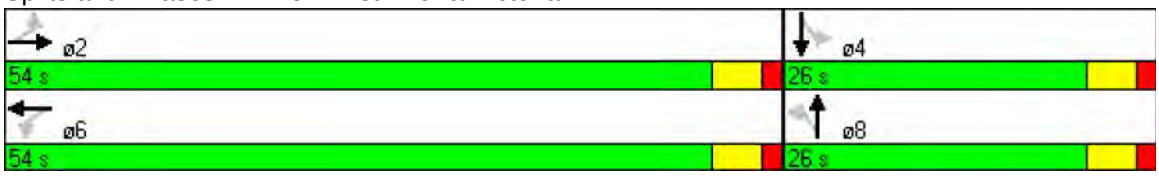


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	0	1861	0	0	3458	0	0	3486	0	0	3430	0
Flt Permitted								0.874			0.695	
Satd. Flow (perm)	0	1861	0	0	3458	0	0	3065	0	0	2423	0
Satd. Flow (RTOR)		1			49			8			14	
Volume (vph)	0	1077	12	0	1109	200	39	261	20	100	180	30
Lane Group Flow (vph)	0	1184	0	0	1422	0	0	348	0	0	338	0
Turn Type	Perm			Perm			Perm			Perm		
Protected Phases		2			6			8			4	
Permitted Phases	2			6			8			4		
Total Split (s)	54.0	54.0	0.0	54.0	54.0	0.0	26.0	26.0	0.0	26.0	26.0	0.0
Act Effct Green (s)		50.0			50.0			22.0			22.0	
Actuated g/C Ratio		0.62			0.62			0.28			0.28	
v/c Ratio		1.02			0.65			0.41			0.50	
Control Delay		51.0			5.1			24.9			26.4	
Queue Delay		0.0			0.0			0.0			0.0	
Total Delay		51.0			5.1			24.9			26.4	
LOS		D			A			C			C	
Approach Delay		51.0			5.1			24.9			26.4	
Approach LOS		D			A			C			C	

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 80
Offset: 35 (44%), Referenced to phase 2:EBTL and 6:WBTL, Start of Green
Control Type: Pretimed
Maximum v/c Ratio: 1.02
Intersection Signal Delay: 25.9 Intersection LOS: C
Intersection Capacity Utilization 85.2% ICU Level of Service E
Analysis Period (min) 15

Splits and Phases: 118: E 1st Ave. & Victoria Dr

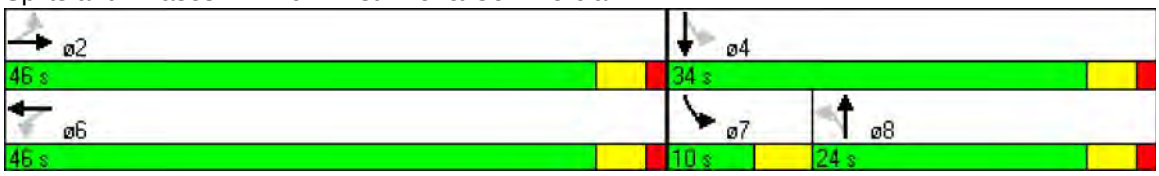


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	3517	0	1770	1832	0	1770	3341	0	1770	3417	0
Flt Permitted	0.095			0.228			0.577			0.325		
Satd. Flow (perm)	177	3517	0	422	1832	0	966	3341	0	535	3417	0
Satd. Flow (RTOR)		6			7			19			20	
Volume (vph)	33	841	27	30	946	72	59	342	49	125	233	29
Lane Group Flow (vph)	36	943	0	33	1106	0	64	425	0	136	285	0
Turn Type	Perm			Perm			Perm			pm+pt		
Protected Phases		2			6			8		7	4	
Permitted Phases	2			6			8			4		
Total Split (s)	46.0	46.0	0.0	46.0	46.0	0.0	24.0	24.0	0.0	10.0	34.0	0.0
Act Effct Green (s)	46.4	46.4		46.4	46.4		15.6	15.6		25.6	25.6	
Actuated g/C Ratio	0.58	0.58		0.58	0.58		0.20	0.20		0.32	0.32	
v/c Ratio	0.35	0.46		0.13	1.04		0.34	0.64		0.52	0.26	
Control Delay	27.2	12.8		4.8	48.0		31.8	32.4		26.6	18.7	
Queue Delay	0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0	
Total Delay	27.2	12.8		4.8	48.0		31.8	32.4		26.6	18.7	
LOS	C	B		A	D		C	C		C	B	
Approach Delay		13.4			46.8			32.3			21.2	
Approach LOS		B			D			C			C	

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 80
Offset: 54 (68%), Referenced to phase 2:EBTL and 6:WBTL, Start of Green
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 1.04
Intersection Signal Delay: 30.1 Intersection LOS: C
Intersection Capacity Utilization 84.7% ICU Level of Service E
Analysis Period (min) 15

Splits and Phases: 119: E 1st Ave. & Commercial Dr

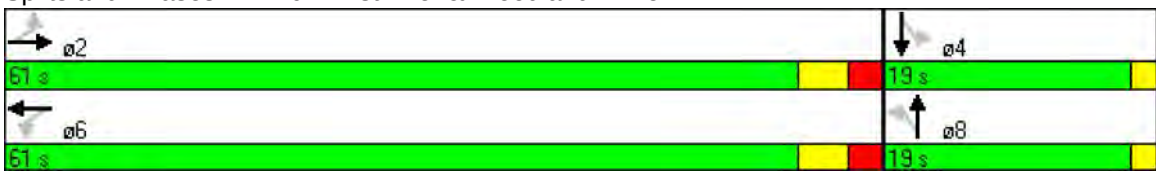


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	0	3536	0	0	3525	0	0	1700	0	0	1752	0
Flt Permitted		0.945			0.933			0.983			0.979	
Satd. Flow (perm)	0	3341	0	0	3292	0	0	1681	0	0	1729	0
Satd. Flow (RTOR)		2			5			25			10	
Volume (vph)	8	915	6	16	954	17	5	10	23	4	11	9
Lane Group Flow (vph)	0	1011	0	0	1072	0	0	41	0	0	26	0
Turn Type	Perm			Perm			Perm			Perm		
Protected Phases		2			6			8			4	
Permitted Phases	2			6			8			4		
Total Split (s)	61.0	61.0	0.0	61.0	61.0	0.0	19.0	19.0	0.0	19.0	19.0	0.0
Act Effct Green (s)		57.0			57.0			15.0			15.0	
Actuated g/C Ratio		0.71			0.71			0.19			0.19	
v/c Ratio		0.42			0.46			0.12			0.08	
Control Delay		5.7			1.2			16.4			20.6	
Queue Delay		0.0			0.0			0.0			0.0	
Total Delay		5.7			1.2			16.4			20.6	
LOS		A			A			B			C	
Approach Delay		5.7			1.2			16.4			20.6	
Approach LOS		A			A			B			C	

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 80
Offset: 70 (88%), Referenced to phase 2:EBTL and 6:WBTL, Start of Green
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 0.46
Intersection Signal Delay: 3.9 Intersection LOS: A
Intersection Capacity Utilization 48.3% ICU Level of Service A
Analysis Period (min) 15

Splits and Phases: 120: E 1st Ave. & Woodland Drive

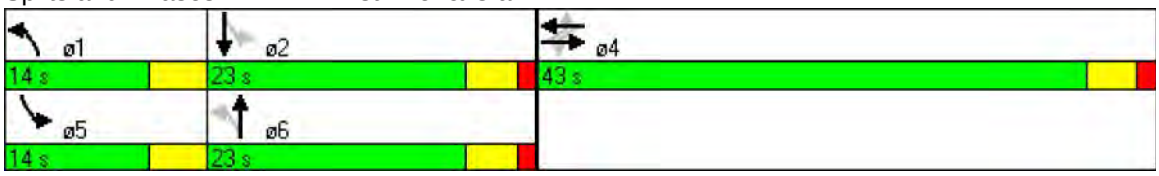


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	0	3391	0	0	3451	0	1770	4963	0	1770	4989	0
Flt Permitted					0.955		0.211			0.211		
Satd. Flow (perm)	0	3391	0	0	3295	0	393	4963	0	393	4989	0
Satd. Flow (RTOR)		98			40			45			31	
Volume (vph)	0	621	239	1	767	152	309	1078	203	129	782	114
Lane Group Flow (vph)	0	935	0	0	1000	0	336	1393	0	140	974	0
Turn Type	Perm			Perm			pm+pt			pm+pt		
Protected Phases		4			4		1	6		5	2	
Permitted Phases	4			4			6			2		
Total Split (s)	43.0	43.0	0.0	43.0	43.0	0.0	14.0	23.0	0.0	14.0	23.0	0.0
Act Effct Green (s)		39.0			39.0		30.2	20.2		27.8	19.0	
Actuated g/C Ratio		0.49			0.49		0.38	0.25		0.35	0.24	
v/c Ratio		0.55			0.61		1.05	1.08		0.48	0.81	
Control Delay		14.1			4.8		86.8	81.5		21.3	34.0	
Queue Delay		0.0			0.0		0.0	0.0		0.0	0.0	
Total Delay		14.1			4.8		86.8	81.5		21.3	34.0	
LOS		B			A		F	F		C	C	
Approach Delay		14.1			4.8			82.5			32.4	
Approach LOS		B			A			F			C	

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 80
Offset: 18 (23%), Referenced to phase 4:EBWB, Start of Green
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 1.08
Intersection Signal Delay: 41.2 Intersection LOS: D
Intersection Capacity Utilization 71.5% ICU Level of Service C
Analysis Period (min) 15

Splits and Phases: 121: E 1st Ave. & Clark Dr

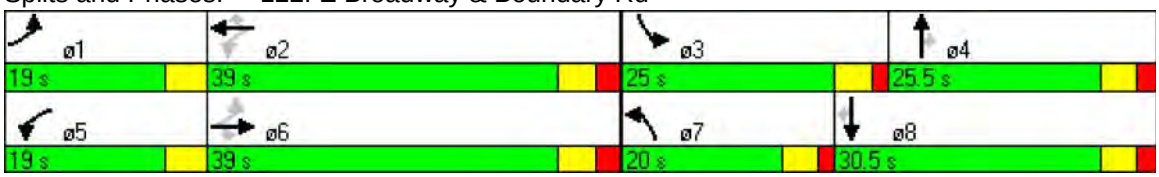


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	3539	1583	1770	3539	1583	3433	3539	1583	1770	3539	1583
Flt Permitted	0.114			0.153			0.950			0.950		
Satd. Flow (perm)	212	3539	1583	285	3539	1583	3433	3539	1583	1770	3539	1583
Satd. Flow (RTOR)			167			131			108			273
Volume (vph)	169	757	154	126	1438	184	309	401	99	231	588	374
Lane Group Flow (vph)	184	823	167	137	1563	200	336	436	108	251	639	407
Turn Type	pm+pt		Perm	pm+pt		Perm	Prot		Perm	Prot		Perm
Protected Phases	1	6		5	2		7	4		3	8	
Permitted Phases	6		6	2		2			4			8
Total Split (s)	19.0	39.0	39.0	19.0	39.0	39.0	20.0	25.5	25.5	25.0	30.5	30.5
Act Effct Green (s)	48.4	36.9	36.9	45.0	35.2	35.2	14.6	20.3	20.3	18.5	24.2	24.2
Actuated g/C Ratio	0.48	0.36	0.36	0.44	0.35	0.35	0.14	0.20	0.20	0.18	0.24	0.24
v/c Ratio	0.66	0.64	0.25	0.51	1.27	0.32	0.68	0.62	0.27	0.78	0.76	0.70
Control Delay	30.8	30.7	4.9	22.0	160.3	11.5	49.8	42.2	9.1	57.5	43.0	19.0
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	30.8	30.7	4.9	22.0	160.3	11.5	49.8	42.2	9.1	57.5	43.0	19.0
LOS	C	C	A	C	F	B	D	D	A	E	D	B
Approach Delay		27.0			134.7			41.0			38.2	
Approach LOS		C			F			D			D	

Intersection Summary

Cycle Length: 108.5
Actuated Cycle Length: 101.6
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 1.27
Intersection Signal Delay: 71.1 Intersection LOS: E
Intersection Capacity Utilization 87.7% ICU Level of Service E
Analysis Period (min) 15

Splits and Phases: 122: E Broadway & Boundary Rd

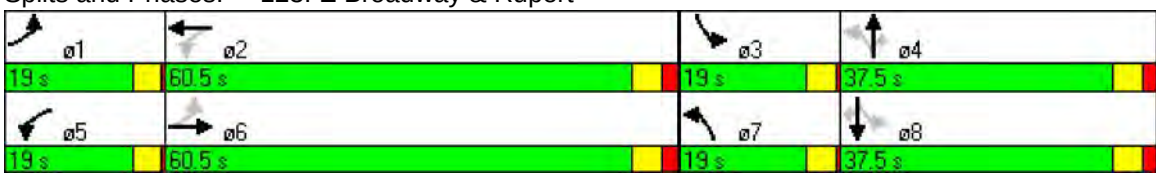


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	5004	0	1770	5075	0	1770	3539	1583	1770	3539	1583
Flt Permitted	0.071			0.156			0.343			0.457		
Satd. Flow (perm)	132	5004	0	291	5075	0	639	3539	1583	851	3539	1583
Satd. Flow (RTOR)		19			2				191			146
Volume (vph)	43	927	113	193	1721	24	262	287	176	56	394	134
Lane Group Flow (vph)	47	1131	0	210	1897	0	285	312	191	61	428	146
Turn Type	pm+pt			pm+pt			pm+pt		Perm	pm+pt		Perm
Protected Phases	1	6		5	2		7	4		3	8	
Permitted Phases	6			2			4		4	8		8
Total Split (s)	19.0	60.5	0.0	19.0	60.5	0.0	19.0	37.5	37.5	19.0	37.5	37.5
Act Effct Green (s)	63.5	56.7		73.1	64.3		40.8	30.6	30.6	30.2	21.8	21.8
Actuated g/C Ratio	0.51	0.46		0.60	0.53		0.33	0.25	0.25	0.24	0.18	0.18
v/c Ratio	0.30	0.48		0.65	0.71		0.81	0.35	0.35	0.23	0.68	0.36
Control Delay	16.8	23.7		22.0	24.8		51.7	40.1	7.3	30.7	52.7	9.3
Queue Delay	0.0	0.0		0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	16.8	23.7		22.0	24.8		51.7	40.1	7.3	30.7	52.7	9.3
LOS	B	C		C	C		D	D	A	C	D	A
Approach Delay		23.5			24.5			36.4			40.6	
Approach LOS		C			C			D			D	

Intersection Summary

Cycle Length: 136
Actuated Cycle Length: 122
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 0.81
Intersection Signal Delay: 28.4 Intersection LOS: C
Intersection Capacity Utilization 78.3% ICU Level of Service D
Analysis Period (min) 15

Splits and Phases: 123: E Broadway & Rupert

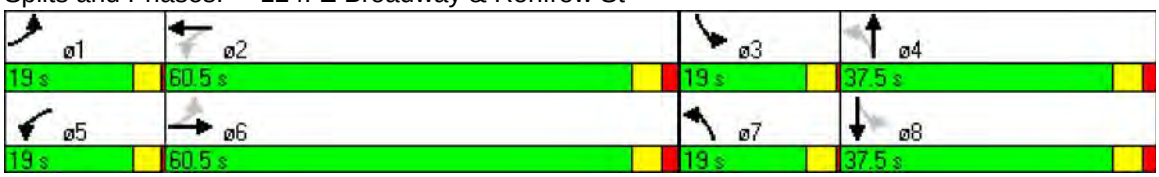


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	5019	0	1770	5065	0	1770	3437	0	1770	3405	0
Flt Permitted	0.071			0.125			0.201			0.281		
Satd. Flow (perm)	132	5019	0	233	5065	0	374	3437	0	523	3405	0
Satd. Flow (RTOR)		14			4			21			33	
Volume (vph)	83	1051	98	84	1958	54	124	369	89	66	409	140
Lane Group Flow (vph)	90	1249	0	91	2187	0	135	498	0	72	597	0
Turn Type	pm+pt			pm+pt			pm+pt			pm+pt		
Protected Phases	1	6		5	2		7	4		3	8	
Permitted Phases	6			2			4			8		
Total Split (s)	19.0	60.5	0.0	19.0	60.5	0.0	19.0	37.5	0.0	19.0	37.5	0.0
Act Effct Green (s)	64.3	57.6		63.9	57.4		41.4	31.6		34.5	25.9	
Actuated g/C Ratio	0.54	0.49		0.54	0.49		0.35	0.27		0.29	0.22	
v/c Ratio	0.48	0.51		0.39	0.88		0.49	0.53		0.30	0.77	
Control Delay	24.7	23.0		18.1	34.5		33.0	38.6		29.3	48.3	
Queue Delay	0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0	
Total Delay	24.7	23.0		18.1	34.5		33.0	38.6		29.3	48.3	
LOS	C	C		B	C		C	D		C	D	
Approach Delay		23.1			33.8			37.4			46.3	
Approach LOS		C			C			D			D	

Intersection Summary

Cycle Length: 136
Actuated Cycle Length: 117.4
Control Type: Semi Act-Uncoord
Maximum v/c Ratio: 0.88
Intersection Signal Delay: 33.0 Intersection LOS: C
Intersection Capacity Utilization 79.6% ICU Level of Service D
Analysis Period (min) 15

Splits and Phases: 124: E Broadway & Renfrew St

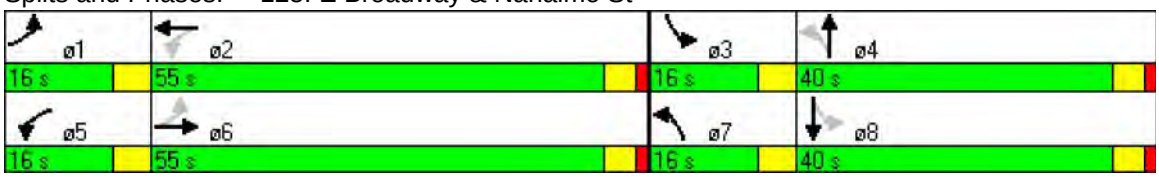


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	5055	0	1770	5065	0	1770	4984	0	1770	4867	0
Flt Permitted	0.078			0.120			0.277			0.278		
Satd. Flow (perm)	145	5055	0	224	5065	0	516	4984	0	518	4867	0
Satd. Flow (RTOR)		6			3			23			79	
Volume (vph)	90	1107	46	116	2104	51	149	528	83	61	438	175
Lane Group Flow (vph)	98	1253	0	126	2342	0	162	664	0	66	666	0
Turn Type	pm+pt			pm+pt			pm+pt			pm+pt		
Protected Phases	1	6		5	2		7	4		3	8	
Permitted Phases	6			2			4			8		
Total Split (s)	16.0	55.0	0.0	16.0	55.0	0.0	16.0	40.0	0.0	16.0	40.0	0.0
Act Effct Green (s)	56.8	48.7		59.0	51.7		33.5	24.6		27.6	19.5	
Actuated g/C Ratio	0.54	0.47		0.57	0.50		0.32	0.24		0.26	0.19	
v/c Ratio	0.48	0.53		0.49	0.93		0.55	0.56		0.29	0.68	
Control Delay	21.7	21.3		17.3	34.6		33.5	37.1		28.4	38.8	
Queue Delay	0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0	
Total Delay	21.7	21.3		17.3	34.6		33.5	37.1		28.4	38.8	
LOS	C	C		B	C		C	D		C	D	
Approach Delay		21.4			33.7			36.4			37.9	
Approach LOS		C			C			D			D	

Intersection Summary

Cycle Length: 127
Actuated Cycle Length: 104.1
Control Type: Semi Act-Uncoord
Maximum v/c Ratio: 0.93
Intersection Signal Delay: 31.6 Intersection LOS: C
Intersection Capacity Utilization 80.7% ICU Level of Service D
Analysis Period (min) 15

Splits and Phases: 125: E Broadway & Nanaimo St



Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	5070	0	1770	5065	0	1770	1863	1583	1770	1794	0
Flt Permitted	0.098			0.219			0.455			0.559		
Satd. Flow (perm)	183	5070	0	408	5065	0	848	1863	1583	1041	1794	0
Satd. Flow (RTOR)		7			9				70		2	
Volume (vph)	30	967	23	89	2208	68	88	199	64	78	205	66
Lane Group Flow (vph)	33	1076	0	97	2474	0	96	216	70	85	295	0
Turn Type	Perm			Perm			Perm		Perm	Perm		
Protected Phases		2			6			8			4	
Permitted Phases	2			6			8		8	4		
Total Split (s)	45.0	45.0	0.0	45.0	45.0	0.0	30.0	30.0	30.0	30.0	30.0	0.0
Act Effct Green (s)	41.0	41.0		41.0	41.0		26.0	26.0	26.0	26.0	26.0	
Actuated g/C Ratio	0.55	0.55		0.55	0.55		0.35	0.35	0.35	0.35	0.35	
v/c Ratio	0.33	0.39		0.43	0.89		0.33	0.33	0.12	0.24	0.47	
Control Delay	23.1	8.5		17.9	20.5		22.0	19.9	5.3	19.7	22.1	
Queue Delay	0.0	0.0		0.0	0.0		0.0	0.0	0.0	0.0	0.0	
Total Delay	23.1	8.5		17.9	20.5		22.0	19.9	5.3	19.7	22.1	
LOS	C	A		B	C		C	B	A	B	C	
Approach Delay		9.0			20.4			17.8			21.6	
Approach LOS		A			C			B			C	

Intersection Summary

Cycle Length: 75
Actuated Cycle Length: 75
Offset: 34 (45%), Referenced to phase 2:EBTL and 6:WBTL, Start of Green
Control Type: Pretimed
Maximum v/c Ratio: 0.89
Intersection Signal Delay: 17.4 Intersection LOS: B
Intersection Capacity Utilization 80.5% ICU Level of Service D
Analysis Period (min) 15

Splits and Phases: 126: E Broadway & Victoria Dr

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	5040	0	1770	5070	0	0	4989	0	0	4888	0
Flt Permitted	0.154			0.154				0.823			0.838	
Satd. Flow (perm)	287	5040	0	287	5070	0	0	4139	0	0	4121	0
Satd. Flow (RTOR)		14			4			19			61	
Volume (vph)	62	983	60	55	1911	40	101	452	45	31	167	56
Lane Group Flow (vph)	67	1133	0	60	2120	0	0	650	0	0	277	0
Turn Type	pm+pt			pm+pt			Perm			Perm		
Protected Phases	1	6		5	2			4			4	
Permitted Phases	6			2			4			4		
Total Split (s)	15.0	30.0	0.0	15.0	30.0	0.0	30.0	30.0	0.0	30.0	30.0	0.0
Act Effct Green (s)	45.9	41.5		46.1	41.6			18.6			18.6	
Actuated g/C Ratio	0.61	0.55		0.61	0.55			0.25			0.25	
v/c Ratio	0.22	0.40		0.19	0.75			0.62			0.26	
Control Delay	8.0	11.9		10.4	18.3			26.5			17.1	
Queue Delay	0.0	0.0		0.0	0.0			0.0			0.0	
Total Delay	8.0	11.9		10.4	18.3			26.5			17.1	
LOS	A	B		B	B			C			B	
Approach Delay		11.7			18.1			26.5			17.1	
Approach LOS		B			B			C			B	

Intersection Summary

Cycle Length: 75
Actuated Cycle Length: 75
Offset: 47 (63%), Referenced to phase 2:WBTL and 6:EBTL, Start of Green
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 0.75
Intersection Signal Delay: 17.5 Intersection LOS: B
Intersection Capacity Utilization 72.2% ICU Level of Service C
Analysis Period (min) 15

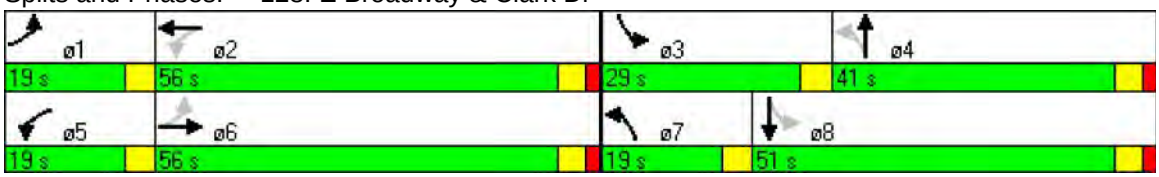
Splits and Phases: 127: E Broadway & Commercial Dr

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	5040	0	1770	5009	0	1770	5024	0	1770	4938	0
Flt Permitted	0.077			0.191			0.297			0.098		
Satd. Flow (perm)	143	5040	0	356	5009	0	553	5024	0	183	4938	0
Satd. Flow (RTOR)		8			15			9			40	
Volume (vph)	138	812	52	155	1680	192	64	1030	88	250	588	139
Lane Group Flow (vph)	150	940	0	168	2035	0	70	1216	0	272	790	0
Turn Type	pm+pt			pm+pt			pm+pt			pm+pt		
Protected Phases	1	6		5	2		7	4		3	8	
Permitted Phases	6			2			4			8		
Total Split (s)	19.0	56.0	0.0	19.0	56.0	0.0	19.0	41.0	0.0	29.0	51.0	0.0
Act Effct Green (s)	64.2	52.2		64.8	52.5		44.8	36.3		60.8	50.5	
Actuated g/C Ratio	0.47	0.38		0.47	0.38		0.32	0.26		0.44	0.37	
v/c Ratio	0.72	0.49		0.57	1.06		0.28	0.91		0.86	0.43	
Control Delay	49.0	34.2		28.0	78.8		26.7	60.1		61.2	32.5	
Queue Delay	0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0	
Total Delay	49.0	34.2		28.0	78.8		26.7	60.1		61.2	32.5	
LOS	D	C		C	E		C	E		E	C	
Approach Delay		36.2			74.9			58.3			39.9	
Approach LOS		D			E			E			D	

Intersection Summary

Cycle Length: 145
Actuated Cycle Length: 137.4
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 1.06
Intersection Signal Delay: 57.0 Intersection LOS: E
Intersection Capacity Utilization 93.4% ICU Level of Service F
Analysis Period (min) 15

Splits and Phases: 128: E Broadway & Clark Dr

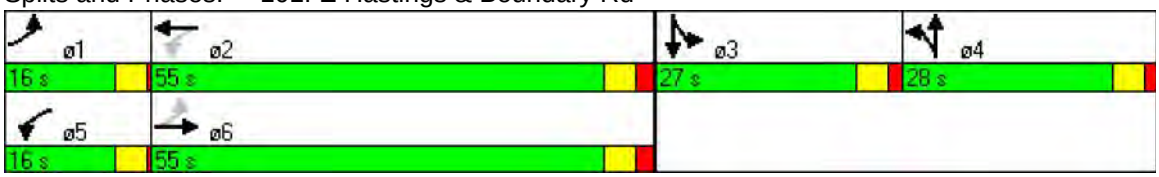


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	5019	0	1770	3525	0	1610	3157	0	1770	3429	0
Flt Permitted	0.097			0.078			0.950	0.995		0.950		
Satd. Flow (perm)	181	5019	0	145	3525	0	1610	3157	0	1770	3429	0
Satd. Flow (RTOR)		14			3			126			22	
Volume (vph)	156	1631	151	169	992	27	246	211	194	43	121	31
Lane Group Flow (vph)	170	1937	0	184	1107	0	215	492	0	47	166	0
Turn Type	pm+pt			pm+pt			Split			Split		
Protected Phases	1	6		5	2		4	4		3	3	
Permitted Phases	6			2								
Total Split (s)	16.0	55.0	0.0	16.0	55.0	0.0	28.0	28.0	0.0	27.0	27.0	0.0
Act Effct Green (s)	58.7	48.7		61.3	49.9		19.5	19.5		11.3	11.3	
Actuated g/C Ratio	0.55	0.46		0.57	0.47		0.18	0.18		0.11	0.11	
v/c Ratio	0.68	0.85		0.72	0.67		0.73	0.73		0.25	0.43	
Control Delay	32.5	30.8		40.1	25.8		57.7	37.6		50.4	44.3	
Queue Delay	0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0	
Total Delay	32.5	30.8		40.1	25.8		57.7	37.6		50.4	44.3	
LOS	C	C		D	C		E	D		D	D	
Approach Delay		31.0			27.8			43.7			45.6	
Approach LOS		C			C			D			D	

Intersection Summary

Cycle Length: 126
Actuated Cycle Length: 107
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 0.85
Intersection Signal Delay: 32.8 Intersection LOS: C
Intersection Capacity Utilization 77.0% ICU Level of Service D
Analysis Period (min) 15

Splits and Phases: 101: E Hastings & Boundary Rd

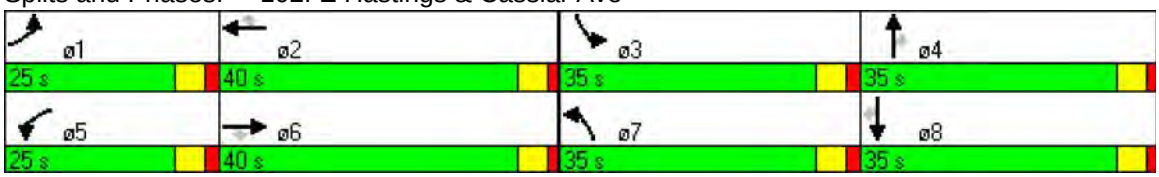


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	5085	1583	1770	3539	1583	3433	3539	1583	3433	3539	1583
Flt Permitted	0.950			0.950			0.950			0.950		
Satd. Flow (perm)	1770	5085	1583	1770	3539	1583	3433	3539	1583	3433	3539	1583
Satd. Flow (RTOR)			298			382			74			163
Volume (vph)	132	1269	575	67	783	509	404	327	68	721	66	150
Lane Group Flow (vph)	143	1379	625	73	851	553	439	355	74	784	72	163
Turn Type	Prot		Perm	Prot		Perm	Prot		Perm	Prot		Perm
Protected Phases	1	6		5	2		7	4		3	8	
Permitted Phases			6			2			4			8
Total Split (s)	25.0	40.0	40.0	25.0	40.0	40.0	35.0	35.0	35.0	35.0	35.0	35.0
Act Effct Green (s)	14.9	39.8	39.8	10.9	33.0	33.0	20.4	17.5	17.5	30.5	27.6	27.6
Actuated g/C Ratio	0.13	0.35	0.35	0.10	0.29	0.29	0.18	0.16	0.16	0.27	0.25	0.25
v/c Ratio	0.61	0.76	0.83	0.43	0.82	0.75	0.70	0.64	0.24	0.84	0.08	0.32
Control Delay	59.0	37.2	29.2	58.8	45.3	18.9	50.6	51.2	12.0	49.8	37.2	8.0
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	59.0	37.2	29.2	58.8	45.3	18.9	50.6	51.2	12.0	49.8	37.2	8.0
LOS	E	D	C	E	D	B	D	D	B	D	D	A
Approach Delay		36.3			36.1			47.6			42.2	
Approach LOS		D			D			D			D	

Intersection Summary

Cycle Length: 135
Actuated Cycle Length: 112.2
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 0.84
Intersection Signal Delay: 39.1 Intersection LOS: D
Intersection Capacity Utilization 71.9% ICU Level of Service C
Analysis Period (min) 15

Splits and Phases: 102: E Hastings & Cassiar Ave

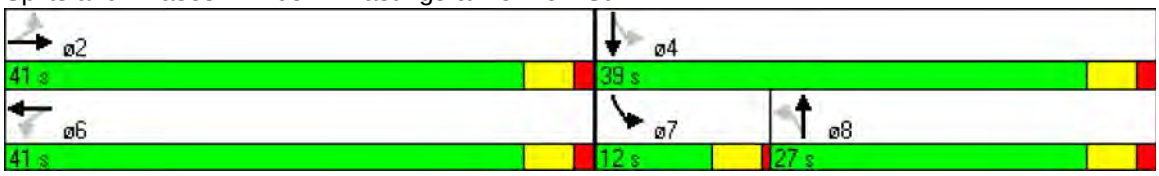


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	5050	0	1770	3483	0	0	4984	0	0	3437	0
Flt Permitted	0.108			0.108				0.790			0.575	
Satd. Flow (perm)	201	5050	0	201	3483	0	0	3965	0	0	2019	0
Satd. Flow (RTOR)		12			21			20			9	
Volume (vph)	57	1466	73	137	1116	132	67	387	43	251	308	32
Lane Group Flow (vph)	62	1672	0	149	1356	0	0	541	0	0	643	0
Turn Type	Perm			Perm			Perm			pm+pt		
Protected Phases		2			6			8		7	4	
Permitted Phases	2			6			8			4		
Total Split (s)	41.0	41.0	0.0	41.0	41.0	0.0	27.0	27.0	0.0	12.0	39.0	0.0
Act Effct Green (s)	37.0	37.0		37.0	37.0			23.0			35.0	
Actuated g/C Ratio	0.46	0.46		0.46	0.46			0.29			0.44	
v/c Ratio	0.67	0.71		1.60	0.84			0.47			0.62	
Control Delay	50.2	28.9		339.0	24.4			11.2			18.8	
Queue Delay	0.0	0.0		0.0	0.0			0.0			0.0	
Total Delay	50.2	28.9		339.0	24.4			11.2			18.8	
LOS	D	C		F	C			B			B	
Approach Delay		29.6			55.6			11.2			18.8	
Approach LOS		C			E			B			B	

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 80
Offset: 60 (75%), Referenced to phase 2:EBTL and 6:WBTL, Start of Green
Control Type: Pretimed
Maximum v/c Ratio: 1.60
Intersection Signal Delay: 34.6 Intersection LOS: C
Intersection Capacity Utilization 80.8% ICU Level of Service D
Analysis Period (min) 15

Splits and Phases: 103: E Hastings & Renfrew St

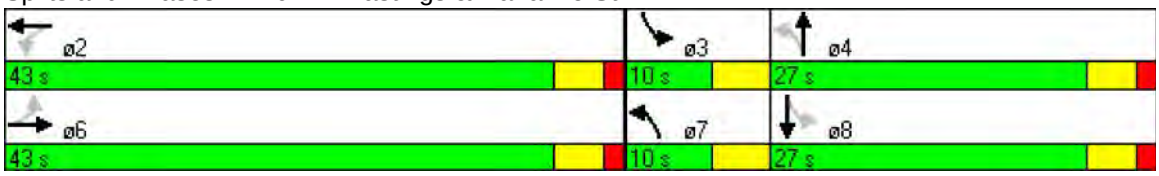


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	0	4973	0	0	3519	0	1770	4900	0	1770	4745	0
Flt Permitted		0.939			0.616		0.320			0.426		
Satd. Flow (perm)	0	4670	0	0	2173	0	535	4900	0	713	4745	0
Satd. Flow (RTOR)		13			1			24			47	
Volume (vph)	2	1774	88	60	1112	10	89	395	44	59	496	92
Lane Group Flow (vph)	0	2026	0	0	1285	0	97	477	0	64	639	0
Turn Type	Perm			Perm			pm+pt			pm+pt		
Protected Phases		6			2		7	4		3	8	
Permitted Phases	6			2			4			8		
Total Split (s)	43.0	43.0	0.0	43.0	43.0	0.0	10.0	27.0	0.0	10.0	27.0	0.0
Act Effct Green (s)		39.0			39.0		29.8	25.0		29.8	25.0	
Actuated g/C Ratio		0.49			0.49		0.37	0.31		0.37	0.31	
v/c Ratio		0.89			1.21		0.33	0.31		0.19	0.42	
Control Delay		19.7			125.4		14.2	20.2		15.9	21.8	
Queue Delay		0.0			0.0		0.0	0.0		0.0	0.0	
Total Delay		19.7			125.4		14.2	20.2		15.9	21.8	
LOS		B			F		B	C		B	C	
Approach Delay		19.7			125.4			19.2			21.2	
Approach LOS		B			F			B			C	

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 80
Offset: 23 (29%), Referenced to phase 2:WBTL and 6:EBTL, Start of Green
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 1.21
Intersection Signal Delay: 49.5 Intersection LOS: D
Intersection Capacity Utilization 105.3% ICU Level of Service G
Analysis Period (min) 15

Splits and Phases: 104: E Hastings & Nanaimo St

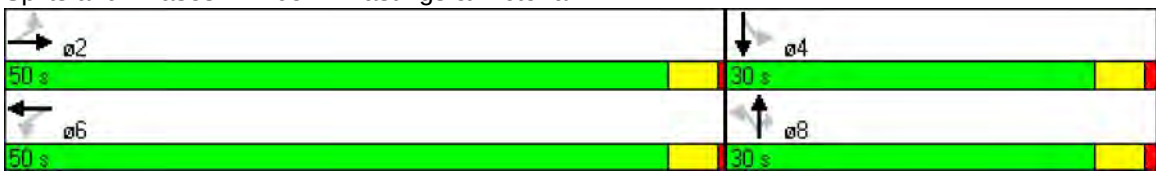


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	5065	0	1770	3525	0	0	1840	1583	0	3434	0
Flt Permitted	0.168			0.087				0.869			0.773	
Satd. Flow (perm)	313	5065	0	162	3525	0	0	1619	1583	0	2700	0
Satd. Flow (RTOR)		8			5				9		13	
Volume (vph)	26	1827	48	78	1053	28	48	148	258	82	139	20
Lane Group Flow (vph)	28	2038	0	85	1175	0	0	213	280	0	262	0
Turn Type	Perm			Perm			Perm		Perm	Perm		
Protected Phases		2			6			8			4	
Permitted Phases	2			6			8		8	4		
Total Split (s)	50.0	50.0	0.0	50.0	50.0	0.0	30.0	30.0	30.0	30.0	30.0	0.0
Act Effct Green (s)	46.0	46.0		46.0	46.0			26.0	26.0		26.0	
Actuated g/C Ratio	0.58	0.58		0.58	0.58			0.32	0.32		0.32	
v/c Ratio	0.16	0.70		0.91	0.58			0.40	0.54		0.30	
Control Delay	3.2	3.1		30.1	3.3			27.9	30.3		20.2	
Queue Delay	0.0	0.0		0.0	0.0			0.0	0.0		0.0	
Total Delay	3.2	3.1		30.1	3.3			27.9	30.3		20.2	
LOS	A	A		C	A			C	C		C	
Approach Delay		3.1			5.1			29.2			20.2	
Approach LOS		A			A			C			C	

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 80
Offset: 65 (81%), Referenced to phase 2:EBTL and 6:WBTL, Start of Green
Control Type: Pretimed
Maximum v/c Ratio: 0.91
Intersection Signal Delay: 8.0 Intersection LOS: A
Intersection Capacity Utilization 73.7% ICU Level of Service D
Analysis Period (min) 15

Splits and Phases: 105: E Hastings & Victoria Dr



Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	5042	0	1770	3528	0	1770	1709	0	1770	1814	0
Flt Permitted	0.247			0.100			0.577			0.493		
Satd. Flow (perm)	454	5042	0	186	3528	0	965	1709	0	890	1814	0
Satd. Flow (RTOR)		8			3			45			6	
Volume (vph)	62	1754	62	116	990	16	52	138	93	84	161	16
Lane Group Flow (vph)	67	1974	0	126	1093	0	57	251	0	91	192	0
Turn Type	Perm			pm+pt			Perm			Perm		
Protected Phases		2		1	6			8			4	
Permitted Phases	2			6			8			4		
Total Split (s)	40.0	40.0	0.0	10.0	50.0	0.0	30.0	30.0	0.0	30.0	30.0	0.0
Act Effct Green (s)	38.0	38.0		46.0	46.0		26.0	26.0		26.0	26.0	
Actuated g/C Ratio	0.48	0.48		0.58	0.58		0.32	0.32		0.32	0.32	
v/c Ratio	0.31	0.82		0.56	0.54		0.18	0.43		0.31	0.32	
Control Delay	9.8	12.2		22.1	20.2		18.0	17.8		24.1	21.6	
Queue Delay	0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0	
Total Delay	9.8	12.2		22.1	20.2		18.0	17.8		24.1	21.6	
LOS	A	B		C	C		B	B		C	C	
Approach Delay		12.1			20.4			17.8			22.4	
Approach LOS		B			C			B			C	

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 80
Offset: 50 (63%), Referenced to phase 2:EBTL and 6:WBTL, Start of Green
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 0.82
Intersection Signal Delay: 15.9 Intersection LOS: B
Intersection Capacity Utilization 74.5% ICU Level of Service D
Analysis Period (min) 15

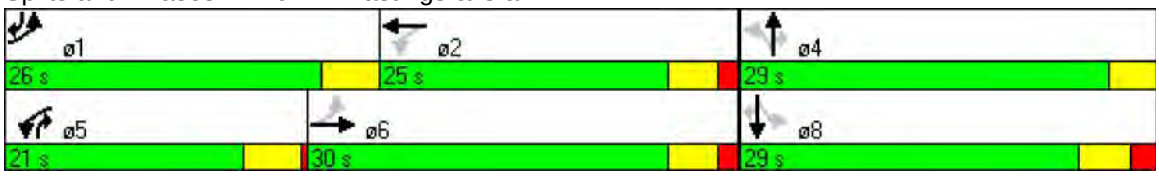
Splits and Phases: 106: E Hastings & Commercial Dr

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	5040	0	1770	3525	0	0	3522	1583	0	3518	1583
Flt Permitted	0.160			0.190				0.802			0.701	
Satd. Flow (perm)	298	5040	0	354	3525	0	0	2838	1583	0	2481	1583
Satd. Flow (RTOR)		13			3				1			9
Volume (vph)	128	1410	92	275	849	23	71	604	277	54	402	32
Lane Group Flow (vph)	139	1633	0	299	948	0	0	734	301	0	496	35
Turn Type	pm+pt			pm+pt			Perm		pm+ov	Perm		pm+ov
Protected Phases	1	6		5	2			4	5		8	1
Permitted Phases	6			2			4		4	8		8
Total Split (s)	26.0	30.0	0.0	21.0	25.0	0.0	29.0	29.0	21.0	29.0	29.0	26.0
Act Effct Green (s)	37.7	29.3		47.0	36.7			25.0	42.7		25.0	37.4
Actuated g/C Ratio	0.47	0.37		0.59	0.46			0.31	0.53		0.31	0.47
v/c Ratio	0.47	0.88		0.66	0.59			0.83	0.36		0.64	0.05
Control Delay	15.4	31.7		10.8	16.8			36.3	28.0		28.2	9.0
Queue Delay	0.0	0.0		0.0	0.0			0.0	0.0		0.0	0.0
Total Delay	15.4	31.7		10.8	16.8			36.3	28.0		28.2	9.0
LOS	B	C		B	B			D	C		C	A
Approach Delay		30.4			15.4			33.9			26.9	
Approach LOS		C			B			C			C	

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 80
Offset: 26 (33%), Referenced to phase 2:WBTL and 6:EBTL, Start of Green
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 0.88
Intersection Signal Delay: 26.7 Intersection LOS: C
Intersection Capacity Utilization 94.9% ICU Level of Service F
Analysis Period (min) 15

Splits and Phases: 107: E Hastings & Clark Dr

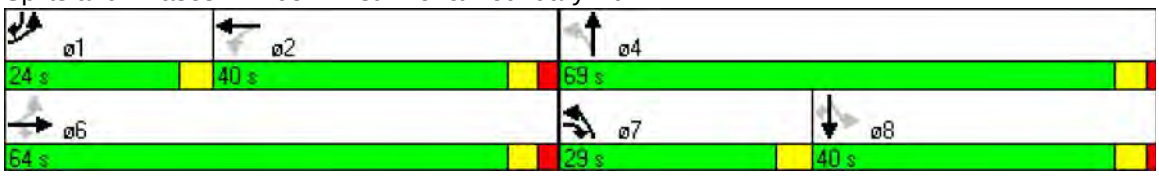


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	1863	1583	1770	1831	0	0	4979	0	0	3536	1583
Flt Permitted	0.386			0.674				0.660			0.890	
Satd. Flow (perm)	719	1863	1583	1255	1831	0	0	3323	0	0	3150	1583
Satd. Flow (RTOR)			37		5			11				172
Volume (vph)	200	119	41	73	193	25	221	668	61	19	626	198
Lane Group Flow (vph)	217	129	45	79	237	0	0	1032	0	0	701	215
Turn Type	pm+pt		pm+ov	Perm			pm+pt			Perm		pm+ov
Protected Phases	1	6	7		2		7	4			8	1
Permitted Phases	6		6	2			4			8		8
Total Split (s)	24.0	64.0	29.0	40.0	40.0	0.0	29.0	69.0	0.0	40.0	40.0	24.0
Act Effct Green (s)	38.4	38.4	50.1	22.1	22.1			33.3			26.9	43.3
Actuated g/C Ratio	0.48	0.48	0.59	0.28	0.28			0.42			0.34	0.54
v/c Ratio	0.43	0.14	0.05	0.23	0.47			1.22dl			0.66	0.23
Control Delay	17.3	14.5	3.9	29.6	30.7			20.7			27.7	3.6
Queue Delay	0.0	0.0	0.0	0.0	0.0			0.0			0.0	0.0
Total Delay	17.3	14.5	3.9	29.6	30.7			20.7			27.7	3.6
LOS	B	B	A	C	C			C			C	A
Approach Delay		14.9			30.5			20.7			22.0	
Approach LOS		B			C			C			C	

Intersection Summary

Cycle Length: 133
Actuated Cycle Length: 80.1
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 0.70
Intersection Signal Delay: 21.5 Intersection LOS: C
Intersection Capacity Utilization 79.9% ICU Level of Service D
Analysis Period (min) 15
dl Defacto Left Lane. Recode with 1 though lane as a left lane.

Splits and Phases: 108: E 1st Ave. & Boundary Rd

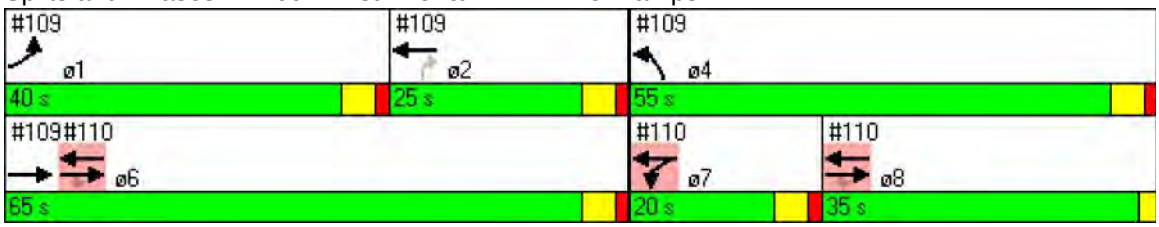


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	3539	0	0	5085	1583	3433	0	1583	0	0	0
Flt Permitted	0.950						0.950					
Satd. Flow (perm)	1770	3539	0	0	5085	1583	3433	0	1583	0	0	0
Satd. Flow (RTOR)						291			35			
Volume (vph)	366	173	0	0	239	294	969	0	81	0	0	0
Lane Group Flow (vph)	398	188	0	0	260	320	1053	0	88	0	0	0
Turn Type	Prot					Free	Prot		custom			
Protected Phases	1	6			2		4					
Permitted Phases						Free			2			
Total Split (s)	40.0	65.0	0.0	0.0	25.0	0.0	55.0	0.0	25.0	0.0	0.0	0.0
Act Effct Green (s)	36.0	61.0			21.0	120.0	51.0		21.0			
Actuated g/C Ratio	0.30	0.51			0.18	1.00	0.42		0.18			
v/c Ratio	0.75	0.10			0.29	0.20	0.72		0.29			
Control Delay	45.3	12.7			44.1	0.3	32.1		29.7			
Queue Delay	24.4	0.0			0.1	0.0	0.1		0.0			
Total Delay	69.6	12.7			44.1	0.3	32.2		29.7			
LOS	E	B			D	A	C		C			
Approach Delay		51.4			19.9							
Approach LOS		D			B							

Intersection Summary

Cycle Length: 120
Actuated Cycle Length: 120
Offset: 0 (0%), Referenced to phase 2:WBT and 6:EBT, Start of Green
Control Type: Pretimed
Maximum v/c Ratio: 0.98
Intersection Signal Delay: 33.9 Intersection LOS: C
Intersection Capacity Utilization 114.7% ICU Level of Service H
Analysis Period (min) 15

Splits and Phases: 109: E 1st Ave. & HW1 WB on ramps



Lane Group	ø7	ø8
Lane Configurations		
Total Lost Time (s)		
Satd. Flow (prot)		
Flt Permitted		
Satd. Flow (perm)		
Satd. Flow (RTOR)		
Volume (vph)		
Lane Group Flow (vph)		
Turn Type		
Protected Phases	7	8
Permitted Phases		
Total Split (s)	20.0	35.0
Act Effct Green (s)		
Actuated g/C Ratio		
v/c Ratio		
Control Delay		
Queue Delay		
Total Delay		
LOS		
Approach Delay		
Approach LOS		

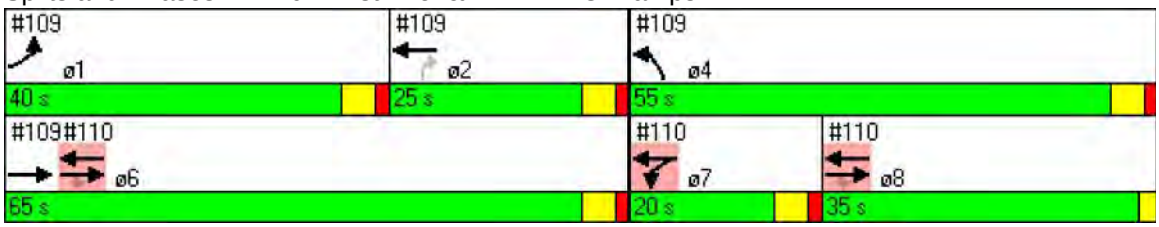
Intersection Summary

Lane Group	EBT	EBR	WBL	WBT	NBL	NBR	ø1	ø2	ø4	ø6	ø8
Lane Configurations											
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0					
Satd. Flow (prot)	5085	1583	1770	5085	0	0					
Flt Permitted			0.950								
Satd. Flow (perm)	5085	1583	1770	5085	0	0					
Satd. Flow (RTOR)		190									
Volume (vph)	640	1170	164	1244	0	0					
Lane Group Flow (vph)	696	1272	178	1352	0	0					
Turn Type		Perm	Prot								
Protected Phases	6 8		7	6 7 8			1	2	4	6	8
Permitted Phases		6 8									
Total Split (s)	100.0	100.0	20.0	120.0	0.0	0.0	40.0	25.0	55.0	65.0	35.0
Act Effct Green (s)	96.0	96.0	16.0	120.0							
Actuated g/C Ratio	0.80	0.80	0.13	1.00							
v/c Ratio	0.17	0.98	0.75	0.27							
Control Delay	2.9	30.5	75.6	0.1							
Queue Delay	0.0	0.0	3.7	0.0							
Total Delay	2.9	30.5	79.3	0.1							
LOS	A	C	E	A							
Approach Delay	20.7			9.3							
Approach LOS	C			A							

Intersection Summary

Cycle Length: 120
Actuated Cycle Length: 120
Offset: 0 (0%), Referenced to phase 2:WBT and 6:EBT, Start of Green
Control Type: Pretimed
Maximum v/c Ratio: 0.98
Intersection Signal Delay: 15.7 Intersection LOS: B
Intersection Capacity Utilization 114.7% ICU Level of Service H
Analysis Period (min) 15

Splits and Phases: 110: E 1st Ave. & HW1 EB On ramps

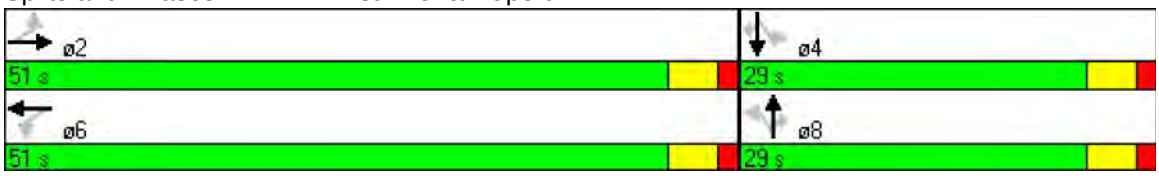


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	0	5060	0	0	3529	0	1770	1513	1504	1770	3539	1583
Flt Permitted		0.923			0.776		0.421			0.492		
Satd. Flow (perm)	0	4670	0	0	2746	0	784	1513	1504	916	3539	1583
Satd. Flow (RTOR)		11						56	56			67
Volume (vph)	12	1198	41	62	1128	0	175	7	417	113	398	103
Lane Group Flow (vph)	0	1360	0	0	1293	0	190	234	227	123	433	112
Turn Type	Perm			Perm			Perm		Perm	Perm		Perm
Protected Phases		2			6			8			4	
Permitted Phases	2			6			8		8	4		4
Total Split (s)	51.0	51.0	0.0	51.0	51.0	0.0	29.0	29.0	29.0	29.0	29.0	29.0
Act Effct Green (s)		47.0			47.0		25.0	25.0	25.0	25.0	25.0	25.0
Actuated g/C Ratio		0.59			0.59		0.31	0.31	0.31	0.31	0.31	0.31
v/c Ratio		0.49			0.80		0.78	0.46	0.45	0.43	0.39	0.21
Control Delay		2.9			17.8		48.9	20.0	19.6	27.6	22.8	10.7
Queue Delay		0.0			0.0		0.0	0.0	0.0	0.0	0.0	0.0
Total Delay		2.9			17.8		48.9	20.0	19.6	27.6	22.8	10.7
LOS		A			B		D	B	B	C	C	B
Approach Delay		2.9			17.8			28.3			21.7	
Approach LOS		A			B			C			C	

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 80
Offset: 9 (11%), Referenced to phase 2:EBTL and 6:WBTL, Start of Green
Control Type: Pretimed
Maximum v/c Ratio: 0.80
Intersection Signal Delay: 15.1 Intersection LOS: B
Intersection Capacity Utilization 91.3% ICU Level of Service F
Analysis Period (min) 15

Splits and Phases: 111: E 1st Ave. & Rupert

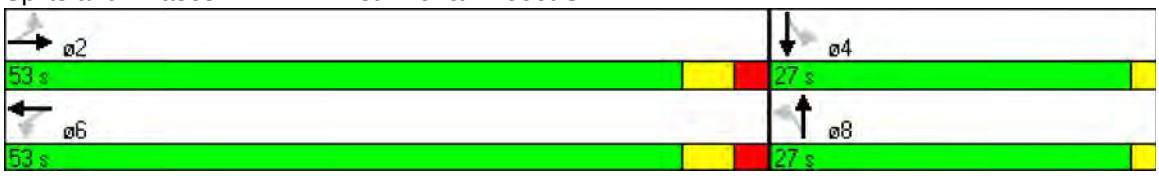


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	0	3529	0	0	3525	0	0	1743	0	0	1721	0
Flt Permitted		0.893			0.915			0.957			0.937	
Satd. Flow (perm)	0	3154	0	0	3229	0	0	1694	0	0	1641	0
Satd. Flow (RTOR)		3			5			10			23	
Volume (vph)	26	1318	17	19	1349	28	7	8	9	17	10	21
Lane Group Flow (vph)	0	1479	0	0	1517	0	0	27	0	0	52	0
Turn Type	Perm			Perm			Perm			Perm		
Protected Phases		2			6			8			4	
Permitted Phases	2			6			8			4		
Total Split (s)	53.0	53.0	0.0	53.0	53.0	0.0	27.0	27.0	0.0	27.0	27.0	0.0
Act Effct Green (s)		49.0			49.0			23.0			23.0	
Actuated g/C Ratio		0.61			0.61			0.29			0.29	
v/c Ratio		0.77			0.77			0.05			0.11	
Control Delay		9.0			24.3			15.8			14.4	
Queue Delay		0.0			0.0			0.0			0.0	
Total Delay		9.0			24.3			15.8			14.4	
LOS		A			C			B			B	
Approach Delay		9.0			24.3			15.8			14.4	
Approach LOS		A			C			B			B	

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 80
Offset: 67 (84%), Referenced to phase 2:EBTL and 6:WBTL, Start of Green
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 0.77
Intersection Signal Delay: 16.7 Intersection LOS: B
Intersection Capacity Utilization 66.1% ICU Level of Service C
Analysis Period (min) 15

Splits and Phases: 112: E 1st Ave. & Lillooet ST

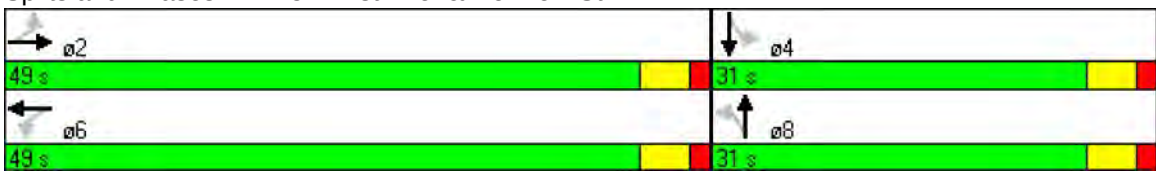


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	3518	0	1770	3500	0	1770	3476	0	1770	3500	0
Flt Permitted	0.131			0.183			0.292			0.196		
Satd. Flow (perm)	244	3518	0	341	3500	0	544	3476	0	365	3500	0
Satd. Flow (RTOR)		8			17			21			11	
Volume (vph)	56	984	40	77	1104	87	70	639	89	71	536	42
Lane Group Flow (vph)	61	1113	0	84	1295	0	76	792	0	77	629	0
Turn Type	Perm			Perm			Perm			Perm		
Protected Phases		2			6			8			4	
Permitted Phases	2			6			8			4		
Total Split (s)	49.0	49.0	0.0	49.0	49.0	0.0	31.0	31.0	0.0	31.0	31.0	0.0
Act Effct Green (s)	45.0	45.0		45.0	45.0		27.0	27.0		27.0	27.0	
Actuated g/C Ratio	0.56	0.56		0.56	0.56		0.34	0.34		0.34	0.34	
v/c Ratio	0.45	0.56		0.44	0.66		0.41	0.67		0.63	0.53	
Control Delay	11.7	3.0		25.7	24.5		28.9	25.3		44.6	24.8	
Queue Delay	0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0	
Total Delay	11.7	3.0		25.7	24.5		28.9	25.3		44.6	24.8	
LOS	B	A		C	C		C	C		D	C	
Approach Delay		3.5			24.5			25.6			26.9	
Approach LOS		A			C			C			C	

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 80
Offset: 43 (54%), Referenced to phase 2:EBTL and 6:WBTL, Start of Green
Control Type: Pretimed
Maximum v/c Ratio: 0.67
Intersection Signal Delay: 19.2 Intersection LOS: B
Intersection Capacity Utilization 74.4% ICU Level of Service D
Analysis Period (min) 15

Splits and Phases: 113: E 1st Ave. & Renfrew St

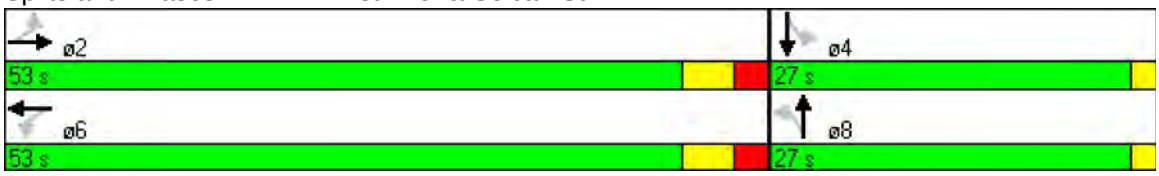


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	0	3532	0	0	3532	0	0	1745	0	0	1724	0
Flt Permitted		0.927			0.946			0.971			0.992	
Satd. Flow (perm)	0	3278	0	0	3341	0	0	1711	0	0	1717	0
Satd. Flow (RTOR)		2			3			16			20	
Volume (vph)	16	1076	8	7	1128	16	7	15	15	3	14	18
Lane Group Flow (vph)	0	1196	0	0	1251	0	0	40	0	0	38	0
Turn Type	Perm			Perm			Perm			Perm		
Protected Phases		2			6			8			4	
Permitted Phases	2			6			8			4		
Total Split (s)	53.0	53.0	0.0	53.0	53.0	0.0	27.0	27.0	0.0	27.0	27.0	0.0
Act Effct Green (s)		49.0			49.0			23.0			23.0	
Actuated g/C Ratio		0.61			0.61			0.29			0.29	
v/c Ratio		0.60			0.61			0.08			0.07	
Control Delay		3.9			23.0			15.1			13.5	
Queue Delay		0.0			0.0			0.0			0.0	
Total Delay		3.9			23.0			15.1			13.5	
LOS		A			C			B			B	
Approach Delay		3.9			23.0			15.1			13.5	
Approach LOS		A			C			B			B	

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 80
Offset: 16 (20%), Referenced to phase 2:EBTL and 6:WBTL, Start of Green
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 0.61
Intersection Signal Delay: 13.7 Intersection LOS: B
Intersection Capacity Utilization 51.7% ICU Level of Service A
Analysis Period (min) 15

Splits and Phases: 114: E 1st Ave. & Solcan St

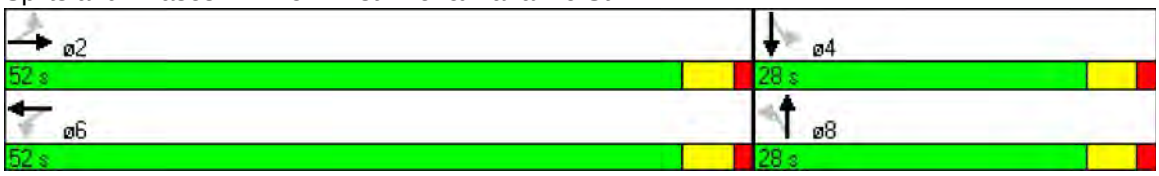


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	3511	0	1770	3504	0	1770	3497	0	1770	5024	0
Flt Permitted	0.166			0.152			0.219			0.167		
Satd. Flow (perm)	309	3511	0	283	3504	0	408	3497	0	311	5024	0
Satd. Flow (RTOR)		13			16			12			19	
Volume (vph)	72	1100	63	77	1045	73	54	722	65	80	714	64
Lane Group Flow (vph)	78	1264	0	84	1215	0	59	856	0	87	846	0
Turn Type	Perm			Perm			Perm			Perm		
Protected Phases		2			6			8			4	
Permitted Phases	2			6			8			4		
Total Split (s)	52.0	52.0	0.0	52.0	52.0	0.0	28.0	28.0	0.0	28.0	28.0	0.0
Act Effct Green (s)	48.0	48.0		48.0	48.0		24.0	24.0		24.0	24.0	
Actuated g/C Ratio	0.60	0.60		0.60	0.60		0.30	0.30		0.30	0.30	
v/c Ratio	0.42	0.60		0.49	0.58		0.48	0.81		0.94	0.56	
Control Delay	8.1	3.0		15.6	6.5		38.7	32.8		107.8	24.5	
Queue Delay	0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0	
Total Delay	8.1	3.0		15.6	6.5		38.7	32.8		107.8	24.5	
LOS	A	A		B	A		D	C		F	C	
Approach Delay		3.3			7.1			33.2			32.3	
Approach LOS		A			A			C			C	

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 80
Offset: 60 (75%), Referenced to phase 2:EBTL and 6:WBTL, Start of Green
Control Type: Pretimed
Maximum v/c Ratio: 0.94
Intersection Signal Delay: 16.5 Intersection LOS: B
Intersection Capacity Utilization 76.5% ICU Level of Service D
Analysis Period (min) 15

Splits and Phases: 115: E 1st Ave. & Nanaimo St

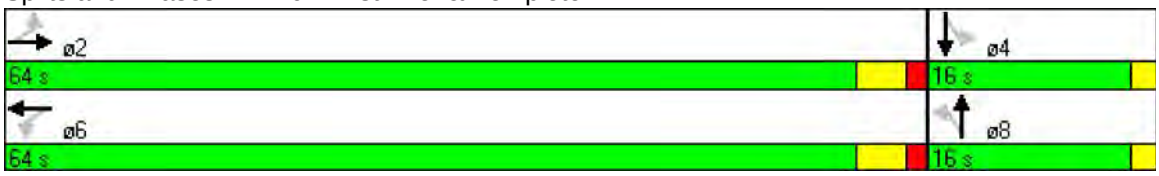


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	0	3536	0	0	3536	0	0	1653	0	0	1662	0
Flt Permitted		0.947			0.944			0.990				
Satd. Flow (perm)	0	3348	0	0	3338	0	0	1645	0	0	1662	0
Satd. Flow (RTOR)		2			2			8			12	
Volume (vph)	7	1205	6	8	1118	7	1	1	7	0	3	11
Lane Group Flow (vph)	0	1325	0	0	1232	0	0	10	0	0	15	0
Turn Type	Perm			Perm			Perm			Perm		
Protected Phases		2			6			8			4	
Permitted Phases	2			6			8			4		
Total Split (s)	64.0	64.0	0.0	64.0	64.0	0.0	16.0	16.0	0.0	16.0	16.0	0.0
Act Effct Green (s)		60.0			60.0			12.0			12.0	
Actuated g/C Ratio		0.75			0.75			0.15			0.15	
v/c Ratio		0.53			0.49			0.04			0.06	
Control Delay		1.9			6.9			19.2			18.1	
Queue Delay		0.0			0.0			0.0			0.0	
Total Delay		1.9			6.9			19.2			18.1	
LOS		A			A			B			B	
Approach Delay		1.9			6.9			19.2			18.1	
Approach LOS		A			A			B			B	

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 80
Offset: 35 (44%), Referenced to phase 2:EBTL and 6:WBTL, Start of Green
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 0.53
Intersection Signal Delay: 4.4 Intersection LOS: A
Intersection Capacity Utilization 48.4% ICU Level of Service A
Analysis Period (min) 15

Splits and Phases: 116: E 1st Ave. & Templeton Dr

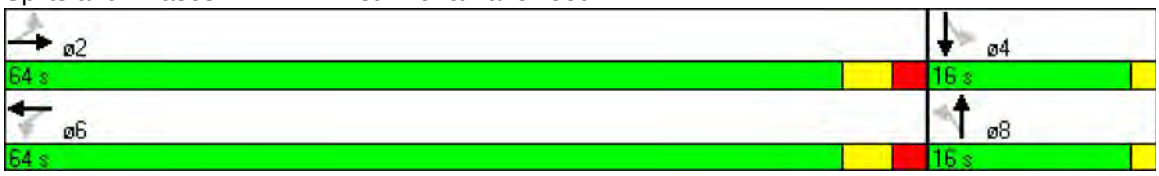


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	0	3536	0	0	3532	0	0	1700	0	0	1665	0
Flt Permitted		0.942			0.953			0.981			0.973	
Satd. Flow (perm)	0	3331	0	0	3366	0	0	1679	0	0	1638	0
Satd. Flow (RTOR)		1			4			12			10	
Volume (vph)	11	1124	5	3	999	12	3	5	11	3	1	9
Lane Group Flow (vph)	0	1239	0	0	1102	0	0	20	0	0	14	0
Turn Type	Perm			Perm			Perm			Perm		
Protected Phases		2			6			8			4	
Permitted Phases	2			6			8			4		
Total Split (s)	64.0	64.0	0.0	64.0	64.0	0.0	16.0	16.0	0.0	16.0	16.0	0.0
Act Effct Green (s)		60.0			60.0			12.0			12.0	
Actuated g/C Ratio		0.75			0.75			0.15			0.15	
v/c Ratio		0.50			0.44			0.08			0.06	
Control Delay		1.6			8.6			20.1			19.5	
Queue Delay		0.0			0.0			0.0			0.0	
Total Delay		1.6			8.6			20.1			19.5	
LOS		A			A			C			B	
Approach Delay		1.6			8.6			20.1			19.5	
Approach LOS		A			A			C			B	

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 80
Offset: 32 (40%), Referenced to phase 2:EBTL and 6:WBTL, Start of Green
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 0.50
Intersection Signal Delay: 5.1 Intersection LOS: A
Intersection Capacity Utilization 49.0% ICU Level of Service A
Analysis Period (min) 15

Splits and Phases: 117: E 1st Ave. & Lakewood Dr

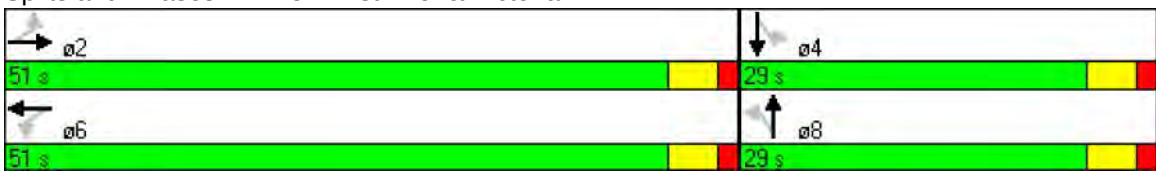


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	0	1850	0	0	3444	0	0	3472	0	0	3483	0
Flt Permitted		0.925			0.954			0.899			0.713	
Satd. Flow (perm)	0	1714	0	0	3285	0	0	3131	0	0	2511	0
Satd. Flow (RTOR)		4			57			16			5	
Volume (vph)	39	927	34	2	832	183	19	310	39	146	486	23
Lane Group Flow (vph)	0	1087	0	0	1105	0	0	400	0	0	712	0
Turn Type	Perm			Perm			Perm			Perm		
Protected Phases		2			6			8			4	
Permitted Phases	2			6			8			4		
Total Split (s)	51.0	51.0	0.0	51.0	51.0	0.0	29.0	29.0	0.0	29.0	29.0	0.0
Act Effct Green (s)		47.0			47.0			25.0			25.0	
Actuated g/C Ratio		0.59			0.59			0.31			0.31	
v/c Ratio		1.08			0.57			0.40			0.90	
Control Delay		69.7			18.5			14.3			44.2	
Queue Delay		0.0			0.0			0.0			0.0	
Total Delay		69.7			18.5			14.3			44.2	
LOS		E			B			B			D	
Approach Delay		69.7			18.5			14.3			44.2	
Approach LOS		E			B			B			D	

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 80
Offset: 12 (15%), Referenced to phase 2:EBTL and 6:WBTL, Start of Green
Control Type: Pretimed
Maximum v/c Ratio: 1.08
Intersection Signal Delay: 40.4 Intersection LOS: D
Intersection Capacity Utilization 121.4% ICU Level of Service H
Analysis Period (min) 15

Splits and Phases: 118: E 1st Ave. & Victoria Dr

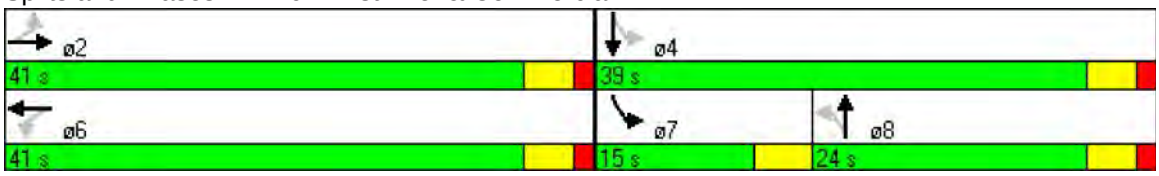


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	3482	0	1770	1797	0	1770	3051	0	1770	3450	0
Flt Permitted	0.108			0.251			0.440			0.307		
Satd. Flow (perm)	201	3482	0	446	1797	0	672	3051	0	445	3450	0
Satd. Flow (RTOR)		7			8			34			8	
Volume (vph)	21	726	35	57	657	62	45	333	79	288	496	24
Lane Group Flow (vph)	23	827	0	62	781	0	49	448	0	313	565	0
Turn Type	Perm			Perm			Perm			pm+pt		
Protected Phases		2			6			8		7	4	
Permitted Phases	2			6			8			4		
Total Split (s)	41.0	41.0	0.0	41.0	41.0	0.0	24.0	24.0	0.0	15.0	39.0	0.0
Act Effct Green (s)	39.4	39.4		39.4	39.4		17.6	17.6		32.6	32.6	
Actuated g/C Ratio	0.49	0.49		0.49	0.49		0.22	0.22		0.41	0.41	
v/c Ratio	0.23	0.48		0.28	0.88		0.33	0.64		0.86	0.40	
Control Delay	21.3	16.8		31.6	46.5		20.9	20.3		40.5	15.4	
Queue Delay	0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0	
Total Delay	21.3	16.8		31.6	46.5		20.9	20.3		40.5	15.4	
LOS	C	B		C	D		C	C		D	B	
Approach Delay		16.9			45.4			20.3			24.4	
Approach LOS		B			D			C			C	

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 80
Offset: 74 (93%), Referenced to phase 2:EBTL and 6:WBTL, Start of Green
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 0.88
Intersection Signal Delay: 27.4 Intersection LOS: C
Intersection Capacity Utilization 85.1% ICU Level of Service E
Analysis Period (min) 15

Splits and Phases: 119: E 1st Ave. & Commercial Dr

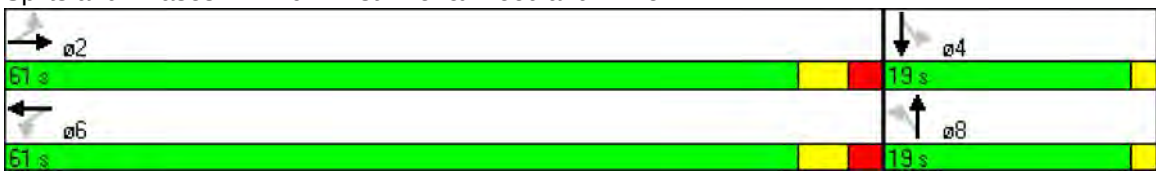


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	0	3522	0	0	3511	0	0	1738	0	0	1826	0
Flt Permitted		0.942			0.812			0.993			0.933	
Satd. Flow (perm)	0	3321	0	0	2865	0	0	1731	0	0	1728	0
Satd. Flow (RTOR)		9			6			28			3	
Volume (vph)	12	729	22	61	598	13	3	26	26	17	39	3
Lane Group Flow (vph)	0	829	0	0	730	0	0	59	0	0	63	0
Turn Type	Perm			Perm			Perm			Perm		
Protected Phases		2			6			8			4	
Permitted Phases	2			6			8			4		
Total Split (s)	61.0	61.0	0.0	61.0	61.0	0.0	19.0	19.0	0.0	19.0	19.0	0.0
Act Effct Green (s)		57.0			57.0			15.0			15.0	
Actuated g/C Ratio		0.71			0.71			0.19			0.19	
v/c Ratio		0.35			0.36			0.17			0.19	
Control Delay		7.5			8.1			18.4			28.2	
Queue Delay		0.0			0.0			0.0			0.0	
Total Delay		7.5			8.1			18.4			28.2	
LOS		A			A			B			C	
Approach Delay		7.5			8.1			18.4			28.2	
Approach LOS		A			A			B			C	

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 80
Offset: 53 (66%), Referenced to phase 2:EBTL and 6:WBTL, Start of Green
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 0.36
Intersection Signal Delay: 8.9 Intersection LOS: A
Intersection Capacity Utilization 58.8% ICU Level of Service B
Analysis Period (min) 15

Splits and Phases: 120: E 1st Ave. & Woodland Drive

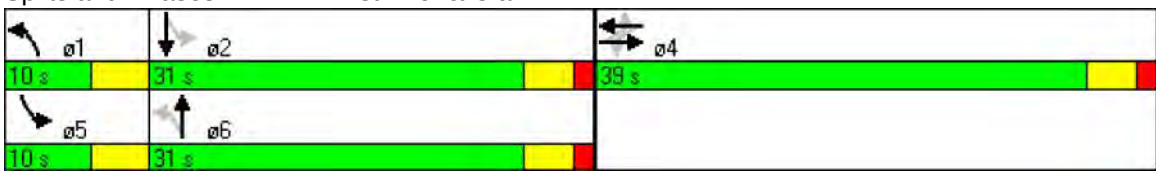


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	0	3231	0	0	3458	0	1770	4917	0	1770	5019	0
Flt Permitted		0.954					0.148			0.148		
Satd. Flow (perm)	0	3083	0	0	3458	0	276	4917	0	276	5019	0
Satd. Flow (RTOR)		210			33			96			20	
Volume (vph)	1	235	325	0	506	91	167	1055	298	202	1132	104
Lane Group Flow (vph)	0	609	0	0	649	0	182	1471	0	220	1343	0
Turn Type	Perm			Perm			pm+pt			pm+pt		
Protected Phases		4			4		1	6		5	2	
Permitted Phases	4			4			6			2		
Total Split (s)	39.0	39.0	0.0	39.0	39.0	0.0	10.0	31.0	0.0	10.0	31.0	0.0
Act Effct Green (s)		35.3			35.3		32.7	26.7		32.7	26.7	
Actuated g/C Ratio		0.44			0.44		0.41	0.33		0.41	0.33	
v/c Ratio		0.41			0.42		0.81	0.86		0.98	0.80	
Control Delay		10.7			21.6		43.6	29.7		71.7	24.9	
Queue Delay		0.0			0.0		0.0	0.0		0.0	0.0	
Total Delay		10.7			21.6		43.6	29.7		71.7	24.9	
LOS		B			C		D	C		E	C	
Approach Delay		10.7			21.6			31.2			31.5	
Approach LOS		B			C			C			C	

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 80
Offset: 34 (43%), Referenced to phase 4:EBWB, Start of Green
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 0.98
Intersection Signal Delay: 27.1 Intersection LOS: C
Intersection Capacity Utilization 66.6% ICU Level of Service C
Analysis Period (min) 15

Splits and Phases: 121: E 1st Ave. & Clark Dr

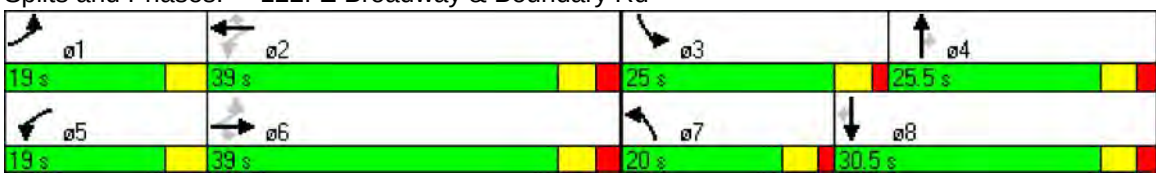


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	3539	1583	1770	3539	1583	3433	3539	1583	1770	3539	1583
Flt Permitted	0.114			0.114			0.950			0.950		
Satd. Flow (perm)	212	3539	1583	212	3539	1583	3433	3539	1583	1770	3539	1583
Satd. Flow (RTOR)			161			101			104			253
Volume (vph)	236	1224	192	199	1189	118	357	604	101	240	585	233
Lane Group Flow (vph)	257	1330	209	216	1292	128	388	657	110	261	636	253
Turn Type	pm+pt		Perm	pm+pt		Perm	Prot		Perm	Prot		Perm
Protected Phases	1	6		5	2		7	4		3	8	
Permitted Phases	6		6	2		2			4			8
Total Split (s)	19.0	39.0	39.0	19.0	39.0	39.0	20.0	25.5	25.5	25.0	30.5	30.5
Act Effct Green (s)	50.0	36.2	36.2	47.9	35.1	35.1	15.4	21.5	21.5	19.2	25.3	25.3
Actuated g/C Ratio	0.47	0.34	0.34	0.45	0.33	0.33	0.15	0.20	0.20	0.18	0.24	0.24
v/c Ratio	0.84	1.10	0.32	0.76	1.10	0.22	0.78	0.91	0.27	0.81	0.75	0.44
Control Delay	49.4	91.5	9.1	40.2	92.7	9.1	55.5	60.4	10.2	61.7	43.9	6.9
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	49.4	91.5	9.1	40.2	92.7	9.1	55.5	60.4	10.2	61.7	43.9	6.9
LOS	D	F	A	D	F	A	E	E	B	E	D	A
Approach Delay		75.9			79.2			54.0			39.8	
Approach LOS		E			E			D			D	

Intersection Summary

Cycle Length: 108.5
Actuated Cycle Length: 105.7
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 1.10
Intersection Signal Delay: 65.2 Intersection LOS: E
Intersection Capacity Utilization 89.3% ICU Level of Service E
Analysis Period (min) 15

Splits and Phases: 122: E Broadway & Boundary Rd

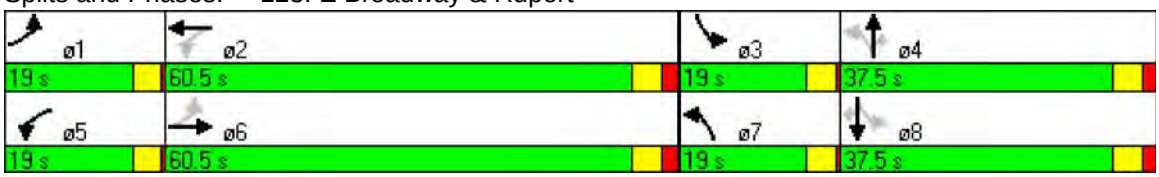


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	4943	0	1770	5060	0	1770	3539	1583	1770	3539	1583
Flt Permitted	0.071			0.071			0.281			0.294		
Satd. Flow (perm)	132	4943	0	132	5060	0	523	3539	1583	548	3539	1583
Satd. Flow (RTOR)		47			4				216			80
Volume (vph)	125	1526	351	223	1394	46	217	443	199	45	458	83
Lane Group Flow (vph)	136	2041	0	242	1565	0	236	482	216	49	498	90
Turn Type	pm+pt			pm+pt			pm+pt		Perm	pm+pt		Perm
Protected Phases	1	6		5	2		7	4		3	8	
Permitted Phases	6			2			4		4	8		8
Total Split (s)	19.0	60.5	0.0	19.0	60.5	0.0	19.0	37.5	37.5	19.0	37.5	37.5
Act Effct Green (s)	67.3	56.6		74.4	60.9		43.5	33.7	33.7	32.6	24.7	24.7
Actuated g/C Ratio	0.53	0.45		0.59	0.48		0.34	0.27	0.27	0.25	0.19	0.19
v/c Ratio	0.65	0.92		0.89	0.65		0.73	0.51	0.37	0.23	0.72	0.24
Control Delay	38.7	40.4		66.5	27.6		45.9	42.6	6.7	30.8	54.4	12.6
Queue Delay	0.0	0.0		0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	38.7	40.4		66.5	27.6		45.9	42.6	6.7	30.8	54.4	12.6
LOS	D	D		E	C		D	D	A	C	D	B
Approach Delay		40.3			32.8			35.1			46.7	
Approach LOS		D			C			D			D	

Intersection Summary

Cycle Length: 136
Actuated Cycle Length: 127.1
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 0.92
Intersection Signal Delay: 37.7 Intersection LOS: D
Intersection Capacity Utilization 87.7% ICU Level of Service E
Analysis Period (min) 15

Splits and Phases: 123: E Broadway & Rupert

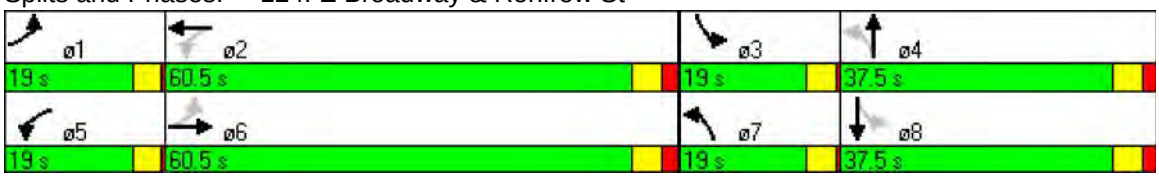


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	5034	0	1770	5040	0	1770	3429	0	1770	3465	0
Flt Permitted	0.071			0.071			0.165			0.119		
Satd. Flow (perm)	132	5034	0	132	5040	0	307	3429	0	222	3465	0
Satd. Flow (RTOR)		11			9			23			13	
Volume (vph)	202	1774	132	148	1697	112	154	581	155	135	510	85
Lane Group Flow (vph)	220	2071	0	161	1967	0	167	800	0	147	646	0
Turn Type	pm+pt			pm+pt			pm+pt			pm+pt		
Protected Phases	1	6		5	2		7	4		3	8	
Permitted Phases	6			2			4			8		
Total Split (s)	19.0	60.5	0.0	19.0	60.5	0.0	19.0	37.5	0.0	19.0	37.5	0.0
Act Effct Green (s)	72.0	58.0		68.1	56.0		45.3	32.4		44.2	31.8	
Actuated g/C Ratio	0.55	0.44		0.52	0.43		0.35	0.25		0.34	0.24	
v/c Ratio	0.88	0.93		0.73	0.91		0.67	0.92		0.67	0.76	
Control Delay	67.5	43.3		48.2	43.0		42.1	64.1		44.7	52.0	
Queue Delay	0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0	
Total Delay	67.5	43.3		48.2	43.0		42.1	64.1		44.7	52.0	
LOS	E	D		D	D		D	E		D	D	
Approach Delay		45.7			43.4			60.3			50.7	
Approach LOS		D			D			E			D	

Intersection Summary

Cycle Length: 136
Actuated Cycle Length: 130.9
Control Type: Semi Act-Uncoord
Maximum v/c Ratio: 0.93
Intersection Signal Delay: 47.8 Intersection LOS: D
Intersection Capacity Utilization 88.3% ICU Level of Service E
Analysis Period (min) 15

Splits and Phases: 124: E Broadway & Renfrew St

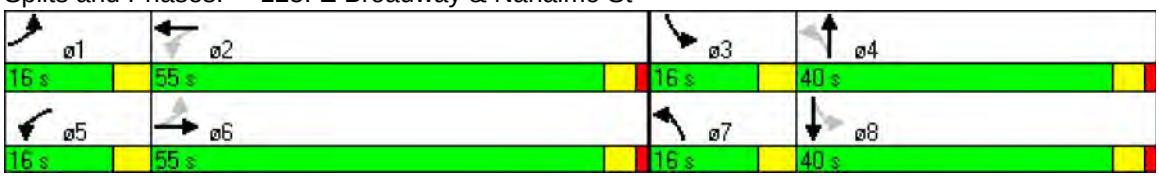


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	5055	0	1770	5055	0	1770	4953	0	1770	4887	0
Flt Permitted	0.078			0.078			0.181			0.199		
Satd. Flow (perm)	145	5055	0	145	5055	0	337	4953	0	371	4887	0
Satd. Flow (RTOR)		6			6			34			70	
Volume (vph)	167	1818	81	141	1804	79	87	627	129	121	587	208
Lane Group Flow (vph)	182	2064	0	153	2047	0	95	822	0	132	864	0
Turn Type	pm+pt			pm+pt			pm+pt			pm+pt		
Protected Phases	1	6		5	2		7	4		3	8	
Permitted Phases	6			2			4			8		
Total Split (s)	16.0	55.0	0.0	16.0	55.0	0.0	16.0	40.0	0.0	16.0	40.0	0.0
Act Effct Green (s)	63.2	52.2		61.4	51.3		34.9	25.5		37.7	28.9	
Actuated g/C Ratio	0.55	0.46		0.54	0.45		0.30	0.22		0.33	0.25	
v/c Ratio	0.77	0.89		0.69	0.90		0.44	0.73		0.53	0.67	
Control Delay	47.0	35.8		39.3	36.8		31.9	43.5		33.7	38.8	
Queue Delay	0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0	
Total Delay	47.0	35.8		39.3	36.8		31.9	43.5		33.7	38.8	
LOS	D	D		D	D		C	D		C	D	
Approach Delay		36.7			37.0			42.3			38.1	
Approach LOS		D			D			D			D	

Intersection Summary

Cycle Length: 127
Actuated Cycle Length: 114.3
Control Type: Semi Act-Uncoord
Maximum v/c Ratio: 0.90
Intersection Signal Delay: 37.8 Intersection LOS: D
Intersection Capacity Utilization 80.9% ICU Level of Service D
Analysis Period (min) 15

Splits and Phases: 125: E Broadway & Nanaimo St



Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	5075	0	1770	5060	0	1770	1863	1583	1770	1837	0
Flt Permitted	0.087			0.087			0.245			0.488		
Satd. Flow (perm)	162	5075	0	162	5060	0	456	1863	1583	909	1837	0
Satd. Flow (RTOR)		5			10				14		7	
Volume (vph)	78	1672	27	101	1810	62	37	235	109	211	367	38
Lane Group Flow (vph)	85	1846	0	110	2034	0	40	255	118	229	440	0
Turn Type	Perm			Perm			Perm		Perm	Perm		
Protected Phases		2			6			8			4	
Permitted Phases	2			6			8		8	4		
Total Split (s)	50.0	50.0	0.0	50.0	50.0	0.0	30.0	30.0	30.0	30.0	30.0	0.0
Act Effct Green (s)	46.0	46.0		46.0	46.0		26.0	26.0	26.0	26.0	26.0	
Actuated g/C Ratio	0.58	0.58		0.58	0.58		0.32	0.32	0.32	0.32	0.32	
v/c Ratio	0.91	0.63		1.18	0.70		0.27	0.42	0.23	0.78	0.73	
Control Delay	79.2	4.5		176.1	13.6		25.9	23.8	18.7	57.2	48.8	
Queue Delay	0.0	0.0		0.0	0.0		0.0	0.0	0.0	0.0	0.0	
Total Delay	79.2	4.5		176.1	13.6		25.9	23.8	18.7	57.2	48.8	
LOS	E	A		F	B		C	C	B	E	D	
Approach Delay		7.8			22.0			22.5			51.7	
Approach LOS		A			C			C			D	

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 80
Offset: 47 (59%), Referenced to phase 2:EBTL and 6:WBTL, Start of Green
Control Type: Pretimed
Maximum v/c Ratio: 1.18
Intersection Signal Delay: 20.6 Intersection LOS: C
Intersection Capacity Utilization 79.0% ICU Level of Service D
Analysis Period (min) 15

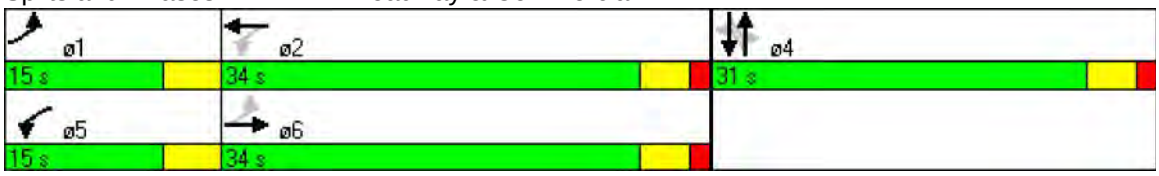
Splits and Phases: 126: E Broadway & Victoria Dr

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	5055	0	1770	5060	0	0	4969	0	0	4999	0
Flt Permitted	0.133			0.133				0.784			0.832	
Satd. Flow (perm)	248	5055	0	248	5060	0	0	3927	0	0	4184	0
Satd. Flow (RTOR)		9			7			25			18	
Volume (vph)	86	1707	70	82	1568	53	70	337	44	61	446	41
Lane Group Flow (vph)	93	1931	0	89	1762	0	0	490	0	0	596	0
Turn Type	pm+pt			pm+pt			Perm			Perm		
Protected Phases	1	6		5	2			4			4	
Permitted Phases	6			2			4			4		
Total Split (s)	15.0	34.0	0.0	15.0	34.0	0.0	31.0	31.0	0.0	31.0	31.0	0.0
Act Effct Green (s)	51.9	46.0		53.9	47.0			15.9			15.9	
Actuated g/C Ratio	0.65	0.58		0.67	0.59			0.20			0.20	
v/c Ratio	0.32	0.66		0.28	0.59			0.61			0.70	
Control Delay	7.7	14.6		11.9	20.2			30.8			43.7	
Queue Delay	0.0	0.0		0.0	0.0			0.0			0.0	
Total Delay	7.7	14.6		11.9	20.2			30.8			43.7	
LOS	A	B		B	C			C			D	
Approach Delay		14.3			19.8			30.8			43.7	
Approach LOS		B			B			C			D	

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 80
Offset: 47 (59%), Referenced to phase 2:WBTL and 6:EBTL, Start of Green
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 0.70
Intersection Signal Delay: 21.5 Intersection LOS: C
Intersection Capacity Utilization 72.1% ICU Level of Service C
Analysis Period (min) 15

Splits and Phases: 127: E Broadway & Commercial Dr

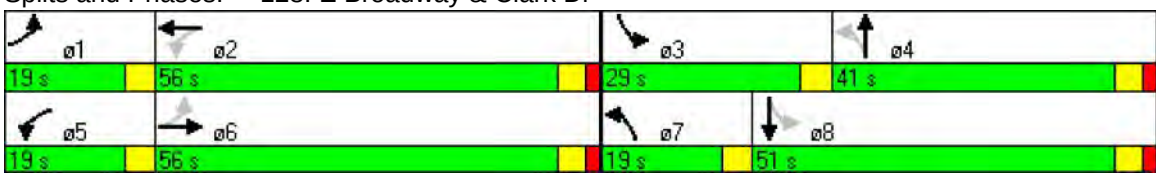


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	5050	0	1770	4994	0	1770	4943	0	1770	5014	0
Flt Permitted	0.077			0.077			0.108			0.098		
Satd. Flow (perm)	143	5050	0	143	4994	0	201	4943	0	183	5014	0
Satd. Flow (RTOR)		6			19			35			12	
Volume (vph)	112	1618	82	181	1370	189	71	767	178	372	1215	121
Lane Group Flow (vph)	122	1848	0	197	1694	0	77	1027	0	404	1453	0
Turn Type	pm+pt			pm+pt			pm+pt			pm+pt		
Protected Phases	1	6		5	2		7	4		3	8	
Permitted Phases	6			2			4			8		
Total Split (s)	19.0	56.0	0.0	19.0	56.0	0.0	19.0	41.0	0.0	29.0	51.0	0.0
Act Effct Green (s)	63.2	52.1		69.0	55.1		43.7	34.7		63.7	52.9	
Actuated g/C Ratio	0.45	0.37		0.49	0.39		0.30	0.24		0.45	0.37	
v/c Ratio	0.64	1.00		0.85	0.87		0.48	0.83		1.12	0.77	
Control Delay	41.9	64.6		65.1	46.0		35.6	56.0		122.9	43.3	
Queue Delay	0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0	
Total Delay	41.9	64.6		65.1	46.0		35.6	56.0		122.9	43.3	
LOS	D	E		E	D		D	E		F	D	
Approach Delay		63.2			48.0			54.5			60.6	
Approach LOS		E			D			D			E	

Intersection Summary

Cycle Length: 145
Actuated Cycle Length: 142
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 1.12
Intersection Signal Delay: 56.9 Intersection LOS: E
Intersection Capacity Utilization 95.8% ICU Level of Service F
Analysis Period (min) 15

Splits and Phases: 128: E Broadway & Clark Dr



Appendix A-19

STREET TREE ASSESSMENT REPORT

STREET TREE ASSESSSMENT

Metro IP Line – Woodlands Area

SUMMARY REPORT

Report prepared for:
FortisBC
16705 Fraser Highway
Surrey, BC, V4N 5R8

August, 2014

EXECUTIVE SUMMARY

FortisBC Energy Inc. (FortisBC) is proposing to replace an existing intermediate pressure (IP) natural gas line, Metro IP, extending from Coquitlam to Vancouver. Locally significant street trees have been identified along the western portion of the Metro IP line in the Woodlands area of Vancouver that could potentially be impacted by proposed construction activities. Five (5) potential alignment alternatives were evaluated in order to examine potential risk to locally significant street trees. Each of these alignments (A – E) consists of a combination of east-west sections of 1st Avenue E, 2nd Avenue E, 3rd Avenue E or Graveley Street E and smaller north-south sections of Woodland Drive, Kamloops Street and Windermere Street.

A street tree assessment was completed by John Martyn (JPM Tree Services) to determine potential risk of tree death and potential canopy loss due to open trench construction activities. The assessment concluded that all alignment alternatives posed some level of risk of tree death, although no street trees were identified at a high risk rating. Some canopy loss was anticipated along two of the alignments. The assessment concluded that a balanced approach utilizing various mitigation techniques (e.g., bolting, cabling, pruning, branch tie-back, machine/tree avoidance) or tree removal strategies will be required and will need to be finalized through consultation with the City of Vancouver.

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1.0 INTRODUCTION

FortisBC Energy Inc. (FortisBC) is proposing to upgrade four existing Transmission Pressure (TP) and Intermediate Pressure (IP) natural gas lines as part of FortisBC's long-term infrastructure projects titled "Lower Mainland Natural Gas System Upgrades" (LMSU). One of these natural gas lines, the Metro IP, extends from Coquitlam Station through Burnaby to the intersection of Woodland Drive and 2nd Avenue East in Vancouver. The existing 508 mm outside diameter (OD) pipeline is proposed to be replaced with a 762 mm OD pipeline.

Due to the presence of locally significant street trees in the Woodlands area of Vancouver in addition to other socio-economic and environmental factors, FortisBC is considering various potential alignments for this section of the Metro IP natural gas line.

John Martyn of JPM Tree Service (JPM), a Certified Arborist and Danger Tree Assessor, was retained to conduct a general assessment of mature street trees along the existing Metro IP alignment and each proposed alternative alignment. The overall objective of the assessment was to:

- Identify the potential impacts to mature street trees due to proposed open trench construction activities for a new natural gas line; and
- Determine the potential risk of tree death and canopy removal for each of the natural gas line alternative alignments.

The assessment of JPM took into consideration various potential sources of risk to trees including:

- Trimming - it is expected that a number of trees will require trimming of branches to accommodate trenching activities.
- Compaction - potential compaction of roots from people and heavy equipment can cause root damage.
- Root Damage - some tree roots may be impacted during trenching operations.
- Miscellaneous - potential impacts due to potential spills, vibration, machine exhaust / heat, dust, etc.

This report provides a summary of the findings of the Tree Assessment completed by JPM.

1.1 Alignment Alternatives

The street tree assessment evaluated five (5) potential alignments for the natural gas line replacement of the Metro IP line in the Woodlands area of Vancouver. Each of these alignments is described in further detail below:

Alternative A (Figure 1)

- West along 1st Avenue East from the Trans-Canada Highway to Woodland Drive
- South along Woodland Drive to 2nd Avenue East

Alternative B (Figure 2)

- West along 1st Avenue East from the Trans-Canada Highway to Kamloops Street
- South along Kamloops Street to 3rd Avenue East
- West along 3rd Avenue East to Woodland Drive
- North along Woodland Drive to 2nd Avenue East

Alternative C (Figure 3)

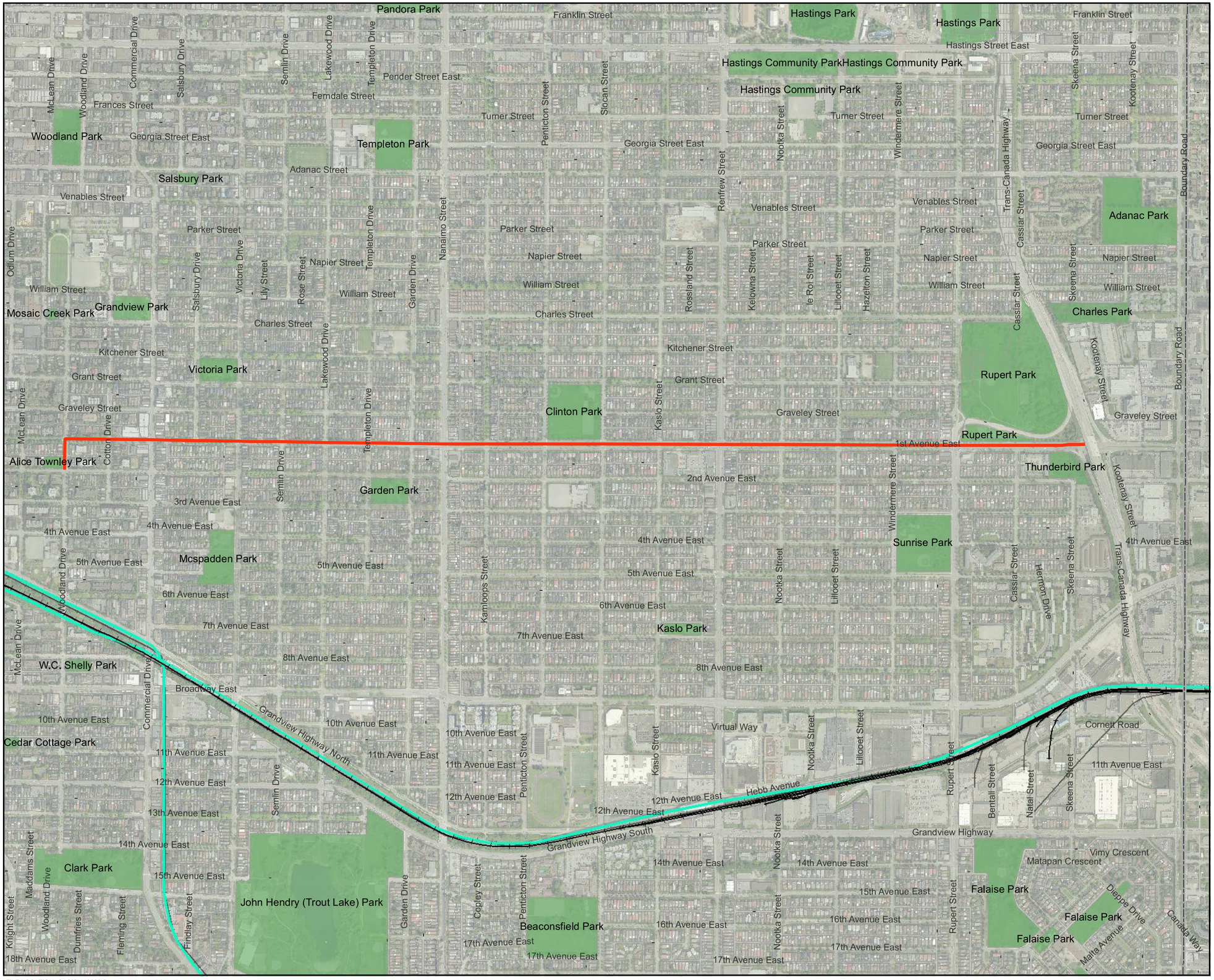
- West along 1st Avenue East from the Trans-Canada Highway to Kamloops Street
- North on Kamloops Street to Graveley Street
- West along Graveley Street to Woodland Drive
- South on Woodland Drive to 2nd Avenue East

Alternative D (Figure 4)

- West along 1st Avenue East to Windermere Street
- South on Windermere Street to 3rd Avenue East
- West on 3rd Avenue East to Woodland Drive
- North on Woodland Drive to 2nd Avenue East

Alternative E (Figure 5)

- West along 1st Avenue East from the Trans-Canada Highway to Kamloops Street
- South on Kamloops Street to 2nd Avenue East
- West along 2nd Avenue East to Woodland Drive



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FORTIS BC™

FortisBC
Lower Mainland Natural Gas System Upgrades

Alternate Alignment A

Figure 1

- Proposed Metro IP Route Replacement
- Skytrain
- Roads
- Railway
- Lots

0 100 200 400 Meters

SCALE 1:12,000

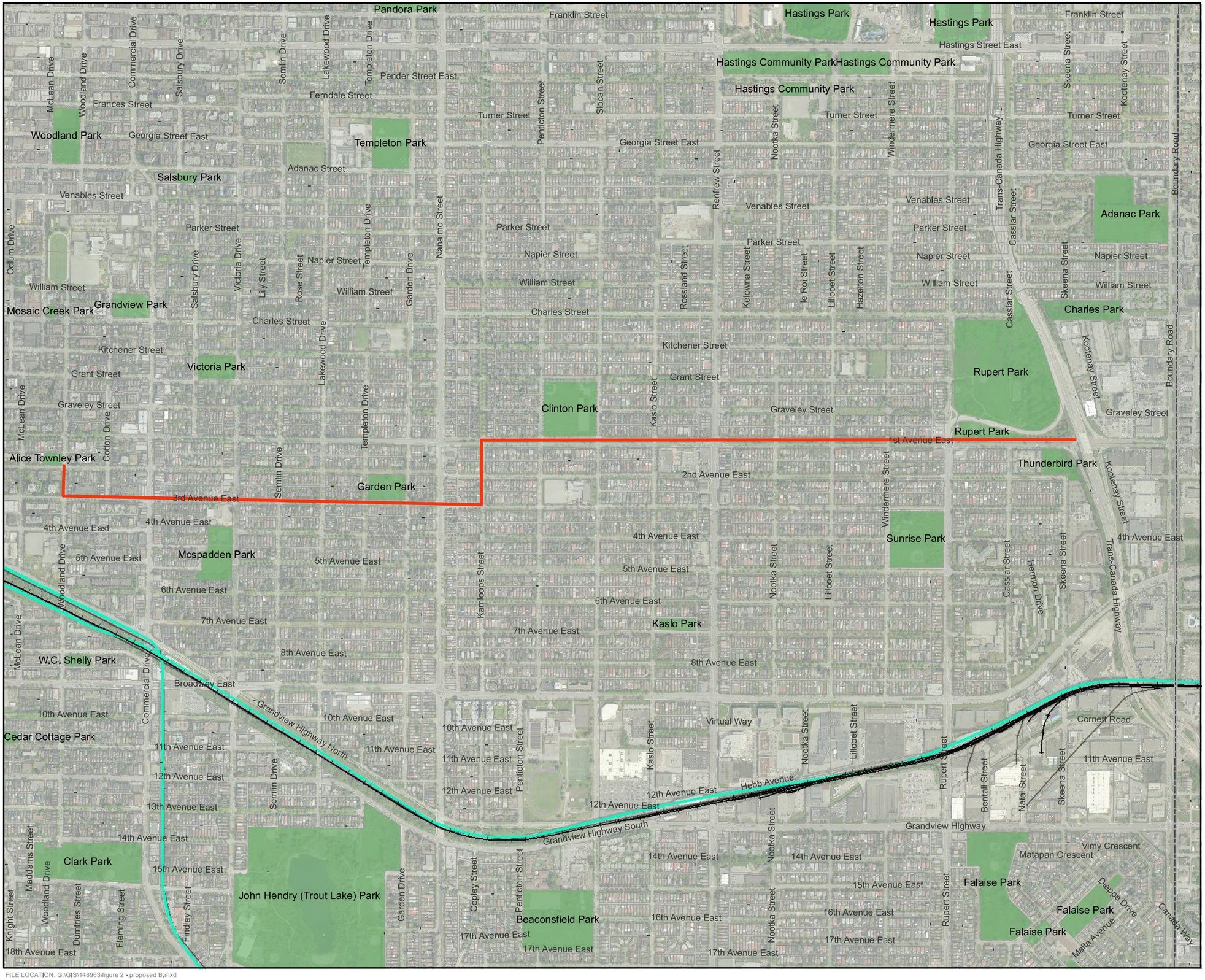
N W E S

MAP DRAWING INFORMATION:
City of Vancouver, Province of British Columbia, FortisBC, Dillon Created.
Drawing recreated from Worleyparsons Canada, Project Number 407071-00064

MAP CREATED BY: MZO
MAP CHECKED BY: LAK
MAP PROJECTION: NAD 1983 UTM Zone 10N

DILLON CONSULTING

PROJECT: 14-8963
STATUS: FINAL
DATE: 8/19/2014



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Lower Mainland Natural Gas System Upgrades

Alternate Alignment B

Figure 2

- Proposed Metro IP Route Replacement
- Skytrain
- Roads
- Railway
- Lots

0 100 200 400 Meters

SCALE 1:12,000

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City of Vancouver, Province of British Columbia, FortisBC, Dillon Created.
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MAP CREATED BY: MZO
MAP CHECKED BY: LAK
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DILLON CONSULTING

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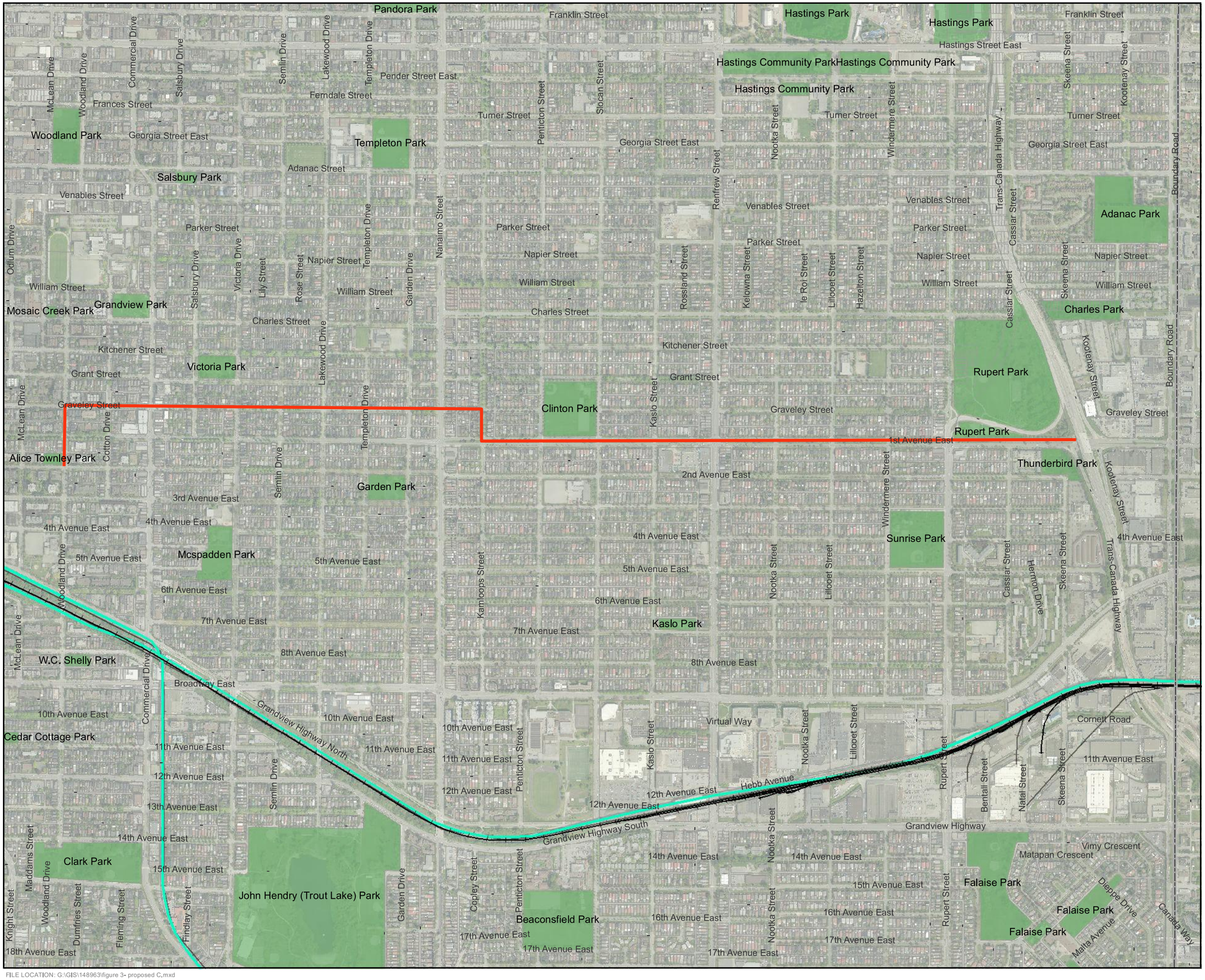

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FORTIS BC™

FortisBC
Lower Mainland Natural Gas System Upgrades

Alternate Alignment C

Figure 3

- Proposed Metro IP Route Replacement
- Skytrain
- Roads
- Railway
- Lots

0 100 200 400 Meters

SCALE 1:12,000

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PROJECT: 14-8963

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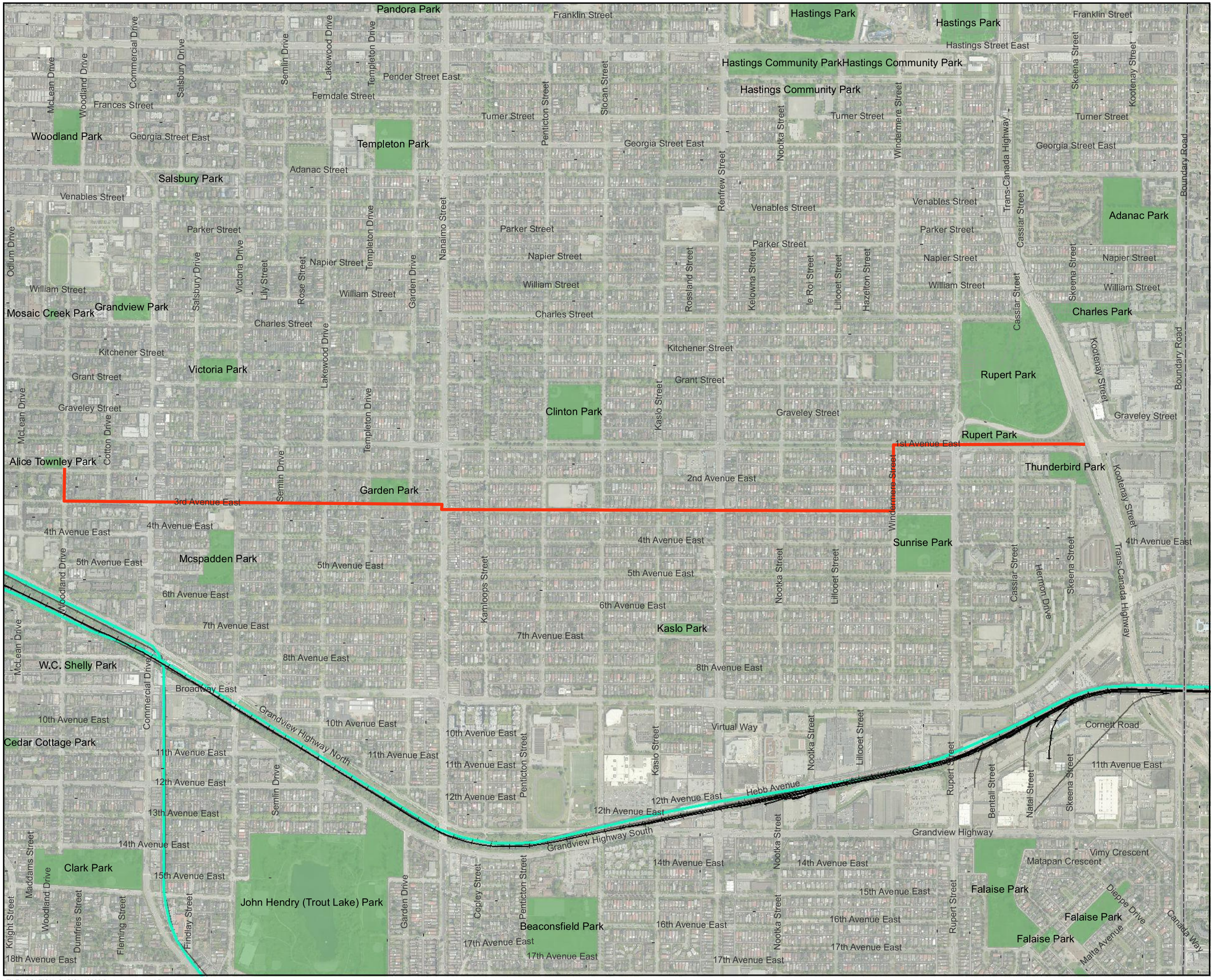
DATE: 8/19/2014



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FortisBC
Lower Mainland Natural Gas System Upgrades

Alternate Alignment D

Figure 4

- Proposed Metro IP Route Replacement
- Skytrain
- Roads
- Railway
- Lots

0 100 200 400 Meters

SCALE 1:12,000

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DILLON CONSULTING

PROJECT: 14-8963

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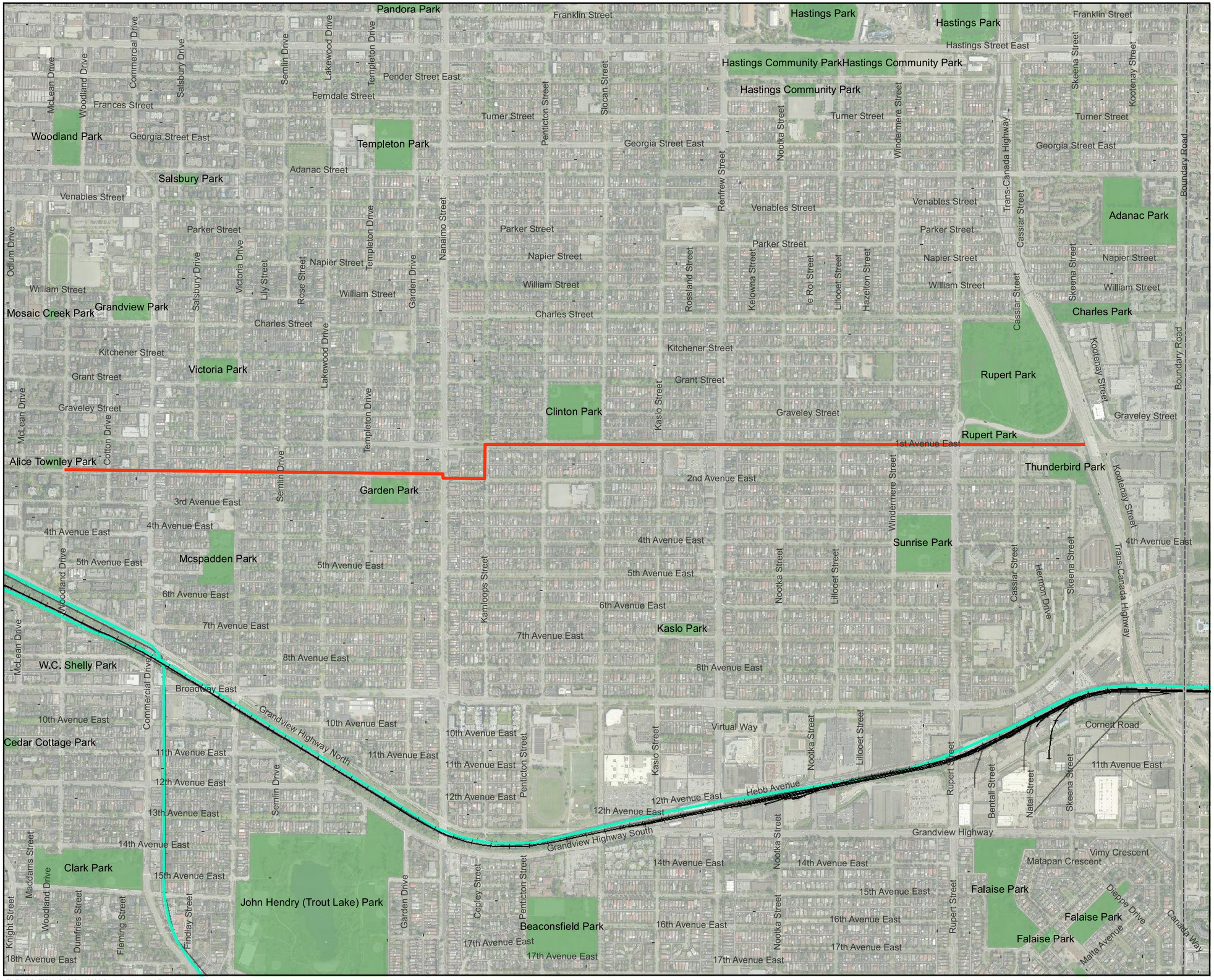
DATE: 8/19/2014



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FORTIS BC™

FortisBC
Lower Mainland Natural Gas System Upgrades

Alternate Alignment E

Figure 5

- Proposed Metro IP Route Replacement
- Skytrain
- Roads
- Railway
- Lots

0 100 200 400 Meters

SCALE 1:12,000

N W E S

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City of Vancouver, Province of British Columbia, FortisBC, Dillon Created.
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MAP CHECKED BY: LAK
MAP PROJECTION: NAD 1983 UTM Zone 10N

DILLON CONSULTING

PROJECT: 14-8963

STATUS: FINAL

DATE: 8/19/2014

2.0 METHODOLOGY

Street tree attributes including tree location, species and other characteristics were obtained from the City of Vancouver Open Data Catalogue to supplement a site-specific Visual Tree Assessment (VTA) along each of the potential alignments.

VTAs were completed by traveling each alternative natural gas line alignment on foot, bicycle and vehicle. VTAs are used to determine if the root plate of a tree has shifted. A tree root plate is a stiff, shallow, horizontal disk-shaped rooting area, and associated soil mass, under and near the stem base (Coder 2010). Trees with a shifted root plate are generally classified as an extreme risk.

Other factors evaluated as part of VTAs include, but are not limited to:

- Tree lean;
- Presence and location of conks (a fungal fruiting body, often hard and perennial);
- Wildlife nesting cavities;
- Trunk cracks;
- Significant bark loss;
- Live crown ratio (the percentage of green crown to overall tree height);
- Diameter at breast height (DBH; diameter of the trunk measured 1.4 m above grade);
- Height to trunk ratio (height of the tree divided by its diameter);
- Excessive cone production;
- Witches' broom (twiggy growth found on trees caused by fungus or insects); and
- Widow makers (unattached canopy deadwood that could fall and injure people).

For this project, VTAs were used to determine the potential risk of tree death and risk to the canopy of street trees due to open trench construction along adjacent road ways for the replacement of the Metro IP natural gas line. Risk of tree death and potential canopy loss due to open trench construction adjacent to street trees were evaluated using the following scales:

Scale	Risk of Tree Death	Scale	Potential Canopy Loss
0	Low Risk	0	No Canopy Loss
1	Medium Risk	1	Small Canopy Loss
2	High Risk	2-3	Medium Canopy Loss
		4-5	Large Canopy Loss

Ascertaining present tree health and future likelihood of tree death/decline was based on the current scientific literature, the arborist's extensive experience in the Lower Mainland, as well as the Tree Care Industry Association (TCIA) Standards (e.g., TCIA 2011) and International Society of Arboriculture (ISA) Best Practices (e.g., ISA 2011).

3.0 RESULTS AND DISCUSSION

3.1 General Findings

In general, the north-south routes along Woodland Drive, Kamloops Street and Windermere Street have relatively wide-open streets and small trees (Photo 1). Potential risk of tree death and canopy loss resulting from open trench construction of a natural gas line would be minimal in these areas.

Photo 1: Representative photo illustrating wide streets and small trees typical of north-south routes. This photo is of Kamloops Street.

None of the alignment alternatives completely avoid risk to street trees along their east-west routes. An example of a "challenging" tree along 2nd Avenue is illustrated in Photo 2. In this instance the tree has two root paths descending into the potential trenching area, and as such, would have a risk rating of 1. It must be noted that a risk rating of 1 does not mean that the tree could not survive following construction activities. It entirely possible that the tree would adjust to the new site conditions; and with the implementation of appropriate best management practices (e.g., canopy-thinning to eliminate weak, inferior branches, opening up the windsail) the remaining tree could be stronger with a long term branch structure.

Photo 2: Representative photo illustrating a "challenging" tree on 2nd Avenue where the root path of the tree descends into the potential trenching area.

The risk of potential tree death and potential for canopy loss along each alignment alternative is discussed in detail below.

3.2 Alignment Alternative A

Open trench construction for this alignment alternative is proposed within the road right-of-way of 1st Avenue East and along Woodland Drive.

Five (5) trees along this alignment were identified as having a medium risk of tree death resulting from open trench construction (Table 1), although it was noted that one of the trees was already in poor condition and may need to be removed due to the presence of a large cavity (Photo 3).

No canopy loss is anticipated along this alignment alternative.

Table 1: Risk Assessment of Open Trench Construction on Vancouver Street Trees along Alignment Alternative A

Street Block	Risk of Tree Death*	Potential Canopy Loss
1st Avenue East		
Boundary Rd – Skeena St	0	0
Skeena St – Cassiar St	0	0
Cassiar St – Rupert St	0	0
Rupert St – Windermere St	0	0
Windermere St – Lillooet St	0	0
Lillooet St – Nootka St	0	0
Nootka St – Renfrew St	1	0
Renfrew St – Kaslo St	0	0
Kaslo St – Slocan St	0	0
Slocan St – Penticton St	0	0
Penticton St – Kamloops St	0	0
Kamloops St – Nanaimo St	0	0
Nanaimo St – Garden Dr	0	0
Garden Dr – Templeton Dr	0	0
Templeton Dr – Lakewood Dr	0	0
Lakewood Dr – Semlin Dr	1	0
Semlin Dr – Victoria Dr	0	0
Victoria Dr – Salisbury Dr	0	0
Salisbury Dr – Commercial Dr	1 + 1	0
Commercial Dr – Cotton Dr	0	0
Cotton Dr – Woodland Dr	1	0
Woodland Drive		
1st Avenue E – 2nd Avenue E	0	0
Total	5	0

*"+" indicates multiple trees with risk of tree death along the same block

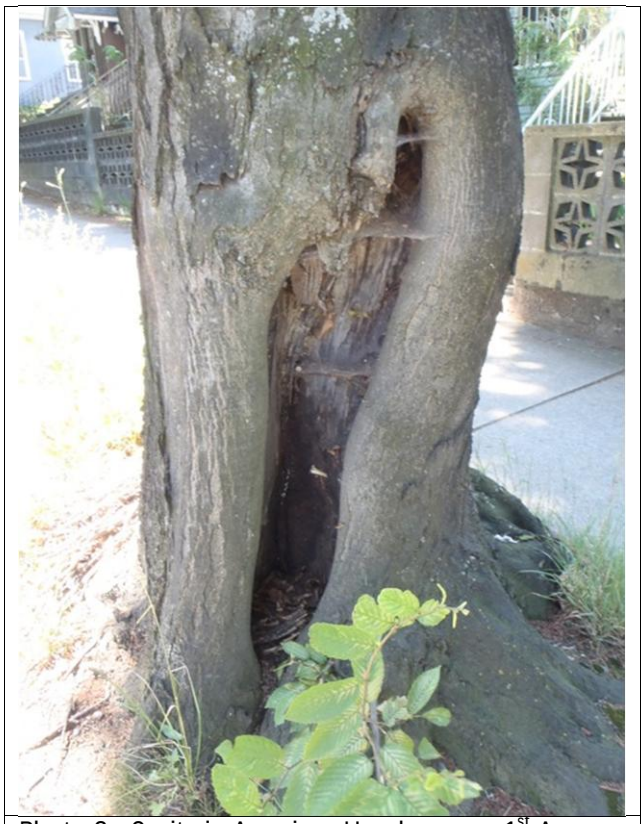


Photo 3: Cavity in American Hornbeam on 1st Avenue, just past Victoria Drive.

3.3 Alignment Alternative B

Open trench construction for this alignment alternative is proposed within the road right-of-way along 1st Avenue East, Kamloops Street, 3rd Avenue East and Woodland Drive.

Eleven (11) trees along this alignment were identified as having a medium risk of potential tree death resulting from construction activities (Table 2). Most of these mature trees are located near Garden Park along 3rd Avenue East, which have large scaffold limbs extending over the road right-of-way (Photo 4). Decay was observed in the main trunk of at least one tree, which may be a candidate for removal and replacement. If not, then open trench construction activities may have to be altered along 3rd Avenue East to accommodate the large limb. Discussions with the City of Vancouver would be required for the Garden Park area to determine workable solutions for both the City and FortisBC.

No canopy loss is anticipated along this alignment alternative.

Table 2: Risk Assessment of Open Trench Construction on Vancouver Street Trees along Alignment Alternative B

Street Block	Risk of Tree Death*	Potential Canopy Loss
1st Avenue East		
Boundary Rd – Skeena St	0	0
Skeena St – Cassiar St	0	0
Cassiar St – Rupert St	0	0
Rupert St – Windermere St	0	0
Windermere St – Lillooet St	0	0
Lillooet St - Nootka	0	0
Nootka St – Renfrew St	1	0
Renfrew St – Kaslo St	0	0
Kaslo St – Slocan St	0	0
Slocan St – Penticton St	0	0
Penticton St – Kamloops St	0	0
Kamloops Street		
1st Ave E – 2nd Ave E	0	0
2nd Ave E – 3rd Ave E	0	0
3rd Avenue East		
Kamloops St – Nanaimo St	0	0
Nanaimo St – Garden Dr	1 + 1 + 1	0
Garden Dr – Templeton Dr	1 + 1 + 1	0
Templeton Dr – Lakewood Dr	1 + 1	0
Lakewood Dr – Semlin Dr	1	0
Semlin Dr – Victoria Dr	0	0
Victoria Dr – Commercial Dr	1	0
Commercial Dr – Woodland Dr	0	0
Woodland Drive		
3rd Avenue to 2nd Avenue	0	0
Total	11	0

*"+" indicates multiple trees with risk of tree death along the same block

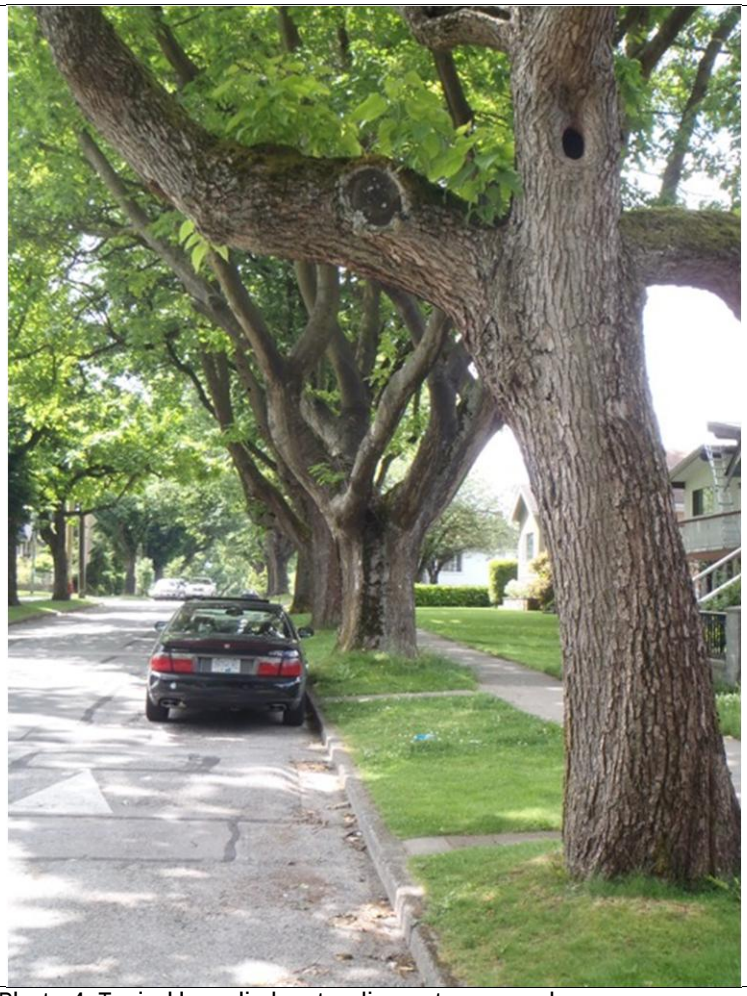


Photo 4: Typical large limb extending out over roadway.

3.4 Alignment Alternative C

Open trench construction for this alignment alternative is proposed within the road right-of-way along 1st Avenue East, Kamloops Street, Graveley Street, and Woodland Drive.

Six (6) trees along this alignment were identified as having a medium risk of tree death resulting from open trench construction (Table 3). Most of these trees are located between Victoria and Commercial Drive, and include a number of tall, thinned-trunked Chinese Elm. Potential best management practices to reduce the risk level of these trees could include full, windsail pruning from top to bottom.

No canopy loss is anticipated along this alignment alternative. Several areas such as along Graveley Street were characterized by high clearance heights (Photo 5).

Table 3: Risk Assessment of Open Trench Construction on Vancouver Street Trees along Alignment Alternative C

Street Block	Risk of Tree Death*	Potential Canopy Loss
1st Avenue East		
Boundary Rd – Skeena St	0	0
Skeena St – Cassiar St	0	0
Cassiar St – Rupert St	0	0
Rupert St – Windermere St	0	0
Windermere St – Lillooet St	0	0
Lillooet St - Nootka	0	0
Nootka St – Renfrew St	1	0
Renfrew St – Kaslo St	0	0
Kaslo St – Slocan St	0	0
Slocan St – Penticton St	0	0
Penticton St – Kamloops St	0	0
Kamloops Street		
1st Ave. E – Graveley St	0	0
Graveley Street		
Kamloops St – Nanaimo St	0	0
Nanaimo St – Garden Dr	0	0
Garden Dr – Templeton Dr	0	0
Templeton Dr – Lakewood Dr	1	0
Lakewood Dr – Semlin Dr	0	0
Semlin Dr – Victoria Dr	0	0
Victoria Dr – Salisbury Dr	1 + 1	0
Salisbury Dr – Commercial Dr	1 + 1	0
Commercial Dr – Cotton Dr	0	0
Cotton Dr – Woodland Dr	0	0
Nanaimo St – Garden Dr	0	0
Woodland Drive		
Graveley St – 2nd Ave. E	0	0
Total	6	0

*"+" indicates multiple trees with risk of tree death along the same block

Photo 5: High clearance along Graveley Street.

3.5 Alignment Alternative D

Open trench construction for this alignment alternative is proposed within the road right-of-way along 1st Avenue East, Windermere Street, 3rd Avenue East and Woodland Drive.

Twelve (12) trees along this alignment were assessed as having a medium risk of tree death resulting from open trench construction (Table 4). In addition, small canopy loss is anticipated for one (1) tree. Most of these mature trees are located near Garden Park along 3rd Avenue East. An example of a risk tree found along this potential alignment is illustrated in Photo 6. In this case the Linden tree identified in the photo is an example of where a large wound site might not adequately recover and keep up with the size and shape of its neighbouring street trees. Therefore, removal and replacement could be the better option for the overall health and beauty of the street tree presentation.

Table 4: Risk Assessment of Open Trench Construction on Vancouver Street Trees along Alignment Alternative D

Street Block	Risk of Tree Death*	Potential Canopy Loss
1st Avenue East		
Boundary Rd – Skeena St	0	0
Skeena St – Cassiar St	0	0
Cassiar St – Rupert St	0	0
Rupert St – Windermere St	0	0
Windermere Street		
1st Ave E – 2nd Ave E	0	0
2nd Ave E – 3rd Ave E	0	1
3rd Avenue East		
Windermere St – Lillooet St	0	0
Lillooet St – Nootka St	1	0
Nootka St – Renfrew St	0	0
Renfrew St – Kaslo St	0	0
Kaslo St – Slocan St	0	0
Slocan St – Penticton St	1	0
Penticton St – Kamloops St	0	0
Kamloops St – Nanaimo St	0	0
Nanaimo St – Garden Dr	1 + 1 + 1	0
Garden Dr – Templeton Dr	1 + 1 + 1	0
Templeton Dr – Lakewood Dr	1 + 1	0
Lakewood Dr – Semlin Dr	1	0
Semlin Dr – Victoria Dr	0	0
Victoria Dr – Commercial Dr	1	0
Commercial Dr – Woodland Dr	0	0
Woodland Drive		
3rd Avenue to 2nd Avenue	0	0
Total	12	1

*"+" indicates multiple trees with risk of tree death along the same block

Photo 6: Potential Risk Tree observed along Alignment D.

3.6 Alignment Alternative E

Open trench construction for this alignment alternative is proposed within the road right-of-way along 1st Avenue East, Kamloops Street and 2nd Avenue East. The west end of this alignment has some of the largest mature trees compared to other alignments. Some of these trees may be in their declining years and are no longer contributing to long term, optimum tree health, beauty and safety.

Thirteen (13) trees along this alignment were identified as having a medium risk of tree death resulting from proposed open trench construction activities (Table 5). In addition, medium and large canopy loss is anticipated for two (2) trees. A large structural crack was observed in one tree along 2nd Avenue East that may require bolting/cabling for long-term retention (Photo 7). Trunk problems were observed in another 2nd Avenue East tree where a large limb overhangs the road right-of-way (Photo 8). Cutting the large limb to accommodate open trench construction activities would likely lead to a large loss of the canopy. Alternatives, such as cabling, bolting and pruning may be considered to minimize or avoid loss.

Table 5: Risk Assessment of Open Trench Construction on Vancouver Street Trees along Alignment Alternative E

Alignment Alternative	Street Block	Risk of Tree Death*	Potential Canopy Loss
E	*1st Avenue East*		
	Boundary Rd – Skeena St	0	0
	Skeena St – Cassiar St	0	0
	Cassiar St – Rupert St	0	0
	Rupert St – Windermere St	0	0
	Windermere St – Lillooet St	0	0
	Lillooet St - Nootka	0	0
	Nootka St – Renfrew St	1	0
	Renfrew St – Kaslo St	0	0
	Kaslo St – Slocan St	0	0
	Slocan St – Penticton St	0	0
	Penticton St – Kamloops St	0	0
	Kamloops Street		
	1st Ave E – 2nd Ave E	0	0
	2nd Avenue East		
	Kamloops St – Nanaimo St	1	0
	Nanaimo St – Garden Dr	1 + 1	4
	Garden Dr – Templeton Dr	1 + 1	3
	Templeton Dr – Lakewood Dr	1 + 1	0
	Lakewood Dr – Semlin Dr	1 + 1 + 1	0
	Semlin Dr – Victoria Dr	0	0
	Victoria Dr – Commercial Dr	0	0
	Commercial Dr – Cotton Dr	1	0
	Cotton Dr – Woodland Dr	1	0
Total		13	7

*"+" indicates multiple trees with risk of tree death along the same block

Photo 7: Large structural crack on 2nd Avenue specimen may require bolting / cabling for long term retention. Notice 'banana crack' on upper, far right hand side.

Photo 8: A 2nd Avenue specimen with potential trunk problems. Cutting the large limb to accommodate trenching equipment would likely lead to a canopy loss.

4.0 GENERAL RECOMMENDATIONS

The following is a list of general practices and items of consideration that will assist in the prevention of injury and death of street trees:

- Potential risk of tree death and canopy loss would result from branch, limb and root cutting during open trench construction activities. Smaller trees with smaller root systems will not interfere with road excavation and equipment to the same extent as larger trees, which have larger interference branches and potentially larger interference roots. Larger trees can generally tolerate more cutting of roots and branches than smaller trees. Smaller trees are more fragile and can be impacted severely by soil compaction, machine exhaust and other pressures during construction activities.
- The clearance above the roadway for trenching machinery is 8 m. The City of Vancouver presently skirts street trees to facilitate large trucks and buses to a height of 5 m.
- Root cutting may result in limb shedding (dying) after the completion of the proposed natural gas line construction activities. Most limbs are shed within one to five years.
- Any large root cutting (generally 10 cm in diameter or greater) required for Vancouver street trees to accommodate open trench construction should ideally be completed during the winter months (i.e., November to February) when the tree is dormant. If large roots need to be cut outside of the winter months then the tree and associated root system should be evaluated and appropriate recommendations made by a certified arborist. Smaller feeder roots can be cut at other times of the year.
- The long stretch of trees along 1st Avenue East, that is common to most of the Alignment Alternatives, could be viewed as one long giant tree between major intersections, owing to the likelihood of interlocking tree roots and canopy proximity.
- There may be a greater likelihood of tree roots interfering in open trench construction activities on streets that are in low bog areas and may include the four Vancouver park areas along the Alignment Alternatives (Rupert Park, Clinton Park, Garden Park and Alice Townley Park).
- Limb cutting to accommodate construction activities will be an unlikely factor in tree death, although any pruning must be completed in a way to maximize tree aesthetics.
- Branches from private property trees extending out over and above the construction areas may need to be cut back. Note that this report did not investigate private property tree health or risk.
- The focus of preservation efforts for street trees must be the prevention of damage as the ability to cure construction injury is very limited.
- If a tree is in poor health before it is exposed to construction pressures then it is unlikely to improve. Pressures include soil compaction, root or branch cutting, vibration, damage from machinery etc.
- The effects of damage to trees following open trench construction activities may take up to five (5) years, or more, to show.

- Generally, up to 25% of a tree's foliage can be cut in a given year, however each species will vary.
- If more than one third of a branch is removed, then the branch should be taken back to the joint.

5.0 SUMMARY

Based on the Street Tree Assessment each of the alignment alternatives proposed by FortisBC for the western portion of the Metro IP natural gas line replacement have low to medium risk of potential tree death. Total route risks for potential tree death (determined by adding tree risks along the entire route) range from five (5) along Alignment A to thirteen (13) along Alignment E (Table 6). Canopy loss is anticipated for one (1) tree along Alignment D and two (2) trees along Alignment E.

Table 6: Summary of Risk to Vancouver Street Trees Resulting from Open Trench Construction Activities

Alignment Alternative	Risk of Potential Tree Death	Potential Canopy Loss
A	5	0
B	11	0
C	6	0
D	12	1
E	13	7

A balanced approach using strategies such as bolting, cabling, pruning, branch tie-back, machine/tree avoidance and/or tree removal will be required to ensure that risks to street trees are minimized during construction activities. Once a preferred alignment has been selected, discussions with the City of Vancouver will need to take place to review appropriate best management practices. Also once a preferred alignment has been confirmed, further studies, such as Sounding/Probing and Invasive Tree Assessments can be completed, where required.

6.0 LIMITATIONS

According to the report completed by John Martyn of JPM Tree Service, this arboricultural field review report is based only on ground level site observations. No aerial tree assessments were done on any of the trees. Effort has been made to ensure that the opinions expressed are a reasonable and accurate representation of the general condition of all trees reviewed. The assessment was completed based on VTA only. Aerial assessments may have gathered additional information that could have been important to the conclusions of the report. The subject trees were not dissected. All trees or groups of trees have the potential to fail. No guarantees are offered or implied by JPM Tree Service that the trees reviewed and referenced in this report will remain safe given all conditions. Trees can be managed, but they cannot be controlled. To reside, work or play anywhere near trees is to accept some degree of risk. The only way to eliminate *all risk* associated with trees is to eliminate the trees themselves. Prior to agreeing to provide this service to FortisBC, the client was advised and agreed that *JPM Tree Service* would not be held liable for any damages resulting from the behaviour of the subject trees. Assessments are valid on the day of the report, and it is understood that adverse weather conditions can change the structural integrity of the trees, which can lead to subsequent failure.

The opinions expressed in this report have been provided without bias based on site observations and the supporting information provided by others. Any trees retained should be reviewed on a regular basis to ensure acceptable risk levels. It is recommended that trees always be re-inspected after atypical weather events. The trees surrounding this site on adjacent property were not reviewed, and it is believed that all fences and hedges separating private and public property lines are valid.

7.0 REFERENCES

Coder, K.D. 2010. Root Strength & Tree Anchorage. Warnell School of Forestry & Natural Resources, Univeristy of Georgia. 88pp.

Tree Care Industry Association. 2011. American National Standard for Tree Care Operations – Tree, Shrub, and Other Woody Plant Management – Standard Practices (Tree Risk Assessment a. Tree Structure Assessment).

International Society of Arboriculture. 2011. Best Management Practices Series. Tree Risk Assessment. 81pp.

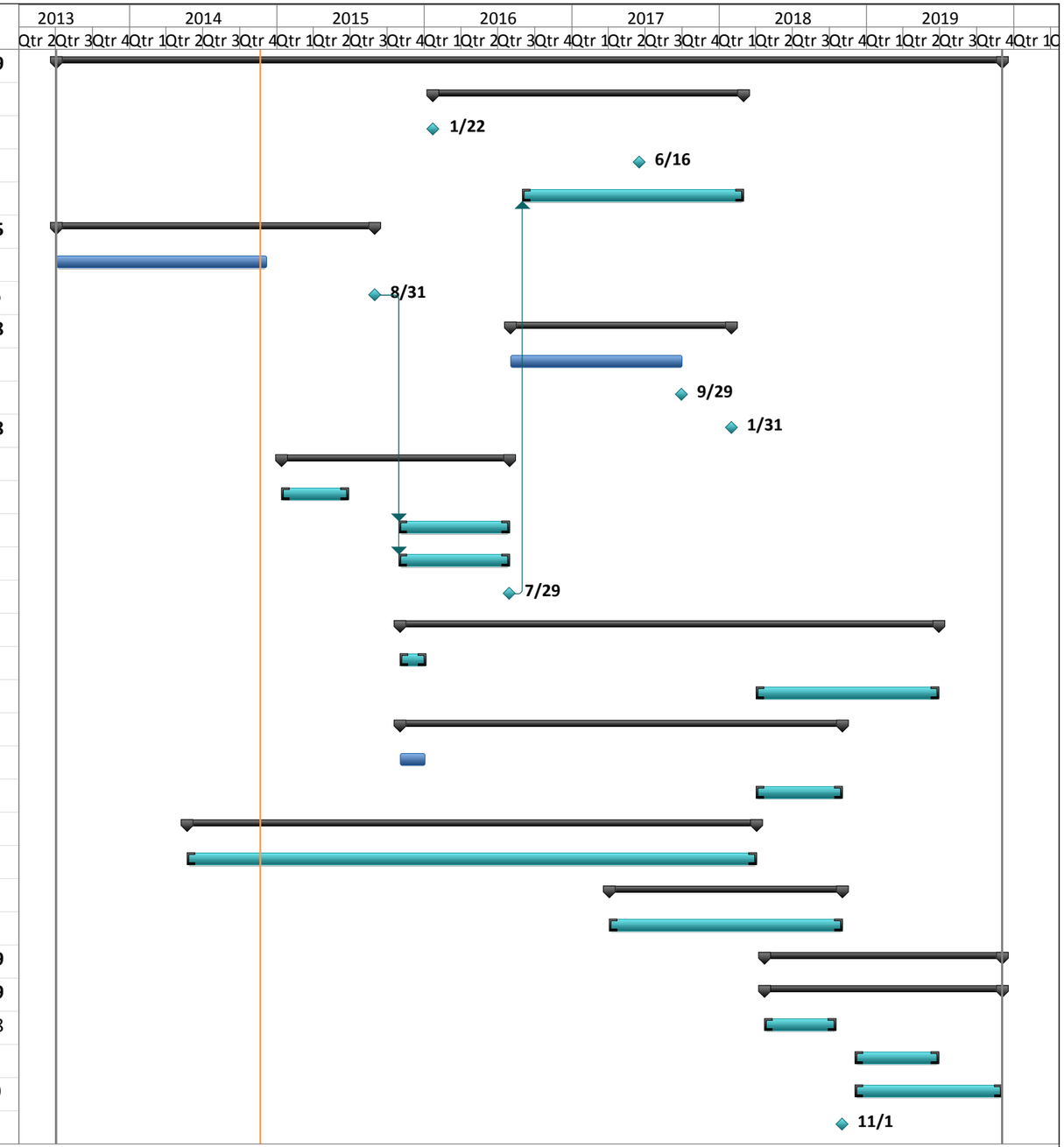
Appendix A-20

PROJECT SCHEDULES

Appendix A-20-1

PROJECT SCHEDULE - COQUITLAM IP

ID	Task Mode	Task Name	Duration	Start	Finish
1		**LMSU Coquitlam IP Schedule Overview**	**1674 days**	**Wed 7/3/13**	**Mon 12/2/19**
2		**Project Management**	**550 days**	**Fri 1/22/16**	**Thu 3/1/18**
3		Contract Award - EPCM	0 days	Fri 1/22/16	Fri 1/22/16
4		Contract Award - Construction	0 days	Fri 6/16/17	Fri 6/16/17
5		Procure Long Lead Material Items	392 days	Wed 8/31/16	Thu 3/1/18
6		**Regulatory - BCUC**	**563 days**	**Wed 7/3/13**	**Mon 8/31/15**
7		CPCN Application Preparation	373 days	Wed 7/3/13	Fri 12/5/14
8		CPCN Application Approved	0 days	Mon 8/31/15	Mon 8/31/15
9		**Regulatory - OGC**	**392 days**	**Mon 8/1/16**	**Wed 1/31/18**
10		Prepare OGC Application (Pipeline and Stations)	305 days	Mon 8/1/16	Fri 9/29/17
11		Submit OGC Application	0 days	Fri 9/29/17	Fri 9/29/17
12		**Obtain OGC permit approvals**	**0 days**	**Wed 1/31/18**	**Wed 1/31/18**
13		**Engineering (Pipeline and Stations)**	**405 days**	**Mon 1/12/15**	**Fri 7/29/16**
14		Field Investigations	120 days	Mon 1/12/15	Fri 6/26/15
15		Detailed Routing	196 days	Fri 10/30/15	Fri 7/29/16
16		100% Detailed Design	196 days	Fri 10/30/15	Fri 7/29/16
17		Material Specifications - Long Lead items	0 days	Fri 7/29/16	Fri 7/29/16
18		**Environmental**	**955 days**	**Mon 11/2/15**	**Fri 6/28/19**
19		Develop Fortis BC Environmental Specification	46 days	Mon 11/2/15	Mon 1/4/16
20		Construction Monitoring/Inspection	325 days	Mon 4/2/18	Fri 6/28/19
21		**Archeological**	**784 days**	**Mon 11/2/15**	**Thu 11/1/18**
22		Develop Archaeological Management Plan	45 days	Mon 11/2/15	Fri 1/1/16
23		Construction Monitoring/Inspection	154 days	Mon 4/2/18	Thu 11/1/18
24		**Community Relations**	**1007 days**	**Fri 5/23/14**	Mon 4/2/18
25		Information sessions (Surrey, Burnaby, Coquitlam, Vancouver)	1007 days	Fri 5/23/14	Mon 4/2/18
26		**Property Services**	**414 days**	**Mon 4/3/17**	**Thu 11/1/18**
27		Construction Communication via Land Agents	414 days	Mon 4/3/17	Thu 11/1/18
28		**Construction**	**421 days**	**Mon 4/23/18**	**Mon 12/2/19**
29		**Coquitlam IP**	**421 days**	**Mon 4/23/18**	**Mon 12/2/19**
30		Construction	127 days	Mon 4/23/18	Tue 10/16/18
31		Restoration/Clean up	150 days	Mon 12/3/18	Fri 6/28/19
32		Project Close Out	261 days	Mon 12/3/18	Mon 12/2/19
33		**In-Service Date**	**0 days**	**Thu 11/1/18**	**Thu 11/1/18**



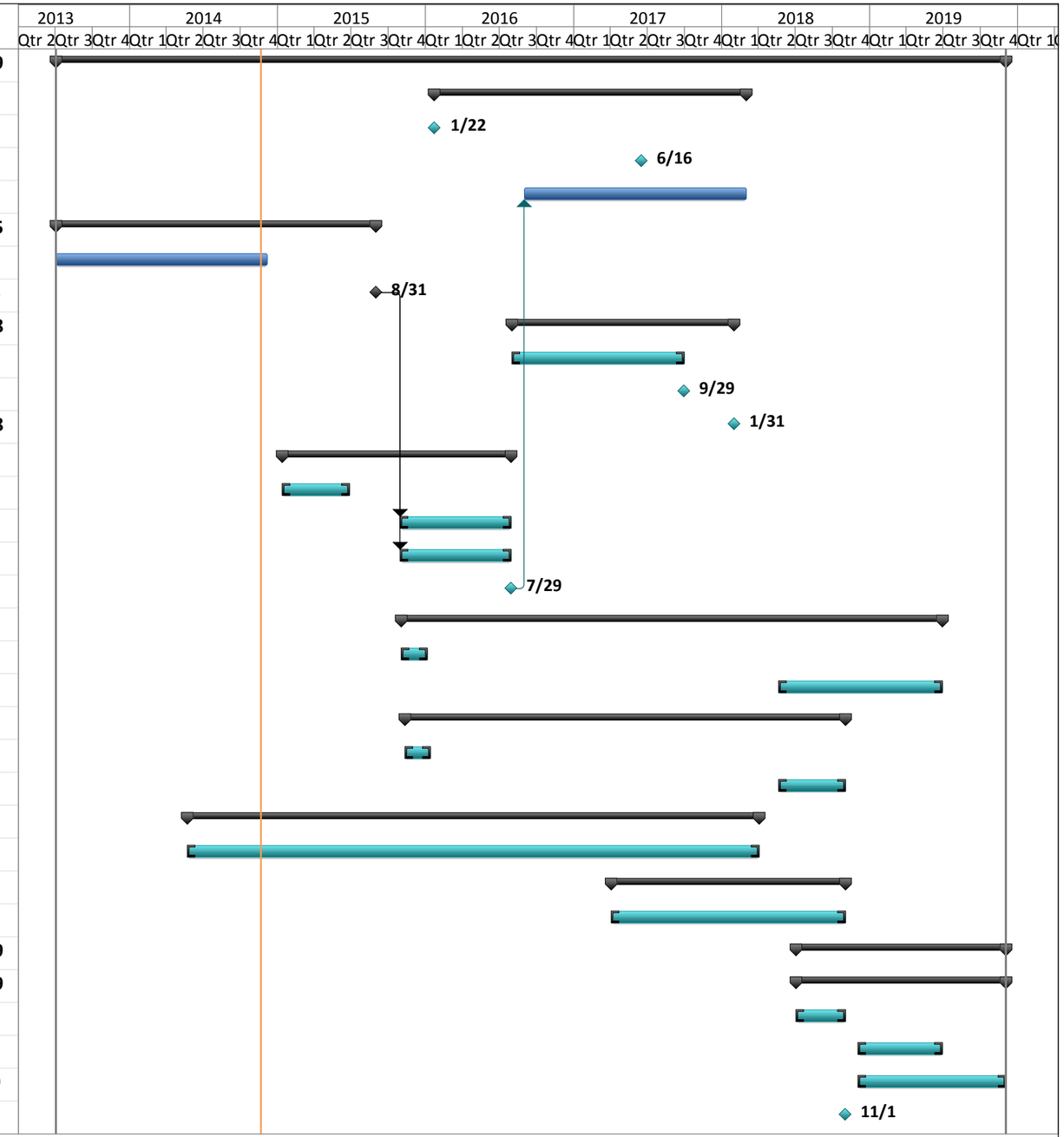
Project: IP
Date: Fri 11/21/14

Task		Project Summary		Inactive Milestone		Manual Summary Rollup		Deadline	
Split		External Tasks		Inactive Summary		Manual Summary		Progress	
Milestone		External Milestone		Manual Task		Start-only			
Summary		Inactive Task		Duration-only		Finish-only			

Appendix A-20-2

PROJECT SCHEDULE - FRASER IP

ID	Task Mode	Task Name	Duration	Start	Finish
1		**LMSU Fraser IP Schedule Overview**	**1674 days**	**Wed 7/3/13**	**Mon 12/2/19**
2		**Project Management**	**550 days**	**Fri 1/22/16**	**Thu 3/1/18**
3		Contract Award - EPCM	0 days	Fri 1/22/16	Fri 1/22/16
4		Contract Award - Construction	0 days	Fri 6/16/17	Fri 6/16/17
5		Procure Long Lead Material Items	392 days	Wed 8/31/16	Thu 3/1/18
6		**Regulatory - BCUC**	**563 days**	**Wed 7/3/13**	**Mon 8/31/15**
7		CPCN Application Preparation	373 days	Wed 7/3/13	Fri 12/5/14
8		CPCN Application Approved	0 days	Mon 8/31/15	Mon 8/31/15
9		**Regulatory - OGC**	**392 days**	**Mon 8/1/16**	**Wed 1/31/18**
10		Prepare OGC Application (Pipeline and Stations)	305 days	Mon 8/1/16	Fri 9/29/17
11		Submit OGC Application	0 days	Fri 9/29/17	Fri 9/29/17
12		**Obtain OGC permit approvals**	**0 days**	**Wed 1/31/18**	**Wed 1/31/18**
13		**Engineering (Pipeline and Stations)**	**405 days**	**Mon 1/12/15**	**Fri 7/29/16**
14		Field Investigations	120 days	Mon 1/12/15	Fri 6/26/15
15		Detailed Routing	196 days	Fri 10/30/15	Fri 7/29/16
16		100% Detailed Design	196 days	Fri 10/30/15	Fri 7/29/16
17		Material Specifications - Long Lead items	0 days	Fri 7/29/16	Fri 7/29/16
18		**Environmental**	**955 days**	**Mon 11/2/15**	**Fri 6/28/19**
19		Develop Fortis BC Environmental Specification	46 days	Mon 11/2/15	Mon 1/4/16
20		Construction Monitoring/Inspection	290 days	Mon 5/21/18	Fri 6/28/19
21		**Archeological**	**777 days**	**Wed 11/11/15**	**Thu 11/1/18**
22		Develop Archaeological Management Plan	45 days	Wed 11/11/15	Tue 1/12/16
23		Construction Monitoring/Inspection	119 days	Mon 5/21/18	Thu 11/1/18
24		**Community Relations**	**1007 days**	**Fri 5/23/14**	**Mon 4/2/18**
25		Information sessions (Surrey, Burnaby, Coquitlam, Vancouver)	1007 days	Fri 5/23/14	Mon 4/2/18
26		**Property Services**	**414 days**	**Mon 4/3/17**	**Thu 11/1/18**
27		Construction Communication via Land Agents	414 days	Mon 4/3/17	Thu 11/1/18
28		**Construction**	**370 days**	**Tue 7/3/18**	**Mon 12/2/19**
29		**Fraser IP**	**370 days**	**Tue 7/3/18**	**Mon 12/2/19**
30		Construction	88 days	Tue 7/3/18	Thu 11/1/18
31		Restoration/Clean up	150 days	Mon 12/3/18	Fri 6/28/19
32		Project Close Out	261 days	Mon 12/3/18	Mon 12/2/19
33		**In-Service Date**	**0 days**	**Thu 11/1/18**	**Thu 11/1/18**



Project: IP
Date: Fri 11/21/14

Task		Project Summary		Inactive Milestone		Manual Summary Rollup		Deadline	
Split		External Tasks		Inactive Summary		Manual Summary		Progress	
Milestone		External Milestone		Manual Task		Start-only			
Summary		Inactive Task		Duration-only		Finish-only			

Appendix A-21

FEI RISK REGISTER

FILED CONFIDENTIALLY

Appendix A-22

ESTIMATE PREPARATION PLAN

FILED CONFIDENTIALLY

Appendix A-23

BASIS OF ESTIMATE

FILED CONFIDENTIALLY

Appendix A-24

PIPELINE ESTIMATE

FILED CONFIDENTIALLY

Appendix A-25

STATIONS ESTIMATE

FILED CONFIDENTIALLY

Appendix A-26

CIVIL ESTIMATE

FILED CONFIDENTIALLY

Appendix A-27

WORLEY PARSONS
COST RISK ANALYSIS

FILED CONFIDENTIALLY

Appendix A-28

FEI GUIDELINE DES 09-02
SEISMIC DESIGN REQUIREMENTS FOR BURIED PIPELINES

DES 09-02 GUIDELINE
16 December 2010 **DESIGN**
Seismic Design

Seismic Design Requirements for Buried Pipelines

Replaces: DES 09-02 dated 27 February 2004

Overview

This standard provides recommended practices for defining seismic design requirements of buried natural gas pipelines operated by FortisBC (Natural Gas) (FBC (Gas)) in British Columbia. This standard will also be used as a basis for evaluating the level of strengthening needed for both new and existing pipelines. This standard does not address other natural hazards like landslides, bank erosion, or floods.

This standard provides recommended practices for implementing the seismic design in order to guide the efforts of FBC (Gas) personnel as well as geotechnical specialists and pipeline engineering consultants.

Audience

This standard is intended to be used by Asset Management, engineers, and specialists responsible for the assessment, planning, and design for new pipelines and upgrades to existing installations.

Definitions

Annual Exceedance Probability

Probability that a specific level of seismic hazard (ground shaking, liquefaction, ground displacement) will be exceeded in one year; equal to $^{1}/_{\text{Mean Return Period}}$.

Distribution Pipeline

A pipeline operating at a gauge pressure of less than or equal to 700 kPa.

Intermediate Pressure

A pipeline operating at a gauge pressure less than or equal to 2070 kPa in the FBC (Gas) Lower Mainland or Interior Systems or less than or equal to 3100 kPa in the TGVI system, but greater than 700 kPa.

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Lateral Spread

Ground displacement that generally occurs in a down-slope direction as a result of liquefaction-induced soil strength loss.

Liquefaction

Process by which the strength of saturated granular soil layers, usually below the water table, is reduced as a result of an increase in pore water pressure generated by shearing deformation of the soil caused by earthquake ground shaking.

Mean Return Period

The inverse of the annual exceedance probability.

Permanent Ground Deformation

Permanent ground deformation is the large-scale, non-recoverable ground deformation due to landslide, faulting, or liquefaction induced lateral spreading.

Return Period

Average time interval between earthquake events.

Transmission Pressure (TP) Pipeline

A pipeline operating at a gauge pressure greater than 2070 kPa in the FBC (Gas) Lower Mainland or Interior Systems or greater than 3100 kPa in the TGVI System.

References

- ADM 06-11 *Gas System Assets - Records Management and Retention Schedules*
- OPM 09-05 *Managing Risk from Natural Hazards*
- CSA Z662-07 Oil and Gas Pipeline Systems, Canadian Standards Association
- Honegger, D.G., 2010. "Regional Seismic Assessment of FBC (Gas) Natural Gas Pipelines," report prepared by D.G. Honegger Consulting to FBC (Gas), August
- Honegger, D.G. and D.J. Nyman, 2002. Seismic Design and Assessment of Natural Gas and Liquid Hydrocarbon Pipelines, PRCI Inc., Catalog No. L51927
- PRCI, 2009. Guidelines for Constructing Natural Gas and Liquid Hydrocarbon Pipelines Through Areas Prone To Landslide and

Caution: Printed documents may not be current. Verify online.

Subsidence Hazards, report prepared by C-CORE, D.G. Honegger Consulting, and SSD, Inc., Catalog No. L52292

Responsibilities

Accountability for the assessment of existing assets and the responsibility for the design of new or retrofit projects are specified within the FBC (Gas) Asset Integrity Management Program.

Background

Significant parts of the FBC (Gas) gas supply and distribution system are situated within one of the zones of the highest seismic activity in Canada. Historically, the overall performance record of gas pipeline systems in past (e.g. Kobe, Japan (1995), Loma Prieta Earthquake in California (1989)) has been relatively good. Failures that have occurred are largely limited to areas where unstable soils led to large permanent ground displacements and the pipelines exposed to the ground displacements were not constructed in a manner consistent with modern practice.

This standard was first issued in 2004 and was based primarily upon the findings of a regional risk assessment of FBC (Gas) pipelines performed in 1994 and experience in numerous detailed site investigation and pipeline seismic improvement projects undertaken as a follow-on to the 1994 assessment. The previous version of the standard relied upon a rating system that assigned a score to be used to determine whether or not seismic design measures were necessary. The scoring system in the previous version accounted for various factors related to safety (class location, pipe size, pipe pressure), the severity of a potential outage (number of customers without service, duration of outage), and the hazard (liquefaction susceptibility and lateral spread severity).

Substantial modifications have been incorporated into this version of the standard:

1. Findings from the 2010 regional seismic study and changes in 3rd generation to 4th generation seismic hazard mapping were incorporated into the standard.
2. The process for determining whether seismic design measures are needed was greatly simplified.
3. The areas where a credible potential for significant seismic ground displacement hazard exists have been clarified.

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4. The need to determine surficial soil characteristics has been replaced by providing explicit maps.

PART 1

Seismic Design Objective

The minimum seismic design objective is to provide a reasonable level of confidence that the FBC (Gas) TP and IP pipelines will maintain pressure integrity and not pose a hazard to the public immediately following ground displacements during a major earthquake. A major earthquake is defined as an earthquake with a level of ground shaking consistent with that associated with a probabilistic estimate of ground shaking with a mean return period of 2,500 years. The 2,500-year return period is consistent with the findings of the FBC (Gas) Seismic Workshop 2010 that addressed, among other things, the seismic design requirements used by other Lower Mainland utilities for new and existing utility installations (Honegger, 2010). The 2,500-year hazard will be based upon the fourth-generation seismic hazard definitions established by the Geological Survey of Canada for the 2005 National Building Code of Canada.

Seismic Hazards Considered

Potential seismic hazards affecting the FBC (Gas) service area include the following:

- Ground shaking
- Liquefaction
- Lateral spread displacement
- Slope movement caused by ground shaking

Two types of pipelines are considered in this standard:

- steel TP, IP, and DP pipelines with butt-welded joints and dates of construction that are recent enough that all pipelines can be considered to be "modern" (i.e., no gasket-jointed pipelines, or pipelines with unshielded arc or oxyacetylene welded joints or joints with belled ends and interior backing rings)
- polyethylene DP pipelines with fused joints

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For both of these types of pipelines, the potential for damage from earthquake ground shaking is insignificant and earthquake-generated permanent ground displacement (lateral spread displacement and triggered slope movement) is considered to be the only credible hazard. Sources of earthquake-generated permanent ground displacement in the FBC (Gas) service area are limited to earthquake-triggered landslides, lateral spread displacement, and settlement related to liquefaction.

Existing pipelines with unshielded arc or oxyacetylene welded joints or joints with belled ends and interior backing rings may have very limited longitudinal strain capacity. These types of pipelines may be vulnerable to damage from strong ground shaking and have been the focus of past utility pipeline replacement programs aimed at improving seismic performance. A potential for random seismic damage should be considered wherever these types of pipelines exist on the Lower Mainland, Vancouver Island, and Whistler systems and portions of the Interior System identified as having a significant seismic hazard in the FBC (Gas) AM/FM system.

In addition, there is a potential for collateral damage from interaction with other structures or systems (limited to pipelines supported on bridges and in close proximity to other utilities damaged as a result of the seismic hazards listed above) however collateral damage is not addressed in this standard.

Seismic Design Process

Detailed seismic design of buried pipelines typically requires a site-specific soils investigation, analytical assessment of likely permanent ground displacements along the pipeline alignment, and detailed analysis of pipeline response to the estimated ground displacements. The general process for implementing the design is illustrated in Figure 1 and discussed in more detail in Part 2 of this standard.

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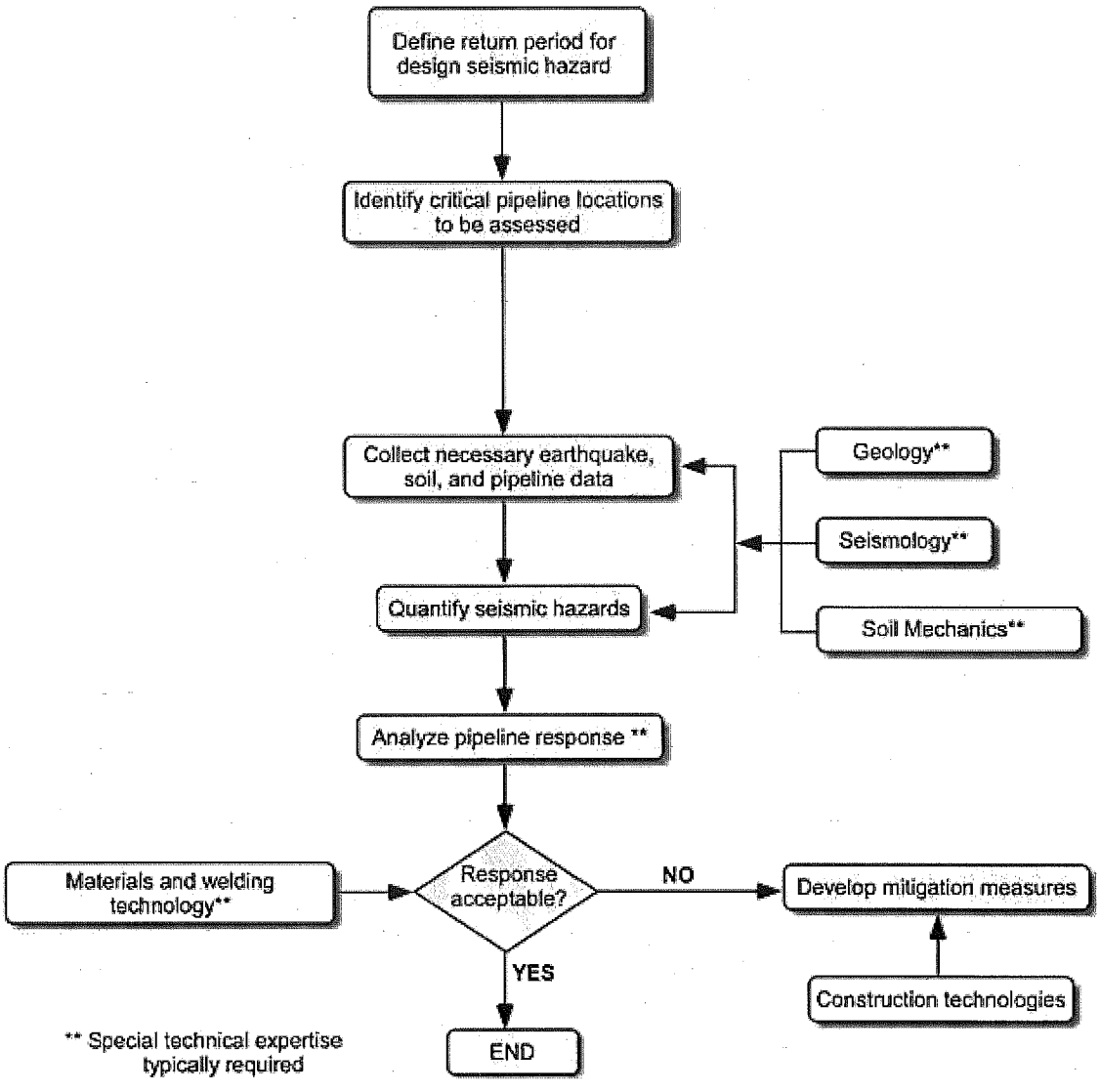
Figure 1: General Seismic Design Process



Seismic Design Criteria

For projects involving the construction of new transmission or intermediate pressure pipelines, the minimum seismic hazard will be defined with a mean return period of 2,475 years. This design criterion is to maintain the pressure integrity of the gas pipelines; however, it is expected that pipelines may require repair or limited replacement following a relatively rare seismic hazard. the FBC (Gas) approach is consistent with the severity of the seismic hazard incorporated into the National Building Code of Canada.

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With the acceptance of the Asset Manager, upgrades of existing pipelines for improved seismic performance may consider hazards with mean return periods less than 2,475 years. Factors that might justify a lower return period for a seismic upgrade project can include the following:

1. Limited planned remaining life for the pipeline installation (e.g., planned future replacement or need for increased flow capacity).
2. Limited potential for significant safety, environmental, or business consequences if seismic failure occurs.
3. Where potential seismic damage would not result in significant safety consequences, substantial increase in project costs relative to incremental benefits.
4. The length of existing pipeline under consideration is a short section of a longer line and upgrades to the short section will not significantly reduce the overall seismic vulnerability.

In some situations where the pipeline provides especially critical service or the consequences from the loss of pressure integrity are likely to be unusually severe, it may be desirable to specify lower acceptable pipeline stress or strain limits or increase the severity of the seismic hazard. This means a higher mean return period may be specified for important pipelines.

Pipelines that Need Seismic Design Measures

Seismic design measures are required for the pipelines that meet the following conditions:

- The following inequality is satisfied:
  $PD^3 \geq 3.5(10)^{10}$

where P is pressure in kPa and D is the pipeline outside diameter in millimeters

COMMENT ON INEQUALITY EXPRESSION The limit on P and D is based upon the framework used for the guidance on reliability-based design in non-mandatory annex O to Z662. The inequality is based upon the assumption of one potential fatality for the situation where the population density is 20 persons per hectare (referenced in Z662 Table O.2 as the average population density in Class 3), 100% of the population is exposed to thermal radiation, 100% chance of a fatality at a thermal radiation limit greater than 12.6 kW/m2, and a 75% chance that persons will be in the area at the time of the earthquake.

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Since the loss of gas throughput is roughly related to PD2, this measure also approximately provides a gradation for loss of service.

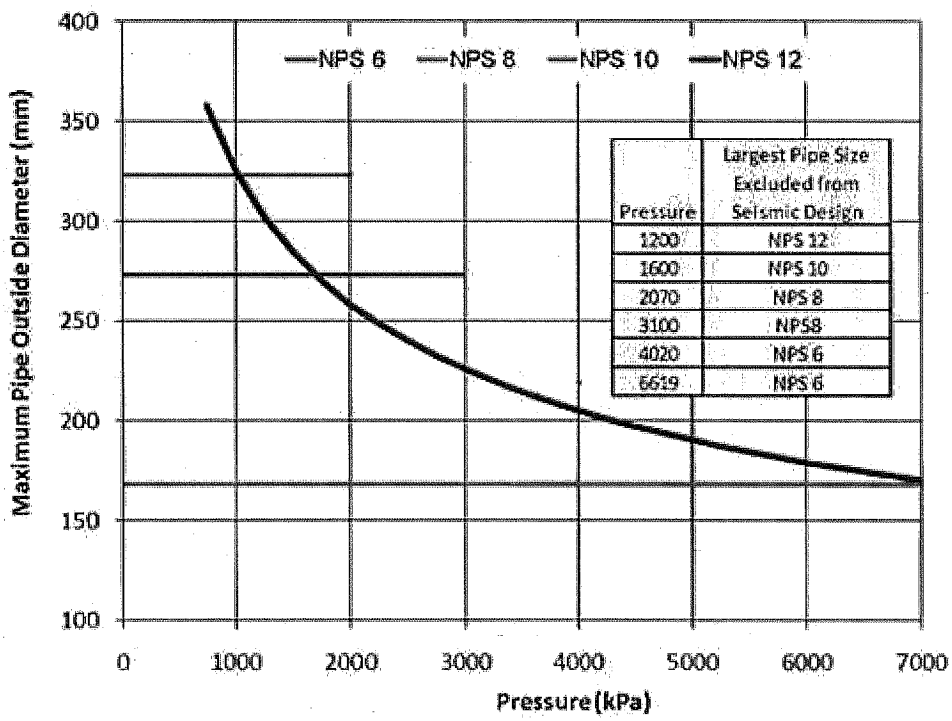
- The pipeline is located in an area where significant seismic hazard exists. Areas of significant seismic hazard may be found in the FBC (Gas) AMFM system.

The above inequality related to pressure and pipeline diameter is based upon a safety criterion for population densities consistent with Class 3 or lower locations and does not consider impacts related to severity or duration of gas service outage in the event seismic damage occurs. The following provides some examples of the pressure and diameter criteria for:

- NPS 6, an operating pressure no greater than 7,345 kPa
- NPS 8, an operating pressure no greater than 3,330 kPa
- NPS 10, an operating pressure no greater than 1,720 kPa
- NPS 12, an operating pressure no greater than 1030 kPa

See Figure 2 for additional pipe sizes or pressures.

Figure 2: Pressure and Diameter Criteria



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The project engineer has the discretion to require special design measures where it is considered appropriate with the approval of the responsible Asset Manager. Factors that might justify requiring seismic design include the following:

- class 4 locations
- number of customers interrupted by potential loss of gas service
- duration of service outage caused by potential loss of gas service
- potential for physical damage to adjacent property or adjacent infrastructure due to pipeline failure (e.g., cratering, fire)
- cost and/or time to repair pipeline in the event of seismic damage

Pipelines Excluded from Need to Include Seismic Design Measures

Seismic design measures are not required for pipelines that do not meet any of the conditions that indicate that seismic design is required.

Seismic Reviews of Existing Assets

Seismic reviews of existing pipelines, facilities, and installations are typically necessary when there are significant changes to the regional seismic hazard definitions reflected in codes or standards or significant changes are made to the gas system. The review will be focused on determining the change in seismic risk for critically important pipelines and the degree to which unacceptable risks could be reduced through mitigation measures (e.g., strengthening, relocation, or providing emergency back-up).

PART 2

Guidance for Implementing Seismic Design Measures

This part of the guideline addresses the considerations and recommended approaches for implementing seismic design measures for buried pipelines. More detailed guidance is provided in industry guidelines developed for the Pipeline Research Council International, Inc. (Honegger and Nyman, 2004).

Regulatory Requirements

Existing regulatory requirements do not specifically address mandatory measures for the seismic design of buried pipelines. Section 4.2.4.1 of CSA Z-662-07 explicitly excludes loading related to: "(a) occasional

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extreme loads, such as inertial earthquakes, (b) slope movements, (c) fault movements, and (d) seismic-related earth movements."

General Pipeline Response to Earthquake Ground Displacement

Permanent ground displacements induce loads in a buried pipeline when there is relative displacement between the pipeline and the surrounding soil. This may occur when the soil restricts the free movement of a pipeline or when the pipeline attempts to resist the movement of the surrounding soil.

The longitudinal strain (combined axial and bending strain) condition in a buried pipeline subject to ground displacement generally varies directly with soil restraint conditions, i.e., the greater the resistance of the soil to the relative displacement of the pipeline within the soil mass, the more concentrated the loads become at the location of differential ground movement, and the larger the pipe strains must become to conform to the ground at the location of differential ground movement.

The longitudinal strain developed in a buried pipeline from imposed ground displacement cannot exceed what is necessary to cause pipeline deformations to match the ground displacement. Therefore, exceeding the pipeline yield stress does not imply uncontrolled increase in pipeline displacement as might occur if an aboveground span of pipe was loaded above the yield capacity of the pipeline. This condition is referred to as displacement-controlled.

Occasionally, seismic hazards can produce conditions that are not displacement-controlled. For example, possible scenario for a pipeline constructed along the side of a hill that is susceptible to earthquake-triggered shallow soil failure is the loss of soil around a length of pipeline resulting in an exposed span but carrying soil load from the failure of the slope above the pipeline. In this scenario, the pipeline span must be able to carry the external soil load while maintaining stresses to only slightly above the yield stress to avoid pipeline collapse. This condition is referred to as load-controlled.

The level of pipeline strain that can be developed without compromising pressure integrity is influenced primarily by the properties of the pipe steel, welding materials and procedures, and quality control over the welding process. Although Annex C of CSA Z-662-07 addresses limit state design for ground movement, the provisions of Annex C are generally only applicable when the design requirements are focused on preventing significant permanent deformation of the pipe. This design requirement is generally far too

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conservative for use in assessing earthquake performance where some pipeline damage can be tolerated on a temporary basis provided there is no uncontrolled release of gas.

Achieving pipeline pressure integrity for the 2,500-year hazard for load-controlled conditions can be assumed provided stresses are below the minimum specified yield strength of the pipe material. For displacement-controlled conditions, achieving pressure integrity is achieved if longitudinal pipeline strains are below the tensile or compressive buckling strain limits without applying resistance factors or other safety factors. Guidance on acceptable strain limits for pressure integrity is provided in Honegger and Nyman (2004).

Design Process to be Followed with Direction by FBC (Gas)

Site specific seismic design will require outside contractors with expertise in geotechnical engineering, analytical assessment of buried pipelines, and in some cases, local geology and seismology. This expertise is generally available only by obtaining the services of outside consulting firms. The following actions will typically be necessary to adequately address potential seismic hazards to buried pipelines:

- Perform a geotechnical assessment to determine the potential of the earthquake-generated permanent ground displacement. This assessment will typically require subsurface investigations to determine site stratigraphy, appropriate laboratory tests, dynamic soil parameters determination, and analytical studies to assess site stability. The major output of this assessment is the distribution of magnitude and direction of ground displacement along the pipeline.
- Perform an analytical assessment of pipeline response to earthquake-generated permanent ground displacement. The pipeline assessment should use numerical approaches such as finite element and/or finite difference methods analysis methods that have the ability to account for geometric, material, and boundary condition nonlinearities.
- Establish specific construction criteria to ensure that the pipeline installation is consistent with the assumptions used in the analytical assessment. Construction criteria will typically focus on weld acceptance criteria (number and size of permissible flaws), weld inspection (typically 100% radiographic and/or ultrasonic inspection), pipe material specifications (e.g., limits on maximum yield stress and the ratio of yield to ultimate strength), pipe coating (use of hard, smooth, external coatings and alternatives to the use of concrete coating), and placement of backfill (e.g., backfill material, degree of compaction).

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Quantifying the Seismic Hazard

The quantification of a seismic hazard on a project-specific basis involves defining the amount (magnitude and distribution) of earthquake-induced ground displacement, the orientation of earthquake-induced ground displacement with respect to the pipeline alignment, and the likelihood of the earthquake-induced ground displacement. For new pipeline installations, earthquake hazards must consider hazards associated with a probability of being exceeded no greater than 2% in 50 years (mean return period not less than 2,475 years). More severe seismic hazards may be specified for especially important pipelines installations. Less severe seismic hazards may be specified for upgrades of existing installations on a case-by-case basis with the approval of Asset Management.

Most of the approaches for quantifying seismic hazards are based upon empirical relationships developed from past earthquake observations. Understanding the relative importance of these limits and rational approaches for implementing modifications for site-specific conditions is the primary reason for relying on individuals with special technical expertise. Current methods often require assumptions based upon professional judgment and caution is necessary to avoid compounding conservatism. Since the seismic hazard for design is based on an unlikely event, assumptions should be aimed at capturing the most likely conditions as opposed to unlikely worse-case condition.

The approach to seismic design is often iterative and requires the consideration of modifications to pipeline material or wall thickness, pipeline alignment, and pipeline construction details in order to arrive at an acceptable design. Because of the iterative nature of the process, it is important that the seismic design be considered early in the planning process, preferably before rights-of-way have been secured for the pipeline alignment.

Assessing Buried Pipeline Response

In general, analytical assessment of pipeline performance should focus on strain acceptance criteria consistent with accepting permanent deformation of the pipeline but maintaining pressure integrity. This approach requires post-earthquake investigation of pipeline response and replacing deformed sections of the pipeline.

An assessment of the likelihood of damage to buried pipelines involves many factors. Some of the most important factors include the length of pipe traversing an area of potential permanent ground displacement, the

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direction of ground displacement relative to the pipeline alignment, the presence of significant bends (side bends, sag bends, and over bends greater than about 10°) within or adjacent to the zone of ground displacement, and the pipeline diameter-to-thickness ratio.

It is not possible to draw conclusions regarding the likely vulnerability of buried pipelines to permanent ground displacement without the benefit of a detailed analysis using finite element methods. In nearly all cases, the detailed analysis of pipeline response to ground displacement will be made using specialty consulting resources. A credible analysis of pipeline response should be performed in accordance with guidance contained in PRCI seismic guidelines (Honegger and Nyman, 2004) and the more recent soil restraint formulations contained in PRCI guidelines for constructing pipelines through areas with landslide and subsidence hazards (PRCI, 2009).

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Appendix A-29

FRASER GATE IP ROUTE SELECTION DETAILS MAP

Legend

- Proposed Metro IP Route Replacement Kilometre Post Rev. C
- Kilometre Post 100m Submarker Rev. C
- Tee Junction
- Gas Valve
- BCHYDRO Manhole
- BCHYDRO Power Pole
- BCHYDRO Pull Box
- BCHYDRO Service Box
- BCHYDRO Transmission Tower
- BCHYDRO Switching Kiosk
- BCHYDRO U.G. Transformer
- TELUS Telecoms. Facility
- TELUS Telecoms. Structure
- SHAW Manhole
- SHAW Pole
- SHAW Telecoms. Facility
- Traffic Signal
- Communications Box
- Street Light
- Street Lighting Junction Boxe
- Combined Manhole
- Sanitary Capped End
- Sanitary Cleanout
- Sanitary Pump Station
- Sanitary Valve
- Sanitary Manhole
- Storm Manhole
- Storm Intake
- Storm Catch Basin
- Storm Cleanout
- Water Hydrant
- Water Control Valve
- Proposed Metro IP Route Replacement Rev. C
- Existing Metro IP Line and Offtakes
- Gas Distribution Pipe
- Communications Duct
- Combined Main
- Combined Service Connection
- Sanitary Main
- Sanitary Service Connection
- Storm Main
- Storm Service Connection
- Water Main
- Water Service Connection
- Water Abandoned Main
- Water Hydrant Feed
- BCHYDRO Duct Bank
- BCHYDRO U.G. Primary
- BCHYDRO U.G. Secondary
- BCHYDRO O/H Wire
- SHAW Telecoms. U.G. Line
- TELUS Cable (Wire) Line
- Land Parcel
- Water Chamber

PRELIMINARY - SUBJECT TO REVISION

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NOTES:
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CHECK: JB
DESIGN: VI
APPR.:

FORTIS BC LOWER MAINLAND NATURAL GAS SYSTEM UPGRADE (LMSU) PROJECT
PROPOSED METRO IP GAS LINE REPLACEMENT
ROUTE MAP LEGEND

PROJECTION	DATUM	CONTRACTOR NAME	MAP NUMBER	REV.
UTM 10N	NAD83	WORLEYPARSONS CANADA	03-003-000a	1

SCALE	DATE	PROJECT NUMBER	ORIG.PAGE SIZE
1:1,000	29 Apr 2014	407071-00064	11X17

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FORTIS BC

FORTIS BC LMSU

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KR	JB	VI	

FORTIS BC LOWER MAINLAND NATURAL GAS SYSTEM UPGRADE (LMSU) PROJECT
PROPOSED FRASER IP GAS LINE REPLACEMENT
ROUTE MAP

PROJECTION	DATUM	CONTRACTOR NAME	MAP NUMBER	REV.
UTM 10N	NAD83	WORLEYPARSONS CANADA	03-008-001	3

SCALE	DATE	PROJECT NUMBER	ORIG.PAGE SIZE
1:1,000	6 Nov 2014	407071-00064	11X17

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NOTES:
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KR	JB	VI	

FORTIS BC LOWER MAINLAND NATURAL GAS SYSTEM UPGRADE (LMSU) PROJECT
PROPOSED FRASER IP GAS LINE REPLACEMENT
ROUTE MAP

PROJECTION	DATUM	CONTRACTOR NAME	MAP NUMBER	REV.
UTM 10N	NAD83	WORLEYPARSONS CANADA	03-008-002	3

SCALE	DATE	PROJECT NUMBER	ORIG.PAGE SIZE
1:1,000	6 Nov 2014	407071-00064	11X17

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Appendix B

ENVIRONMENTAL, ARCHAEOLOGICAL AND SOCIO-ECONOMIC ASSESSMENTS

Appendix B-1

ENVIRONMENTAL OVERVIEW ASSESSMENT

FortisBC – Lower Mainland Natural Gas System Upgrades

Metro Vancouver Reinforcements

Environmental Overview Assessment

FINAL

August 2014

Submitted to:
FortisBC
16705 Fraser Highway
Surrey, BC
V4N 5R8
Attention: Leslie Kristoff, BIT

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EXECUTIVE SUMMARY

FortisBC Energy Inc. (FortisBC) is proposing to upgrade four existing natural gas pipelines as part of its long-term infrastructure projects strategy for the Greater Vancouver Area. According to Section 46(1) of the *Utilities Commission Act* (1996), the projects will require a Certificate of Public Convenience and Necessity (CPCN). Dillon Consulting Limited (Dillon) was retained by FortisBC to undertake a high level, environmental and land use scoping assessment to support FortisBC's CPCN application for these projects.

The four pipeline projects are as follows:

- Fraser Gate to Marine & Elliott IP Pipeline Replacement (Vancouver);
- Metro IP Pipeline Replacement (Vancouver, Burnaby and Coquitlam);
- Cape Horn to Coquitlam TP Pipeline Loop (Coquitlam); and
- Nichol to Port Mann TP Pipeline Loop (Surrey).

In general, the four pipeline projects are located in urban environments following existing roadways or utility corridors with previous disturbance. Background reviews of available data and site records were completed and combined with field studies to identify key natural and environmental features along each of the proposed pipeline alignments and surrounding 100 m. Key findings are summarized below:

Pipeline Segment	Areas of Potential Environmental Concern	Aquatic Systems	Parks / Significant Green Space / Environmentally Sensitive Areas
Fraser Gate to Marine & Elliott IP	2	• Fraser River	• Gladstone-Riverside Park • Riverfront Park
Metro IP	14	15 watercourses including the following: • Beecher Creek • Eagle Creek • Silver Creek • Stoney Creek • Pollywog Creek	• Burnaby Mountain Golf Course (Green Zone and Heritage Trees) • Burnaby Mountain Conservation Reserve (ESA of regional importance) • Burnaby Mountain tributaries to Burnaby Lake and Deer Lake (Green Zone) • 15 parks in Vancouver, Burnaby and Coquitlam • Burnaby 200 Conservation Area • Locally significant street trees (Vancouver)
Cape Horn to Coquitlam	3	• Lost Creek • Mundy Creek • Unnamed Watercourse	• Mundy Park (ESA) • Riverview Forest (ESA) • Hickey Park (ESA) • Mariner Way Park
Nichol to Port Mann	0	• Hawthorne Creek • Quibble Creek • Unnamed Watercourses	• Victoria Park • Invergarry Park • Hawthorne Park • Utility SRW • Quibble Creek Greenbelt (Ecological Site) • Bon Accord Terrestrial Hub • Potential Ecological Corridor

Sixteen (16) species-at-risk were identified as having the potential to occur within the four pipeline project areas. One of these species, Northern red-legged frog (*Rana aurora*), was observed during field investigations in the Cape Horn to Coquitlam project area.

Due to the extensive urban environment covered by the four pipeline projects, various Areas of Potential Environmental Concern (APECs) (i.e. potential sources of contamination) were recorded along each of the alignments. These areas have the capacity to contaminate soils and groundwater in the project areas. The following recommendations are based on historical land use, site activities and the distance to pipeline alignments:

- For all low risk areas (APECs with LW classification), contamination can be managed during construction activities; and
- For medium – high risk areas (APECs with MH classification), subsurface soil and groundwater investigation can be conducted to better define the associated risks.

The assessment also noted that environmental effects could potentially occur during both the site preparation and construction phases of the Project. Physical activities that will occur include the establishment of site access/egress and laydown areas; site clearing and grading; pipeline construction; and overall operations/maintenance of the pipelines.

Pipeline replacements have the potential to disrupt or alter both instream and riparian fish habitats at watercourse crossings. Mitigation measures should be implemented to avoid potential negative impacts to aquatic habitat including, but not necessarily limited to undertaking instream work within appropriate timing windows, restoring disturbed instream and riparian habitat, assigning an Environmental Monitor to the projects and undertaking aquatic life salvages in isolated work areas prior to construction.

In addition, construction activities have the potential to disturb environmentally sensitive areas, wildlife habitat, locally significant trees and species-at-risk. To minimize potential impacts, land clearing activities should take place within the window of least risk for nesting migratory birds in the Lower Mainland (August 1 to March 31). If clearing activities are required outside of the timing window it must be preceded by a bird nest survey to determine the presence/absence of nesting birds.

Relevant environmental legislation and regulatory requirements anticipated for the projects include:

- *Fisheries Act* – Request for Project Review may be required for watercourse crossings that have the potential to result in serious harm to fish or fish habitat. If DFO deems that serious harm to fish or fish habitat is likely, a *Fisheries Act* Authorization may be required.
- *Species at Risk Act* – A permit may be required for pre-construction surveys and trapping of Pacific water shrew and/or Northern Red-legged frog.
- *Migratory Birds Convention Act* – Prohibits the taking or killing of migratory bird nests and eggs and the deposition of harmful substances in areas frequented by migratory birds.
- BC *Environmental Management Act* – includes compliance with Water Discharge Regulations, Oil and Gas Waste Regulation, Spill Reporting Regulations, Hazardous Waste Regulation and Contaminated Site Regulation;

- BC *Water Act* – Oil and Gas Commission Approval for Changes in and About a Stream (Section 9) required for all watercourse crossings;
- BC *Wildlife Act* - Any land clearing activities scheduled between April 1 and July 31 will require a bird nest survey completed by a Qualified Environmental Professional; and
- Multiple ByLaws for the City of Vancouver, City of Burnaby, City of Coquitlam and City of Surrey.

It is expected that potential environmental impacts associated with the Projects can be avoided or mitigated by following applicable provincial and federal guidelines and through the application of standard best management practices and mitigation measures.

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Figure B1–B9:	Metro IP Pipeline Replacement
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APPENDICES

Appendix A:	Figures
Appendix B:	BC Environmental Site Registry
Appendix C:	Photo Log
Appendix D:	List of Waterbodies (FortisBC)
Appendix E:	APEC Information and Overview Maps
Appendix F:	City of Burnaby Green Zone Lands

1.0 INTRODUCTION

FortisBC is proposing to upgrade approximately 30,300 meters (m) of existing Transmission Pressure (TP) and Intermediate Pressure (IP) pipelines as part of FortisBC's long-term infrastructure projects titled, "Lower Mainland Natural Gas System Upgrades" (LMSU).

The existing TP and IP pipelines extend across four municipalities in the Lower Mainland (**Figure 1**, **Appendix A**). The four pipeline projects discussed within this report are as follows:

Intermediate Pressure Pipeline

A. Fraser Gate to Marine & Elliott IP Pipeline Replacement – 700 m, Vancouver, BC
B. Metro IP Pipeline Replacement – 19,700 m through Vancouver, Burnaby, and Coquitlam, BC

Transmission Pressure Pipelines

C. Cape Horn to Coquitlam TP Pipeline Loop– 4,500 m, Coquitlam, BC
D. Nichol to Port Mann TP Pipeline Loop – 5,400 m, Surrey, BC

Collectively, these four pipeline upgrades are referred to as "the Projects". According to Section 46(1) of the *Utilities Commission Act* (1996), the Project will require a Certificate of Public Convenience and Necessity (CPCN). Dillon Consulting Limited (Dillon) was retained by FortisBC to undertake a high level, environmental and land use scoping assessment to support FortisBC's CPCN application for this project. The 2010 *CPCN Application Guidelines* document was used to scope this report.

The purpose/scope of this high level environmental and land use assessment was to determine what:

- Environmental or land use resources/constraints are present within or adjacent to this pipeline alignment;
- Environmental or land use risks are posed by the project; and
- Mitigation measures should be utilized for environmental protection.

The overview assessment included the following five general categories:

1. Current Land Use
2. Soils and Surficial Geology
3. Contaminated Sites
4. Natural Environment
5. Species-at-risk

The environmental and land use overview assessment is presented below.

1.1 Project Scope and Area

FortisBC is proposing to undertake upgrade work on four alignments of pipeline in the Lower Mainland. The scope of each project is discussed below:

Fraser Gate to Marine and Elliot Replacement: This project involves the direct replacement of approximately 700 m of the existing 762 millimeter (mm) outside diameter (OD) IP pipeline. The alignment of this pipeline is along East Kent Street from Fraser Gate (2700 Block of East Kent Street) to the south east corner of Marine Drive and Elliot Street, Vancouver. This pipeline is primarily situated within residential and commercial land use areas.

Metro Pipeline Replacement: This pipeline consists of three alignments, Coquitlam, Burnaby and Vancouver. The Project involves the replacement of approximately 19,700 m of 508 mm OD IP pipeline with a 762 mm OD IP pipeline between Coquitlam Gate station to East 2nd and Woodland station in Vancouver. The Coquitlam alignment is approximately 6 kilometers (km) long and follows Como Lake Ave, starting at Mariner Way and ending at North Road (crosses 30 intersections). The Burnaby alignment is 10 km long and generally follows Broadway Street, starting at North Road and ending at Boundary Road (crosses 30 intersections). The Vancouver alignment is approximately 4 km long and follows 2nd Ave East, starting at Boundary Road and ending at Woodland Road (approximately 25 intersections). This pipeline is primarily situated within residential and commercial land use areas; although does cross park land and some natural areas.

Cape Horn to Coquitlam Looping: This project involves looping approximately 4,500 m of the existing 508 mm OD TP pipeline with a 914 mm OD TP pipeline. The alignment of this pipeline is from the Cape Horn Valve Station (Rogers Ave) to Coquitlam Station (Spurway Ave) in Coquitlam. This pipeline alignment is situated within industrial/commercial, residential and park greens space land use areas.

Nichol to Port Mann Looping: This project involves looping approximately 5,400 m of the existing 610 mm OD TP pipeline with a 914 mm OD TP pipeline. The alignment of this pipeline starts at the Nichol Vale Assembly (138th Street and 93rd Ave) and ends at Port Mann (King Road). The alignment is situated in an urban residential area in North Surrey.

Unless otherwise noted, the study area for each of the pipeline alignments introduced above is 100 m on either side of the alignment.

1.2 Methods

This overview assessment was initially completed as a desktop scoping exercise. Each of the alignments was viewed using available ortho-imagery and assessed according to the five categories outlined above. Dillon utilized municipal mapping information from Surrey, Vancouver and Coquitlam, particularly relevant GIS layers that contained environmental and land use information. Digital records were not obtained from the City of Burnaby, as they would not release the requested information. Further, civic information including lot lines and land use/zoning was not available for the City of Burnaby. Information for Burnaby was obtained from web-based municipal mapping resources and other publically-accessible mapping/image sources. A comprehensive list of information resources used in the desktop study is provided in **Table 1**. A description of the data collection methods and study areas for each of the five categories is provided below. Field investigations were completed to confirm and identify features along the proposed alignment.

Table 1: Records and Resources Searched and Analysed

Record Source	Records Reviewed
Provincial Government	
DataBC Data Distribution Service	Masked and non-masked occurrences of sensitive species; Watercourses and water bodies
Ministry of Environment	Site Registry for contaminated sites, Fisheries Inventory: Fisheries Information Summary System
BC Conservation Data Centre – Mapped Known Locations of Species at Risk	Accessed in April 2014 to determine the locations of known occurrences of non-masked Species at Risk.
Federal Government	
Ministry of Environment Species at Risk Public Registry	Accessed in April 2014 to determine status of non-masked occurrences as a Species-at-risk
Committee on the Status of Endangered Wildlife in Canada (COSEWIC)	Reviewed the October 2011 report
Natural Resources Canada - Canvec	Accessed for topographic mapping
Geological Survey of Canada	Reviewed surficial geology mapping
Agriculture and Agri-Food Canada	Reviewed Detailed Soil Survey Compilation Digital Data
Municipality	
City of Surrey	Reviewed the Official Community Plan, Ecological Management Study and City of Surrey Open Data was used for mapping
City of Vancouver	City of Vancouver Open Data used for mapping
City of Coquitlam	Citywide Official Community Plan and City data used for mapping
City of Burnaby	Official Community Plan, ESA Strategy for Burnaby
Other Resources	
Google Earth Pro and Google Maps	Lower Mainland ortho-imagery
FortisBC	Watercourse crossing information and pipeline routes
UBC Geographic Information Centre	Aerial photographs

1.2.1 Land Use

Land use designations, parks and other Environmentally Sensitive Areas (ESAs) were identified within the study area of the four pipeline alignments from municipal Official Community Plans and other resources identified in **Table 1**.

1.2.2 Soils and Surficial Geology

Agriculture and Agri-Food Canada Detailed Soil Survey digital data (2013) was reviewed for soil classifications along each of the four pipeline alignments across the Lower Mainland. Mapping from the Canadian Geological Survey (1980) was reviewed for surficial geology within the same areas.

1.2.3 Contaminated Sites

Contaminated sites with related environmental and land use constraints along the four pipeline alignments were identified utilizing "Site Registry" information from the British Columbia (BC) Ministry of Environment (MoE), local government resources, aerial photographs obtained from UBC geographic information centre, and existing mapping and on-line data sources listed in **Table 1**.

The BC MoE maintains an Environmental Site Registry to provide public information and keep records of environmental investigations and remediation activities for sites throughout the province. The registry contains information on sites in BC that have been investigated and remediated since 1988. The Site Registry is not a database solely of contaminated sites, but also contains numerous sites that require little, if any, remediation or have already been remediated to government standards.

Dillon requested copies of the Site Registry information (Synopsis Reports) to search for contaminated sites within 500 m of each pipeline alignment (**Figure 2**, **Appendix A**). All sites located within 40 m of each pipeline alignment were evaluated further. The United States Environmental Protection Agency (2002), recommends 30.5 m (100 feet); however, 40 m was used as a conservative approach. The site identification number associated with each registered location (where included on the pipeline alignment figures) can be used to obtain BC Site Registry information for most sites. This information is attached in **Appendix B**.

Detail Reports of the Site Registry were requested for selected properties to further evaluate available historical environmental information. A Detail Report includes everything in the Synopsis Report, plus details of all associated items such as notations, documents, site associations, site participants, suspected land uses, and parcel descriptions. The BC Registry searches were conducted through West Coast Title Search.

Copies of selected notations and documents provided on the Detail Report were requested from BC MOE. Technical review of the available documents was completed for each site. Technical conclusions were made based on findings of the historical review.

Aerial photographs were obtained from the UBC Geographic Information Centre and include photographs from years 1940 through 2004. Aerial photographs were evaluated to determine the chronological history of activities that occurred at a site. It is noted that the scale and resolution of the photographs varied, and did not always allow for a detailed evaluation of the surface conditions at evaluated sites.

The sites along the pipeline alignments were further evaluated using on-line data sources (*i.e.,* Google Maps and Google Earth). Any sites with fuel dispensing, long-term truck and flatbed storage, auto repair facilities, dry cleaners, industrial equipment storage facilities, waste management

activities or abandoned commercial buildings with unknown use were identified as sites of potential environmental concern related to contamination.

The impact from potentially contaminated sites located along the alignment were divided into two groups based on land use, site activities distance to the pipeline alignment and findings of the historical document and aerial photograph review: Low Impact Sites and Medium to High Impact Sites. Areas of Potential Environmental Concern (APECs) were identified along the alignment and further discussed in the following sections.

1.2.4 Natural Environment

A study area of 100 m was assessed on either side of the FortisBC Statutory Right-of-Way (SRW). Aquatic and terrestrial resources were identified using the various resources outlined above in **Table 1**. Field investigations were completed on March 5, 12 and 26, 2014 along sections of the pipeline alignments. And additional field investigation was completed May 22, 2014 where further assessment was required. A photo log of pipeline alignments that were visited is provided in **Appendix C**.

1.2.4.1 Aquatic Resources

Aquatic resources including watercourses and waterbodies, riparian vegetation and fish presence were identified within each of the study areas of the four pipeline alignments by various resources outlined above in **Table 1**. Dillon assessed the waterbody information provided by FortisBC (**Appendix D**) in addition to map resources. Ortho-imagery from municipal digital resources was obtained, when available, in addition to Google Earth/Maps.

Fish habitat classification can vary between municipalities; however, for the purposes of this assessment we have used the most common terminology adopted by most municipalities in the Lower Mainland (**Table 2**).

Table 2: Watercourse Classification and Descriptions

Watercourse Classification	Description	Typical Streamside Setback
Class A or Red-coded	Fish bearing year round	30 m
Class A(O) or Red-dash coded	Fish bearing seasonally	30 – 15 m
Class B or Yellow-coded	Non-fish bearing, but food and nutrient contributing	15 m
Class C or Green-coded	No fish habitat characteristics	None

Field investigations were used to confirm and assess watercourse and waterbodies and identify any unmapped features and their associated riparian vegetation. In addition, areas of standing water and evidence of groundwater were noted where appropriate.

1.2.4.2 Terrestrial Resources

Terrestrial resources including parks, conservation areas, green space, locally significant trees as well as plant and wildlife records were identified within the study areas of the four pipeline alignments by various resources outlined above in **Table 1**.

1.2.5 Species-at-Risk

Species-at-risk queries were completed from the provincial BC Conservation Data Centre (BC CDC) and federal *Species at Risk Act* (SARA) listings specific to each of the study areas. The SARA Public Registry was accessed to collect information on species-at-risk that may potentially occur within or adjacent to the study areas and to determine their current status under the *Act*. The SARA website contains a searchable mapping utility that lists potential federally-listed species that may be present in a given area. Of note, only species placed on Schedule 1 of SARA receive full regulatory protection.

The BC Species and Ecosystems Explorer and CDC rare element occurrence mapping webpage was also accessed to retrieve available records of provincially-listed rare wildlife, plants and ecological communities within the study areas. The provincial ranking system includes Red- and Blue-listed species or ecosystems.

The BC MoE defines the "Red-list" as the following:

> *"Includes any ecological community, and indigenous species and subspecies that is extirpated, endangered, or threatened in British Columbia. Extirpated elements no longer exist in the wild in British Columbia, but do occur elsewhere. Endangered elements are facing imminent extirpation or extinction. Threatened elements are likely to become endangered if limiting factors are not reversed. Red-listed species and sub-species may be legally designated as, or may be considered candidates for legal designation as Extirpated, Endangered or Threatened under the Wildlife Act.* (http://www.env.gov.bc.ca/wld/faq.htm#2) *Not all Red-listed taxa will necessarily become formally designated. Placing taxa on these lists flags them as being at risk and requiring investigation."* (http://www.env.gov.bc.ca/atrisk/red-blue.htm)

The BC MoE defines the "Blue-List" as the following:

> *"Includes any ecological community, and indigenous species and subspecies considered to be of special concern (formerly vulnerable) in British Columbia. Elements are of special concern because of characteristics that make them particularly sensitive to human activities or natural events. Blue-listed elements are at risk, but are not Extirpated, Endangered or Threatened."* (http://www.env.gov.bc.ca/atrisk/red-blue.htm)

The Red-list includes any indigenous species or sub-species that are considered to be "Extirpated", "Endangered" or "Threatened" in BC. Definitions of the status categories for the CDC are:

- "Extirpated" species no longer occur in British Columbia but do occur elsewhere in Canada or other countries;
- "Endangered" elements are facing imminent extirpation or extinction; and

- "Threatened" elements are likely to become "Endangered" if limiting factors are not reversed.

Species or sub-species on the Blue-list are of "Special Concern" because they are considered to be vulnerable or particularly sensitive to human activities or natural events. Blue-listed taxa are at-risk, but are not Extirpated, Endangered, or Threatened. The CDC does not make laws about managing or conserving species-at-risk or their habitats, but it maintains a database that can inform government decisions on legal designation of species-at-risk.

Dillon also identified species-at-risk which could potentially occur within the study areas based on habitat suitability assessed at the desktop level and our understanding of the local environment from previous studies in each of the study areas. The list of species generated represents those that have known occurrences in the areas or have the highest likelihood of presence based on a high-level assessment of habitat suitability. Areas with high potential for species-at-risk were assessed during field investigations.

2.0 ENVIRONMENTAL OVERVIEW

This section describes the results of our desktop assessment of environmental and land use attributes present within each of the four pipeline alignments.

2.1 Fraser Gate to Marine & Elliott IP Pipeline Replacement

The Fraser Gate IP Pipeline extends from the Fraser Gate Station on Kent Avenue 700 m to the intersection of Marine Drive and Elliott Street in Vancouver (**Figure A1, Appendix A**). The existing 762 mm OD pipeline will be replaced with the same diameter pipe. The existing pipeline is aligned through an urban environment and is not located within an established statutory right of way (SRW).

2.1.1 Current Land Use

According to the City of Vancouver's Open Data (2013), the Fraser Gate to Marine & Elliott study area falls within the following land use areas:

- Comprehensive Development (CD-1);
- Industrial (M-2); and
- One Family Residential (RS-1, RS-1B).

2.1.2 Soils and Surficial Geology

2.1.2.1 Soils

According to Agriculture and Agri-Food Canada's Detailed Soil Survey Compilations digital data (2013), the soil within the Fraser Gate to Marine & Elliott study area is unclassified due to its urban environment.

2.1.2.2 Surficial Geology

Surficial geology in the vicinity of the study area consists of Fraser River Sediments, which are deltaic and distributary channel fill sediments overlying and cutting estuarine sediments and overlain in part of the area by overbank sediments (Geological Survey of Canada 1980). These sediments are characterized by overbank silty to silt clay loam up to 2 m thick overlying 15 m or more of channel fill (Geological Survey of Canada 1980).

2.1.3 Contaminated Sites

A total of two Areas of Potential Environmental Concern (APECs) and related environmental risks and liabilities were identified along the Fraser Gate to Marine & Elliott study area. The locations of these APECs are listed in **Table 3** and shown on **Figure A1, Appendix A.** Detailed APEC information and overview maps are provided in **Appendix E.**

Table 3: Summary of APECs - Fraser Gate IP Pipeline Alignment

APEC #	Associated Registry Number	Figure*	Site details	Classification / Impact
A1	1481	A1	Current FortisBC Fraser IP Station	Low
A2	291	A1 & A2	Along Fraser Lands Riverpoint Park	Medium to High
	1289	A1 & A2	Current residential property (Commercial/Industrial land prior to rezoning)	

*All figures are provided in **Appendix A**.

2.1.4 Natural Environment

2.1.4.1 Aquatic Resources

The main branch of the Fraser River was the single watercourse identified within the Fraser Gate to Marine & Elliott study area (**Figure A1, Appendix A**). The Fraser River is located 40 m south of the pipeline alignment. The Fraser River is a large Class A watercourse, draining into the Pacific Ocean west of the study area.

2.1.4.2 Terrestrial Resources

Two parks have been identified in the Fraser Gate to Marine & Elliott study area, Gladstone-Riverside Park and Riverfront Park. Both of these parks are located on the south side of East Kent Avenue South (**Figure A1, Appendix A**). The pipeline alignment extends through Riverside Park between East Kent Avenue South and Elliott Street. Vegetation disturbance is expected to be minimal.

2.1.5 Species-at-Risk

Occurrences for two species-at-risk; White Sturgeon (*Acipenser transmontanus* pop. 4), and Eulachon (*Thaleichthys pacificus*) were identified in the Fraser Gate to Marine & Elliott study area according to the BC CDC (2013) and COSEWIC (2011). Specific information regarding these species is listed below in **Table 4.**

Table 4: Species-at-risk Observed or Have the Potential to Occupy Habitat within the Fraser Gate Study Area

Species		Status in Canada (SARA)	COSEWIC Status	Provincial Status	Habitat	Observation and Distribution Details
Scientific Name	Common Name					
Vertebrates						
Acipenser transmontanus pop. 4	White Sturgeon (Lower Fraser River population)	-	Threatened	Red	Riverine: Big River; High Gradient; Low Gradient; Moderate Gradient Estuarine: River Mouth; Tidal Flat	Present from the mouth of the Fraser River to Hell's Gate.
Thaleichthys pacificus	Eulachon	-	Endangered	Blue	Pacific Ocean; Lower Fraser River	Lower Fraser River

2.2 Metro IP Pipeline Replacement

The Metro IP Pipeline extends from the Coquitlam Station through Burnaby to the intersection of Woodland Drive and 2nd Ave West in Vancouver (**Figure B1** to **B9, Appendix A**). The existing 508 mm OD pipeline will be replaced with a 762 mm OD pipeline. In general, this pipeline is aligned through an urban environment and is not located within an established SRW.

2.2.1 Current Land Use

The Metro IP study area crosses three municipal boundaries; City of Vancouver, City of Burnaby and City of Coquitlam. Land use within each of these municipalities is discussed below.

2.2.1.1 City of Vancouver

According to the City of Vancouver's Open Data (2013), the Metro IP study area fall within the following land use areas:

- Comprehensive Development (Multiple CD-1 zones);
- Industrial (I-2 and M-2);
- One Family Residential (RS-1, RS-5 and RS-7);
- Two Family Residential (RT-4 and RT-5);
- Multiple Dwelling Residential (RM-4); and
- Commercial (C-1, C-2C, and C-2C1).

2.2.1.2 City of Burnaby

According to Burnaby's Official Community Plan (1998), the Metro IP study area falls within the following land use areas:

- Residential – Single and Two Family;
- Residential – Townhouses and Low-rise Apartments;
- Commercial;
- Industrial;
- Open and Undeveloped Land (active and vacant); and
- Recreation and Protected Natural Areas.

In addition, green zone lands were identified for the City of Burnaby, which includes ESAs. The pipeline alignment intersects two main green zone areas associated with Burnaby Mountain Golf Course, Burnaby Mountain tributaries to Burnaby Lake and Deer Lake (**Appendix F**).

Burnaby Mountain Conservation Reserve was identified as a Site of Regional Importance in the ESA Strategy for Burnaby (1994). These sites are clearly identified features on the landscape that are regionally significant. Planning and design principles for the ESAs applicable to potential pipeline activities include:

- Achieving a zero net increase in stormwater run-off and avoiding degradation of water flowing into the City of Burnaby's three major watersheds;
- Controlling construction damage to sites; and
- Removal of invasive species and installation of native plants.

2.2.1.3 City of Coquitlam

According to the City of Coquitlam's Open Data (2013), the Metro IP study area falls within the following land use areas:

- School;
- Parks and Recreation;
- One Family Residential;
- Service Commercial;
- Natural Areas;
- Medium Density Apartment Residential;
- Civic and Major Institutional;
- Transit Village Commercial;
- General Commercial;
- Neighborhood Attached Residential; and
- Medium Density Apartment Residential.

2.2.2 Soils and Surficial Geology

2.2.2.1 Soils

According to Agriculture and Agri-Food Canada's Detailed Soil Survey Compilations digital data (2013), the soil within the Metro IP pipeline alignment is unclassified due to its urban environment.

2.2.2.2 Surficial Geology

Four classifications of surficial geology were identified along the Metro IP study area between Vancouver and Coquitlam (Geological Survey of Canada 1980). The four types are:

- **Vashon Drift and Capilano Sediments**: Glacial drift including lodgement and minor flow till, lenses and interbeds of sub-stratified glaciofluvial sand to gravel, and lenses and interbeds of glaciolacustrine laminated stony silt up to 25 m thick (but in most places less than 8 m thick), overlain by glaciomarine and marine deposits normally less than 3 m, but in places up to 10 m thick. Marine derived lag gravel normally less than 1 m thick containing marine shell casts has been found mantling till and glaciomarine deposits up to 175 m above sea level. Above 175 m till is mantled by boulder gravel that may be in part ablation till in part colluvium and in part marine shore in origin;
- **Capilano Sediments**: Raised marine beach, spit, bar and lag veneer, poorly sorted sand to gravel (except in bar deposits) normally less than 1 m thick but up to 8 m thick. Raised beach medium to coarse sand 1 to 5 m thick containing fossil marine shell casts;
- **Postglacial and Pleistocene**: Marine shore and fluvial sand up to 8 m thick; and

- **Salish Sediments**: Lowland and mountain stream deltaic, channel fill and overbank sediments. Lowland stream channel fill and overbank sandy loam to clay loam, also organic sediments up to 8 m thick.

2.2.3 Contaminated Sites

A total of 14 APECs and related environmental risks and liabilities were identified along the Metro IP study area. The locations of these APECs are listed in **Table 5** and shown on **Figures B1** to **B9**, **Appendix A**. Detailed APEC information and overview maps are provided in **Appendix E.**

Table 5: Summary of APECs - Metro IP Study Area

APEC #	Associated Registry Number	Figure*	Site Details	Classification / Impact
B1	7671	B1	Fortis BC Woodland Muster Point Station	Medium to High
B2	12967	B1	Residential Property	Low
B3	1237	B1	Chevron Service Station	Medium to High
	1332	B1	Petro Canada Service Station	
	16076	B1	Residential Property	
B4	8757	B2	Residential Property	Low
B5	148	B2	Capanga Auto Service	Medium to High
	15828	B2	Brush Dental Clinic	
B6	322	B2	Petro Canada Service Station	Medium to High
	1231	B2	Petro Chevron Service Station	
B7	6577	B2	Vancouver Police Department	Low
	11851	B2	Mazda Dealership	
B8	15092	B4	Residential Property	Low
B9	10866	B4	Residential Property	Low
	10958	B4	Residential Property	
	13044	B4	Residential Property	
B10	6658	B6	Sears Distribution Centre	Medium to High
	9963	B6	Shell Terminal Property	
B11	147	B7	Vacant/Historically Shell Service Station	Medium to High
	13430	B7	Vacant/ Historically Esso Service Station	
	13099	B7	Vacant/ Historically Mahawk service station	
	12673	B7	Residential 4 storey condo	
	13673	B7	Residential 4 storey condo	
	15298	B7	Roadway	
	15860	B7	Roadway	
B12	-	B8	Race Trac Service Station	Medium to High
B13	1434	B8	Chevron Service Station	Medium to High
	1459	B8	Residential Property	

APEC #	Associated Registry Number	Figure*	Site Details	Classification / Impact
B14	84	B8	Vacant/Historically Shell Service Station	Medium to High
	350	B8	Commercial Property	
	4827	B8	Commercial Property	

*All figures are provided in **Appendix A**.

2.2.4 Natural Environment

2.2.4.1 Aquatic Resources

Fifteen watercourses were identified within the Metro IP study area in Burnaby and Coquitlam. Nine of these watercourses cross the pipeline alignment. The City of Burnaby does not utilize a watercourse classification model; therefore, the official classifications of watercourses within Burnaby are unknown. However based on the classification system widely accepted in the Lower Mainland, one Class A and one Class B watercourse were identified in the City of Coquitlam. The location of these watercourses and their classification is listed below in **Table 6**. Two additional unmapped watercourse crossings were identified by Dave Konesky, Envirow Consulting Ltd. (pers. comm. May 2013; **Figure B6**).

Table 6: Watercourses Identified Within 100 m of the Metro IP Study Area

Watercourse	Classification	Figure Reference*	Mapped Watercourse	Distance to Pipeline
City of Burnaby				
Stickleback Creek	Unclassified	**N/A**	Mapped by the City of Burnaby	10 m
Beecher Creek	Unclassified; assumed Class A due to fish data	**Figure B4**	Yes	Crossing
Crab-Apple Creek	Unclassified	**N/A**	Mapped by the City of Burnaby	Crossing
Pollywog Creek Tributary 1)	Unclassified; likely Class B fish habitat	**Figure B5**	Yes (unnamed)	22 m
Pollywog Creek	Unclassified; likely Class B fish habitat	**Figure B5**	Yes (unnamed)	37 m
Eagle Creek Tributary 2	Unclassified; likely Class B fish habitat	**Figure B5**	Yes	Crossing
Eagle Creek	Unclassified; likely Class A due to fish data	**Figure B5**	Yes	Crossing
Silver Creek Tributary 1-1	Unclassified; likely Class B fish habitat	**Figure B6**	Yes	Crossing
Silver Creek Tributary 1	Unclassified; likely Class B fish habitat	**Figure B6**	Yes	Crossing
Silver Creek	Unclassified	**Figure B6**	Yes	Crossing
Stoney Creek Tributary 1	Unclassified	**Figure B6**	Yes	Crossing
Stoney Creek Tributary 2	Unclassified	**Figure B6**	Yes	Crossing
Stoney Creek	Unclassified; assumed Class A due to fish data	**Figure B6**	Yes	Crossing
City of Coquitlam				

Watercourse	Classification	Figure Reference*	Mapped Watercourse	Distance to Pipeline
South Schoolhouse Creek	Class A	**Figure B7**	Yes	18 m
Pinnacle Creek	Class A	**Figure B9**	Yes	30 m

*All figures are provided in **Appendix A**.

Stickleback Creek is a tributary of Still Creek and is located in the Central Valley Watershed. This tributary was identified using Burnaby Map (City of Burnaby 2014) in Delta-Halifax Park Site, which is located south of Halifax Street and west of Delta Avenue (**Figure B4, Appendix A**). During field investigations, channel bank-full width averaged 2.0 m with a wetted depth of 0.05 m (see **Photo 1**). Riparian vegetation was characterized by mixed forest dominated by black cottonwood, western redcedar and bigleaf maple with a dense understory consisting of Himalayan blackberry, vine maple, English holly, salmonberry, yellow buttercup, sword fern, bracken fern and beaked hazel. No watercourse classification or fish records were available for Stickleback Creek. It is likely that this creek contributes flow and nutrients to fish habitat in Still Creek. Flow was conveyed from Halifax Street south into the park by a concrete culvert. This suggests that Stickleback Creek extends beyond its mapped extent and crosses the pipeline alignment. Construction of the pipeline at this crossing will be completed using open trench methodology. Pipelines will be constructed under/over existing culverts which will remove any direct impacts to Stickleback Creek. The potential for indirect (temporary) impacts during construction is considered low. The exact location of the Stickleback Creek culvert should be determined prior to construction.

Photo 1. Stickleback Creek south of Halifax Street in Delta-Halifax Park Site. Facing downstream. Photo taken May 22, 2014.

Beecher Creek, a tributary of Still Creek, is located in the Central Valley Watershed (see **Photo 2**). No watercourse classification information was available from the City of Burnaby; however, a Class A watercourse designation is recommended based on the observance of Coho salmon and cutthroat

trout in Beecher Creek, south of Broadway Avenue (Geographic Data Discovery Service: BC MOE 2014). According to the City of Burnaby (2012a) this creek provides spawning habitat for salmon. During field investigations channel bank-full width was approximately 3.0 m wide with a water depth of approximately 0.15 m. Mature red alder trees with a dense understory characterize the riparian habitat. The pipeline alignment crosses Beecher Creek as it passes under Broadway Avenue, east of Springer Avenue (**Figure B4, Appendix A**). Construction of the pipeline at this crossing will be completed using open trench methodology in the roadway Pipelines will be constructed under/over existing culverts which will remove any direct impacts to Beecher Creek. The potential for indirect (temporary) impacts during construction is considered low.

Photo 2. Beecher Creek near KP 12.7, north of Broadway Avenue. Facing upstream (north). Photo taken March 26, 2014.

Crab-Apple Creek is a tributary of Still Creek in the Central Valley Watershed. This unmapped tributary was identified by Burnaby Map (City of Burnaby 2014) and the Waterways of Burnaby map (City of Burnaby 2012b) crossing Broadway Avenue, east of Kensington Avenue into Still Creek Conservation Area (**Figure B4, Appendix A**). According to the Waterways of Burnaby (City of Burnaby 2012b), Crab-Apple Creek is piped under Broadway Avenue. No watercourse classification or fish records were available. The creek likely contributes flow and nutrients to downstream fish habitat in Still Creek. The watercourse was not identified during field investigations and is likely piped under residential properties. Construction of the pipeline at this crossing will be completed using open trench methodology in the roadway. Pipelines will be constructed under/over existing culverts which will remove any direct impacts to Crab-Apple Creek. The potential for indirect (temporary) impacts during construction is considered low.

Pollywog Creek and Pollywog Creek Tributary 1 are tributaries of Still Creek in the Central Valley Watershed. Both tributaries flow southwest from Broadway Avenue to Still Creek Conservation Area and are piped under Lougheed Highway (City of Burnaby 2012b). These tributaries are shown on

Figure B5 in **Appendix A** however they are unlabeled. During field investigations flow originated from concrete culverts on the south side of Broadway Avenue (8 m and 10 m south of the road edge, respectively) which suggests that both watercourses extend beyond their mapped extents and cross the pipeline alignment. Pollywog Creek Tributary 1 had a channel bank-full width of 1.9 m with a wetted depth of 0.05 m (see **Photo 3**). Riparian habitat was characterized by deciduous trees such as cherry, horse chestnut and red alder with an understory consisting of laurel species and English holly. Pollywog Creek had a channel bank-full width averaging 2.1 m with a water depth of 0.2 m (see **Photo 4**). Riparian vegetation was dominated by willow, western redcedar and beaked hazel with an understory of yellow lamium, English ivy, laurel and Japanese knotweed. No watercourse classification or fish records were available. It is likely that these tributaries contribute flow and nutrients to fish habitat downstream.

Construction of the pipeline at these Pollywog Creek crossings will be completed using open trench methodology in the roadway. Pipelines will be constructed under/over existing culverts which will remove any direct impacts to Pollywog Creek and Pollywog Creek Tributary 1. The potential for indirect (temporary) impacts during construction is considered low. The exact location of the tributaries under Broadway Avenue should be determined prior to construction.

Photo 3. Pollywog Creek Tributary south of Broadway Avenue., facing upstream. Photo taken May 22, 2014.

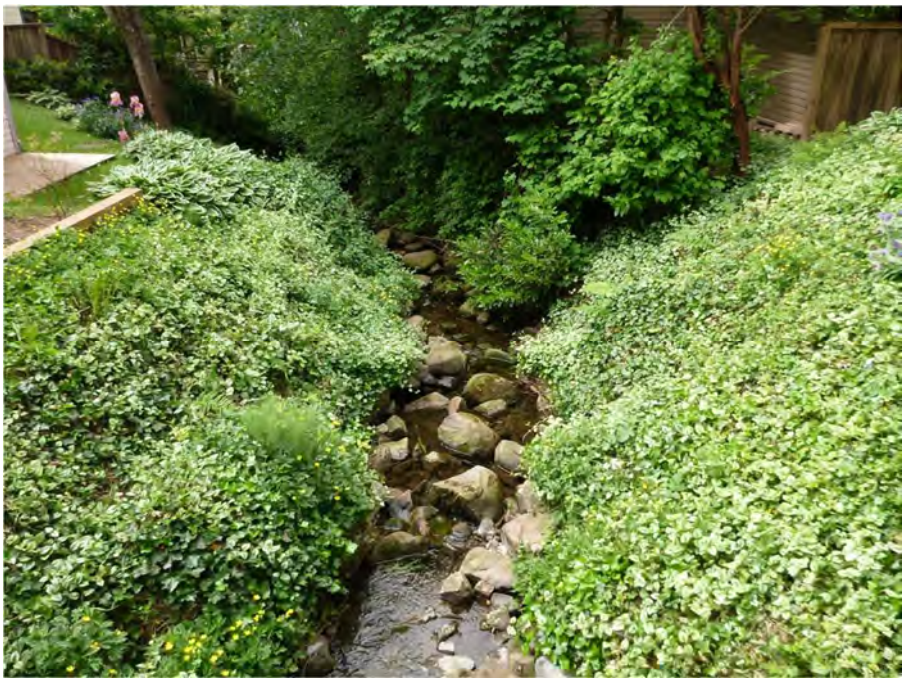

Photo 4. Pollywog Creek south of Broadway Avenue, facing downstream. Photo taken May 22, 2014.

Eagle Creek and Eagle Creek Tributary 2 are tributaries of Burnaby Lake in the Central Valley Watershed. The pipeline alignment crosses these tributaries at the west and east end of the Burnaby Mountain Golf Course (**Figure B5, Appendix A**). During field investigations the channel bank-full width of Eagle Creek Tributary 2 averaged 2.0 m with a water depth of 0.03 m (see **Photo 5**). Riparian vegetation was characterized by red alder, black cottonwood, western red cedar, salmon berry, skunk cabbage, vine maple, yellow lamium, Indian plum, sword fern, herb Robert, Himalayan blackberry, horsetail, lilac and Oregon grape. No watercourse classification or fish records were available. It is likely that this tributary contributes flow and nutrients to fish habitat in Eagle Creek. A culvert extends under Broadway Avenue, crossing the pipeline alignment. Construction of the pipeline at this crossing will be completed using open trench methodology in the roadway. Pipelines will be constructed under/over existing culverts which will remove any direct impacts to Eagle Creek Tributary 2. The potential for indirect (temporary) impacts during construction is considered low.

The channel bank-full width of Eagle Creek, south of Broadway Avenue was 6.0 m with a water depth of 0.25 m (see **Photo 6**). Riparian vegetation was characterized by bigleaf maple, black cottonwood, red alder, western red cedar, stinging nettle, yellow buttercup, Himalayan blackberry, bracken fern, Japanese knotweed, English ivy, Indian plum, vine maple and sword fern. No watercourse classification was available from the City of Burnaby; however, a Class A watercourse designation is recommended based on the observance of cutthroat trout and stickleback species in Eagle Creek within Burnaby Mountain Golf Course and Chinook salmon, south of Lougheed Highway (Geographic Data Discovery Service: BC MOE 2014). Paired corrugated steel pipe (CSP) culverts extend under Broadway Avenue, crossing the pipeline alignment. Iron staining was observed downstream of the culverts. Construction of the pipeline at this crossing will be completed using open trench methodology in the roadway. Pipelines will be constructed under/over existing culverts which will remove any direct impacts to Eagle Creek. The potential for indirect (temporary) impacts during construction is considered low.

Photo 5. Eagle Creek Tributary 2, north of Broadway Avenue, facing downstream. Photo taken May 22, 2014.

Photo 6. Eagle Creek, south of Broadway Avenue, facing upstream. Photo taken May 22, 2014.

Silver Creek and its tributaries (Tributary 1-1 and Tributary 1) convey flow south to the Brunette River and are located in the Central Valley Watershed. These watercourses convey flow south through the Burnaby 200 Conservation Area and are piped under Broadway Avenue, across the pipeline alignment (**Figure B5** and **B6**, **Appendix A**). No watercourse classification or fish records were available. During field investigations the channel bank-full width of Silver Creek Tributary 1-1 averaged 2.8 m with a water depth of 0.05 to 0.1 m (see **Photo 7**). Riparian vegetation was characterized by bigleaf maple, western hemlock, red alder, western red cedar, black cottonwood,

salmonberry, sword fern, Indian Plum, vine maple, Himalayan blackberry, horsetail species, stinging nettle, thimbleberry, herb Robert and policeman's helmet. This vegetation was consistent at all tributaries within the Burnaby 200 Conservation Area. A culvert conveys flow under the Burnaby Mountain Urban Trail and development to the south.

Photo 7. Silver Creek Tributary 1-1, north of Burnaby Mountain Urban Trail, facing downstream. Photo taken May 22, 2104.

The channel bank-full width of Silver Creek Tributary 1 averaged 2.1 m with a water depth of 0.03 m (see **Photo 8**). Riparian vegetation was consistent with Silver Creek Tributary 1-1. This tributary passes under the Burnaby Mountain Urban Trail by a CSP culvert that is perched 1.2 m at the downstream end (see **Photo 8**). The channel bank-full width of Silver Creek averaged 4.3 m with a water depth of 0.05 to 0.1 m (see **Photo 9**). Riparian vegetation was consistent with Silver Creek Tributary 1-1 and Tributary 1. A culvert conveys flow under the Burnaby Mountain Urban Trail and development to the south.

No watercourse classification or fish records were available for Silver Creek and its tributaries. These watercourses are likely headwater streams, originating on Burnaby Mountain, that contribute flow and nutrients to fish habitat downstream. Construction of the pipeline at this crossing will be completed using open trench methodology which will have direct (temporary) impacts on flow and water quality along Silver Creek and its tributaries.

Photo 8. Silver Creek Tributary 1, south of Burnaby Mountain Urban Trail, facing upstream towards perched culvert. Photo taken May 22, 2014.

Photo 9. Silver Creek, north of Burnaby Mountain Urban Trail, facing upstream. Photo taken May 22, 2014.

Stoney Creek and its tributaries convey flow south to the Brunette River and are located in the Central Valley Watershed. The Metro IP pipeline intersects Stoney Creek Tributary 1 along the Burnaby Mountain Urban Trail, west of Production Way (**Figure B6, Appendix A**). According to Waterways of Burnaby map (City of Burnaby 2012b), this watercourse is piped under the Urban Trail to the east side of Gaglardi Way, just north of its confluence with Stoney Creek in Eastlake Park. During field investigations the channel bank-full width averaged 3.0 m with a water depth of 0.5 m (see **Photo 10**).

Photo 10. Stoney Creek Tributary 1, north of Burnaby Mountain Urban Trail, facing upstream. Photo taken May 22, 2014.

The Metro IP pipeline intersects Stoney Creek Tributary 2 along the utility SRW between Gaglardi Way and Forest Grove Drive (**Figure B6, Appendix A**). During field investigations the channel bank-full width at the crossing area was approximately 0.5 m with a water depth of approximately 0.1 m (**Photo 11**). Channel morphology was considered to be run habitat. Vegetation has been cleared along the crossing with dense Himalayan blackberry within the riparian area. Mixed forest is located approximately 10 m north and south of the crossing. No watercourse classification or fish records were available for this tributary. It is likely that Stoney Creek Tributary 2 contributes flow and nutrients downstream to fish habitat. Construction of the pipeline at this crossing will be completed using open trench methodology which will have direct (temporary) impacts on Stoney Creek Tributary 2 during construction.

Stoney Creek is a large Class A watercourse flowing under Broadway Avenue, east of Gaglardi Way (**Figure B6, Appendix A**). During field investigations the channel bank-full width was approximately 4.0 m wide, with a water depth was approximately 0.2 m. Channel morphology was considered to be riffle-run in the area of the crossing (see **Photo 12**). Large sections of rock armouring were observed on both banks with minimal vegetation. Red alder and Western redcedar were observed as the dominant riparian tree species. Construction of the pipeline at this crossing will be completed using trenchless technology, minimizing impacts to aquatic habitat, aquatic species and riparian vegetation. The exact method of trenchless construction has not been determined at this time, but may involve a combination of micro-tunnelling and horizontal directional drilling (HDD).

Photo 11. Stoney Creek Tributary 2 along hydro corridor between KP 6.5 and KP 6.6. Facing downstream (south). Photo taken March 12, 2014.

Photo 12. Stoney Creek under Broadway Avenue bridge crossing, east of Gaglardi Way. Facing downstream (south). Photo Taken March 12, 2014

In addition to the watercourses outlined above, an unmapped groundwater upwelling area and associated channel were identified during field investigations along the north side of Gaglardi Way.

This crossing is shown on **Figure B6** in **Appendix A**. The groundwater upwelling area (see **Photo 13**) is located approximately 35 m east of the crossing identifier.

Photo 13. Unmapped groundwater upwelling and channel located along the north side of Gaglardi Way between KP 6.3 and KP 6.4.

South Schoolhouse Creek is a Class A watercourse that conveys flow north of Como Lake Avenue to the Port Moody Arm of Burrard Inlet (**Figure B7, Appendix A**). According to the City of Coquitlam's GIS mapping, Q the Map (2014), a drainage main runs under Como Lake Avenue to an outfall at the southern extent of South Schoolhouse Creek. Construction of the pipeline at this crossing will be completed using open trench methodology in the roadway which may have indirect (temporary) impacts on South Schoolhouse Creek due to the drainage main crossing. In addition, construction will occur in the streamside protection and enhancement area (SPEA) for the creek.

Pinnacle Creek is a Class A watercourse that conveys flow from the north side of Como Lake Avenue Road to the Coquitlam River in the Lower Coquitlam River Watershed (**Figure B9, Appendix A**). Similar to South Schoolhouse Creek, a drainage main was identified under Como Lake Avenue that extends to an outfall at the southern extent of Pinnacle Creek (City of Coquitlam 2014). Construction of the pipeline at this crossing will be completed using open trench methodology. There is a low potential for indirect (temporary) impacts to Pinnacle Creek due to the drainage main crossing.

2.2.4.2 Terrestrial Resources

In general, the Metro IP study area represents an urban environment with moderate areas of green space. Terrestrial resources include street trees, city parks, conservation areas, and utility corridors. The Metro IP pipeline alignment almost exclusively follows existing roadways. Exceptions include the following areas:

- Willingdon Heights Park between Gilmore Avenue and Carleton Avenue (**Figure B3, Appendix A** and *Photo B23* in **Appendix C**);
- Burnaby Mountain Urban Trail between Underhill Avenue and Production Way (**Figure B6, Appendix A** and *Photo B9* to *B12* in **Appendix C**); and
- Utility corridor between Broadway Avenue and the crossing of Gaglardi Way (**Figure B6, Appendix A** and *Photo B4* to *B6* in **Appendix C**).

These areas represent actively managed parks and right of ways with previously disturbed or cultivated vegetation. Construction of the pipeline along these areas will be completed using open trench methodology. Disturbance to vegetation is expected in these natural areas. Tree and shrub removal will be minimized and avoided where possible. Deciduous forest with a dense understory was identified along sections of the Burnaby Mountain Urban Trail (see *Photo B10* in **Appendix C**) which will be disturbed during construction.

Parks

Fourteen parks were identified within the Metro IP study area within Vancouver, Burnaby and Coquitlam. These parks and their locations are outlined below in **Table 7**.

Table 7: Parks Identified Within 100 m of the Metro IP Study Area.

Park	Location**
City of Vancouver	
Alice Towney Park	Northwest of 2nd Ave East and Woodland Drive Intersection **Figure B1**
Clinton Park	Located between Slocan Street and Penticton Street, north of the pipeline **Figure B1** and **B2**
Rupert Park	Located between Rupert Street and the Trans-Canada Highway, north of 1st Avenue **Figure B2**
Thunderbird Park	Located between 1st Ave East and 2nd Ave East adjacent to the Trans-Canada Highway **Figure B2**
City of Burnaby*	
Willingdon Heights Park	Pipeline crosses park between Gilmore Avenue and Carleton Avenue along Graveley Street alignment
Delta-Halifax Park Site	Intersection of Delta and Halifax, south of pipeline
Broadway – Woolwich Park	North of Broadway between Woolwich Avenue and Kensington Avenue
Camrose Park	North of Phillips Avenue encompassing a tributary of Eagle Creek
Eagle Creek Ravine Park	South of Broadway at the east end of Burnaby Mountain Golf Course along Eagle Creek
Maple Grove Park	North and south of Broadway Avenue along rail line and Stoney Creek Tributary
Stoney Creek Ravine Park	Located south of Broadway Avenue extending south to the Brunette River Conservation Area, encompassing Stoney Creek
City of Coquitlam	
Schoolhouse Creek Ravine and Natural Areas (south of Miller Park)	Located along South Schoolhouse Creek north of Como Lake Ave between Dalip Court and Fowler Court **Figure B7**
James Park	North of Como Lake Ave, West of Thermal Drive **Figure B9**
Mundy Park	Southwest of Como Lake Ave and Mariner Way Intersection **Figure B9**

*Parks identified using Burnaby Map, web-based municipal mapping website (City of Burnaby 2014)

All figures are provided in **Appendix A.

Conservation Areas

Two Conservation Areas within the City of Burnaby were identified in the Metro IP study area, including:

1. Burnaby 200 Conservation Area - This conservation area is located between Broadway and Forest Grove Drive, connecting to Burnaby Mountain Conservation Area through Stoney Creek and Silver Creek riparian corridors. The pipeline alignment runs within and adjacent to the southern border of this Conservation Area.

2. Burnaby Mountain Conservation Reserve - This conservation area is located at border of Burnaby and Coquitlam, extending south to the Broadway Avenue and Gaglardi Way intersection and has been deemed an Environmentally Significant Area by the City of Burnaby. The details of this Conservation Area are described in **Section 2.2.1.2**.

Burnaby Mountain Golf Course – Heritage Trees

A number of trees lining the southern end of the Burnaby Mountain Golf Course represent species of local value and interest and should be preserved where possible. This area has been identified on **Figure B5**, **Appendix A**. If impacts to these trees are anticipated, communication with the City of Burnaby is highly recommended.

Street Trees

A number of trees lining the north, south and island of 1st Avenue along the west end of the Metro IP pipeline alignment represent species of local value and interest. An arborist will be consulted to determine potential impacts to trees along the proposed alignment. Impacts to these trees will be minimized and avoided where possible.

2.2.5 Species-at-Risk

Nine species considered at-risk according to the BC CDC (2013) were identified as having the potential to occur in the Metro IP study area, four of which are also listed under SARA. Details of each species-at-risk are provided in **Table 8** and are shown on **Figures B1** to **B9**, **Appendix A**.

Multiple masked occurrences were identified along the northern section of the Metro IP study area. A request was sent to the BC CDC to obtain more detailed information to determine whether the proposed project has the potential to impact these species. Based on information received, the masked species-at-risk occurrences identified are located well outside of the study area. Due to the sensitive nature of the species-at-risk and its location, it is prohibited to include specific details in this report.

Table 8: Species-at-risk Observed or Have the Potential to Occupy Habitat within the Metro IP Study Area

Species		Status in Canada (SARA)	COSEWIC Status	Provincial Status	Habitat	Observation and Distribution Details
Scientific Name	Common Name					
Vertebrates						
Anaxyrus boreas	Western Toad	-	Special Concern	Blue	Adults utilize a wide variety of habitats, including wet and dry forest types, fields and meadows, clear cuts and aquatic sites. Roads, dikes and ditches are utilized as movement corridors.	Widely distributed throughout the Coast Region and Metro Vancouver.
Chrysemys picta pop. 1	Western Painted Turtle (Pacific Coast Population)	Schedule 1 Endangered	Endangered	Red	Typically found in mud-bottom lakes, ponds, and lowland streams with basking sites and aquatic vegetation. Adults overwinter underwater, buried in mud sediments.	A number of populations known to occur in urban areas including the Brunette watershed in Burnaby. Occurrence documented in Como Lake, Mundy Lake, and Lost Lake.
Monadenia fidelis	Pacific Sideband	-	-	Blue	Associated with upland forests including Coastal Douglas fir with a range of understory shrubs and herbaceous species. Can also be found in landscaped areas and gardens, on trails and on road edges (within close proximity to vegetative cover).	Similar distribution to the Oregon Forestsnail, but has a more extensive overall range in the Lower Mainland.
Oncorhynchus clarkii clarkii	Coastal Cutthroat Trout	-	-	Blue	Juveniles are generally found in small streams (<5 m in width) typically used for spawning. Adults may never leave a stream, or may move to large lakes, major rivers, headwater wetlands, estuaries, or inshore marine waters for various periods of time.	Potentially found in several watercourse crossings, including Beecher Creek and Eagle Creek; tributaries to Still Creek.
Rana aurora	Northern Red-legged Frog	Schedule 1 Special Concern	Special Concern	Blue	Associated with shallow ponds, lake margins, slow-flowing streams and wetlands, especially with intact mixed or coniferous forests.	Found throughout the Lower Mainland of BC.
Sorex bendirii	Pacific Water Shrew	Schedule 1 Endangered	Endangered	Red	Found along the Pacific Coast where it is limited to lowland riparian forests and marshes in the Lower Mainland. Individuals are typically found within 25 m of streams in mature coniferous or mixed forests.	Known to occur in the Fraser Valley out to Hope, and low elevation areas in the Lower Mainland. An occurrence was documented near Lost Lake

Species		Status in Canada (SARA)	COSEWIC Status	Provincial Status	Habitat	Observation and Distribution Details
Scientific Name	Common Name					
Invertebrates						
Allegona townsendiana	Oregon Forestsnail	Schedule 1 Endangered	Endangered	Red	Commonly associated with broadleaf maple forests with stands that support bigleaf maple, western red cedar, red alder, salmonberry, stinging nettle, and sword fern. Can also be found in landscaped areas and gardens, on trails and on road edges (within close proximity to vegetative cover).	Restricted to the Fraser Lowlands, including the lower Coquitlam River east to Chilliwack.
Pachydiplax longipennis	Blue Dasher	-	-	Blue	Most often associated with still waters such as marshes or ponds with abundant emergent vegetation. Can be found in large numbers where suitable habitat occurs.	Found throughout the south coast, including Burnaby, Vancouver, and the Fraser Estuary. Occurrences have been observed in John Hendry Park
Sympetrum vicinum	Autumn Meadowhawk	-	-	Blue	Typically found in well vegetated areas, freshwater wetlands, and aquatic habitats including bogs, ponds, lakes, and slow moving streams usually associated with forest cover. Roadside drainages, sloughs, and stormwater detention ponds may also be used for breeding and foraging.	Found from Metro Vancouver to Hope. Occurrences documented near Como Lake and Mundy Lake.

"-" no current designation

2.3 Cape Horn to Coquitlam TP Pipeline Loop

This pipeline alignment runs 4,600 m from Mariner Way and Como Lake Avenue, south to Rogers Avenue generally following the BC Hydro power lines (**Figures C1** and **C2**, **Appendix A**). The existing 508 mm OD pipeline will be twinned with a new 914 mm OD pipeline. The northern half of the alignment runs along the eastern side of Mundy Park, through residential areas on the west side of the Riverview Hospital lands and has one watercourse crossing. The southern half is primarily associated with highly urbanized commercial and industrial lands in the Cape Horn and Mary Hill Bypass areas and crosses multiple watercourses.

2.3.1 Current Land Use

According to the City of Coquitlam's Open Data (2013), the Cape Horn to Coquitlam study area falls within the following land use areas:

- General Commercial;
- One Family Residential;
- Townhouses;
- Natural Areas;
- Compact One Family Residential;
- Medium Density Apartment Residential;
- Civic and Major Institutional;
- Unclassified;
- Parks and Recreation;
- Service Commercial; and
- Industrial.

2.3.2 Soils and Surficial Geology

2.3.2.1 Soils

According to Agriculture and Agri-Food Canada's Detailed Soil Survey Compilations digital data (2013), the soil within the Cape Horn to Coquitlam study area is unclassified due to its urban environment.

2.3.2.2 Surficial Geology

Three classifications of surficial geology were identified along the Cape Horn to Coquitlam study area (Geological Survey of Canada 1980). The three types are:

- **Vashon Drift and Capilano Sediments**: Glacial drift including lodgement and minor flow till, lenses and interbeds of substratified glaciofluvial sand to gravel, and lenses and interbeds of glaciolacustrine laminated stony silt, up to 25 m thick but in most places less than 8 m thick overlain by glaciomarine and marine deposits normally less than 3 m but in places up to 10 m thick. Marine derived lag gravel normally less than 1 m thick containing marine shell casts has been found mantling till and glaciomarine deposits up to 175 m above sea level; above 175 m till is mantled by boulder gravel that may be in part ablation till in part colluvium and in part marine shore in origin;

- **Fraser River Sediments**: Deltaic and distributary channel fill sediments overlying and cutting estuarine sediments and overlain in part of the area by overbank sediments. Overbank silty to silt clay loam up to 2 m thick overlying 15 m or more of channel fill; and
- **Salish Sediments:** Bog, swamp and shallow lake deposits. Lowland peat up to 14 m thick, in part overlying sandy to silt loam.

2.3.3 Contaminated Sites

A total of three APECs and related environmental risks and liabilities were identified along the Cape Horn to Coquitlam study area. The locations of these APECs are listed in **Table 9** and shown on **Figures C1** and **C2**, **Appendix A**. Detailed APEC information and overview maps are provided in **Appendix E.**

Table 9: Summary of APECs – Cape Horn to Coquitlam Study Area

APEC #	Associated Registry Number	Figure*	Site details	Classification
C1	-	C1	Mariner Fire Hall (#2 Fire Hall)	Low
C2	364	C1	City of Coquitlam Works Yard	Medium to High
C3	-	C2	Industrial and Commercial Sites	Low

*All figures are provided in **Appendix A**.

2.3.4 Natural Environment

2.3.4.1 Aquatic Resources

The Cape Horn to Coquitlam study area is located within the Lower Coquitlam River Watershed. Five watercourse crossings over three different watercourses were identified along the pipeline alignment (**Table 10**).

Table 10: Watercourses Identified Within 100 m of the Cape Horn to Coquitlam Study Area

Watercourse	Classification	Figure Reference*	Mapped Watercourse	Distance to Pipeline
Lost Creek	Class B	**Figure C1**	Yes	Crossing
Mundy Creek	Class A	**Figure C2**	Yes	Crossing
Unnamed Watercourse (3 crossings)	Unknown (considered significant by FortisBC at the time of investigation)	**Figure C2**	Yes	Crossing

*All figures are provided in **Appendix A**.

Lost Creek conveys flow from Lost Lake in Mundy Park, southeast to Riverview Roadside Ditch, Riverview Creek and ultimately the Coquitlam River (**Figure C1, Appendix A**). During field investigations the channel bank-full width averaged 0.4 m with a water depth of approximately 0.08 m (see **Photo 14** below). This small channel does not provide direct fish habitat but it does contribute to fish habitat downstream. Vegetation along the existing TP pipeline has been previously disturbed and adjacent areas contain dense stands of hardhack (*Spiraea douglasii*). Given the ill-defined channel and minimal flow observed, there is a potential for Lost Creek to be intermittent.

Construction of the pipeline at this crossing will be completed using open trench methodology which will have direct (temporary) impacts on Lost Creek during construction, if flow is observed.

Photo 14. Lost Creek crossing along the pipeline alignment. Photo facing upstream, taken March 12, 2014.

Mundy Creek flows south across the proposed pipeline alignment, west of United Boulevard to a habitat improvement area (**Figure C2, Appendix A**). During field investigations channel bank-full in the area of the crossing was approximately 2.25 m with a water depth of 0.1 m (see **Photo 15**). South of the crossing, a backwater channel was created with large woody debris and stream-side plantings as part of the Port Mann – Highway 1 Improvement Project in collaboration with the City of Coquitlam (TIC 2014). The existing channel provides salmon spawning habitat and the constructed channel provides winter habitat for young Coho salmon which prefer small streams with less flow. This constructed channel was connected to Mundy Creek in 2010 (see *Photo C5* in **Appendix C**). In addition to Coho salmon, threespine stickleback and cutthroat trout have also been observed in the Mundy Creek channel and compensation area (Geographic Data Discovery Service: BC MOE 2014). Construction of the pipeline at this crossing will be completed using trenchless technology, minimizing impacts to aquatic habitat, aquatic species and riparian vegetation. The exact method of trenchless construction has not been determined at this time, but may involve a combination of micro-tunnelling and HDD.

Photo 15. Mundy Creek west of United Boulevard, north of Lougheed Highway. Facing southwest. Photo taken March 12, 2014.

Three unnamed watercourse crossings were identified by FortisBC (Dave Konesky, Envirow Consulting Ltd. (pers. comm. May 2013). Ongoing construction along the Trans-Canada Highway and surrounding roads has changed the drainage of former watercourses, according to updated mapping (**Figure C2, Appendix A**). Any water observed in this area represents drainage ditches and would not be considered fish habitat. Due to the location of these crossings, field investigations could not be conducted. Construction of the pipeline at these potential crossings will be completed using trenchless technology, minimizing impacts to any aquatic habitat, aquatic species and/or riparian vegetation that are present. The exact method of trenchless construction has not been determined at this time, but may involve a combination of micro-tunnelling and HDD.

In addition to the mapped watercourses outlined above, an unmapped watercourse and a large open water area were observed along the pipeline alignment. The unmapped watercourse was located within Mariner Way Park (near KP 2.5), south of the pipeline alignment. This narrow channel was characterized by steep banks within a dense patch of Himalayan blackberry (see **Photo 16**). The channel conveyed flow towards Mariner Way. During field investigations the open water area was approximately 80 m long and 4 m wide (see **Photo 17**). This area may provide amphibian habitat. Construction of the pipeline along this area will be completed using open trench methodology which will require dewatering and salvaging of the area for aquatic life, if water is present during construction.

Photo 16. Unnamed watercourse adjacent to pipeline alignment in Mariner Way Park. Facing upstream. Photo taken March 12, 2014.

Photo 17. Large open water area adjacent to pipeline alignment between KP 4.0 and KP 4.1. Facing south towards KP 4.0. Photo taken March 12, 2014.

Low lying areas with standing water were observed throughout this pipeline alignment (see *Photo C9, Photo C26, Photo C29, Photo C30* and *Photo C31* in **Appendix C).** In addition, evidence of groundwater (rust colouring due to the oxidation of dissolved iron) was observed east of the pipeline on the west side of Mariner Way as shown in **Photo 18** below.

Photo 18. Iron staining, indicative of groundwater upwelling, observed east of the pipeline alignment. Facing northwest towards KP 2.3.

2.3.4.2 Terrestrial Resources

The Cape Horn to Coquitlam study area is aligned along a utility corridor in an urban residential area, which represents an actively managed right of way with previously disturbed vegetation. The Lower Coquitlam River Watershed Plan (Coquitlam River Watershed Strategy 2013) identified Mundy Park, Riverview Forest and a section of Hickey Park as Environmentally Sensitive Areas. In addition, abundant areas of invasive species were identified along the pipeline alignment.

Four parks were identified in the Cape Horn to Coquitlam study area. The parks and their locations are listed below in **Table 11**. This pipeline alignment runs along Mundy Park, Hickey Street Reservoir Park and the eastern edge of Mariner Way Park.

Table 11: Parks Identified Within the Cape Horn to Coquitlam Study Area

Park	Location
Mundy Park	West of Mariner Way. **Figure C1**.
Riverview Forest	East of Mariner Way, encompassing Lost Creek. **Figure C1**.
Hickey Street Reservoir Park	West of Mariner Way adjacent to R.C. Macdonald Elementary School. **Figure C1**.
Mariner Way Park	Southwest corner of Mariner Way and Hickey Drive. **Figure C1**.

Vegetation removal along the pipeline alignment is expected to be minimal. All disturbed areas will be hydro-seeded after construction has been completed.

2.3.5 Species-at-Risk

Multiple species considered at-risk under provincial/ federal legislation have been identified or have the potential to occur within the Cape Horn to Coquitlam study area. These species are listed and described below in **Table 12** and the general locations shown on **Figures C1** and **C2** in **Appendix A**, where information was available. Two masked occurrences were also identified along the pipeline alignment. Based on information received from BC CDC, the masked species-at-risk occurrences identified are located well outside of the study area. Due to the sensitive nature of the species-at-risk and its location, it is prohibited to include specific details in this report.

The Coquitlam Watershed Report (Quadra Planning Consultants Ltd. 2003) identified Sundew as an additional species of concern due to its rarity in the Coquitlam River Watershed. This species has been identified east of Mundy Park, west of Mariner Way, under power lines, where the pipeline alignment is proposed.

During site investigations, an individual northern red-legged frog was observed in a large area of standing water adjacent to the pipeline alignment (see **Photo 17** above) between KP 4.0 and KP 4.1.

Table 12: Species-at-risk Observed or have the Potential to Occupy Habitat within the Cape Horn to Coquitlam Pipeline Alignment

Species		Status in Canada (SARA)	COSEWIC Status	Provincial Status	Habitat	Observation and Distribution Details
Scientific Name	Common Name					
Vertebrates						
Anaxyrus boreas	Western Toad	-	Special Concern	Blue	Adults utilize a wide variety of habitats, including wet and dry forest types, fields and meadows, clear-cuts and aquatic sites. Roads, dikes and ditches are utilized as movement corridors.	Widely distributed throughout the Coast Region and Metro Vancouver.
Chrysemys picta pop. 1	Western Painted Turtle (Pacific Coast Population)	Schedule 1 Endangered	Endangered	Red	Typically found in mud-bottom lakes, ponds, and lowland streams with basking sites and aquatic vegetation. Adults overwinter underwater, buried in mud sediments.	Observed in Lost Lake and Mundy Lake in Mundy Park, Coquitlam between 2007 and 2009.
Oncorhynchus clarkii clarkii	Coastal Cutthroat Trout	-	-	Blue	Juveniles are generally found in small streams (<5 m in width) typically used for spawning. Adults may never leave a stream, or may move to large lakes, major rivers, headwater wetlands, estuaries, or inshore marine waters for various periods of time.	Potentially found in several watercourse crossings, including Mundy Creek.
Rana aurora	Northern Red-legged Frog	Schedule 1 Special Concern	Special Concern	Blue	Associated with shallow ponds, lake margins, slow-flowing streams and wetlands, especially with intact mixed or coniferous forests.	Found throughout the Lower Mainland of BC.
Sorex bendirii	Pacific Water Shrew	Schedule 1 Endangered	Endangered	Red	Found along the Pacific Coast where it is limited to lowland riparian forests and marshes in the Lower Mainland. Individuals are typically found within 25 m of streams in mature coniferous or mixed forests.	Known to occur in the Fraser Valley out to Hope, and low elevation areas in the Lower Mainland. Observed on the east end of Mundy Park in 2000.
Invertebrates						
Allegona townsendiana	Oregon Forestsnail	Schedule 1 Endangered	Endangered	Red	Commonly associated with broadleaf maple forests with stands that support bigleaf maple, western red cedar, red alder, salmonberry, stinging nettle, and sword fern. Can also be found in landscaped areas	Restricted to the Fraser Lowlands, including the lower Coquitlam River east to Chilliwack. Occurrences have been documented along

Species		Status in Canada (SARA)	COSEWIC Status	Provincial Status	Habitat	Observation and Distribution Details
Scientific Name	Common Name					
					and gardens, on trails and on road edges (within close proximity to vegetative cover).	Mundy Creek in Colony Farm Regional Park.
Monadenia fidelis	Pacific Sideband	-	-	Blue	This snail is commonly associated with upland forests including Coastal Douglas fir with a range of understory shrubs and herbaceous species. Can also be found in landscaped areas and gardens, on trails and on road edges (within close proximity to vegetative cover).	Similar distribution to the Oregon Forestsnail, but has a more extensive overall range in the Lower Mainland.
Epitheca canis	Beaverpond Baskettail	-	-	Blue	This dragonfly Prefers marshy lakeshores, bogs, beaver ponds, and sluggish streams.	14 found along the east side of the Coquitlam River adjacent to Colony Farm Regional Park and the First Nation Land in 1996.
Pachydiplax longipennis	Blue Dasher	-	-	Blue	This dragonfly is most often associated with still waters such as marshes or ponds with abundant emergent vegetation. Can be found in large numbers where suitable habitat occurs.	Found throughout the south coast, including Burnaby, Vancouver, and the Fraser Estuary.
Sympetrum vicinum	Autumn Meadowhawk	-	-	Blue	This dragonfly is typically found in well vegetated areas, freshwater wetlands, and aquatic habitats including bogs, ponds, lakes, and slow moving streams usually associated with forest cover. Roadside drainages, sloughs, and stormwater detention ponds may also be used for breeding and foraging.	Found from Metro Vancouver to Hope.
Vascular Plants						
Elodea nuttallii	Nuttall's Waterweed	-	-	Blue	Perennial aquatic herb found in still or slow moving water in lakes, ponds, and streams.	Observed in Colony Farm Regional Park.
Cardamine parviflora	Small-flowered Bittercress	-	-	Blue	Various habitat types including riparian areas, mixed forest, and wetlands	Observed along a sandy hillside on Mary Hill in Port Coquitlam in

Species		Status in Canada (SARA)	COSEWIC Status	Provincial Status	Habitat	Observation and Distribution Details
Scientific Name	Common Name					
						1991.
Myriophyllum ussuriense	Ussurian Water-milfoil	-	-	Blue	Aquatic perennial found submerged or partially submerged in shallow waters along muddy lake margins, estuaries, and riverbanks at low elevations.	Observed in damp soil within the margins of the Coquitlam River floodplain near the Port Mann Bridge in 1987 (in Colony Farm Regional Park).
Wolffia borealis	Northern Water-meal	-	-	Red	Tiny (<1.5 mm), free-floating, annual, aquatic species among the smallest flowering plants on earth. Plants grow in ponds, lakes and slow-moving streams at low elevations.	Observed in Colony Farm Regional Park.

"-" no current designation

2.4 Nichol to Port Mann TP Pipeline Loop

This pipeline alignment is located entirely in the City of Surrey. It commences on the south side of the Fraser River immediately opposite the southern terminus of the Cape Horn to Coquitlam alignment at the South Fraser Perimeter Road and runs 5,400 m south to the 93a Avenue and 138a Street intersection (**Figures D1** to **D2**, **Appendix A**). The existing 610 mm OD pipeline will be twinned with a new 914 mm OD pipeline. This alignment is aligned within mainly residential and commercial areas and intersects with several creek crossings.

2.4.1 Current Land Use

According to the City of Surrey's Open Data (2013), the Nichol to Port Mann study area falls within the following land use areas:

- Residential (*i.e.,* Single Family, Duplex, Multiple, One Acre and Family);
- Commercial (*i.e.,* Community, Town Centre and Downtown);
- Comprehensive Development Zone;
- Assembly Hall 2 Zone;
- Light Impact Industrial Zone; and
- Natural Areas.

2.4.2 Soils and Surficial Geology

2.4.2.1 Soils

According to Agriculture and Agri-Food Canada's Detailed Soil Survey Compilations digital data (2013), the soil within the Nichol to Port Mann study area is unclassified due to its urban environment.

2.4.2.2 Surficial Geology

Four classifications of surficial geology were identified along the Nichol to Port Mann study area (Geological Survey of Canada 1980). The four types are:

- **Vashon Drift and Capilano Sediments**: Glacial drift including lodgement and minor flow till, lenses and interbeds of sub-stratified glaciofluvial sand to gravel, and lenses and interbeds of glaciolacustrine laminated stony silt, up to 25 m thick but in most places less than 8 m thick overlain by glaciomarine and marine deposits normally less than 3 m but in places up to 10 m thick. Marine derived lag gravel normally less than 1 m thick containing marine shell casts has been found mantling till and glaciomarine deposits up to 175 m above sea level; above 175 m till is mantled by boulder gravel that may be in part ablation till in part colluvium and in part marine shore in origin;
- **Capilano Sediments**: Raised beach medium to coarse sand 1 to 5 m thick containing fossil marine shell casts. Marine and glaciomarine stony (including till-like deposits) to stoneless silt loam to clay loam with minor sand and silt normally less than 3 m thick but up to 30 m thick, containing marine shells;
- **Vashon Drift**: Lodgement till (with sandy loam matrix) and minor flow till containing lenses and interbeds of glaciolacustrine laminated stony silt; and

- **Pre-Vashon Deposits**: Quadra fluvial channel fill and floodplain deposits, cross-bedded and containing minor silt and gravel lenses and interbeds. Quadra marine inter-bedded fine sand to clayey silt.

2.4.3 Contaminated Sites

No potential contaminated sites were identified within 40 m of the Nichol to Port Mann study area.

2.4.4 Natural Environment

2.4.4.1 Aquatic Resources

Three named watercourses were identified within the Nichol to Port Mann study area in addition to numerous road side ditches. These watercourses are described below in **Table 13** and shown on **Figures D1** and **D2**, in **Appendix A**.

Table 13: Watercourses Identified Within 100 m of the Nichol to Port Mann Study Area

Watercourse	Classification	Figure Reference	Mapped Watercourse	Distance to Pipeline
Unnamed (7 crossings)	Class C	**Figures D1 – D2**	Yes	Crossing
Hawthorne Creek	Class A	**Figure D1**	Yes	8.0 m
Hawthorne Creek	Class B	**Figure D1**	Yes	Crossing
Quibble Creek (2 crossings)	Class A	**Figure D2**	Yes	Crossing
Unnamed Ditches (Multiple)	Class C	**Figures D1 – D2**	Yes	Various distances

Multiple unnamed ditch crossings (Class C) were identified within the Nichol to Port Mann study area (**Figure D1, Appendix A**). During site investigations, no water was observed at the seven crossing locations (see Photo Log - **Appendix C**). Water presence in these areas would be considered ephemeral and would not contribute to fish habitat or provide habitat for any aquatic life.

Hawthorne Creek is a tributary of Bon Accord Creek. At the location of the pipeline alignment, Hawthorne Creek is classified as a Class B watercourse (**Figure D1, Appendix A**). Along the east boundary of the utility SRW in Hawthorne Park, approximately 8 m from the pipeline alignment, Hawthorne Creek is classified as a Class A watercourse. During site investigations, channel bank-full width at the crossing averaged 0.5 m with a water depth of 0.1 m (see **Photo 19**). Riparian vegetation within the utility SRW was minimal given the disturbed nature of the maintained corridor. Species were limited to grasses and Himalayan blackberry. A large deciduous forest is located east of the crossing in Hawthorne Park. Construction of the pipeline at this crossing will be completed using open trench methodology which will have direct (temporary) impacts on Hawthorne Creek, if flow is observed. These impacts are expected to be minimal.

Photo 19. Hawthorne Creek crossing along the pipeline alignment with existing culvert, south of 106 Avenue. Facing east towards Hawthorne Park. Photo taken March 12, 2014.

Quibble Creek is a large Class A watercourse that drains into Bear Creek. The pipeline alignment crosses Quibble Creek twice within the Nichol to Port Mann study area; south of the Fraser Highway (upper reach) and south of 94a Avenue (lower reach; **Figure D2, Appendix A**). Coho salmon, cutthroat trout and threespine stickleback have been identified in Quibble Creek near the Nichol the Port Mann study area (Geographic Data Discovery Service: BC MOE 2014). During site investigations the channel bank-full width at the upper reach of Quibble Creek was 3.5 m with an average water depth of 0.3 m (see **Photo 20**). Channel morphology was considered to be riffle-run. Riparian vegetation within the utility SRW was minimal given the disturbed nature of the maintained corridor. Species were limited to grasses and Himalayan blackberry. High beaver activity was observed at the lower reach of Quibble Creek which has created pools and braided channels through vegetation (**see Photo 21**). The channel bank-full width downstream of the beaver activity was approximately 4.0 m with a water depth of 0.2 m. Channel morphology in this area was considered riffle-run.

Construction of the pipeline at the two Quibble Creek crossings will be completed using trenchless technology, minimizing impacts to aquatic habitat, aquatic species and riparian vegetation. The exact method of trenchless construction has not been determined at this time, but may involve a combination of micro-tunnelling and HDD.

Photo 20. Quibble Creek crossing south of Fraser Highway, facing south towards KP 0.8. Photo taken March 5, 2014.

Photo 21. Quibble Creek crossing south of 94a Avenue and 188 Street near KP 0.1 with extensive beaver activity. Facing upstream (east). Photo taken March 5, 2014.

In addition to the mapped watercourses discussed above, multiple low lying areas with standing water were observed along the Nichol to Port Mann study area during site investigations (see *Photo D14, Photo D15* and *Photo D16* in **Appendix C**). All of these areas were considered ephemeral and do not contribute to fish habitat or provide sufficient habitat for aquatic life.

2.4.4.2 Terrestrial Resources

In general, the pipeline alignment is located along a utility corridor in an urban residential area, which represents an actively managed right of way with previously disturbed vegetation. Multiple municipal parks and a greenbelt along Quibble Creek were identified within the Nichol to Port Mann study area. These areas are listed below in **Table 14**. The locations of these natural areas are shown on **Figure D1** and **D2** in **Appendix A**.

Table 14: Parks Identified Within the Nichol to Port Mann Study Area

Park/Greenbelt	Location
Victoria Park	South of 116th Ave in North Surrey. **Figure D1**.
Invergarry Park	Connected to and immediately south of Victoria park, encompassing Bon Accord Creek. **Figure D1**.
Hawthorne Park	South of 108th Ave and east of 141 Street. **Figure D1**.
Utility SRW	West of 140th Street. **Figure D2**.
Quibble Creek Greenbelt	South of Laurel Drive and east of 138th Street. **Figure D2**.

The City of Surrey Ecosystem Management Study (HB Lanarc 2011) identified ecological hubs, sites and corridors within the City. Hubs represent the largest intact sites of naturally-functioning ecosystems and corridors which provide physical or functional linkages between hubs. Sites are considered smaller areas of less complex ecological activity. Evaluation of these features were completed by assessing area, shape, naturalness, presence of high quality habitats, presence of sensitive species, surrounding land uses and other factors.

A large terrestrial hub (Bon Accord) was identified at the north end of the Nichol to Port Mann alignment between 115 Avenue and Highway 17. In addition, this terrestrial hub is adjacent to study area between 114 Avenue and Currie Drive and south of 106 Avenue. The utility SRW in which the pipeline is aligned is considered a potential ecological corridor. In addition, the riparian woodland around Quibble Creek is considered an ecological site.

Vegetation disturbance within these areas is expected to be minimal given the disturbed nature of the existing vegetation community in the utility SRW. Tree and shrub removal will be avoided and minimized where possible. All disturbed areas will be restored after pipeline construction is completed.

2.4.5 Species at Risk

A total of six species-at-risk were identified as having the potential to occur in the Nichol to Port Mann study area. These species are listed and described below in **Table 15** and shown on **Figures D1** and **D2** in **Appendix A,** where information was available.

Table 15: Species at Risk Observed or Have the Potential to Occupy Habitat within the Nichol to Port Mann Study Area

Species		Status in Canada (SARA)	COSEWIC Status	Provincial Status	Habitat	Observation and Distribution Details
Scientific Name	Common Name					
Allegona townsendiana	Oregon Forestsnail	Schedule 1 Endangered	Endangered	Red	Commonly associated with broadleaf maple forests with stands that support bigleaf maple, western red cedar, red alder, salmonberry, stinging nettle, and sword fern. Can also be found in landscaped areas and gardens, on trails and on road edges (within close proximity to vegetative cover).	Restricted to the Fraser Lowlands, including the lower Coquitlam River east to Chilliwack.
Anaxyrus boreas	Western Toad	-	Special Concern	Blue	Adults utilize a wide variety of habitats, including wet and dry forest types, fields and meadows, clear cuts and aquatic sites. Roads, dikes and ditches are utilized as movement corridors.	Widely distributed throughout the Coast region and Metro Vancouver.
Monadenia fidelis	Pacific Sideband	-	-	Blue	Associated with upland forests including Coastal Douglas fir with a range of understory shrubs and herbaceous species. Can also be found in landscaped areas and gardens, on trails and on road edges (within close proximity to vegetative cover).	Similar distribution to the Oregon Forestsnail, but has a more extensive overall range in the Lower Mainland.
Oncorhynchus clarkii clarkii	Coastal Cutthroat Trout	-	-	Blue	Juveniles are generally found in small streams (<5 m in width) typically used for spawning. Adults may never leave a stream, or may move to large lakes, major rivers, headwater wetlands, estuaries, or inshore marine waters for various periods of time.	Potentially found in watercourse crossings including Quibble Creek.
Rana aurora	Northern Red-legged Frog	Schedule 1 Special Concern	Special Concern	Blue	Associated with shallow ponds, lake margins, slow-flowing streams and wetlands, especially with intact mixed or coniferous forests.	Found throughout the Lower Mainland of BC. Occurrences documented in Green Timbers Park area.
Sorex bendirii	Pacific Water Shrew	Schedule 1 Endangered	Endangered	Red	Found along the Pacific Coast where it is limited to lowland riparian forests and marshes in the Lower Mainland. Individuals are typically found within 25 m of streams in mature coniferous or mixed forests.	Known to occur in the Fraser Valley out to Hope, and low elevation areas in the Lower Mainland.

"-" no current designation

3.0 REGULATORY OVERVIEW

To assist FortisBC in the early planning phases of the Projects, this section provides an overview of relevant environmental legislation and the regulatory requirements anticipated for the Projects, including the identification of environment permits, approvals, and licenses that may be required in order to comply with applicable federal, provincial, and municipal legislation.

3.1 Fisheries Act

The *Fisheries Act* is the primary federal legislation providing protection for all fish that are part of a commercial, recreational or Aboriginal fishery, or to fish that support such a fishery, and is administered by Fisheries and Oceans Canada (DFO) and Environment Canada.

Fish habitat is defined as *"spawning grounds and nursery, rearing, food supply, and migration areas on which fish depend directly or indirectly in order to carry out their life processes."* This definition indicates that all watercourses (including ditches) which provide a significant source of water, food or nutrients to a fish-bearing stream are considered fish habitat even if they do not contain fish and/or if they only have temporary or seasonal flows. The definition also indicates that not only the watercourse itself, but also the vegetated streamside (*i.e.,* riparian) areas which provide nutrients and shade to the stream, are considered fish habitat.

The *Fisheries Act* prohibits serious harm to fish or fish habitat unless authorized by DFO. Based on our understanding of the Projects and the Project areas and proposed construction methodology, there is a potential for serious harm to fish or fish habitat at some of the watercourse crossings. Where required, a Request for Project Review will be sent to DFO to determine whether a *Fisheries Act* Authorization is required.

For those alignments with minimal disruption of fish habitat based on construction methodology and proposed best management practices, no action under the *Fisheries Act* is required.

3.2 Species at Risk Act

The *Species at Risk Act* (SARA) is a federal Act that provides legislative protection to species that are assessed as Extirpated, Extinct or Threatened and are listed on Schedule 1 of the Act and their critical habitat. Schedule 1 is the official list of species-at-risk in Canada as determined by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC).

The definitions for the four status categories for species that are considered to be at risk are as follows:

- "Extirpated" species no longer exist in their former range in Canada;
- "Endangered" species are at risk of imminent extirpation or extinction;
- "Threatened" species are likely to become "Endangered" if nothing is done to reverse the factors leading to extirpation or extinction; and
- "Species of Special Concern" are at risk to become "Threatened" or "Endangered" due to a combination of biological characteristics and identified threats.

The purpose of SARA is to:

"*prevent wildlife species from being extirpated or becoming extinct, to provide for the recovery of wildlife species that are extirpated, endangered or threatened as a result of human activity and to manage species of special concern to prevent them from becoming endangered or threatened*" (SARA Section 6 2002).

The protection of wildlife and their habitat is provided in SARA in Sections 32 and 33:

"*No person shall kill, harm, harass, capture or take an individual of a wildlife species that is listed as an extirpated species, an endangered species or a threatened species*" (SARA S. 32(1) 2002).

"*No person shall damage or destroy the residence of one or more individuals of a wildlife species that is listed as an endangered species or a threatened species, or that is listed as an extirpated species if a recovery strategy has recommended the reintroduction of the species into the wild in Canada*" (SARA S. 33 2002).

SARA Permits

SARA contains prohibitions against the killing, harming, harassing, capturing, taking, possessing, collecting, buying, selling or trading of individuals of Endangered, Threatened and Extirpated species listed in Schedule 1 of the Act. The Act also contains a prohibition against the damage or destruction of their residences (*e.g.,* nest or den). According to SARA Section 73, a scientific research permit is required by anyone conducting activities that may affect species listed in Schedule 1 of SARA or contravening the Act's general or critical habitat prohibitions (Sections 32-36).

Permits may be issued for the following purposes:

- The activity is scientific research relating to the conservation of the species and conducted by qualified persons;
- The activity benefits the species or is required to enhance its chance of survival in the wild; or
- Affecting the species is incidental to the carrying out of the activity.

In addition, all of the following pre-conditions must be met:

- All reasonable alternatives to the activity that would reduce the impact on the species have been considered and the best solution has been adopted;
- All feasible measures will be taken to minimize the impact of the activity on the species or its critical habitat or the residences of its individuals; and
- The activity will not jeopardize the survival or recovery of the species.

Section 78 enables the Province of BC to issue permits affecting provincially-managed species at risk, having the same effect as, and meeting the requirements of a Section 73 permit. As such, if the trapping and relocation of a provincially-listed species-at-risk is required for the project, a permit must also be obtained through the Permit and Authorization Service Bureau facilitated through the MFLNRO. A general Wildlife Act permit as well as an Animal Care form is required for

any scientific/research purposes that require trapping or handling live wildlife, including species-at-risk.

Pacific water shrew is a SARA-listed species that may occupy stream habitats within the study areas discussed above, particularly the Cape Horn to Coquitlam section. Therefore, site isolation and trapping/relocation may be required prior to commencing with site disturbance. In addition, Northern red-legged frogs are likely to be present within the wetted habitats on site and will require relocation prior to construction.

Any species-at-risk management activities will require a scientific research permit from the Permit and Authorization Service Bureau as discussed above. A general *Wildlife Act* permit as well as an Animal Care form will also be required as the activities would require trapping and handling of live wildlife, including species-at-risk.

3.3 Migratory Birds Convention Act

The federal *Migratory Birds Convention Act* prohibits the taking or killing of migratory bird nests and eggs, and the deposition of harmful substances in areas frequented by migratory birds. Vegetation removal that will affect trees used by all birds and other wildlife should be avoided while they are breeding, nesting, roosting or rearing young.

3.4 BC Environmental Management Act

The British Columbia *Environmental Management Act* (EMA) was enacted in July 2004, combining the old *Waste Management Act* and a previous version of the EMA. The EMA (2004) brings provisions from both those Acts into one statute by providing an authorization framework and environmental management tools to protect human health and the quality of water, land and air in British Columbia.

It will be the responsibility of FortisBC's to ensure liquid and solid waste management complies with regulations under the EMA. These regulations include:

- Waste Discharge Regulations;
- Spill Reporting Regulations;
- Hazardous Waste Regulations; and
- Oil and Gas Waste Regulation.

Furthermore, if soil, groundwater, sediment or soil vapour at a site contains a hazardous waste or substance exceeding provincial environmental quality standards, that site will also be subjected to the Contaminated Sites Regulation (CSR).

In the absence of detailed information, Dillon recommends that FortisBC allows for potential reactive management of contaminated soils and groundwater (if encountered) during excavation. If contaminated soils and/or groundwater require removal from the site, they should be transported to an approved disposal facility and must comply with all applicable rules and regulations.

3.4.1 Contaminated Site Regulation

Section 11(1) (a) (b) (c) and (c.1) of the CSR defines a contaminated site as a site where:

"(a) the land use is agricultural, commercial, industrial, urban park or residential and the concentration of any substance in the soil at the site is greater than or equal to (i) the applicable generic numerical soil standard, or (ii) the lowest value of the applicable matrix numerical soil standards;

(b) the surface or groundwater located on or flowing from the site is used or has a reasonable probability of being used for aquatic life, irrigation, livestock or drinking water and the concentration of any substance in the surface water or groundwater is greater than the applicable generic numerical water standard;

(c) the concentration of any substance in sediment at the site is greater than the applicable generic numerical sediment criterion; and

(c.1) the concentration of any substance in vapour at the site is greater that the applicable generic numerical vapour criterion."

This framework provides the basis for the environmental standards for the potential contaminants of concern in the relevant media.

Schedules 4, 5 and 10 of the CSR provide numerical standards for assessing soil contamination at sites in BC. Schedule 9 of the CSR provides sediment criteria. Applicable standards and criteria are based on the current and future land use of the Site.

The application of groundwater standards is based on the use of groundwater and surface water on-site or on neighboring properties. Guidance for which standards to apply is provided in the current Technical Guidance 6 (TG6) released in July 2010, "Water Use Determination" (BC MoE 2010).

Schedule 11 of the CSR provides numerical standards for vapour in the breathing zone at sites in BC based on land use. Applicable standards are based on the current and future land use of the Site.

3.5 BC Water Act

The *Water Act* is the main provincial statute regulating water resources in BC. One of the provisions of the *Water Act* provides conditions related to "changes in and about a stream", which means:

- Any modification to the nature of the stream including the land, vegetation, natural environment or flow of water within the stream; or
- Any activity or construction within the stream channel that has or may have an impact on a stream.

It is an offence to divert or use water, or alter a stream, without formal approval from the MFLNRO, or in the case of FortisBC, the provincial Oil and Gas Commission (OGC). Section 9 of the *Water Act* ensures that water quality, riparian habitat, and the rights of licensed water users are not compromised.

An Approval under Section 9 of the *Water Act* should be acquired from the OGC prior to the initiation of the project. Section 9 Approvals typically require a two to three month review period by the OGC following submission.

3.6 BC Wildlife Act

Section 34 of the BC *Wildlife Act* prohibits the destruction of an egg or an active nest of any bird species and prohibits the destruction of a nest of a Bald Eagle, Osprey, Peregrine Falcon, Gyrfalcon, Great-blue Heron or Burrowing Owl, regardless of whether it is occupied.

Any scheduled land clearing activities between April 1 and July 31 will require a bird nest survey by a Qualified Environmental Professional (QEP). Should an active bird nest be discovered, an appropriate buffer will be retained around the nest until the nest is no longer active (subject to re-assessment by the QEP).

3.7 City of Vancouver Street Tree By-Law

The City of Vancouver has a Street Tree By-Law (No. 5985) which states that "*No person shall remove, destroy, cut, deface, trim or in any way injure, impair or interfere with any street tree except as expressly authorized to do so by the Board of Parks and Recreation or, in the case of cutting or trimming, if carried out by a qualified private tree company which holds a valid permit therefore from the Board of Parks and Recreation".* Consultation with the City of Vancouver Board of Parks and Recreation will be required prior to removal of any trees within, or adjacent to, the pipeline alignment.

3.8 City of Burnaby Tree Bylaw

According to the City of Burnaby Tree Bylaw (No. 10482), a tree cutting permit is not required *"to cut down or damage a protected tree where necessary for the construction, installation, maintenance, repair, replacement or removal of (iii) the sewer, water and gas mains and ancillary works of the City, any other government authority or public utility".* Based on this definition, FortisBC is not expected to require a permit for tree removal activities.

3.9 Burnaby Soil Removal Regulation ByLaw, 1961

According to the City of Burnaby Bylaw No. 4251, No person is to remove soil from any lands within the municipality without having a permit. As part of the application, contour plans, proposed surface and topography after construction, type of fill and method of application are to be included.

3.10 Burnaby Watercourse Bylaw 1988

According to the City of Burnaby Bylaw No.9044, "*No person shall discharge or allow leakage of contaminants into a stream, creek, waterway, watercourse, waterworks, ditch, drain, sewer, storm sewer or the soil; or foul obstruct or impede the flow of any stream, creek, waterway, watercourse, waterworks, ditch, drain, sewer or storm sewer, whether or not the same is situated on private property."*

3.11 City of Coquitlam Tree Bylaw

According to the City of Coquitlam Bylaw No. 4091, 2010, Tree Cutting Permits are not required for the cutting or removal of protected trees undertaken by a utility for the purpose of safety, maintenance or operation of the utility's infrastructure.

3.12 City of Coquitlam Soil Removal Regulation Bylaw No.1914, 1998.

Under this Bylaw, the City of Coquitlam regulates or prohibits the removal of soil, sand, gravel, rock and other substances, and to require the holding of a permit for soil removal with a fixed fee.

3.13 City of Surrey Tree Protection Bylaw

According to the Surrey Tree Protection Bylaw No. 16100 (2006), Tree Cutting Permits and the Tree Protection Bylaw do not apply to trees "*that are cut, removed, or damaged pursuant to the Hydro and Power Authority Act, R.S.B.C. 1996, c. 212 or the Pipeline Act, R.S.B.C. 1996, c. 364" or "trees on City-owned property or highways that are cut or removed by the City or its authorized agents in accordance with approved City operations*" (Part 2(4 and 5)). As such, a tree cutting permit is not required by FortisBC in the City of Surrey.

3.14 Surrey Stormwater Drainage Regulation and Charges By-law, 2008, No. 16610

The City of Surrey Stormwater Drainage Regulation and Charges By-law regulates "*extensions, connections, and use of the stormwater drainage system, to impose connection charges to the stormwater drainage system, and to prohibit the fouling, obstructing, or impeding the flow of any stream, creek waterway, watercourse, ditch, or stormwater drainage system".*

3.15 Surrey Soil Removal and Depositing Regulation By-law, 1979, No. 5880

According to this By-law, soil removal or deposition in the City of Surrey may be permitted and shall only occur after a permit has been issued by the General Manager. In addition, all soil removal or deposit activities or operations, shall conform to the standards and requirements prescribed in Schedule A of this By-law.

3.16 City of Surrey Erosion and Sediment Control By-law, 2006, No. 16138

The purpose of this City of Surrey By-law is to ensure that adequate protection of the municipal drainage system is implemented during construction using effective erosion and sediment control measures. All applications for proposed construction on land of 2,000 m^2 or larger require a complete Erosion and Sediment Control (ESC) Permit application to the City. No construction is permitted until the City has issued an ESC Permit. The ESC Plan must be designed, signed and sealed by a Professional Engineer as well as reviewed and signed by the appointed ESC Supervisor for the construction.

An ESC Permit application may be waived by the General Manager of Engineering considering details such as construction timing and schedule; the size of the proposed building or structure; soil conditions; existing ground cover; topographical conditions; and location of the proposed construction with respect to the perimeter of the land. If an ESC Permit is waived, best management practices will be utilized as outlined in Schedule "B" of the By-law.

4.0 ENVIRONMENTAL RISKS, EFFECTS AND PROPOSED MITIGATION MEASURES

This section describes the potential effects of the project on the environment based on the proposed scope of work and the environmental features present within the Project study area. The assessment also identifies mitigation measures and Best Management Practices (BMPs) proposed to minimize potential environmental effects.

4.1 Project Interaction with the Environment

Environmental effects may occur during both the site preparation and construction phases of the Project. A key component of the environmental overview assessment process is identification of

components of the natural environment that could be potentially affected by, or have an influence on, the Projects. **Table 16** presents an interaction matrix for the Project, highlighting the environmental components that may interact with Project construction and operations. Physical activities will occur during Project construction, including: establishment of site access/egress and laydown areas; site clearing and grading; pipeline construction; and operations/maintenance of the SRW.

The environmental components that may be affected by Project construction activities include:

- aquatic resources (*i.e.,* fish and fish habitat and surface water quality); and
- terrestrial resources (*i.e.,* vegetation and wildlife resources and species-at-risk (if present)).

Operational activities are not expected to result in impacts to aquatic resources.

Table 16: Project Environmental Interaction Matrix.

Project Activities	Aquatic Resources			Terrestrial Resources		Species-at-risk	Soil and Topography
	Fish and Fish Habitat	Surface Water Quality	Groundwater	Vegetation	Wildlife		
Site Access/Egress	X	X		X	X	X	X
Materials/ Equipment Storage							
Site Preparation	X	X	X	X	X	X	X
Hydrostatic Testing		X	X				
Pipeline Construction	X	X	X	X	X		X
Water Management	X	X	X				
Landscape Restoration				X			
Operations/Maintenance				X			

4.2 Project Risk Assessment

This section provides a high level overview of the various environmental risks associated with the Project based on assessment of the project scope, existing environment and the regulatory requirements. Mitigation measures are also provided to address each of the assessed risks.

4.2.1 Contaminated Sites

Due to the extensive urban environment covered by the pipeline alignments discussed in this report, various potential sources of contamination were recorded, specifically along the Fraser Gate IP, Metro IP and Cape Horn to Coquitlam pipeline alignments. No APECs were identified along the Nichol to Port Mann pipeline.

The APECs identified along the three referenced pipeline alignments are outlined in **Table 17** below. These areas represent potential sources of contamination to the proposed pipeline replacement activities and have the capacity to contaminate soils and groundwater at the Project areas.

The recommendations provided in **Table 17** are based on the historical land use, site activities, historical file review of the suspected and known contaminated sites along the alignment and the distance to the pipeline alignment (of the suspected and known contaminated sites). Further, and more specific, guidance for potential contaminant management is provided below:

1. For all low risk areas (APECs with LW classification), Dillon recommends that any contamination be managed during construction; and
2. For medium – high risk areas (APECs with MH classification), Dillon recommends conducting a subsurface soil and groundwater investigation to better define the associated risks.

A detailed summary of the subsurface investigation including estimated length of potential contamination, number of boreholes (groundwater monitoring wells) to be installed, number of samples to be collected for analysis, and Potential Contaminants of Concern (PCOCs) associated with each APEC is provided below in **Table 18**. Detailed APEC information is provided in **Appendix E.**

Table 17: Risk Analysis of Contaminated Sites along the Metro Vancouver Reinforcement Projects.

APEC #	Associated Registry Number	Site Location	Figure	Registry Point Address	Site details	Classification	PCOCs	Recommendation	Length (m)
Fraser Gate to Marine & Elliott									
A1	1481	End of alignment south of Chandley Place	A1	2770 EAST KENT AVE SOUTH VANCOUVER	Current FortisBC Fraser IP Station	Low	Unknown. Assumed that the risks are known to FortisBC	Recommend managing risks during construction	10
A2	291	South of the alignment between Blanche Street and Chandley Place	A1 & A2	2582 EAST KENT AVE SOUTH VANCOUVER	Currently Residential / Historical commercial and industrial property	MH	Hydrocarbon, metals and wood waste (PCOCs: LEPH/HEPH, PAH, VOC, PCB and metals)	Recommend subsurface soil and groundwater investigation	500
	1289	North of the alignment between Blanche Street and Chandley Place	A1 & A2	2705 EAST KENT AVE SOUTH VANCOUVER	Currently a Park/ Historical commercial and industrial property				
Metro IP									
B1	7671	At the intersection of Second Avenue and Woodland Drive	B1	1436 EAST SECOND AVENUE, VANCOUVER	Fortis BC Woodland Muster Point Station	MH	Hydrocarbon and metals (PCOCs: LEPH/HEPH, PAH, VOCs including BTEX, Metals)	Recommend subsurface soil and groundwater investigation	31
B2	12967	North of alignment and west of Commercial Drive	B2	1725 EAST FIRST AVENUE, VANCOUVER	Residential Property	Low	Unknown	Low risk, manage during construction	20
B3	1237	South of alignment and east of Nanaimo Street	B3	1720 NANAIMO STREET,VANCOUVER	Chevron Service Station	MH	Hydrocarbon and metals (PCOCs: LEPH/HEPH, PAH, VOCs including BTEX, Metals)	Recommend subsurface soil and groundwater investigation	140
	1332	South of alignment and west of Nanaimo Street	B3	2398 EAST FIRST AVENUE, VANCOUVER	Petro Canada Service Station				
	16076	South of alignment and west of Commercial Drive	B3	2320 EAST FIRST AVENUE, VANCOUVER	Residential Property				
B4	8757	North of alignment and west of Penticton Street	B4	2585 EAST FIRST AVENUE, VANCOUVER	Residential Property	Low	Hydrocarbons and metals (PCOCs: LEPH/HEPH, PAH, VOCs including BTEX, Metals)	Low risk, manage during construction	20
B5	148	North of alignment and east of Renfrew Street	B5	1616 RENFREW STREET, VANCOUVER	Capanga Auto Service	MH	Hydrocarbons and metals (PCOCs: LEPH/HEPH, PAH, VOCs including BTEX, Metals)	Recommend subsurface soil and groundwater investigation	100
	15828	North of alignment and west of Renfrew Street	B5	1615 RENFREW STREET, VANCOUVER	Brush Dental Clinic				
B6	322	North of alignment and west of Rupert Street	B6	1675 RUPERT STREET, VANCOUVER	Petro Canada Service Station	MH	Hydrocarbons and metals (PCOCs: LEPH/HEPH, PAH, VOCs including BTEX, Metals)	Recommend subsurface soil and groundwater investigation	140
	1231	North of alignment and west of Rupert Street	B6	1720 RUPERT STREET, VANCOUVER	Petro Chevron Service Station				
B7	6577	Northwest of alignment (north of Graveley Street)	B7	1570 KOOTENAY STREET, VANCOUVER	Vancouver Police Department	Low	Hydrocarbons and metals (PCOCs: LEPH/HEPH, PAH, VOCs including BTEX, Metals)	Low risk, manage during construction	300
	11851	North and west of alignment (south of Graveley Street)	B7	3595 EAST FIRST AVENUE, VANCOUVER	Gated Parking Lot				
B8	15092	South of alignment and west of Beta Avenue	B8	4672 HIGHLAWN DRIVE, BURNABY	Residential Property	Low	Unknown	Low risk, manage during construction	20
B9	10866	North of alignment and east of Beta Avenue	B9	4821 HIGHLAWN DRIVE, BURNABY	Residential Property	Low	Hydrocarbon and metals(PCOCs: LEPH/HEPH, PAH, VOCs including BTEX, Metals)	Low risk, manage during construction	200
	10958	North of alignment and east of Beta Avenue	B9	4761 HIGHLAWN DRIVE, BURNABY	Residential Property				
	13044	North of alignment and east of Beta Avenue	B9	4720 HIGHLAWN DRIVE, BURNABY	Residential Property				
B10	6658	South of alignment and east of Underhill Avenue	B10	2820 UNDERHILL AVENUE, BURNABY	Sears Distribution Centre	MH	Hydrocarbon and metals (PCOCs: LEPH/HEPH, PAH, VOCs including BTEX, Metals)	Recommend subsurface soil and groundwater investigation	400
	9963	North of alignment and west of Underhill Avenue	B10	2751 UNDERHILL AVENUE, BURNABY	Shell Terminal Property				

APEC #	Associated Registry Number	Site Location	Figure	Registry Point Address	Site details	Classification	PCOCs	Recommendation	Length (m)
B11	147	South of alignment and east of Clarke Road	B11	580, 584, 590 CLARKE ROAD, COQUITLAM	Shell Service Station	MH	Hydrocarbon, metals and historical dry cleaning related contamination (PCOCs: LEPH/HEPH, PAH, VOCs including BTEX, Metals, TCE, PCE)	Recommend subsurface soil and groundwater investigation	310
	13430	South of alignment and west of Clarke Road	B11	581 CLARKE ROAD, COQUITLAM	Retail Property/ Former Esso Service Station				
	13099	North of alignment and west of Clarke Road	B11	603 CLARKE ROAD, COQUITLAM	Vacant/ Former Mahawk Service Station				
	12673	South of alignment and east of Site ID 147	B11	604 & 606 COMO LAKE AVENUE, COQUITLAM	Residential Property				
	13673	South of alignment and east of Site ID 12673	B11	608 & 610 COMO LAKE AVENUE, COQUITLAM	Residential Property				
	15298	South of alignment on Clarke Road	B11	COMO LAKE AVENUE ADJACENT TO 590 CLARKE ROAD	Section of Clarke Road				
	15860	South of alignment on Como Lake Avenue	B11	COMO LAKE AVENUE AND CLARKE ROAD	Section of Como Lake Avenue				
B12	N/A	South of alignment and east of Blue Mountain Street	B12	592 COMO LAKE AVENUE, COQUITLAM	Race Trac Service Station	MH	Hydrocarbon and metals (PCOCs: LEPH/HEPH, PAH, VOCs including BTEX, Metals)	Recommend subsurface soil and groundwater investigation	70
B13	1434	North of alignment and west of Poirier Street	B13	1695 COMO LAKE AVENUE, COQUITLAM	Chevron Service Station	MH	Hydrocarbon and metals (PCOCs: LEPH/HEPH, PAH, VOCs including BTEX, Metals, TCE, PCE)	Recommend subsurface soil and groundwater investigation	100
	1459	South of alignment and east of Poirier Street	B13	1700 COMO LAKE AVENUE, COQUITLAM	Residential Property / Former Petro Canada Service Station				
B14	84	South of alignment and west of Montrose Street	B14	1990 COMO LAKE AVENUE, COQUITLAM	Vacant/ Former Shell Service Station	MH	Hydrocarbon, metals and historical dry cleaning related contamination (PCOCs: LEPH/HEPH, PAH, VOCs including BTEX, Metals, TCE, PCE)	Recommend subsurface soil and groundwater investigation	300
	350	South of alignment and east of Linton Street	B14	1900 COMO LAKE AVENUE	Retail Property/ Former Petro Canada Service Station				
	4827	South of alignment, between Linton Street and Montrose Street	B14	1960 COMO LAKE AVENUE	Commercial Property/Former Dry Cleaner				
Cape Horn to Coquitlam IP									
C1	N/A	West of alignment and south of Spuraway Avenue	C1	775 MARINER WAY, COQUITLAM	Mariner Fire Hall (#2 Fire Hall)	Low	Hydrocarbon and metals (PCOCs: LEPH/HEPH, PAH, VOCs including BTEX, Metals and PFOS)	Low risk, manage during construction	100
C2	364	West of alignment North of Austin Avenue	C1	2647 AUSTIN AVENUE (500 MARINER WAY), COQUITLAM	City of Coquitlam works yard	MH	Hydrocarbon and metals (PCOCs: LEPH/HEPH, PAH, VOCs including BTEX, Metals, and PCBs)	Recommend subsurface soil and groundwater investigation	310
C3	N/A	First kilometre of the alignment	C2	Various Sites	Industrial and Commercial Properties	Low	Hydrocarbon and metals (PCOCs: LEPH/HEPH, PAH, VOCs including BTEX, Metals)	Low risk, manage during construction	1,000

*LEPH = Light Extractable Petroleum Hydrocarbons in Soil; HEPH = Heavy Extractable Petroleum Hydrocarbons in Soil; PAH = Polycyclic Aromatic Hydrocarbons; VOC = Volatile Organic Compounds; PCB = Polychorinated Biphenyls; PFOS = Perfluorooctanesulfonic acid or perfluorooctane sulfonate; BTEX = Benzene, Toluene, Ethylbenzene, and Xylene; TCE = Trichloroethylene; PCE = Perchloroethylene.

Table 18: Details of Proposed Subsurface Soil and Groundwater Investigation

APEC #	Length (m)	# of Boreholes	# of Soil Samples	# of GW Samples	PCOCs*
Fraser Gate to Marine & Elliott					
A2	500 m	5	12	6	LEPH/HEPH, PAHs, VOCs including BTEX, Metals, Tetra and Pentachlorophenol and other wood waste related PCOCs, PCBs
Metro IP					
B1	31 m	2	6	3	LEPH/HEPH, PAH, VOCs including BTEX, Metals
B3	140 m	4	10	5	LEPH/HEPH, PAH, VOCs including BTEX, Metals
B5	100 m	3	8	4	LEPH/HEPH, PAH, VOCs including BTEX, Metals
B6	140 m	4	10	5	LEPH/HEPH, PAH, VOCs including BTEX, Metals
B10	400 m	5	12	6	LEPH/HEPH, PAH, VOCs including BTEX, Metals
B11	310 m	4	10	5	LEPH/HEPH, PAH, VOCs including BTEX, Metals, TCE, PCE
B12	70 m	2	6	3	LEPH/HEPH, PAH, VOCs including BTEX, Metals
B13	100 m	4	10	5	LEPH/HEPH, PAH, VOCs including BTEX, Metals,
B14	300 m	5	12	6	LEPH/HEPH, PAH, VOCs including BTEX, Metals, TCE, PCE
Cape Horn to Coquitlam					
C2	310 m	4	10	5	LEPH/HEPH, PAH, VOCs including BTEX, Metals, and PCBs

*LEPH = Light Extractable Petroleum Hydrocarbons in Soil; HEPH = Heavy Extractable Petroleum Hydrocarbons in Soil; PAH = Polycyclic Aromatic Hydrocarbons; VOC = Volatile Organic Compounds; PCB = Polychorinated Biphenyls; BTEX = Benzene, Toluene, Ethylbenzene, and Xylene; TCE = Trichloroethylene; PCE = Perchloroethylene.

4.2.2 Water Quality and Quantity Management

Any groundwater discharged to the surrounding aquatic environment must not exceed federal (Canadian Council of Ministers of the Environment [CCME] Environmental Quality Guidelines for the Protection of Aquatic Life) and provincial (BC Approved or Working Water Quality Guidelines) water quality standards at the time of discharge. Any water that is known to exceed existing surface water quality conditions should either be suitably treated or prevented from discharging directly into potential fish and amphibian habitat. Failure to meet these criteria may result in water quality considered to be deleterious to aquatic life.

Site investigations occurred after a period of heavy rainfall. Extensive areas of standing water were observed along the SRW so, depending on weather at the time of construction, water management may be required during construction. There was no evidence of groundwater contamination (*e.g.*, iron staining); however, given the long history of use and disturbance within the utility corridor it is likely that high concentrations of dissolved iron (or other metals) will be encountered in certain areas. In order to know with any certainty whether water quality may be a concern during construction, groundwater sampling would be required along the proposed pipeline alignment.

Active erosion and sediment control will also be required during project construction to manage surface runoff and to minimize the mobilization of exposed soil materials, which can function as a deleterious substance at certain concentrations. Site-specific mitigation measures should be developed and communicated within the project Environmental Management Plan. Furthermore, considering the nature and magnitude of the proposed construction work (>2,000 m^2), the City of Surrey By-law No.16138 requires submission of an ESC Plan prepared by a Professional Engineer.

Water used during the hydrostatic testing procedure (used to determine pipe weld integrity) will require disposal following completion of the procedure. As the test water is typically potable (i.e., chlorinated) and may be contaminated with iron oxide and metals, it must be disposed of at a suitable location where infiltration will occur. If a suitable infiltration location is not available, then the test water should be discharged to the sanitary sewer. The volume of test water is expected to be approximately 63,876 m^3. All four pipeline alignments are generally confined within residential areas, so there are no possibilities of discharging large volumes of water to ground within or near the Project area. The recommended approach is to discharge to the Metro Vancouver sanitary sewer. Volume related fees would apply to all water discharged to the sanitary sewer.

4.2.3 Species-at-Risk

In 2010, more than 670 Oregon Forestsnail were observed in Colony Farm Regional Park (BC CDC 2014). In addition, 24 individuals were relocated from a patch of stinging nettle west of the Coquitlam River to a suitable patch of stinging nettle further south in 2011.

Dillon recommends that a detailed ground-based assessment be completed in all natural habitats within the Project areas to assess the quality of the existing habitat for Oregon Forestsnail and the potential for any other rare species to utilize the area. Based on the results of the assessment, a general wildlife permit and a species-at-risk permit may be required, in consultation with the Federal Ministry of Environment and the BC Ministry of Forest, Lands and Natural Resource Operations (MFLNRO).

During field investigations, a single Northern red-legged frog was identified in an area of standing water along the Cape Horn to Coquitlam study area. An assessment of habitat availability and species presence should be completed prior to construction. Based on the results of the assessment, a general wildlife permit may be required, in consultation with the Federal Ministry of Environment and the BC Ministry of Forest, Lands and Natural Resource Operations (MFLNRO) to complete a salvage.

Species-at-risk information packages are useful tools to help contractors identify sensitive species on site.

4.2.4 Fish and Wildlife Protection

Given the proximity of the Project to ESAs, parks, conservation areas and locally significant trees the risk for adverse impacts to the natural environment can be considered high. FortisBC crossings also have the potential disrupt or alter both instream and riparian fish habitats. Both trenchless and open cut pipeline installation methodology will be used at watercourse crossings along the four pipeline alignments. Watercourses crossing the pipeline alignment and proposed installation methods are outlined below in **Table 19**.

Table 19: Watercourse Crossings and Proposed Pipeline Installation Methods.

Watercourse	Classification	Figure Reference*	Proposed Installation Method
Metro IP			
Stickleback Creek	Unclassified; likely Class B fish habitat	Mapped by the City of Burnaby	Open cut
Beecher Creek	Unclassified; assumed Class A due to fish data	Figure B4	Open cut
Crab-Apple Creek	Unclassified	Mapped by the City of Burnaby	Open cut
Pollywog Creek Tributary*	Unclassified; likely Class B fish habitat	Figure B5	Open cut
Pollywog Creek*	Unclassified; likely Class B fish habitat	Figure B5	Open cut
Eagle Creek Tributary 2	Unclassified; likely Class B fish habitat	Figure B5	Open cut
Eagle Creek	Unclassified; likely Class A due to fish data	Figure B5	Open cut
Silver Creek Tributary 1-1	Unclassified; likely Class B fish habitat	Figure B6	Open cut
Silver Creek Tributary 1	Unclassified; likely Class B fish habitat	Figure B6	Open cut
Silver Creek	Unclassified	Figure B6	Open cut
Stoney Creek Tributary 1	Unclassified	Figure B6	Open cut
Stoney Creek Tributary 2	Unclassified	Figure B6	Open cut
Stoney Creek	Unclassified; assumed Class A due to fish data	Figure B6	Trenchless
South Schoolhouse Creek**	Class A	Figure B7	Open cut
Pinnacle Creek**	Class A	Figure B9	Open cut
Cape Horn to Coquitlam			
Lost Creek	Class B	Figure C1	Open cut
Mundy Creek	Class A	Figure C2	Trenchless
Unnamed Watercourse (3 crossings)	Unknown (considered significant by FortisBC at the time of investigation)	Figure C2	Trenchless
Nichol to Port Mann			
Hawthorne Creek	Class B	Figure D1	Open cut
Quibble Creek (2 crossings)	Class A	Figure D2	Trenchless

*Potential for unmapped crossings

**Crossing of a drainage main that connects to the watercourse

Instream work should be undertaken during the appropriate timing windows in order to minimize potential risk to aquatic life forms.

Within the City of Burnaby, City of Surrey and City of Coquitlam, timing windows are as follows:

- Class A: June 15 to September 30;
- Class B: June 1 to September 30; and

- Class C: No timing window requirements.

Riparian habitat adjacent to a watercourse considered to be fish habitat is typically protected by streamside setback areas. Streamside setbacks can vary widely, but are typically between 15 and 30 m perpendicular to the watercourse top of bank. The streamside setback should be determined during the project planning phase. Disruption of this area should be minimized where possible. If disturbance occurs, FortisBC should plan to undertake site restoration activities following construction.

A qualified Environmental Monitor should be assigned to the project and present during all work conducted in sensitive habitats. The role of the Environmental Monitor is important to assisting FortisBC and the Contractor with limiting the environmental effects of the Project.

Prior to dewatering any aquatic habitat, the Environmental Monitor must isolate the work area and undertake an aquatic life form salvage to remove any fish or amphibians present. All rescued life forms should be released in suitable habitat downstream.

In order to reduce risk of disturbance of active bird nests, the MFLNRO has developed a regional 'reduced risk' timing window for land clearing activities. The window of least risk for nesting migratory birds in the Lower Mainland is between August 1 and March 31. Land clearing activities are recommended during this window to prevent potential contravention of the *Wildlife Act* and the *Migratory Bird Convention Act*. Based on past experience undertaking breeding bird nesting sweeps, there are numerous species of birds which are known to nest along the edge of Burns Bog, some of which are ground or grass nesters. Any clearing conducted outside of the timing window (*i.e.,* between April 01 and July 31) must be preceded by a bird nest sweep conducted by a qualified professional.

4.2.5 Environmental Permitting and Approvals

Dillon anticipates the project will require a variety of environmental permits and approval prior to proceeding. Impacts that are considered to be a HADD of fish habitat will require an Authorization from DFO. Furthermore, should the stream crossings be expected to result in a "change in and about a stream", an Approval from the OGC will be required. Details regarding the anticipated environmental approvals are outlined below in Table 20.

Table 20: Potential Permitting and Approvals Required for the Project

Permit or Approval	Government Agency	Expected Timeframe following Submission
Request for Project Review Authorization	DFO	1 – 14 days* 6 months
Approval for Changes in and About a Stream	OGC	4 months
Species at Risk Collection Permits	MFLNRO Environment Canada	3 months
Fish Salvage	DFO and MFLNRO	2 weeks
Surrey Stormwater Drainage Regulation and Charges By-law	City of Surrey	2 months
Erosion and Sediment Control Bylaw	City of Surrey	2 months
Surrey Soil Removal and Depositing Regulation By-law	City of Surrey	2 months

*Based on previous submissions

Proper planning and reporting is required to submit the permit or approval applications on time. If the appropriate level of detail is provided, the expected timeframes for obtaining the permit or permits are generally reliable; however, are subject to work load and availability of regulatory agency staff. If project timelines are firm, then it is recommended to submit permit and approval applications well in advance.

4.3 Anticipated Environmental Effects and Recommended BMPs

Additional relevant environmental standards, guidelines and BMPs for protection of fish and wildlife are also contained within the following documents:

- DFO and Ministry of Environmental, Land and Parks. 1992. Land Development Guidelines for the Protection of Aquatic Habitat;
- Ministry of Water, Land and Air Protection (MWLAP). 2004. Best Management Practices for Amphibians and Reptiles in Urban and Rural Environments in British Columbia;
- DFO. 1995. Freshwater Intake End of Pipe Fish Screen Guidelines; and
- MWLAP. 2004. Standards and Best Practices for Instream Works (BMPs).

Table 21 outlines the potential effects of the Project, the relevant BMPs, and the significance of residual effects (if applicable) associated with the environmental components potentially affected by Project construction activities. The residual effects were described in general terms for each of the four alignments. It is expected that the residual effects assessment can be further refined/defined, if required, during the Project planning stage of the Projects.

Table 21: Potential Effects, BMPs and the Significance of Residual Effects Associated with Project Activities.

Significant Natural Feature Affected by Activity	Project Phase & Activity	Potential Negative/Positive Effect(s)	Frequency of Effect	Duration of Effect	Proposed BMPs	Significance of Residual Effects
Aquatic resources						
Fish , Fish Habitat and Aquatic Life	*Site Preparation* - Land Clearing, Soil Stripping, Grubbing and Grading	▪ Reduced input of organics to waterbodies; ▪ Reduced bank stability and ability to trap sediment from upland areas; increase erosion, sedimentation and turbidity; ▪ Potential for runoff and contaminants into waterbodies; and ▪ Loss of riparian vegetation.	Once during Site Preparation Phase	Temporary during Site Preparation and Construction phases	▪ Maintain surface water flow in all drainages to ensure the volume of water reaching downstream fish habitat is not significantly altered; ▪ Minimize removal/disturbance of vegetation adjacent to waterbodies; ▪ Maximize distance of all construction equipment used from the waterbody edge; ▪ Develop and implement an erosion and sediment control plan prior to site preparation activities; ▪ Erosion and sediment control structures should be monitored regularly to ensure that they are fully functional; ▪ The work area will be clearly defined with flagging and fencing to minimize encroachment into bordering habitat; and ▪ Use existing access roads or grades where possible.	Low to Moderate Residual Effects (For alignments with Class A and B stream crossings)
	Construction - Pipeline installation (open cut), Site Access/Egress	▪ Loss of native substrate and potential for imported material to enter adjacent habitat as a result of increased surface water runoff; and ▪ Limited potential for accidental spills or	One during Construction Phase	Temporary during Construction Phase	▪ Maintain or provide vegetative buffers; ▪ Maintain flow conveyance throughout construction; ▪ Minimize duration of in-stream work and time crossings around sensitive fish life stages (fish timing windows); ▪ Before dewatering, isolate the area and salvage any aquatic life and release them	Moderate Residual Effects (For alignments with Class A and B stream crossings)

Significant Natural Feature Affected by Activity	Project Phase & Activity	Potential Negative/Positive Effect(s)	Frequency of Effect	Duration of Effect	Proposed BMPs	Significance of Residual Effects
		contamination of soil and/or surface runoff.			downstream; ▪ Avoid construction during rain events where possible; and ▪ Restore and stabilize the streambed, substrate and banks to their original shape and condition. ▪ Proper characterization of groundwater and potential treatment is required before groundwater will be permitted for discharge into fish habitat; and ▪ Any water known to exceed water quality guidelines (or existing surface water conditions) will be prevented from discharging into potential fish habitat.	
	Construction - Pipeline installation (trenchless), Site Access/Egress	▪ Limited potential for "frac-out" as a result of a spill, tunnel collapse or rupture of drilling mud to the surface during trenchless installation. ▪ Potential for accidental spills or contamination of soil and/or surface runoff.	Only during Construction Phase	Temporary during Construction Phase	▪ All construction equipment and materials should be storied in areas of the project location that maximize distance between water bodies and construction areas; ▪ Existing vegetation in the project location should be maintained to act as a natural buffer; ▪ Proper geotechnical assessment practices, drill planning and execution should be applied; ▪ Extent of frac-out can be limited by careful monitoring, having appropriate equipment and response plans ready; and ▪ Design an Emergency Response and Communication Plan.	Low Residual Effects

Significant Natural Feature Affected by Activity	Project Phase & Activity	Potential Negative/Positive Effect(s)	Frequency of Effect	Duration of Effect	Proposed BMPs	Significance of Residual Effects
	Site Preparation, Construction and Operations – Machinery and active pipeline	▪ Potential for spills or leaks of oil, gas, diesel and hydraulic fluid; runoff of contaminated soil and/or surface runoff may impact water quality and aquatic life in downstream receiving waters.	During operations phase	Potential throughout project lifespan	▪ A spill response plan will be developed by FortisBC or the chosen contractor prior to commencement of the works to document the appropriate measures to be implemented should fuel, oil or other hazardous materials be spilled or otherwise involuntarily released.	No Residual Effect. (In the event of a spill, the area will be remediated)
TERRESTRIAL RESOURCES						
Terrestrial Habitat	Site Preparation, Construction – Land Clearing, Soil Stripping, Grubbing and Grading, pipeline installation (open cut), access/egress	▪ Direct loss (i.e., removal) of vegetation which may reduce the quantity and quality of available habitat; ▪ Loss of plant richness; ▪ Susceptibility to erosion; ▪ Changes in soil moisture and compaction; decreased cover/shade; ▪ Increased vulnerability of the cleared area to invasion by non-native species; and ▪ Disturbance to wildlife.	Once during Site Preparation	Temporary during Site Preparation and Construction Phases	▪ Minimize removal of vegetation; ▪ Store construction materials on previously disturbed areas to prevent additional vegetation disturbance; ▪ If topsoil or other materials must be stored in undisturbed areas, ensure it is placed on a tarp or other form of ground cover; ▪ Re-vegetate all disturbed areas following construction; ▪ Monitor areas of disturbance following construction to assess establishment of invasive plant species; ▪ Properly remove invasive species where encountered during Project development; ▪ Control noxious weeds prior to disturbance and during the restoration phase, in accordance with the BC *Weed Control Act*; and ▪ Ensure that existing weeds are removed prior to producing seed, and rhizomes are not transferred from site to site within soil material used for site restoration.	Low Residual Effect (Following completion of site restoration measures)

Significant Natural Feature Affected by Activity	Project Phase & Activity	Potential Negative/Positive Effect(s)	Frequency of Effect	Duration of Effect	Proposed BMPs	Significance of Residual Effects
Wildlife	Site Preparation – Land Clearing, Soil Stripping, Grubbing and Grading Construction - Pipeline installation (open cut), Site Access/Egress	▪ Reduced habitat availability due to the removal of vegetation; ▪ Localized temporary displacement of wildlife due to noise and vibration; and ▪ Disturbance/incidental mortality to wildlife.	Once during Site Preparation and Construction	Temporary during Site Preparation and Construction Stages	▪ Minimize encroachment into terrestrial habitat; ▪ Retain existing vegetation and use existing access roads where possible; ▪ Develop and implement an erosion and sediment control plan and minimize any stock piled or excavated materials in the Project Location to prevent runoff and protect surrounding areas prior to site preparation and construction; ▪ Minimize duration of construction activities and schedule construction activities outside of the bird nesting window for the area (April 1 to July 31); ▪ Conduct bird nest surveys if vegetation clearing is required within the breeding bird nesting window; and ▪ Re-vegetate disturbed area with fast growing native species.	Low Residual Effect (Following completion of site restoration measures)

Significant Natural Feature Affected by Activity	Project Phase & Activity	Potential Negative/Positive Effect(s)	Frequency of Effect	Duration of Effect	Proposed BMPs	Significance of Residual Effects
Species at Risk	Site Preparation – Land Clearing, Soil Stripping, Grubbing and Grading Construction - Pipeline installation (open cut), Site Access/Egress	▪ Reduced habitat availability due to the removal of vegetation; ▪ Removal or disturbance of rare or at risk vascular plants; ▪ Localized temporary displacement of species-at-risk due to noise and vibration; and ▪ Disturbance/incidental mortality to species-at-risk.	Once during Site Preparation and Construction	Temporary during Site Preparation and Construction Stages	▪ Moderate likelihood of species-at-risk within the Project Area; ▪ Given that there is the potential for species-at-risk to occur within the project area, consideration will be given prior to, and during site preparation and construction activities to assess the presence of species-at-risk within the Project footprint and adjacent areas; and ▪ If species-at-risk are found during site preparation or construction activities, project activity will temporarily halted and the species encountered will be relocated as required (with proper permits for species-at-risk relocation).	No Residual Effect (None anticipated at this time)

5.0 SUMMARY

This report was prepared in support of FortisBC's CPCN Application for the Lower Mainland Natural Gas System Upgrades composed of the following segments:

- Fraser Gate to Marine and Elliot IP Pipeline Replacement
- Metro IP Pipeline Replacement
- Cape Horn to Coquitlam TP Pipeline Loop
- Nichol to Port Mann TP Pipeline Loop

The content of the report is based on information provided to, or obtained by Dillon through our desktop study, as indicated in the report, and applies solely to site conditions and the regulatory and planning frameworks existing at the time of the study.

This report identified a variety of factors that present risk to the Project in the form of additional cost and activities requiring permits or approvals, which may present potential constraints to the Project timeframe. The key identified risks are as follows:

- The potential for encountering soil/or groundwater contamination is expected to be high, particularly in the urban areas. A total of 19 APECs were identified during our desktop assessment. A total of 8 sites were identifies as low risk sites and 11 were identified has medium to high risk sites. As a result of the number of sites present, the probability or potential risk of encountering contamination within the Project areas is considered to be high. These areas represent potential sources of contamination to the proposed pipeline replacement activities and have the capacity to migrate into soils and groundwater at the Project area.

  The following due diligence measures were recommended to confirm the presence or absence of contamination or to manage risks associated with potential sub-surface contamination (summarized from **Table 17**):

  Fraser Gate IP (2 sites):
  - One site – Manage risks during construction
  - One site – Conduct subsurface soil and water investigation

  Metro IP (14 sites):
  - Five sites – Manage risks during construction
  - Nine sites – Conduct subsurface soil and water investigation

  Cape Horn to Coquitlam (3 sites):
  - Two sites - Manage risks during construction
  - One site – Conduct subsurface soil and water investigation

- Environmental regulatory permits, licenses and approvals will be required in support of the project. Given the proximity of the Project to mature forests and Class A and B fish habitat, there is a high potential for adverse impacts to occur to the natural environment, particularly fish habitat. As such, FortisBC will require a *Water Act* (Section 9) Approval for instream work from the OGC and possibly an Authorization from DFO (depending on the crossing techniques proposed and the extent of riparian and instream disturbance). Instream work is recommended to be conducted during the appropriate timing windows to reduce risks of impacts to fish habitat. The Project may also require a SARA Permit from MFLNRO and Environment Canada for the collection and removal of species-a-risk and a fish collection permit from DFO and MFLNRO prior to undertaking fish salvages;

- Project activities should be conducted during the appropriate periods of reduced risk to the natural environment. Land clearing activities are recommended to be conducted during the window of least risk for nesting migratory birds to prevent potential contravention of the *Wildlife Act* and the *Migratory Bird Convention Act*. Any clearing conducted outside of the timing window (*i.e.*, between April 01 and July 31) will first require a bird nest sweep to be conducted by a qualified professional. Furthermore, instream work should be undertaken during the annual Instream Work Window, which is the period of least risk to fish and fish habitat.

A baseline field study should be undertaken within the Project area to observe, identify and characterize the existing habitat present, potential effects of the Project, any species-at-risk present and to create a site-specific set of BMPs and mitigation measures. The results of the field study can be captured in a report for submission to regulatory agencies and for FortisBC to utilize for due diligence purposes.

Potential environmental impacts associated with the projects can be avoided or mitigated by following applicable provincial and federal guidelines and through the application of standard best management practices and mitigation measures.

This report was prepared by Dillon for the sole benefit of FortisBC. The material in this report reflects Dillon's best judgment in light of the information available at the time of preparation. Any use which a third party makes of this report, or any reliance on or decisions made based on it, are the responsibilities of such third parties. Dillon accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.

If you have any questions regarding the findings contained herein, please do not hesitate to contact the undersigned at 604-278-7847.

Sincerely,

DILLON CONSULTING LIMITED

Richard Pope, R.P.Bio.
Project Manager

Lindsay Knezevich
Project Coordinator

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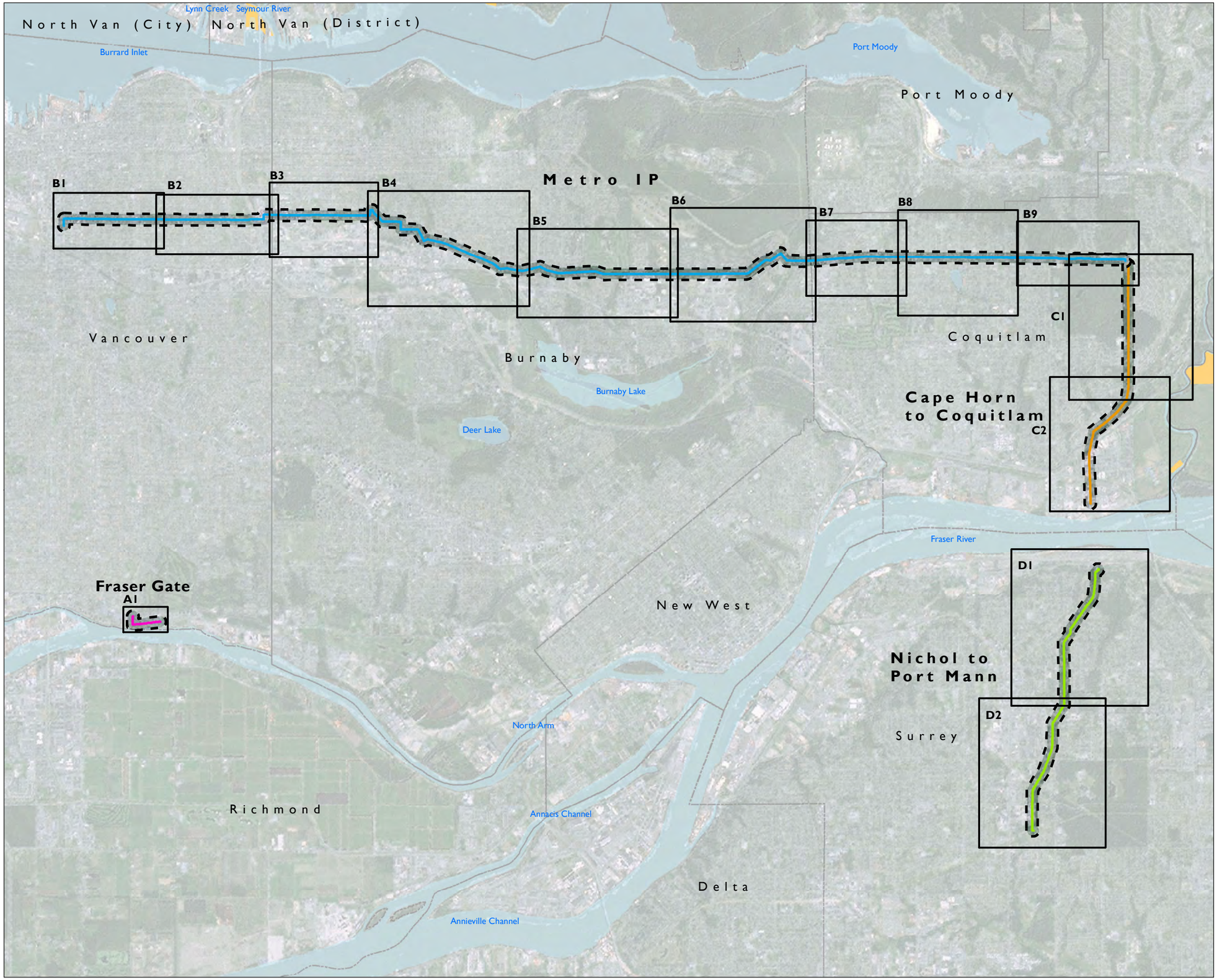
7.0 PERSONAL COMMUNICATION

Dave Konesky, Envirow Consulting, May 2013

APPENDIX A
FIGURES



FortisBC

Lower Mainland Natural Gas System Updates

Pipeline Detailed Map

Figure 1 Pipeline Overview

Legend

- Fraser Gate IP
- Metro IP
- Cape Horn to Coquitlam
- Nichol to Port Mann
- Study Area
- First Nation Reserves
- Municipal Boundaries

SCALE 1:64,972

0 0.5 1 2 Kilometers

N W E S

MAP DRAWING INFORMATION:
City of Surrey, City of Vancouver, City of Coquitlam, Province of British Columbia, CanVec, FortisBC, Dillon Created

MAP CREATED BY: ECH
MAP CHECKED BY: LK/TW/BD
MAP PROJECTION: NAD 1983 UTM Zone 10N

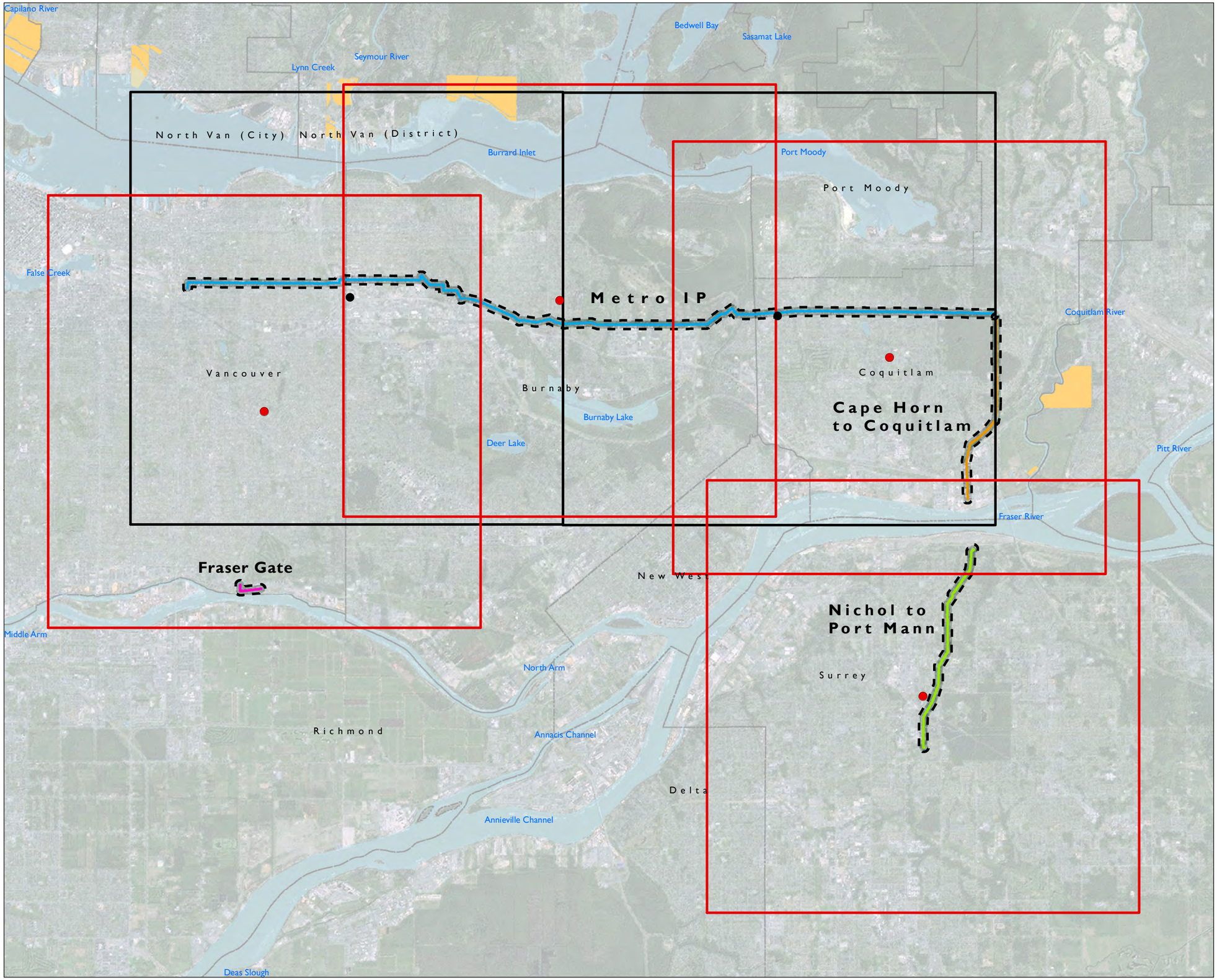
DILLON CONSULTING

PROJECT: 14-8963

STATUS: FINAL

DATE: 5/15/2014

FILE LOCATION: G:\GIS\148963 - FortisBC Coastal Revisited\Figure 1 Overview and Index.mxd



FORTIS BC™

FortisBC
Lower Mainland Natural Gas System Updates

Pipeline Detailed Map

Figure 2 Site Registry Search Extents

Legend

- Updated Site Registry Search Centroid
- Original Site Registry Search Centroid selection
- Updated Site Registry Extent
- Original Site Registry Extent
- Fraser Gate IP
- Metro IP
- Cape Horn to Coquitlam
- Nichol to Port Mann
- Study Area
- First Nation Reserves
- Municipal Boundaries

SCALE 1:85,524

0 0.5 1 2 Kilometers

N W E S

MAP DRAWING INFORMATION:
City of Surrey, City of Vancouver, City of Coquitlam, Province of British Columbia, CanVec, FortisBC, Dillon Created

MAP CREATED BY: ECH
MAP CHECKED BY: LK/TW/BD
MAP PROJECTION: NAD 1983 UTM Zone 10N

DILLON CONSULTING

PROJECT: 14-8963

STATUS: FINAL

DATE: 5/15/2014

FILE LOCATION: G:\GIS\148963 - FortisBC Coastal Revisited\Figure 2 Site Registry Search Areas.mxd

FortisBC
Lower Mainland Natural Gas System Updates

Pipeline Detailed Map

Figure A1 Fraser Gate IP

Legend

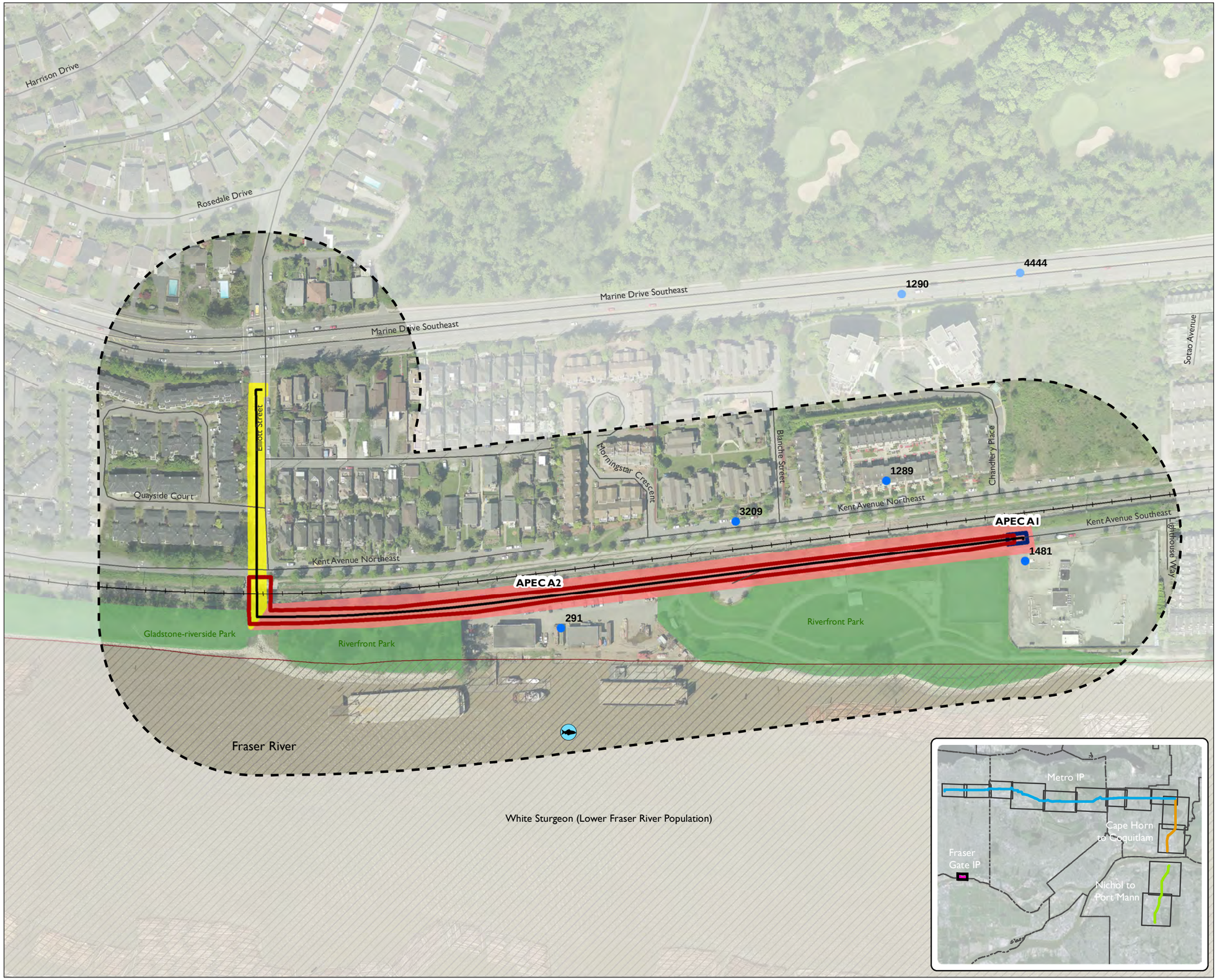
- Known Fish Observations
- Site Registry
- Pipeline Alignments
- Watercourses
- Railways
- Roads
- Study Area
- Parks/Natural Areas
- Non-Masked Sensitive Species Occurrence

APEC

- Low Impact Site
- Medium to High Impact Site

Type of Ground Work

- Open Cut
- Trenchless



SCALE 1:2,340

0 25 50 100 Meters

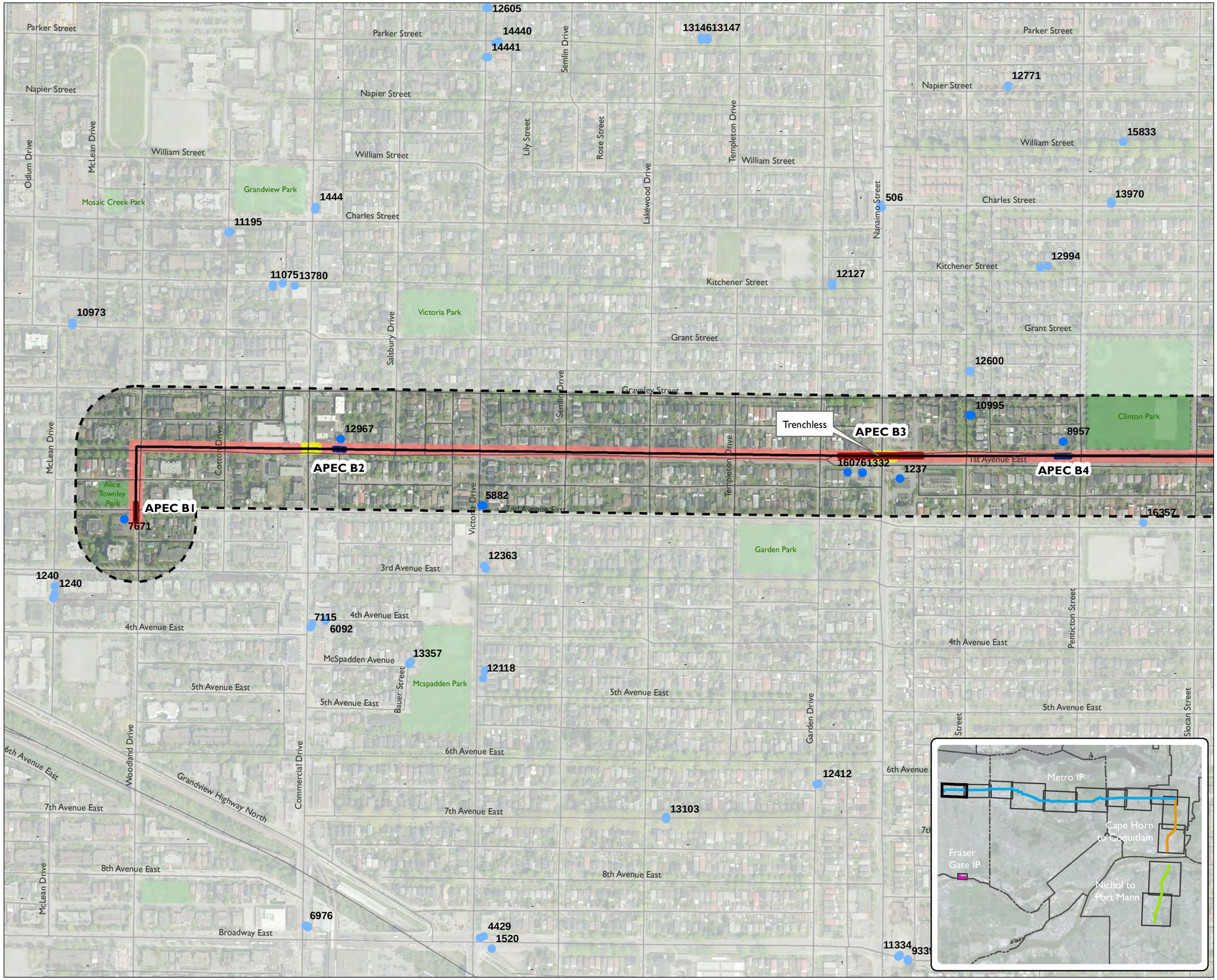
MAP DRAWING INFORMATION:
City of Surrey, City of Vancouver, City of Coquitlam, Province of British Columbia, CanVec, FortisBC, Dillon Created

MAP CREATED BY: ECH
MAP CHECKED BY: LK/TW/BD
MAP PROJECTION: NAD 1983 UTM Zone 10N

DILLON CONSULTING

PROJECT: 14-8963
STATUS: FINAL
DATE: 5/15/2014

FILE LOCATION: G:\GIS\148963 - FortisBC Coastal Revisited\Figure A1 - Fraser Gate.mxd



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FortisBC
Lower Mainland Natural Gas System Updates

Pipeline Detailed Map

Figure B1 Metro IP

Legend

- Site Registry
- Pipeline Alignments
- Watercourses
- Railways
- Roads
- Study Area
- Parks/Natural Areas
- Low Impact Site
- Medium to High Impact Site
- Open Cut
- Trenchless

SCALE 1:6,130

0 25 50 100 Meters

MAP DRAWING INFORMATION:
City of Surrey, City of Vancouver,
City of Coquitlam, Province of
British Columbia, CanVec, FortisBC,
Dillon Created

MAP CREATED BY: ECH
MAP CHECKED BY: LK/TW/BD
MAP PROJECTION: NAD 1983 UTM Zone 10N

DILLON CONSULTING

PROJECT: 14-8963

STATUS: FINAL

DATE: 5/15/2014

FILE LOCATION: G:\GIS\148963 - FortisBC Coastal Revisited\Figure B1 Metro IP.mxd

FortisBC
Lower Mainland Natural Gas System Updates

Pipeline Detailed Map

Figure B2 Metro IP

Legend

- Site Registry
- Pipeline Alignments
- Watercourses
- Railways
- Roads
- Study Area
- Parks/Natural Areas
- Low Impact Site
- Medium to High Impact Site
- Open Cut
- Trenchless
- Municipal Boundaries

SCALE 1:6,770

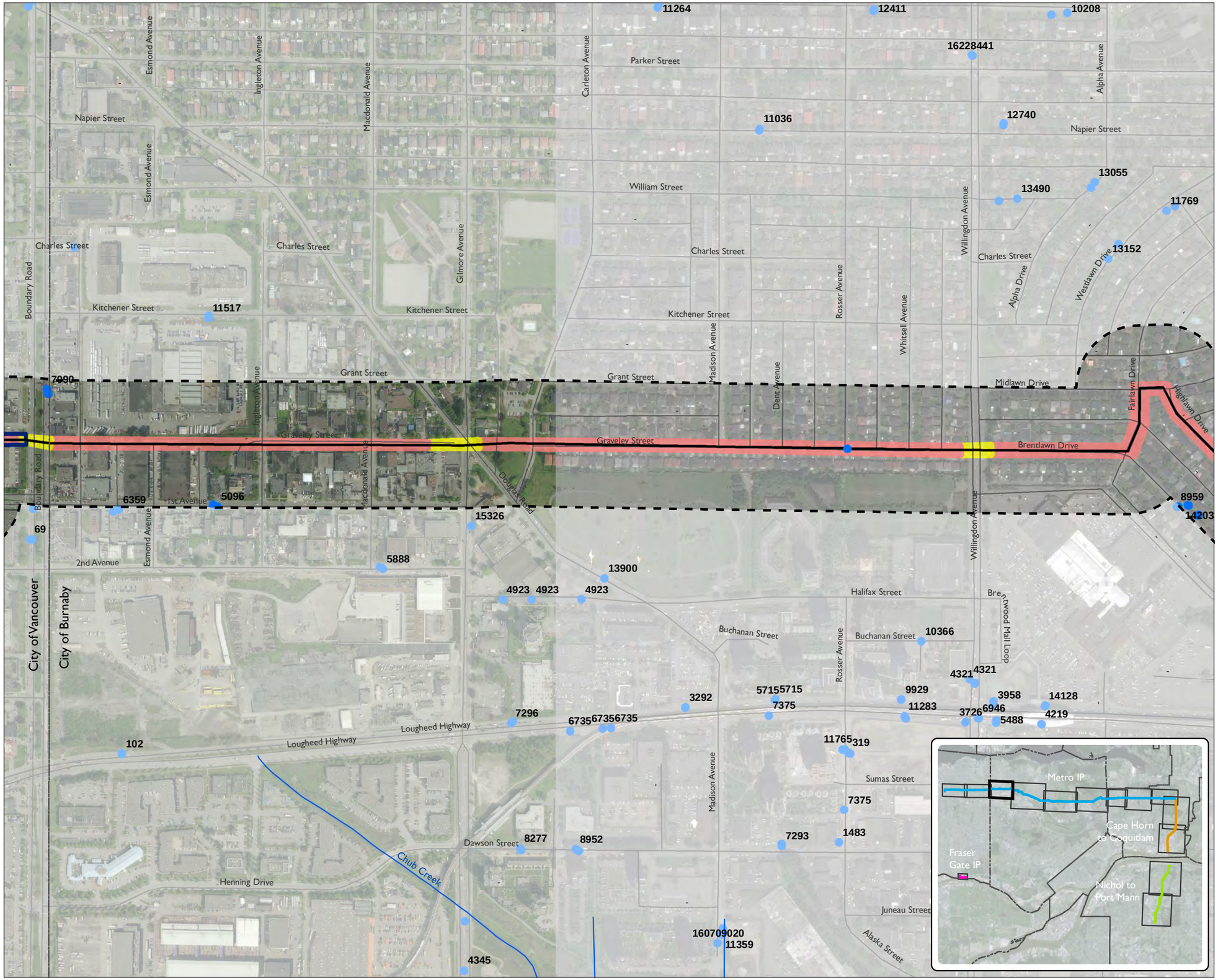
0 25 50 100 Meters

MAP DRAWING INFORMATION:
City of Surrey, City of Vancouver,
City of Coquitlam, Province of
British Columbia, CanVec, FortisBC,
Dillon Created

MAP CREATED BY: ECH
MAP CHECKED BY: LK/TW/BD
MAP PROJECTION: NAD 1983 UTM Zone 10N

PROJECT: 14-8963
STATUS: FINAL
DATE: 5/15/2014

FILE LOCATION: G:\GIS\148963 - FortisBC Coastal Revisited\Figure B2 Metro IP.mxd



FortisBC

Lower Mainland Natural Gas System Updates

Pipeline Detailed Map

Figure B3 Metro IP

Legend

- Site Registry
- Pipeline Alignments
- Watercourses
- Railways
- Roads
- Study Area
- Low Impact Site
- Medium to High Impact Site
- Open Cut
- Trenchless
- Municipal Boundaries

SCALE 1:5,860

0 25 50 100 Meters

MAP DRAWING INFORMATION:
City of Surrey, City of Vancouver, City of Coquitlam, Province of British Columbia, CanVec, FortisBC, Dillon Created

MAP CREATED BY: ECH
MAP CHECKED BY: LK/TW/BD
MAP PROJECTION: NAD 1983 UTM Zone 10N

DILLON CONSULTING

PROJECT: 14-8963

STATUS: FINAL

DATE: 5/15/2014

FILE LOCATION: G:\GIS\148963 - FortisBC Coastal Revisited\Figure B3 Metro IP.mxd

FortisBC
Lower Mainland Natural Gas System Updates

Pipeline Detailed Map

Figure B4 Metro IP

Legend

Watercourse Crossings (FortisBC)
- Class Red
- Class Yellow
- Class Unknown

- Known Fish Observations
- Site Registry
- Pipeline Alignments
- Watercourses
- Railways
- Roads
- Study Area

APEC
- Low Impact Site
- Medium to High Impact Site

Type of Ground Work
- Open Cut
- Trenchless

SCALE 1:8,680

0 25 50 100 Meters

MAP DRAWING INFORMATION:
City of Surrey, City of Vancouver, City of Coquitlam, Province of British Columbia, CanVec, FortisBC, Dillon Created

MAP CREATED BY: ECH
MAP CHECKED BY: LK/TW/BD
MAP PROJECTION: NAD 1983 UTM Zone 10N

PROJECT: 14-8963
STATUS: FINAL
DATE: 5/15/2014

FILE LOCATION: G:\GIS\148963 - FortisBC Coastal Revisited\Figure B4 Metro IP.mxd

FortisBC
Lower Mainland Natural Gas System Updates

Pipeline Detailed Map

Figure B5 Metro IP

Legend

Watercourse Crossings (FortisBC)
- Class Red
- Class Yellow
- Class Unknown

- Known Fish Observations
- Site Registry
- Pipeline Alignments
- Watercourses
- Railways
- Roads
- Study Area
- Locally Significant Trees
- Non-Masked Sensitive Species Occurrence

APEC
- Low Impact Site
- Medium to High Impact Site

Type of Ground Work
- Open Cut
- Trenchless

SCALE 1:8,510

0 25 50 100 Meters

MAP DRAWING INFORMATION:
City of Surrey, City of Vancouver, City of Coquitlam, Province of British Columbia, CanVec, FortisBC, Dillon Created

MAP CREATED BY: ECH
MAP CHECKED BY: LK/TW/BD
MAP PROJECTION: NAD 1983 UTM Zone 10N

DILLON CONSULTING

PROJECT: 14-8963
STATUS: FINAL
DATE: 5/15/2014

FILE LOCATION: G:\GIS\148963 - FortisBC Coastal Revisited\Figure B5 Metro IP.mxd

FortisBC
Lower Mainland Natural Gas System Updates

Pipeline Detailed Map

Figure B6 Metro IP

Legend

Watercourse Crossings (FortisBC)
- Class Red
- Class Yellow
- Class Unknown

- Known Fish Observations
- Site Registry
- Pipeline Alignments
- Watercourses
- Railways
- Roads
- Study Area

APEC
- Low Impact Site
- Medium to High Impact Site

Type of Ground Work
- Open Cut
- Trenchless

SCALE 1:8,160

0 25 50 100 Meters

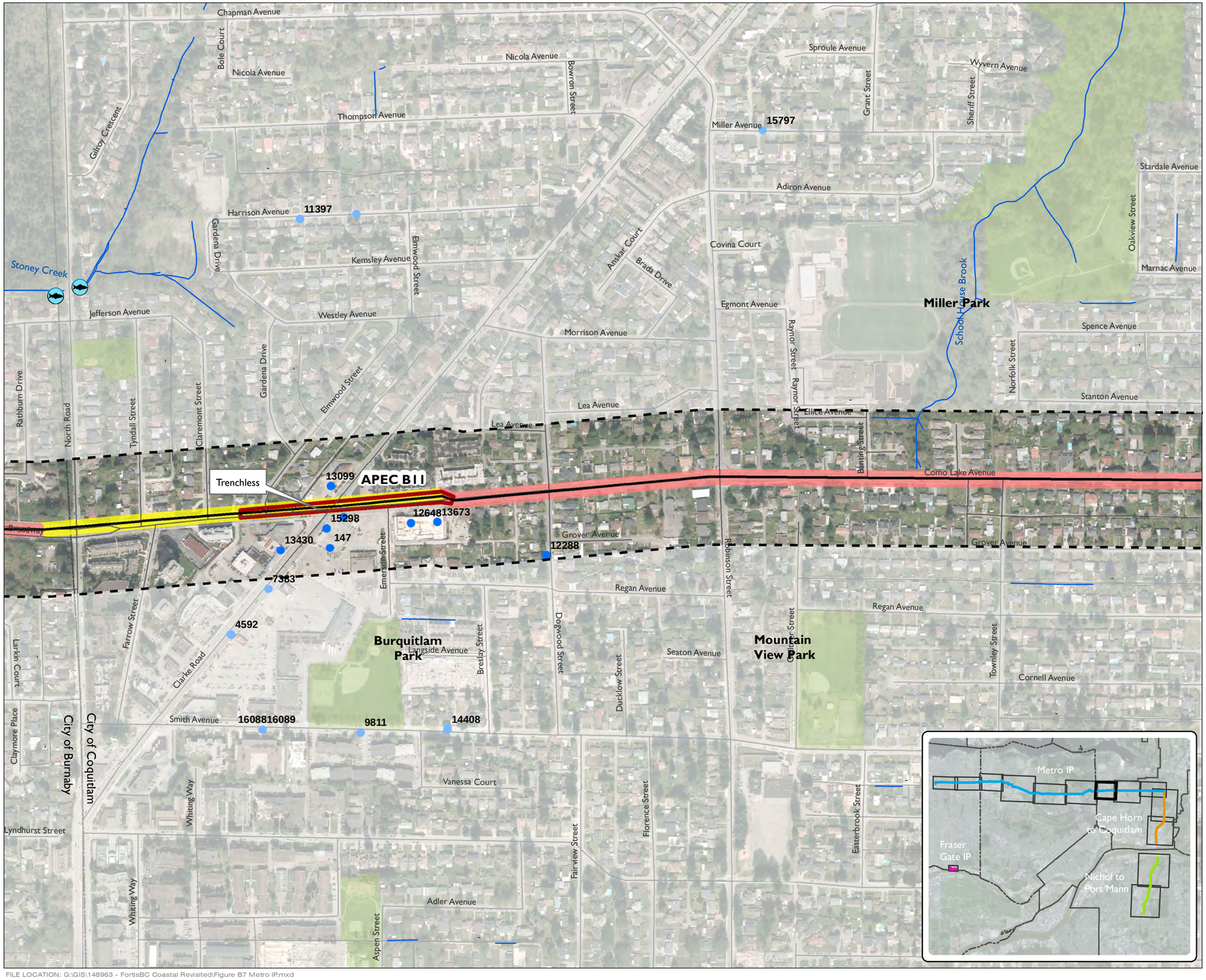
MAP DRAWING INFORMATION:
City of Surrey, City of Vancouver, City of Coquitlam, Province of British Columbia, CanVec, FortisBC, Dillon Created

MAP CREATED BY: ECH
MAP CHECKED BY: LK/TW/BD
MAP PROJECTION: NAD 1983 UTM Zone 10N

DILLON CONSULTING

PROJECT: 14-8963
STATUS: FINAL
DATE: 5/15/2014

FILE LOCATION: G:\GIS\148963 - FortisBC Coastal Revisited\Figure B6 Metro IP.mxd



FortisBC

Lower Mainland Natural Gas System Updates

Pipeline Detailed Map

Figure B7 Metro IP

Legend

- Known Fish Observations
- Site Registry
- Pipeline Alignments
- Watercourses
- Watercourses
- Railways
- Roads
- Study Area
- Parks/Natural Areas
- Low Impact Site
- Medium to High Impact Site
- Open Cut
- Trenchless
- Municipal Boundaries

SCALE 1:5,420

0 25 50 100 Meters

MAP DRAWING INFORMATION:
City of Surrey, City of Vancouver, City of Coquitlam, Province of British Columbia, CanVec, FortisBC, Dillon Created

MAP CREATED BY: ECH
MAP CHECKED BY: LK/TW/BD
MAP PROJECTION: NAD 1983 UTM Zone 10N

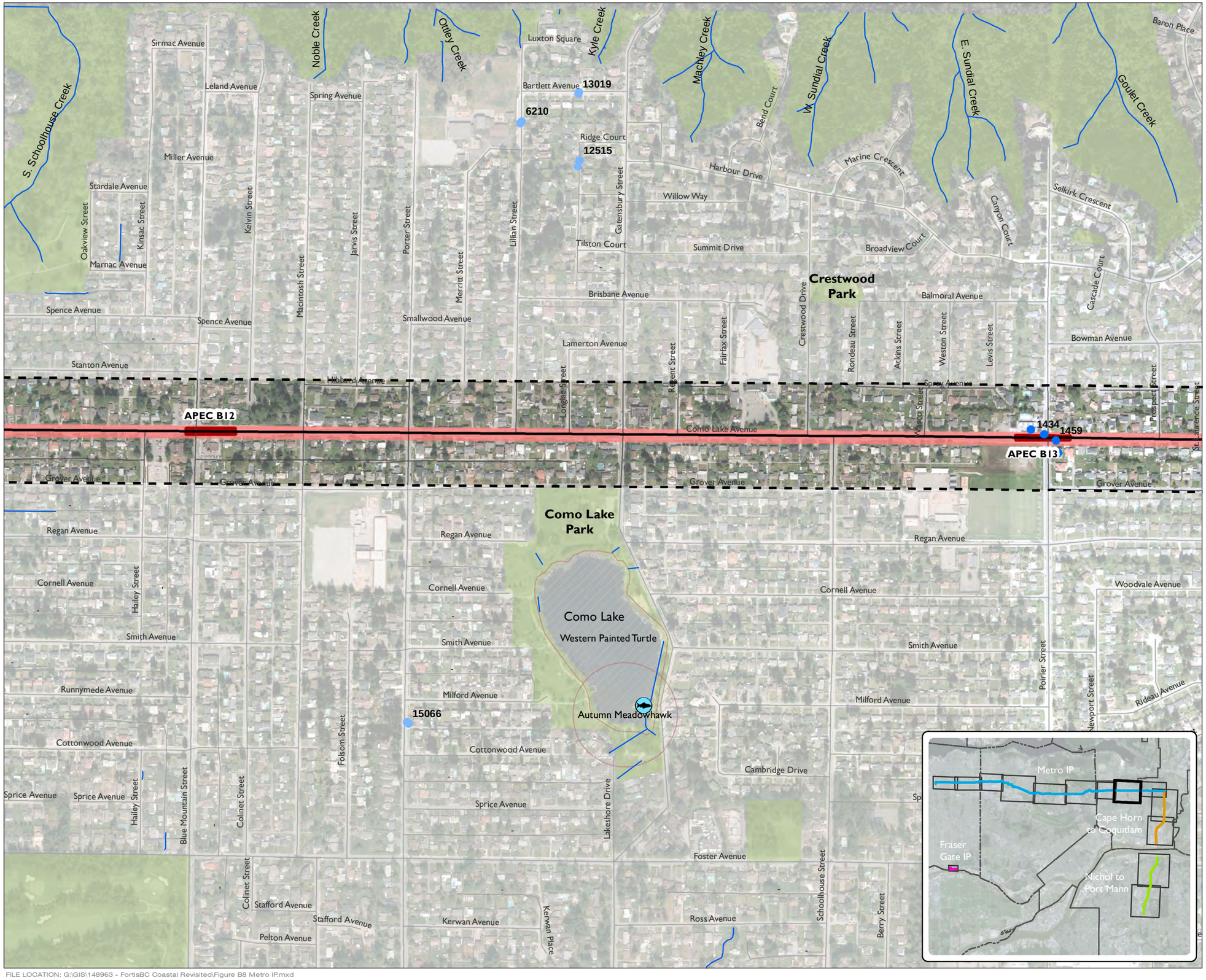
DILLON CONSULTING

PROJECT: 14-8963

STATUS: FINAL

DATE: 5/15/2014

FILE LOCATION: G:\GIS\148963 - FortisBC Coastal Revisited\Figure B7 Metro IP.mxd



FortisBC

Lower Mainland Natural Gas System Updates

Pipeline Detailed Map

Figure B8 Metro IP

Legend

- Known Fish Observations
- Site Registry
- Pipeline Alignments
- Watercourses
- Railways
- Roads
- Study Area
- Parks/Natural Areas
- Non-Masked Sensitive Species Occurrence
- Low Impact Site
- Medium to High Impact Site
- Open Cut
- Trenchless

SCALE 1:6,990

0 25 50 100 Meters

MAP DRAWING INFORMATION:
City of Surrey, City of Vancouver, City of Coquitlam, Province of British Columbia, CanVec, FortisBC, Dillon Created

MAP CREATED BY: ECH
MAP CHECKED BY: LK/TW/BD
MAP PROJECTION: NAD 1983 UTM Zone 10N

DILLON CONSULTING

PROJECT: 14-8963

STATUS: FINAL

DATE: 5/15/2014

FILE LOCATION: G:\GIS\148963 - FortisBC Coastal Revisited\Figure B8 Metro IP.mxd

FortisBC

Lower Mainland Natural Gas System Updates

Pipeline Detailed Map

Figure B9 Metro IP

Legend

- Known Fish Observations
- Site Registry
- Cape_Horn_Block
- Pipeline Alignments
- Watercourses
- Railways
- Roads
- Study Area
- Parks/Natural Areas
- Non-Masked Sensitive Species Occurrence
- Low Impact Site
- Medium to High Impact Site
- Open Cut
- Trenchless

SCALE 1:6,720

0 25 50 100 Meters

MAP DRAWING INFORMATION:
City of Surrey, City of Vancouver, City of Coquitlam, Province of British Columbia, CanVec, FortisBC, Dillon Created

MAP CREATED BY: ECH
MAP CHECKED BY: LK/TW/BD
MAP PROJECTION: NAD 1983 UTM Zone 10N

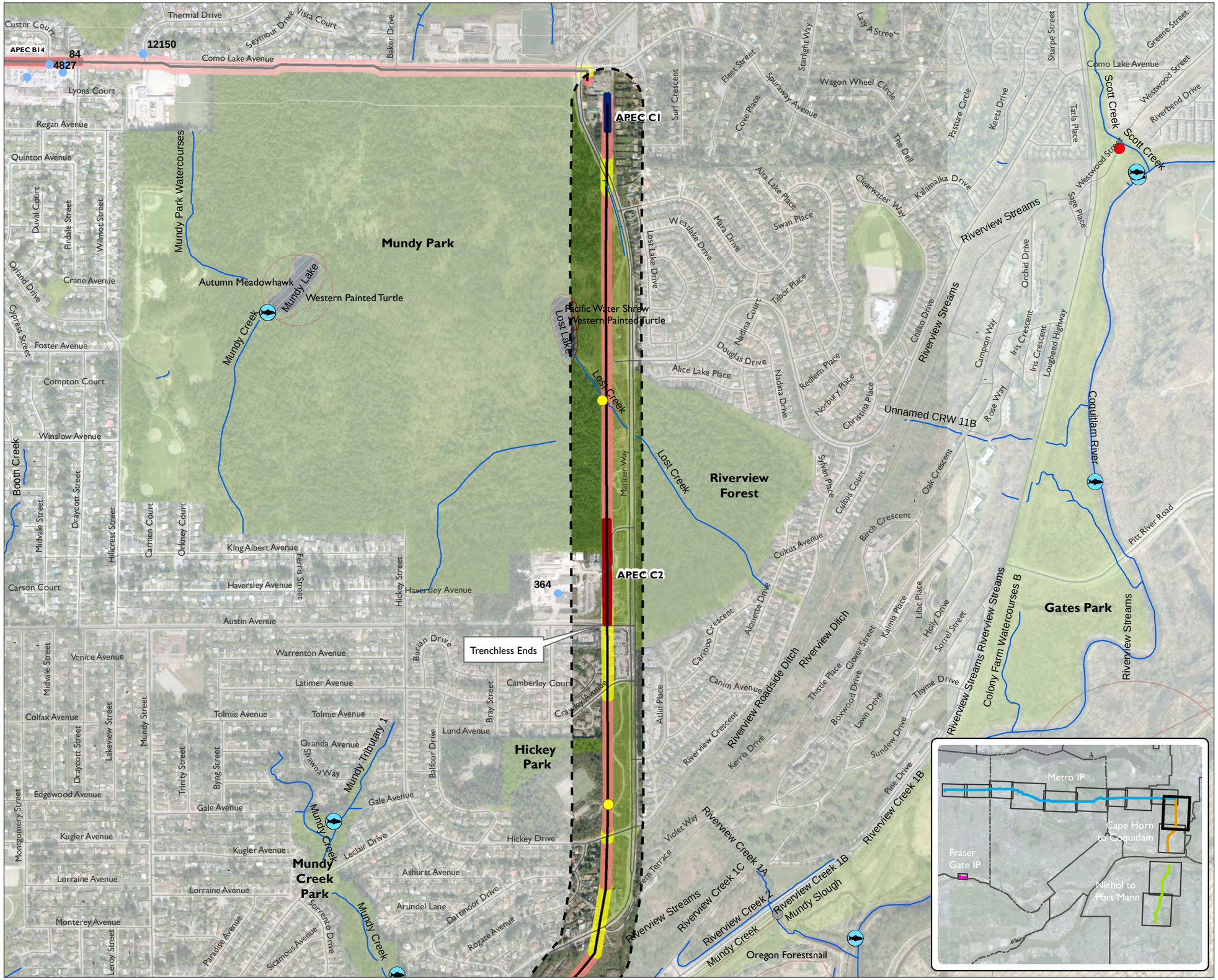
DILLON CONSULTING

PROJECT: 14-8963

STATUS: FINAL

DATE: 5/15/2014

FILE LOCATION: G:\GIS\148963 - FortisBC Coastal Revisited\Figure B9 Metro IP.mxd



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FortisBC
Lower Mainland Natural Gas System Updates

Pipeline Detailed Map

Figure C1 Cape Horn to Coquitlam

Legend

Watercourse Crossings (FortisBC)
- Class Red
- Class Yellow
- Class Unknown

- Known Fish Observations
- Site Registry
- Pipeline Alignments
- Watercourses
- Railways
- Roads
- Study Area
- Non-Masked Sensitive Species Occurrence
- Parks/Natural Areas

APEC
- Low Impact Site
- Medium to High Impact Site

Type of Ground Work
- Open Cut
- Trenchless

SCALE 1:10,380

0 25 50 100 Meters

MAP DRAWING INFORMATION:
City of Surrey, City of Vancouver, City of Coquitlam, Province of British Columbia, CanVec, FortisBC, Dillon Created

MAP CREATED BY: ECH
MAP CHECKED BY: LK/TW/BD
MAP PROJECTION: NAD 1983 UTM Zone 10N

DILLON CONSULTING

PROJECT: 14-8963
STATUS: FINAL
DATE: 5/15/2014

FILE LOCATION: G:\GIS\148963 - FortisBC Coastal Revisited\Figure C1 Cape Horn to Coquitlam.mxd

FortisBC
Lower Mainland Natural Gas System Updates

Pipeline Detailed Map

Figure C2 Cape Horn to Coquitlam

Legend

Watercourse Crossings (FortisBC)
- Class Red
- Class Yellow
- Class Unknown

- Known Fish Observations
- Site Registry
- Pipeline Alignments
- Watercourses
- Railways
- Roads
- Study Area
- Non-Masked Sensitive Species Occurrence
- Parks/Natural Areas

APEC
- Low Impact Site
- Medium to High Impact Site

Type of Ground Work
- Open Cut
- Trenchless

SCALE 1:9,130

0 25 50 100 Meters

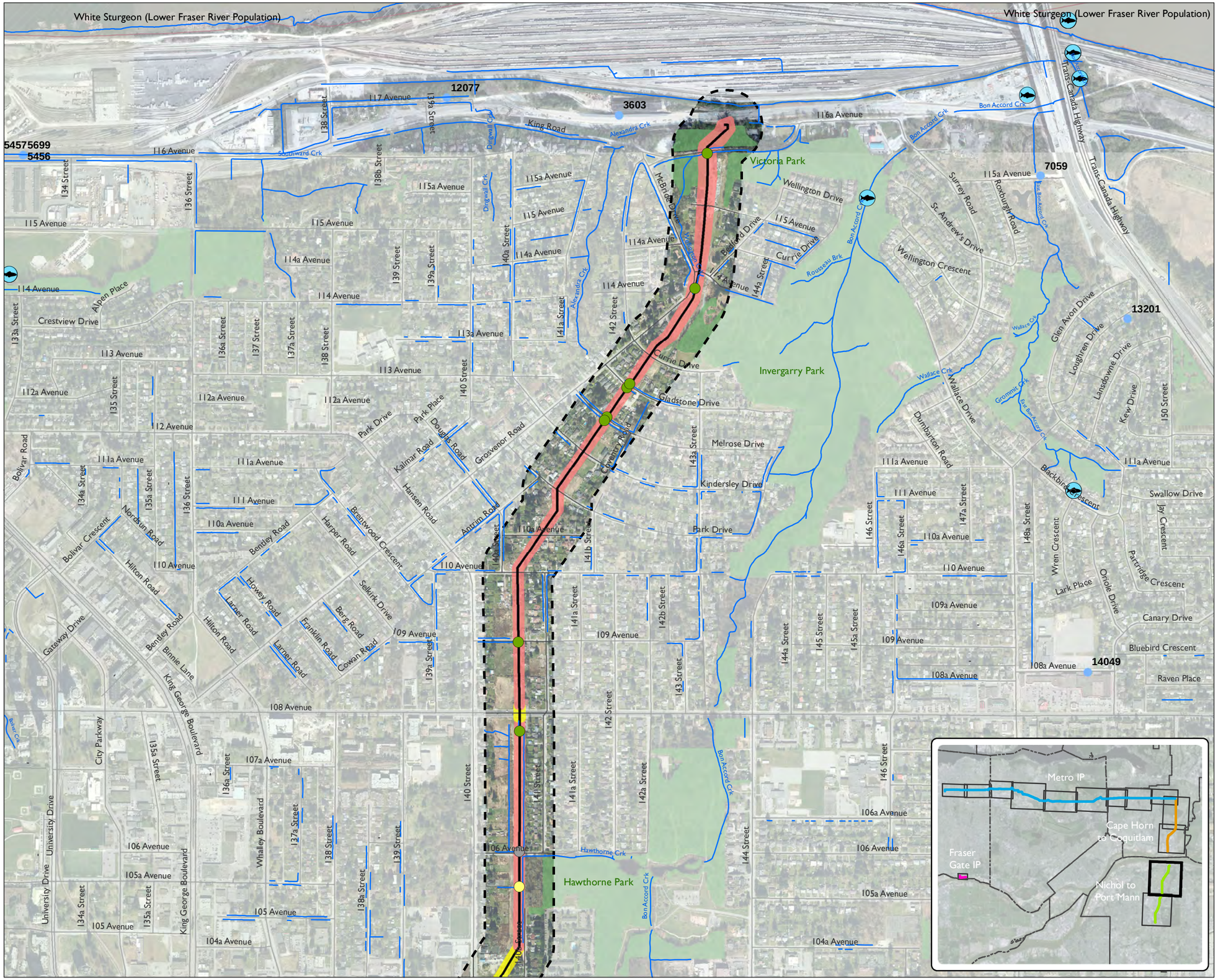
MAP DRAWING INFORMATION:
City of Surrey, City of Vancouver, City of Coquitlam, Province of British Columbia, CanVec, FortisBC, Dillon Created

MAP CREATED BY: ECH
MAP CHECKED BY: LK/TW/BD
MAP PROJECTION: NAD 1983 UTM Zone 10N

DILLON CONSULTING

PROJECT: 14-8963
STATUS: FINAL
DATE: 5/15/2014

FILE LOCATION: G:\GIS\148963 - FortisBC Coastal Revisited\Figure C2 Cape Horn to Coquitlam.mxd



FortisBC

Lower Mainland Natural Gas System Updates

Pipeline Detailed Map

Figure D1 Nichol to Port Mann

Legend

Watercourse Crossing

- Class A
- Class B
- Class C
- Class Unknown

- Known Fish Observations
- Site Registry
- Pipeline Alignments
- Watercourses
- Railways
- Roads
- Study Area
- Parks/Natural Areas
- Non-Masked Sensitive Species Occurrence

APEC

- Low Impact Site
- Medium to High Impact Site

Type of Ground Work

- Open Cut
- Trenchless

SCALE 1:10,730

0 50 100 200 Meters

MAP DRAWING INFORMATION:
City of Surrey, City of Vancouver, City of Coquitlam, Province of British Columbia, CanVec, FortisBC, Dillon Created

MAP CREATED BY: ECH
MAP CHECKED BY: LK/TW/BD
MAP PROJECTION: NAD 1983 UTM Zone 10N

DILLON CONSULTING

PROJECT: 14-8963

STATUS: FINAL

DATE: 5/15/2014

FILE LOCATION: G:\GIS\148963 - FortisBC Coastal Revisited\Figure D1 Nichol to Port Mann.mxd

FortisBC
Lower Mainland Natural Gas System Updates

Pipeline Detailed Map

Figure D2 Nichol to Port Mann

Legend

Watercourse Crossing
- Class A
- Class B
- Class C
- Class Unknown

- Known Fish Observations
- Site Registry
- Pipeline Alignments
- Watercourses
- Railways
- Roads
- Study Area
- Parks/Natural Areas
- Non-Masked Sensitive Species Occurrence

APEC
- Low Impact Site
- Medium to High Impact Site

Type of Ground Work
- Open Cut
- Trenchless

SCALE 1:10,240

0 25 50 100 Meters

MAP DRAWING INFORMATION:
City of Surrey, City of Vancouver, City of Coquitlam, Province of British Columbia, CanVec, FortisBC, Dillon Created

MAP CREATED BY: ECH
MAP CHECKED BY: LK/TW/BD
MAP PROJECTION: NAD 1983 UTM Zone 10N

PROJECT: 14-8963
STATUS: DRAFT FINAL
DATE: 5/15/2014

FILE LOCATION: G:\GIS\148963 - FortisBC Coastal Revisited\Figure D2 Nichol to Port Mann.mxd

APPENDIX B
SITE REGISTRY

Applehi Cre to King Road (-122.84,49.18)

251 records selected for 5.0 km from latitude 49 deg, 11 min, 0.48 sec
and Longitude 122 deg, 50 min, 24.3 sec

Site Id	Lastupd	Address / City
0000018	12DEC06	10483 152ND STREET SURREY
0000040	12OCT24	13576 KING GEORGE HIGHWAY SURREY
0000049	02JAN31	10210 KING GEORGE HIGHWAY SURREY
0000093	04AUG26	68, 88, 95, & 98 BRIGANTINE DRIVE COQUITLAM
0000139	12SEP13	224 FRONT STREET NEW WESTMINSTER
0000183	10JUL22	430 CANFOR AVENUE NEW WESTMINSTER
0000202	02MAR20	328 CLARKSON STREET & 389 COLUMBIA STREET NEW WESTMINSTER
0000228	04JUL26	7760 SCOTT ROAD SURREY
0000241	04APR19	12602 BRIDGEVIEW SHORE ROAD SURREY
0000257	00NOV23	OLD YALE RD & 128TH STREET SURREY
0000259	04AUG26	2131 HARTLEY AVENUE & 1-100 FAWCETT ROAD COQUITLAM
0000265	98OCT02	12434 - 116TH AVENUE SURREY
0000312	04DEC01	425 CANFOR AVENUE NEW WESTMINSTER
0000403	03JAN27	12816 - 80TH AVENUE SURREY
0000428	01JUL06	12905 80TH AVENUE SURREY
0000434	02APR19	25 CAPILANO WAY NEW WESTMINSTER
0000507	04JUL26	10416 & 10472 SCOTT ROAD SURREY
0000947	05FEB21	141 FRONT STREET NEW WESTMINSTER
0001048	02JAN30	10746 PARTON ROAD SURREY
0001058	06JUL14	9620 120 STREET SURREY
0001059	13APR04	9900 KING GEORGE HIGHWAY SURREY
0001094	02JUN26	7800 ANVIL WAY SURREY
0001096	02APR19	300 MCBRIDE BOULEVARD NEW WESTMINSTER
0001129	03JAN08	8650-124TH STREET SURREY
0001140	03JAN31	13216-104TH AVENUE SURREY

251 records selected for 5.0 km from latitude 49 deg, 11 min, 0.48 sec
and Longitude 122 deg, 50 min, 24.3 sec

Site Id	Lastupd	Address / City
0001155	01AUG30	360 EDWORTHY WAY NEW WESTMINSTER
0001161	03FEB06	8592 148TH STREET SURREY
0001169		12795 KING GEORGE HIGHWAY SURREY
0001174		7531 156TH STREET SURREY
0001195	02APR19	14651 76TH AVENUE SURREY
0001224	04JUN02	129 EAST COLUMBIA STREET NEW WESTMINSTER
0001233	03FEB06	10 SPRUCE STREET NEW WESTMINSTER
0001300	00DEC01	11614 96TH AVENUE DELTA
0001309	11NOV04	10305 KING GEORGE HIGHWAY SURREY
0001323	03FEB07	10663 KING GEORGE HIGHWAY SURREY
0001338	12JUL06	15775 FRASER HIGHWAY SURREY
0001347	06SEP05	210 BRUNETTE AVENUE NEW WESTMINSTER
0001367		13321 76TH AVENUE SURREY
0001391		307 EAST COLUMBIA STREET NEW WESTMINSTER
0001401		12180 75TH AVENUE SURREY
0001426	05AUG16	10035 (& 10045) KING GEORGE HIGHWAY SURREY
0001498	12OCT26	8820 120TH STREET SURREY
0001509	02MAY29	10 SPRUCE STREET NEW WESTMINSTER
0001527	12NOV15	1250 GUILDFORD TOWN CENTRE SURREY
0001535	03FEB07	335 CARNARVON STREET NEW WESTMINSTER
0001540	13MAR04	25 BRAID STREET COQUITLAM
0002206	01JAN26	600-800 FRONT STREET NEW WESTMINSTER
0002354		101 EAST COLUMBIA STREET NEW WESTMINSTER
0002367		525 AGNES STREET NEW WESTMINSTER
0003209	01OCT18	2671-75 N KENT AVE, 2683-89 & 2680/82 BLANCHE ST

Applehi Cre to King Road (-122.84,49.18)
VANCOUVER

251 records selected for 5.0 km from latitude 49 deg, 11 min, 0.48 sec
and Longitude 122 deg, 50 min, 24.3 sec

Site Id	Lastupd	Address / City
0003255	05MAR16	11105 BRIDGE STREET SURREY
0003354	10OCT06	8776-8790 120TH STREET SURREY
0003356	01APR20	13785-104TH AVENUE SURREY
0003499	08OCT20	15180 - 96 AVENUE SURREY
0003591		7981 120 STREET DELTA
0003592	02DEC16	10376 - 152ND STREET SURREY
0003603	03FEB04	11698 140 STREET SURREY
0003618	06APR19	10815 - 132ND STREET SURREY
0003631	03OCT17	15 KING EDWARD COQUITLAM
0003647	04JUL26	11927 TANNERY ROAD SURREY
0003713	00SEP28	104TH AVENUE & 160TH STREET SURREY
0003722	10MAY07	125 COLUMBIA STREET NEW WESTMINSTER
0004072	03OCT09	7631 128 STREET SURREY
0004222	04FEB04	13136 - 84TH AVENUE SURREY
0004314	03OCT10	15211 FRASER HIGHWAY SURREY
0004423	00AUG04	10905 - 120TH STREET SURREY
0004495	01MAY23	8985 120TH STREET DELTA
0004550	07MAY28	8038 AND 8050 KING GEORGE HIGHWAY SURREY
0004628	08SEP11	13479 - 77TH AVENUE SURREY
0004722	09APR09	12294 104TH AVENUE SURREY
0004746	11JAN14	13993 FRASER HIGHWAY SURREY
0004747	02APR12	9625 KING GEORGE HIGHWAY SURREY
0004899	12DEC19	10785 KING GEORGE HIGHWAY SURREY

Applehi Cre to King Road (-122.84,49.18)

0004912	00JUN06	10732 - 128TH STREET SURREY
0005016	01APR20	10284-156TH STREET SURREY

251 records selected for 5.0 km from latitude 49 deg, 11 min, 0.48 sec
and Longitude 122 deg, 50 min, 24.3 sec

Site Id	Lastupd	Address / City
0005128	00MAR17	13120 76TH AVENUE SURREY
0005248	13APR05	12543 OLD YALE ROAD SURREY
0005350	00AUG25	13145 - 80TH AVENUE SURREY
0005366	07JUN08	9585 120 STREET DELTA
0005370	00JAN28	8278 120 STREET SURREY
0005396	04FEB04	8657 - 132ND STREET SURREY
0005397	02MAY23	14811 108TH AVENUE SURREY
0005424	00DEC01	FRONT STREET RIGHT OF WAY NEW WESTMINSTER
0005431	06JAN23	10205 128TH STREET SURREY
0005440	10OCT12	10761 DYKE ROAD SURREY
0005456	04FEB04	13477 116 AVENUE SURREY
0005457	04FEB04	13477 116 AVENUE SURREY
0005494	10OCT07	116 FRONT STREET NEW WESTMINSTER
0005658	02MAY17	11 BURBRIDGE STREET COQUITLAM
0005672	04MAR12	11055 BRIDGE ROAD SURREY
0005699	04FEB05	13477 - 116 AVENUE SURREY
0005707	04OCT18	11675-130TH STREET SURREY
0005708	00FEB10	11675 - 130TH STREET SURREY
0005918	11APR14	8020 128 STREET SURREY
0005986	02JUL04	10132 KING GEORGE HIGHWAY SURREY
0006097	04FEB05	13325 - 76TH AVENUE SURREY
0006114	06MAY19	11940 OLD YALE ROAD

		SURREY
0006366	10NOV11	12120 103A AVENUE
		SURREY
0006399	12NOV26	13590 105TH AVENUE
		SURREY
0006428	04FEB06	9500 120TH STREET
		SURREY

251 records selected for 5.0 km from latitude 49 deg, 11 min, 0.48 sec
and Longitude 122 deg, 50 min, 24.3 sec

Site Id	Lastupd	Address / City
0006470	04FEB06	10164 139 STREET
		SURREY
0006480	02OCT25	12830 96TH AVENUE
		SURREY
0006598	03JAN27	10709 & 10719 DYKE ROAD
		SURREY
0006608	04JUL26	14921 104 AVENUE
		SURREY
0006705	12NOV15	8407 KING GEORGE HIGHWAY
		SURREY
0006740	02AUG15	11732 130 STREET
		SURREY
0006843	01JUL18	12330 88 AVENUE
		SURREY
0006865	09JAN29	9985 GRACE ROAD
		SURREY
0007059		14875 115A AVENUE
		SURREY
0007149	04NOV30	50 COLUMBIA STREET EAST
		NEW WESTMINSTER
0007210	10OCT27	10669-10775 FIR, 12094-12184 OLD YALE, 10645 SCOTT
		SURREY
0007227	02MAY10	15988 FRASER HIGHWAY
		SURREY
0007239	03OCT21	10416 KING GEORGE HIGHWAY
		SURREY
0007487	04JUL26	8717 132 STREET
		SURREY
0007570	10DEC09	13750 96 AVENUE
		SURREY
0007621	05JAN21	13340 76 AVENUE
		SURREY
0007715	04MAY20	8037-8195 120 STREET
		DELTA
0007761	08AUG29	8024 120 STREET
		SURREY
0007774		13670 105 AVENUE
		SURREY
0007783	08APR18	12345/12251 88 AVENUE
		SURREY

Applehi Cre to King Road (-122.84,49.18)

0007808	04APR27	15190 101 AVENUE SURREY
0007811	13APR19	4, 6, 18 SPRUCE ST. AND FOOT OF SPRUCE ST. NEW WESTMINSTER
0007845	13FEB22	9 EAST COLUMBIA STREET NEW WESTMINSTER
0007871	08JAN10	9215 & 9225 120TH STREET DELTA
0007884	02DEC17	15588 FRASER HIGHWAY SURREY

251 records selected for 5.0 km from latitude 49 deg, 11 min, 0.48 sec
and Longitude 122 deg, 50 min, 24.3 sec

Site Id	Lastupd	Address / City
0007900		9062 & 9082 140 STREET SURREY
0007972	03JAN27	FRONT STREET NEW WESTMINSTER
0008274	03OCT30	237 EAST COLUMBIA NEW WESTMINSTER
0008394	10OCT12	14780 - 108TH AVENUE SURREY
0008396	04NOV02	8670 AND 8704 120TH STREET SURREY
0008400	12OCT26	12829 80 AVENUE SURREY
0008413	12DEC06	2 KING EDWARD STREET COQUITLAM
0008464	12NOV27	14815 - 108TH AVENUE SURREY
0008654	04NOV02	12054 - 88TH AVENUE, 8748 & 8768 - 120TH STREET SURREY
0008699	04APR19	11969 TANNERY ROAD SURREY
0008773	09JAN29	8579 - 120TH STREET DELTA
0008923	10NOV10	212 SECOND STREET NEW WESTMINSTER
0008984		8115 - 120 STREET DELTA
0009054	12OCT26	15196 104TH AVENUE SURREY
0009083	10NOV26	101 - 15428 FRASER HIGHWAY SURREY
0009109	04NOV03	2100 UNITED BOULEVARD COQUITLAM
0009115	05JUL13	10230, 10250 GRACE ROAD SURREY
0009125	10APR01	220 ROYAL AVENUE NEW WESTMINSTER
0009154	08FEB29	668 & 700 COLUMBIA STREET AND 703 FRONT STREET

Applehi Cre to King Road (-122.84,49.18)

		NEW WESTMINSTER
0009201	06AUG16	8781-120 STREET
		DELTA
0009211	07NOV21	6TH STREET AND CLARKSON (MULTIPLE ADDRESSES)
		NEW WESTMINSTER
0009220	05MAR24	22 LEEDER AVENUE
		COQUITLAM
0009234	06NOV08	10239, 10299 GRACE ROAD
		SURREY
0009272	05MAR17	13845 96 AVENUE
		SURREY
0009381	05MAY03	8285 123RD STREET
		SURREY

251 records selected for 5.0 km from latitude 49 deg, 11 min, 0.48 sec
and Longitude 122 deg, 50 min, 24.3 sec

Site Id	Lastupd	Address / City
0009404	09FEB04	10435 & 10451 SCOTT ROAD
		SURREY
0009405	09FEB04	10337, 10381, 10415, & 10421 GRACE ROAD
		SURREY
0009406	09FEB04	10395 & 10175 - 120TH STREET
		SURREY
0009408	06SEP06	13295 108 AVENUE & 13291 - 1008A AVENUE
		SURREY
0009546		7812-120TH STREET (SCOTT ROAD)
		SURREY
0009584		9055 160TH STREET
		SURREY
0009717	09FEB04	UNIT 10, 7823 - 132 STREET
		SURREY
0009904		2320 AND 2340 ROGERS AVENUE
		COQUITLAM
0009944	13MAR21	KING GEORGE HIGHWAY
		SURREY
0010007		311 8TH AVENUE
		NEW WESTMINSTER
0010059	07NOV30	530 EAST COLUMBIA STREET
		NEW WESTMINSTER
0010075	09FEB27	12481 OLD YALE ROAD
		SURREY
0010076	07MAR05	12160-88TH AVENUE
		SURREY
0010170	09FEB18	8910 - 120TH STREET
		SURREY
0010196	13APR19	12628-12656 82ND AVENUE
		SURREY
0010229	09FEB05	16139 FRASER HIGHWAY AND 8443 162ND STREET
		SURREY
0010284		12320 - 88TH AVENUE
		SURREY

Applehi Cre to King Road (-122.84,49.18)

0010442	10NOV26	8140 SCOTT ROAD (120TH STREET) SURREY
0010505	13FEB28	9093 KING GEORGE HIGHWAY SURREY
0010570	10DEC23	13552 KING BEORGE HIGHWAY SURREY
0010731		10595 KING GEORGE HIGHWAY SURREY
0010782		9770 KING GEORGE HIGHWAY SURREY
0010811	10APR23	13393 BARKER STREET SURREY
0010954		8994, 9037, 9060 RIVER ROAD DELTA
0010960		10045 - 127TH STREET SURREY

251 records selected for 5.0 km from latitude 49 deg, 11 min, 0.48 sec
and Longitude 122 deg, 50 min, 24.3 sec

Site Id	Lastupd	Address / City
0010972		9388 - 126TH STREET SURREY
0011108	12AUG20	151 SPRUCE STREET NEW WESTMINSTER
0011116		436 EAST COLUMBIA STREET NEW WESTMINSTER
0011126	09JUL16	10355 KING GEORGE HIGHWAY SURREY
0011132		13519 KING GEORGE HIGHWAY SURREY
0011217		2450 UNITED BOULEVARD COQUITLAM
0011276		12430 - 88TH AVENUE SURREY
0011291		9553 - 130A STREET SURREY
0011353		430 COLUMBIA STREET NEW WESTMINSTER
0011383	13FEB06	12187 103A AVENUE SURREY
0011470		8007 KING GEORGE HIGHWAY SURREY
0011502		304 RICHMOND STREET NEW WESTMINSTER
0011550		10306 - 126TH STREET SURREY
0011646		12750 82ND AVENUE SURREY
0011737		11347-137A STREET SURREY
0011745		226 CHURCHILL

Applehi Cre to King Road (-122.84,49.18)

		NEW WESTMINSTER
0011761		12381-103A AVENUE
		SURREY
0011834	10JUL05	10498 KING GEORGE HIGHWAY
		SURREY
0011877		9348 KING GEORGE HIGHWAY
		SURREY
0011917	13MAR27	15016 104TH AVENUE
		SURREY
0011946		15845 96TH AVEUE
		SURREY
0011983		127 3RD STREET
		NEW WESTMINSTER
0011985	10FEB05	116TH STREET NORDEL WAY
		DELTA
0011999	10FEB25	12923- 98TH AVENUE
		SURREY
0012004	10MAY28	5 CAPILANO WAY
		NEW WESTMINSTER

251 records selected for 5.0 km from latitude 49 deg, 11 min, 0.48 sec
and Longitude 122 deg, 50 min, 24.3 sec

Site Id	Lastupd	Address / City
0012043		408 KELLY STREET
		NEW WESTMINSTER
0012052	10APR01	108 COLLEGE COURT
		NEW WESTMINSTER
0012067		10350- 125A STREET
		SURREY
0012077		13966 117TH AVENUE
		SURREY
0012113		13733 AND 13739 92ND AVENUE
		SURREY
0012331		63 MERIVALE STREET
		NEW WESTMINSTER
0012420		341 SHERBROOKE STREET
		NEW WESTMINSTER
0012427		10336 - 125TH STREET
		SURREY
0012430	11APR07	13769 104TH AVENUE
		SURREY
0012485	10SEP16	11450 96A AVENUE
		SURREY
0012506		15083 - 80B AVENUE
		SURREY
0012620	12SEP27	13025 AND 13055 80TH AVENUE
		SURREY
0012646	10DEC03	12656 88TH AVENUE
		SURREY
0012660		12255 KING GEORGE BLVD
		SURREY

Applehi Cre to King Road (-122.84,49.18)

0012725	11OCT14	16016 FRASER HIGHWAY SURREY
0012747	11MAY27	16211 AND 16241 84TH AVENUE SURREY
0012778	11FEB04	12850 87TH AVENUE SURREY
0012810		12881 104TH AVENUE SURREY
0012811	11FEB28	7740 132ND STREET SURREY
0012833		10246 125A STREET SURREY
0012888	11APR20	404 GARRETT STREET NEW WESTMINSTER
0012923	12SEP20	13665 102ND AVENUE SURREY
0013086		12474 PARK DRIVE SURREY
0013154		147 EAST 7TH AVENUE NEW WESTMINSTER
0013155		10216 124TH STREET SURREY

251 records selected for 5.0 km from latitude 49 deg, 11 min, 0.48 sec
and Longitude 122 deg, 50 min, 24.3 sec

Site Id	Lastupd	Address / City
0013201	12JAN20	11410 LOUGHREN DRIVE SURREY
0013375	11OCT01	8247 130TH STREET SURREY
0013390		215 3RD STREET NEW WESTMINSTER
0013405		115 4TH AVENUE NEW WESTMINSTER
0013471		12190 112TH AVENUE AND 11134 BRIDGE ROAD SURREY
0013479		13156 107TH AVENUE SURREY
0013821		11095 BOLIVAR CRESCENT SURREY
0013863		11094 BOLIVAR CRESCENT SURREY
0014039	12DEC06	15105 - 105TH AVENUE AND 10585 - 152ND STREET SURREY
0014049	12JUN04	14875 108A AVENUE SURREY
0014114		13140 - 88TH AVENUE SURREY
0014215		413 SCHOOL STREET NEW WESTMINSTER
0014352		142 EAST DURHAM STREET

Applehi Cre to King Road (-122.84,49.18)

		NEW WESTMINSTER
0014360		902 YORK STREET
		NEW WESTMINSTER
0014435	12OCT10	115A STREET & HWY 1 RIGHT OF WAY
		SURREY
0014529	13MAR18	11142 BOLIVAR CRESCENT
		SURREY
0014594	13APR02	14815 - 108TH AVENUE
		SURREY
0014595	13MAR19	325 EDWORTHY WAY
		NEW WESTMINSTER
0014660	13APR02	108A AVENUE AND LANEWAY NORTH OF 14815 108TH AVE
		SURREY
0014702		103 3RD AVENUE
		NEW WESTMINSTER
0014732	13MAR27	SOUTH FRASER PERIMETER ROAD
		SURREY
0014848		119 FIRST STREET
		NEW WESTMINSTER
0015063		123 EAST DURHAM STREET
		NEW WESTMINSTER
0015098		315 EDWORTHY WAY
		NEW WESTMINSTER
0015118		9806-9900 KING GEORGE BLVD, 13662-13748 FRASER HWY
		SURREY

251 records selected for 5.0 km from latitude 49 deg, 11 min, 0.48 sec
and Longitude 122 deg, 50 min, 24.3 sec

Site Id	Lastupd	Address / City
0015142	13APR15	13577 89TH AVENUE
		SURREY

Como Ave to Rogers (122.85,49.25)

As Of: MAY 12, 2013 BC Online: Site Registry 13/05/16
For: PH45881 WEST COAST TITLE SEARCH LTD. 09:42:54
Folio: Page 1

299 records selected for 5.0 km from latitude 49 deg, 15 min, 14.3 sec
and Longitude 122 deg, 51 min, 1.95 sec

Site Id	Lastupd	Address / City
0000084	12MAY29	1990 COMO LAKE AVENUE COQUITLAM
0000085	11APR28	829 BRUNETTE AVENUE COQUITLAM
0000093	04AUG26	68, 88, 95, & 98 BRIGANTINE DRIVE COQUITLAM
0000100	02JAN31	1189 & 1199 WESTWOOD STREET, 3070 GUILDFORD WAY COQUITLAM
0000140	03FEB12	750 LOUGHEED HIGHWAY COQUITLAM
0000147	13APR25	590 CLARKE ROAD COQUITLAM
0000150	12OCT10	SOUTH SIDE 700 BLOCK MCBRIDE BOULEVARD NEW WESTMINSTER
0000168		502 E COLUMBIA STREET NEW WESTMINSTER
0000183	10JUL22	430 CANFOR AVENUE NEW WESTMINSTER
0000184	03FEB24	100 BRAID STREET NEW WESTMINSTER
0000186		901 FIRST STREET NEW WESTMINSTER
0000241	04APR19	12602 BRIDGEVIEW SHORE ROAD SURREY
0000256	03OCT09	7251 CARIBOO DRIVE BURNABY
0000259	04AUG26	2131 HARTLEY AVENUE & 1-100 FAWCETT ROAD COQUITLAM
0000265	98OCT02	12434 - 116TH AVENUE SURREY
0000272	02MAY29	4193 NORTH ROAD BURNABY
0000306	02APR19	70 COLONY FARM ROAD COQUITLAM
0000312	04DEC01	425 CANFOR AVENUE NEW WESTMINSTER
0000350	07NOV30	1900 COMO LAKE AVENUE COQUITLAM
0000363		2528 ST. JOHN'S STREET PORT MOODY
0000364	97DEC04	2647 AUSTIN AVENUE COQUITLAM
0000377	02MAR22	2525 SHAUGHNESSY STREET PORT COQUITLAM
0000427	03OCT09	715 MCBRIDE BOULEVARD NEW WESTMINSTER
0000429	10OCT20	195 SCHOOLHOUSE STREET COQUITLAM
0000434	02APR19	25 CAPILANO WAY NEW WESTMINSTER

299 records selected for 5.0 km from latitude 49 deg, 15 min, 14.3 sec
and Longitude 122 deg, 51 min, 1.95 sec

Site Id	Lastupd	Address / City
0000448	05MAR23	1340/1350 PIPELINE ROAD COQUITLAM
0000504	02SEP05	960 & 1000 LOUGHEED HIGHWAY COQUITLAM
0001027	03JAN31	SW CORNER LOUGHEED HIGHWAY AND NORTH ROAD BURNABY
0001035	03JAN31	5 - 8TH AVENUE NEW WESTMINSTER
0001041	01FEB28	496 EAST COLUMBIA STREET NEW WESTMINSTER
0001046	03JAN31	901 BRUNETTE STREET COQUITLAM
0001054	02JUN26	1190 PIPELINE ROAD AND 1199 EASTWOOD STREET COQUITLAM
0001079	04DEC01	2300 CLARKE STREET PORT MOODY
0001087	03JAN29	REED POINT WAY PORT MOODY
0001096	02APR19	300 MCBRIDE BOULEVARD NEW WESTMINSTER
0001126	03DEC15	8590 BAXTER PLACE BURNABY
0001132	03FEB06	9951 BARNET HIGHWAY BURNABY
0001135	09JAN16	38 VULCAN STREET NEW WESTMINSTER
0001155	01AUG30	360 EDWORTHY WAY NEW WESTMINSTER
0001162	02MAY17	1400 LOUGHEED HIGHWAY COQUITLAM
0001180		STONEY CREEK BURNABY
0001182	09JAN16	2773 BARNET HIGHWAY COQUITLAM
0001217	02APR19	473-485 EAST COLUMBIA STREET NEW WESTMINSTER
0001221	03JAN31	84 ELECTRONIC AVENUE PORT MOODY
0001224	04JUN02	129 EAST COLUMBIA STREET NEW WESTMINSTER
0001227	03OCT09	24/30 BRAID STREET NEW WESTMINSTER
0001230	05NOV14	2609 SHAUGHNESSY STREET PORT COQUITLAM
0001233	03FEB06	10 SPRUCE STREET NEW WESTMINSTER
0001275	13APR23	942 WESTWOOD STREET COQUITLAM
0001284	03FEB06	217 SCHOOLHOUSE STREET

Como Ave to Rogers (122.85,49.25)
COQUITLAM

299 records selected for 5.0 km from latitude 49 deg, 15 min, 14.3 sec
and Longitude 122 deg, 51 min, 1.95 sec

Site Id	Lastupd	Address / City
0001306	00NOV15	3064 LOUGHEED HIGHWAY COQUITLAM
0001308	02APR25	409/425 BLAIR AVENUE NEW WESTMINSTER
0001347	06SEP05	210 BRUNETTE AVENUE NEW WESTMINSTER
0001372	10SEP30	3140 ST. JOHN'S STREET PORT MOODY
0001377	98SEP30	109 BRAID STREET NEW WESTMINSTER
0001391		307 EAST COLUMBIA STREET NEW WESTMINSTER
0001398	03OCT09	1204 PIPELINE ROAD COQUITLAM
0001434	11JUL21	1695 COMO LAKE ROAD COQUITLAM
0001446	97DEC04	1131 AUSTIN AVENUE COQUITLAM
0001454	00MAR16	909 ALDERSON AVENUE COQUITLAM
0001459	11JUL21	1700 COMO LAKE ROAD COQUITLAM
0001489	10SEP30	435 CANFOR AVENUE NEW WESTMINSTER
0001509	02MAY29	10 SPRUCE STREET NEW WESTMINSTER
0001534	04MAR12	9855 AUSTIN STREET BURNABY
0001540	13MAR04	25 BRAID STREET COQUITLAM
0001542	01APR12	3190 MURRAY STREET PORT MOODY
0001843	03OCT10	2502 ST. JOHN'S STREET PORT MOODY
0002194	12SEP13	1001 BRAID STREET COQUITLAM
0002354		101 EAST COLUMBIA STREET NEW WESTMINSTER
0002840	02DEC10	802 BRUNETTE AVENUE COQUITLAM
0003209	01OCT18	2671-75 N KENT AVE, 2683-89 & 2680/82 BLANCHE ST VANCOUVER
0003248		906-908 RODERICK AVENUE COQUITLAM
0003363	04APR07	815 MCBRIDE BOULEVARD NEW WESTMINSTER

Como Ave to Rogers (122.85,49.25)

0003427	03OCT10	2315 PITT RIVER ROAD PORT COQUITLAM
0003489	03JAN30	2400 - 2580 COLUMBIA STREET PORT MOODY

299 records selected for 5.0 km from latitude 49 deg, 15 min, 14.3 sec
and Longitude 122 deg, 51 min, 1.95 sec

Site Id	Lastupd	Address / City
0003583	12NOV26	85 EIGHTH AVENUE (FORMERLY 21 TO 27 EIGHTH AVENUE) NEW WESTMINSTER
0003597		2380 CAPE HORN COQUITLAM
0003603	03FEB04	11698 140 STREET SURREY
0003622	04OCT13	961 & 1035 LOUGHEED AND 976, 990 ADAIR AVENUE COQUITLAM
0003624	02MAR22	2739 BARNETT HIGHWAY COQUITLAM
0003631	03OCT17	15 KING EDWARD COQUITLAM
0003632	03JAN23	103 IOCO ROAD PORT MOODY
0003658	01MAR22	2649 LOUGHEED HIGHWAY PORT COQUITLAM
0003743	12AUG07	455 BRUNETTE AVENUE NEW WESTMINSTER
0003831	04FEB04	4035 NORTH ROAD BURNABY
0004080	02MAY23	3 - 8TH AVENUE NEW WESTMINSTER
0004227	04AUG13	176 GOLDEN DRIVE COQUITLAM
0004236	10OCT06	225 NORTH ROAD COQUITLAM
0004585	09JAN26	800 MCBRIDE BOULEVARD NEW WESTMINSTER
0004592	04APR01	556 CLARKE ROAD COQUITLAM
0004655	09SEP25	145 GOLDEN DRIVE COQUITLAM
0004743	07JAN04	948 AUSTIN AVENUE COQUITLAM
0004748	09JAN02	70 AND 84 ELECTRONIC AVENUE PORT MOODY
0004827	02SEP18	1960 COMO LAKE AVENUE COQUITLAM
0004831	13FEB15	2590 BARNETT HIGHWAY COQUITLAM
0004925	01NOV16	435 BRUNETTE AVENUE NEW WESTMINSTER
0004929	04FEB04	2664 KINGSWAY AVENUE

Como Ave to Rogers (122.85,49.25)

		PORT COQUITLAM
0004949	06MAR08	3275 MURRAY STREET PORT MOODY
0005100	02MAY10	1099 LANSDOWNE DRIVE COQUITLAM
0005165	04NOV30	2706 ST. JOHNS STREET PORT MOODY

299 records selected for 5.0 km from latitude 49 deg, 15 min, 14.3 sec
and Longitude 122 deg, 51 min, 1.95 sec

Site Id	Lastupd	Address / City
0005232	02MAY17	333 NORTH ROAD COQUITLAM
0005297	00MAR17	1111 BRUNETTE AVENUE COQUITLAM
0005361	03FEB26	3105 MURRAY STREET PORT MOODY
0005456	04FEB04	13477 116 AVENUE SURREY
0005457	04FEB04	13477 116 AVENUE SURREY
0005563	02SEP09	1707 AUSTIN AVENUE COQUITLAM
0005566	03OCT10	522 6TH STREET NEW WESTMINSTER
0005658	02MAY17	11 BURBRIDGE STREET COQUITLAM
0005699	04FEB05	13477 - 116 AVENUE SURREY
0005707	04OCT18	11675-130TH STREET SURREY
0005708	00FEB10	11675 - 130TH STREET SURREY
0005794	04OCT21	8699 10TH AVENUE BURNABY
0005795	12DEC03	2643, 2659, 2665, 2669 BEDFORD STREET PORT COQUITLAM
0006210	04FEB09	960 LILLIAN STREET COQUITLAM
0006293	13APR11	1029 AUSTIN AVENUE COQUITLAM
0006401	13FEB15	175 SCHOOLHOUSE STREET COQUITLAM
0006471	04FEB06	3170 ST. JOHN'S STREET PORT MOODY
0006618	13FEB06	955 AUSTIN AVENUE COQUITLAM
0006740	02AUG15	11732 130 STREET SURREY
0006875	02JUL04	3100 PRODUCTION WAY BURNABY

Como Ave to Rogers (122.85,49.25)

0006989		GOVERNMENT STREET BURNABY
0007042	04NOV30	100 WOOLRIDGE STREET COQUITLAM
0007059		14875 115A AVENUE SURREY
0007149	04NOV30	50 COLUMBIA STREET EAST NEW WESTMINSTER
0007233	06APR10	900 BLOCK OF BRUNETTE AVEUNUE COQUITLAM

299 records selected for 5.0 km from latitude 49 deg, 15 min, 14.3 sec
and Longitude 122 deg, 51 min, 1.95 sec

Site Id	Lastupd	Address / City
0007250	02JUL11	2929 BARNET HIGHWAY PORT COQUITLAM
0007317	04AUG13	945 BRUNETTE AVENUE COQUITLAM
0007383	13MAR06	526 TO 572 CLARKE ROAD COQUITLAM
0007640	02FEB13	8411 LOUGHEED HIGHWAY BURNABY
0007711		929 BRUNETTE AVENUE COQUITLAM
0007726	04FEB06	6741 CARIBOO ROAD BURNABY
0007780	04FEB09	140 GLACIER STREET COQUITLAM
0007811	13APR19	4, 6, 18 SPRUCE ST. AND FOOT OF SPRUCE ST. NEW WESTMINSTER
0007829	10SEP23	8-10 KING EDWARD STREET COQUITLAM
0007839	10JUN10	50 ELECTRONIC AVENUE PORT MOODY
0007845	13FEB22	9 EAST COLUMBIA STREET NEW WESTMINSTER
0007958	09OCT23	50 DOUGLAS STREET PORT MOODY
0007994	02OCT30	1335 PINETREE WAY COQUITLAM
0008102		3150 ST. JOHNS STREET PORT MOODY
0008218	10MAY07	858 WESTWOOD STREET COQUITLAM
0008274	03OCT30	237 EAST COLUMBIA NEW WESTMINSTER
0008413	12DEC06	2 KING EDWARD STREET COQUITLAM
0008417	04NOV23	3075 PATHAN AVENUE COQUITLAM
0008583	04FEB25	74 GLACIER STREET

Como Ave to Rogers (122.85,49.25)

		COQUITLAM
0008728		9288 CAMERON STREET
		BURNABY
0008730		9444 CAMERON STREET
		BURNABY
0008735	13APR03	78 GLACIER STREET
		COQUITLAM
0008831		7785 LEE STREET
		BURNABY
0008923	10NOV10	212 SECOND STREET
		NEW WESTMINSTER
0008968	04MAY21	11 BRAID STREET
		NEW WESTMINSTER

299 records selected for 5.0 km from latitude 49 deg, 15 min, 14.3 sec
and Longitude 122 deg, 51 min, 1.95 sec

Site Id	Lastupd	Address / City
0008971	10OCT01	2400 BARNET HIGHWAY
		PORT MOODY
0008993	05MAY02	3051 LOUGHEED HIGHWAY
		COQUITLAM
0009109	04NOV03	2100 UNITED BOULEVARD
		COQUITLAM
0009171	04NOV26	832 CHILLIWACK STREET
		NEW WESTMINSTER
0009220	05MAR24	22 LEEDER AVENUE
		COQUITLAM
0009230	05OCT19	465 BRUNETTE
		NEW WESTMINSTER
0009337		2710 LOUGHEED HIGHWAY
		PORT COQUITLAM
0009352	05APR12	3646 WESTWOOD STREET
		PORT COQUITLAM
0009445	07MAR05	130 IOCO ROAD
		PORT MOODY
0009576		417 FOURTH STREET
		NEW WESTMINSTER
0009775	12SEP11	411-419 EAST COLUMBIA STREET
		VANCOUVER
0009858	06JUL20	950 BRUNETTE AVENUE
		COQUITLAM
0009868	13APR05	545 GARFIELD STREET
		NEW WESTMINSTER
0009890	08MAR28	2102 ST. JOHNS STREET
		PORT MOODY
0009955		831 BARNET HIGHWAY
		PORT MOODY
0009962	07NOV30	916 BARBER STREET
		PORT MOODY
0009966	07NOV30	428 BLAIR AVENUE
		NEW WESTMINSTER

Como Ave to Rogers (122.85,49.25)

0010000	09FEB12	3495 NORTH ROAD BURNABY
0010005		3001 ST. JOHNS STREET PORT MOODY
0010007		311 8TH AVENUE NEW WESTMINSTER
0010059	07NOV30	530 EAST COLUMBIA STREET NEW WESTMINSTER
0010163	08SEP11	905 CLARK ROAD PORT MOODY
0010354		3097 SPURAWAY AVENUE COQUITLAM
0010386		2567 LOUGHEED HIGHWAY PORT COQUITLAM
0010486		7894 CARIBOO ROAD BURNABY

299 records selected for 5.0 km from latitude 49 deg, 15 min, 14.3 sec
and Longitude 122 deg, 51 min, 1.95 sec

Site Id	Lastupd	Address / City
0010579	08MAR28	2573 RUNNEL DRIVE COQUITLAM
0010593		925 BURNABY ST NEW WESTMINSTER BC NEW WESTMINSTER
0010609		3221 ST. JOHNS STREET PORT MOODY
0010636	09JAN13	3540 WESTWOOD STREET PORT COQUITLAM
0010684		205 OSBORNE AVENUE NEW WESTMINSTER
0010693	08MAR14	837 LOUGHEED HIGHWAY COQUITLAM
0010751		440 SIXTH STREET NEW WESTMINSTER
0010806		306 - 7TH AVENUE NEW WESTMINSTER
0010830	08MAY30	2660 KINGSWAY AVENUE PORT COQUITLAM
0010840	08MAY30	331 HOLMES STREET NEW WESTMINSTER
0010865	08MAY09	909 LADNER STREET NEW WESTMINSTER
0010902	10APR16	2601 LOUGHEED HIGHWAY COQUITLAM
0010976		3088 SPURAWAY AVENUE COQUITLAM
0011091		2520 DAVIES AVENUE PORT COQUITLAM
0011108	12AUG20	151 SPRUCE STREET NEW WESTMINSTER
0011217		2450 UNITED BOULEVARD

Como Ave to Rogers (122.85,49.25)

		COQUITLAM
0011222		819 CHERRY STREET
		NEW WESTMINSTER
0011324		453 FADER STREET
		NEW WESTMINSTER
0011335	12OCT26	CANADIAN PACIFIC RAILWAY RIGHT-OF-WAY ADJACENT TO
		PORT MOODY
0011346		2625 MURRAY STREET
		PORT MOODY
0011397		587 HARRISON AVENUE
		COQUITLAM
0011406		8594 / 96 - 11TH AVENUE
		BURNABY
0011412		9387 HOLMES STREET
		BURNABY
0011502		304 RICHMOND STREET
		NEW WESTMINSTER
0011556	12SEP27	955 WALLS AVENUE
		COQUITLAM

299 records selected for 5.0 km from latitude 49 deg, 15 min, 14.3 sec
and Longitude 122 deg, 51 min, 1.95 sec

Site Id	Lastupd	Address / City
0011558		468 KELLY STREET
		NEW WESTMINSTER
0011594		216 LE BLEU STREET
		COQUITLAM
0011609		627 IOCO ROAD & 622 FOREST HILL PLACE
		PORT MOODY
0011654		819 SURREY STREET
		NEW WESTMINSTER
0011729		810 BURNABY STREET
		NEW WESTMINSTER
0011735		8704 CREST DRIVE
		BURNABY
0011745		226 CHURCHILL
		NEW WESTMINSTER
0011856	09OCT23	507 WILSON STREET
		NEW WESTMINSTER
0011875	09OCT23	#5 - 1615 SHAUGHNESSY STREET
		PORT COQUITLAM
0011891		640 ASPEN STREET
		COQUITLAM
0011944		177 WEST BRAEMAR
		NORTH VANCOUVER
0011957		8315 13TH AVENUE
		BURNABY
0012004	10MAY28	5 CAPILANO WAY
		NEW WESTMINSTER
0012043		408 KELLY STREET
		NEW WESTMINSTER

Como Ave to Rogers (122.85,49.25)

0012052	10APR01	108 COLLEGE COURT NEW WESTMINSTER
0012055		559 APPIAN WAY COQUITLAM
0012077		13966 117TH AVENUE SURREY
0012150		806 THERMAL DRIVE COQUITLAM
0012157		2505 LOUGHEED HIGHWAY PORT COQUITLAM
0012176		910 CHILLIWACK STREET NEW WESTMINSTER
0012185		8560 KARRMAN AVENUE BURNABY
0012264		405 4TH AVENUE NEW WESTMINSTER
0012278		8395 13TH AVENUE BURNABY
0012288	11MAR24	748 DOGWOOD STREET COQUITLAM
0012307		532 5TH STREET NEW WESTMINSTER

299 records selected for 5.0 km from latitude 49 deg, 15 min, 14.3 sec
and Longitude 122 deg, 51 min, 1.95 sec

Site Id	Lastupd	Address / City
0012334		1701 LOUGHEED HIGHWAY COQUITLAM
0012410		8338 12TH AVENUE BURNABY
0012420		341 SHERBROOKE STREET NEW WESTMINSTER
0012468		607 ALDERSON AVENUE COQUITLAM
0012469		140 EAST 10TH AVENUE NEW WESTMINSTER
0012515		1212 RIDGE COURT COQUITLAM
0012525		UNITED BLVD & KING EDWARD ST VANCOUVER
0012547		610 AUSTIN STREET COQUITLAM
0012583		8450 11TH AVENUE BURNABY
0012585		831 BURNABY STREET NEW WESTMINSTER
0012648	11NOV25	604 & 606 COMO LAKE AVENUE COQUITLAM
0012653		89 GLOVER AVENUE NEW WESTMINSTER
0012658	12SEP14	8659 12TH AVENUE

Como Ave to Rogers (122.85,49.25)

		BURNABY
0012676		302 EAST 10TH AVENUE
		NEW WESTMINSTER
0012751		566 BROOKMERE AVENUE
		COQUITLAM
0012796	11APR04	1033 AUSTIN AVENUE
		COQUITLAM
0012874		115 GLOVER AVENUE
		NEW WESTMINSTER
0012888	11APR20	404 GARRETT STREET
		NEW WESTMINSTER
0012907	11MAY16	1090 LOUGHEED HIGHWAY
		COQUITLAM
0012916		855 ROCHESTER AVENUE
		COQUITLAM
0012922	12NOV26	9850 AUSTIN RD., 9858 & 9898 GATINEAU PL.
		BURNABY
0012950		8659 10TH AVENUE
		BURNABY
0013019		1207 BARTLETT AVENUE
		COQUITLAM
0013099	12AUG20	603 CLARKE ROAD
		COQUITLAM
0013154		147 EAST 7TH AVENUE
		NEW WESTMINSTER

299 records selected for 5.0 km from latitude 49 deg, 15 min, 14.3 sec
and Longitude 122 deg, 51 min, 1.95 sec

Site Id	Lastupd	Address / City
0013193		647 IOCO ROAD
		PORT MOODY
0013201	12JAN20	11410 LOUGHREN DRIVE
		SURREY
0013210		8731 CREST DRIVE
		BURNABY
0013211		236 4TH AVENUE
		NEW WESTMINSTER
0013313		8623 11TH AVENUE
		BURNABY
0013317		957 SADDLE STREET
		COQUITLAM
0013338		548 COCHRANE AVENUE
		COQUITLAM
0013390		215 3RD STREET
		NEW WESTMINSTER
0013405		115 4TH AVENUE
		NEW WESTMINSTER
0013411		530 DELESTRE AVENUE
		COQUITLAM
0013430	12AUG29	581 CLARKE ROAD
		COQUITLAM

Como Ave to Rogers (122.85,49.25)

0013433		328 4TH STREET NEW WESTMINSTER
0013442		8636 11TH AVENUE BURNABY
0013468	12APR05	41 OVENS AVENUE NEW WESTMINSTER
0013482		961 SADDLE STREET COQUITLAM
0013485		394 BLUE MOUNTAIN STREET COQUITLAM
0013492		456 WALKER STREET COQUITLAM
0013520		UNITED BOULEVARD NEAR THE INTERSECTION OF COQUITLAM
0013574	11DEC12	2713- 2725 CLARKE STREET PORT MOODY
0013663		2909 WOODSTONE COURT COQUITLAM
0013673	12JAN23	608 & 610 COMO LAKE AVENUE COQUITLAM
0013701		2663 DELAHAYE DRIVE COQUITLAM
0013829	12OCT25	SIMON FRASER UNIVERSITY -SOUTH CAMPUS RD BURNABY
0013837		310 3RD AVENUE NEW WESTMINSTER
0013950		7872 CARIBOO ROAD BURNABY

299 records selected for 5.0 km from latitude 49 deg, 15 min, 14.3 sec
and Longitude 122 deg, 51 min, 1.95 sec

Site Id	Lastupd	Address / City
0014030		549 BROOKMERE AVENUE COQUITLAM
0014049	12JUN04	14875 108A AVENUE SURREY
0014215		413 SCHOOL STREET NEW WESTMINSTER
0014352		142 EAST DURHAM STREET NEW WESTMINSTER
0014360		902 YORK STREET NEW WESTMINSTER
0014379	13APR11	8659 11TH AVENUE BURNABY
0014408	12OCT10	617 SMITH AVENUE COQUITLAM
0014435	12OCT10	115A STREET & HWY 1 RIGHT OF WAY SURREY
0014471		727 2ND STREET NEW WESTMINSTER
0014479	12NOV05	GLOVER AVENUE AND COLBORNE STREET

Como Ave to Rogers (122.85,49.25)

		NEW WESTMINSTER
0014488		8554 11TH AVENUE
		BURNABY
0014514		2280 ATKINS AVENUE
		PORT COQUITLAM
0014526	13JAN25	945, 951, 953, 959 CHARLAND AVENUE
		COQUITLAM
0014573		113 WINDSOR DRIVE
		PORT MOODY
0014595	13MAR19	325 EDWORTHY WAY
		NEW WESTMINSTER
0014702		103 3RD AVENUE
		NEW WESTMINSTER
0014732	13MAR27	SOUTH FRASER PERIMETER ROAD
		SURREY
0014751		600 SYDNEY AVENUE
		COQUITLAM
0014848		119 FIRST STREET
		NEW WESTMINSTER
0015063		123 EAST DURHAM STREET
		NEW WESTMINSTER
0015066		684 PORTER STREET
		COQUITLAM
0015098		315 EDWORTHY WAY
		NEW WESTMINSTER
0015139		3090 WESTWOOD STREET
		PORT COQUITLAM
0015216		8623 12TH AVENUE
		BURNABY

Como Lake Avenue to 2nd Avenue (-122.9, 49.26)

447 records selected for 5.0 km from latitude 49 deg, 15 min, 57.4 sec
and Longitude 122 deg, 57 min, 19.2 sec

Site Id	Lastupd	Address / City
0000069	01NOV16	1735 BOUNDARY ROAD VANCOUVER
0000095	02DEC02	2400 BOUNDARY ROAD BURNABY
0000102	10NOV26	3777 LOUGHEED HIGHWAY BURNABY
0000147	13APR25	590 CLARKE ROAD COQUITLAM
0000168		502 E COLUMBIA STREET NEW WESTMINSTER
0000186		901 FIRST STREET NEW WESTMINSTER
0000212	05FEB03	8888 UNIVERSITY DRIVE BURNABY
0000224	97NOV14	3050 NORLAND AVENUE BURNABY
0000226	12JUN25	100 AMHERST AVENUE NORTH VANCOUVER
0000256	03OCT09	7251 CARIBOO DRIVE BURNABY
0000268	03OCT09	OAKMOUNT CRESCENT AND OAKDALE ROAD BURNABY
0000272	02MAY29	4193 NORTH ROAD BURNABY
0000314	11OCT06	4451 STILL CREEK DRIVE BURNABY
0000319	13APR25	2060 ROSSER AVENUE BURNABY
0000347	04OCT12	5060 CANADA WAY BURNABY
0000379	03JAN29	5151 CANADA WAY BURNABY
0000411	04AUG03	7477 6TH STREET AND 7874 17TH AVENUE BURNABY
0000419	11DEC08	2555 GILMORE AVENUE BURNABY
0000425	02APR19	5850 SUNSET STREET BURNABY
0000426	02APR19	1950 BELLWOOD AVENUE BURNABY
0000427	03OCT09	715 MCBRIDE BOULEVARD NEW WESTMINSTER
0000433	04MAR12	489 NORTH DOLLARTON HIGHWAY NORTH VANCOUVER
0000441	06NOV09	975 WILLINGDON AVENUE BURNABY
0000442	12APR27	4301 EAST HASTINGS STREET BURNABY
0000954		3695 GRANDVIEW HWY & 2755 BOUNDARY ROAD VANCOUVER

447 records selected for 5.0 km from latitude 49 deg, 15 min, 57.4 sec
and Longitude 122 deg, 57 min, 19.2 sec

Site Id	Lastupd	Address / City
0001021	06AUG15	3101 AND 3001 WAYBURNE DRIVE BURNABY
0001027	03JAN31	SW CORNER LOUGHEED HIGHWAY AND NORTH ROAD BURNABY
0001035	03JAN31	5 - 8TH AVENUE NEW WESTMINSTER
0001036	01JUL06	NORTH END ROSSER STREET BURNABY
0001041	01FEB28	496 EAST COLUMBIA STREET NEW WESTMINSTER
0001075	03JAN31	4642, 4536, 4510 STILL CREEK AVENUE BURNABY
0001097	02APR19	2475 DOUGLAS ROAD BURNABY
0001126	03DEC15	8590 BAXTER PLACE BURNABY
0001132	03FEB06	9951 BARNET HIGHWAY BURNABY
0001141	03FEB06	5698 EAST HASTINGS STREET BURNABY
0001154	13FEB26	7000 / 7018 / 7090 LOUGHEED HIGHWAY & BURNABY
0001180		STONEY CREEK BURNABY
0001183	09JAN16	201 KENSINGTON AVENUE BURNABY
0001204	02JAN31	6913 WINSTON STREET BURNABY
0001217	02APR19	473-485 EAST COLUMBIA STREET NEW WESTMINSTER
0001224	04JUN02	129 EAST COLUMBIA STREET NEW WESTMINSTER
0001233	03FEB06	10 SPRUCE STREET NEW WESTMINSTER
0001234	01JAN26	3945 MYRTLE STREET BURNABY
0001242	12JUN08	100 FORESTER STREET NORTH VANCOUVER
0001304	03FEB06	1001 DELTA AVENUE BURNABY
0001308	02APR25	409/425 BLAIR AVENUE NEW WESTMINSTER
0001318		6950 EAST HASTINGS STREET BURNABY
0001331	10SEP30	6230 AND 6284 DARNLEY STREET BURNABY
0001333	06MAR24	4805 & 4823 EAST HASTINGS STREET BURNABY
0001337	03JAN31	4505 CANADA WAY

Como Lake Avenue to 2nd Avenue (-122.9, 49.26)
BURNABY

447 records selected for 5.0 km from latitude 49 deg, 15 min, 57.4 sec
and Longitude 122 deg, 57 min, 19.2 sec

Site Id	Lastupd	Address / City
0001347	06SEP05	210 BRUNETTE AVENUE NEW WESTMINSTER
0001359	01NOV16	3791 KINGSWAY HIGHWAY BURNABY
0001377	98SEP30	109 BRAID STREET NEW WESTMINSTER
0001391		307 EAST COLUMBIA STREET NEW WESTMINSTER
0001400		6580 THOMAS STREET BURNABY
0001402		2830 NORLAND AVENUE BURNABY
0001421	02FEB13	SITE 21 LANDFILL - DEER LAKE PARK BURNABY
0001436	12JUN22	4450 STILL CREEK DRIVE BURNABY
0001439	03FEB07	94 RIVERSIDE DRIVE NORTH VANCOUVER
0001441	04JUL08	7320 CANADA WAY BURNABY
0001447	02MAY10	3951 UNDERHILL AVENUE BURNABY
0001449	01MAY22	3650 LOUGHEED HIGHWAY VANCOUVER
0001483		2155 ROSSER STREET BURNABY
0001500	12NOV15	2011 DOLLARTON HIGHWAY NORTH VANCOUVER
0001501	13JAN25	7089 LOUGHEED HIGHWAY BURNABY
0001509	02MAY29	10 SPRUCE STREET NEW WESTMINSTER
0001534	04MAR12	9855 AUSTIN STREET BURNABY
0002091	03JAN31	3975 MYRTLE STREET BURNABY
0002220	02FEB13	5590 GORING STREET BURNABY
0002390		6450 DEER LAKE AVENUE BURNABY
0002391	07JUN08	3876 SMITH AVENUE BURNABY
0002763	03FEB21	4888 STILL CREEK AVENUE BURNABY
0003079	04APR06	4507 EAST HASTINGS STREET BURNABY

Como Lake Avenue to 2nd Avenue (-122.9, 49.26)

0003249	01DEC19	4203 HASTINGS STREET BURNABY
0003292	03OCT09	4265 LOUGHEED HIGHWAY BURNABY

447 records selected for 5.0 km from latitude 49 deg, 15 min, 57.4 sec
and Longitude 122 deg, 57 min, 19.2 sec

Site Id	Lastupd	Address / City
0003325	00MAR17	4755 KINGSWAY AVENUE BURNABY
0003363	04APR07	815 MCBRIDE BOULEVARD NEW WESTMINSTER
0003365	10JUN10	3826 CANADA WAY BURNABY
0003382	10OCT06	2400 BOUNDARY ROAD BURNABY
0003412	12OCT09	3919 DOLLARTON HIGHWAY NORTH VANCOUVER
0003445		CATES PARK NORTH VANCOUVER
0003448	06JUL17	5955 KINGSWAY BURNABY
0003491	09JAN26	4472 EAST HASTINGS STREET BURNABY
0003504	05JAN21	4363 EAST HASTINGS STREET VANCOUVER
0003578	98FEB04	5775 KINGSWAY BURNABY
0003583	12NOV26	85 EIGHTH AVENUE (FORMERLY 21 TO 27 EIGHTH AVENUE) NEW WESTMINSTER
0003588		5549 KINGSWAY BURNABY
0003594		4890 EAST HASTINGS BURNABY
0003613	09SEP25	IOCO ROAD PORT MOODY
0003726	13APR25	4490 LOUGHEED HIGHWAY BURNABY
0003825	04AUG13	326 SEA SHELL LANE NORTH VANCOUVER
0003831	04FEB04	4035 NORTH ROAD BURNABY
0003878	02MAR22	4705 - 4709 HASTINGS STREET BURNABY
0003958	12OCT26	4515 LOUGHEED HIGHWAY BURNABY
0004000	04AUG13	4530/4532 KINGSWAY BURNABY
0004030	04FEB04	3600 GILMORE WAY BURNABY
0004080	02MAY23	3 - 8TH AVENUE

Como Lake Avenue to 2nd Avenue (-122.9, 49.26)

		NEW WESTMINSTER
0004145	13APR04	6500-6626 HASTINGS STREET
		BURNABY
0004214	09JAN26	4242 PHILLIPS AVENUE
		BURNABY
0004219	04OCT18	4550 LOUGHEED HIGHWAY
		BURNABY

447 records selected for 5.0 km from latitude 49 deg, 15 min, 57.4 sec
and Longitude 122 deg, 57 min, 19.2 sec

Site Id	Lastupd	Address / City
0004236	10OCT06	225 NORTH ROAD
		COQUITLAM
0004315	04MAR08	1409 SPERLING AVENUE
		BURNABY
0004321	12SEP12	1967/1969 WILLINGDON AVENUE
		BURNABY
0004345	10OCT06	2338 GILMORE AVENUE
		BURNABY
0004387	05AUG22	200 BRIDGE STREET
		NORTH VANCOUVER
0004585	09JAN26	800 MCBRIDE BOULEVARD
		NEW WESTMINSTER
0004592	04APR01	556 CLARKE ROAD
		COQUITLAM
0004620	10APR16	2102 OLD DOLLARTON ROAD
		NORTH VANCOUVER
0004677	03OCT10	4177 KINGSWAY
		BURNABY
0004766	03OCT17	4401 STILL CREEK DRIVE
		BURNABY
0004842	08JAN10	4444 KINGSWAY
		BURNABY
0004884	09JAN27	7880 18TH AVENUE & 7417 6TH STREET
		BURNABY
0004923	05JAN11	4132, 4150, 4196 HALIFAX STREET
		BURNABY
0004942	10JUL22	8242, 8530, 8550 BARNET HIGHWAY
		BURNABY
0005033	03FEB26	4129 LOZELLS AVENUE
		BURNABY
0005096	01DEC19	3857 1ST AVENUE
		BURNABY
0005125	05JAN07	7118 & 7128 LOUGHEED HIGHWAY
		BURNABY
0005134	13MAY02	4295 EAST HASTINGS
		VANCOUVER
0005203	04FEB04	4553 KINGSWAY
		BURNABY
0005232	02MAY17	333 NORTH ROAD
		COQUITLAM

Como Lake Avenue to 2nd Avenue (-122.9, 49.26)

0005364	06JUL18	4509 KINGSWAY BURNABY
0005488	04APR27	4512 LOUGHEED HIGHWAY BURNABY
0005530	11DEC22	2685 GILMORE AVENUE BURNABY
0005597	04FEB05	3700 WILLINGDON AVENUE BURNABY
0005660	04FEB05	3367 NORLAND AVENUE BURNABY

447 records selected for 5.0 km from latitude 49 deg, 15 min, 57.4 sec
and Longitude 122 deg, 57 min, 19.2 sec

Site Id	Lastupd	Address / City
0005715	99OCT22	4315 AND 4343 LOUGHEED HIGHWAY BURNABY
0005794	04OCT21	8699 10TH AVENUE BURNABY
0005805	13APR11	194 RIVERSIDE DRIVE NORTH VANCOUVER
0005808	04OCT21	6830 WAVERLEY AVENUE BURNABY
0005826	04FEB05	4705 KINGSWAY BURNABY
0005888	00JUL07	4005 SECOND AVENUE BURNABY
0005944	05JAN26	5695 LOUGHEED HIGHWAY BURNABY
0005951	01OCT05	6081 EAST HASTINGS STREET BURNABY
0005971	12JUN22	7885 VENTURE STREET BURNABY
0005984	09APR09	BURNABY LAKE BURNABY
0005996	04OCT21	3450 EAST HASTINGS STREET VANCOUVER
0006034	12OCT11	5608 KINGSWAY BURNABY
0006052	04FEB05	6869 CANADA WAY BURNABY
0006191	04FEB05	75 RIVERSIDE DRIVE NORTH VANCOUVER
0006244	12MAR23	4880 BENNETT STREET (WAS 4860 BENNETT STREET) BURNABY
0006359	04FEB05	3766 EAST 1ST AVENUE BURNABY
0006402	04FEB06	4500 CANADA WAY BURNABY
0006417	04FEB06	3720 IMPERIAL STREET (SE CORNER) BURNABY
0006440	04FEB06	2889 NORLAND AVENUE

Como Lake Avenue to 2nd Avenue (-122.9, 49.26)

		BURNABY
0006502	12NOV26	2151 FRONT STREET NORTH VANCOUVER
0006534	05APR19	2337 DOLLARTON ROAD NORTH VANCOUVER
0006573	09JAN12	6755 CANADA WAY BURNABY
0006581	07SEP12	5708 KINGSWAY BURNABY
0006658	04FEB06	2820 UNDERHILL AVENUE BURNABY
0006735	02JUN26	4120, 4160, 4170 LOUGHEED HIGHWAY BURNABY

447 records selected for 5.0 km from latitude 49 deg, 15 min, 57.4 sec
and Longitude 122 deg, 57 min, 19.2 sec

Site Id	Lastupd	Address / City
0006762	00SEP15	4201 LOZELLS AVENUE BURNABY
0006768	02DEC17	5059 CANADA WAY BURNABY
0006814		3010 NORLAND AVENUE BURNABY
0006875	02JUL04	3100 PRODUCTION WAY BURNABY
0006946	00NOV23	WILLINGDON AVENUE & LOUGHEED HIGHWAY BURNABY
0006989		GOVERNMENT STREET BURNABY
0007090	01FEB22	1502 BOUNDARY ROAD BURNABY
0007094	09FEB27	2999 UNDERHILL AVENUE BURNABY
0007114	04FEB06	6000 & 6150 LOUGHEED HIGHWAY BURNABY
0007143		3845-3847 KINGSWAY BURNABY
0007277		NORTH OF 6 STREET BETWEEN MAYFIELD AND BERKLEY BURNABY
0007293	05JAN26	4349 DAWSON STREET BURNABY
0007296	12OCT26	4051 LOUGHEED HIGHWAY BURNABY
0007350	03JAN27	4950 IMPERIAL STREET BURNABY
0007375	05AUG31	4336 LOUGHEED HIGHWAY & 2151 ROSSER AVENUE BURNABY
0007383	13MAR06	526 TO 572 CLARKE ROAD COQUITLAM
0007406	05MAR17	2849 NORLAND AVENUE BURNABY

Como Lake Avenue to 2nd Avenue (-122.9, 49.26)

0007572		8335 EASTLAKE DRIVE BURNABY
0007640	02FEB13	8411 LOUGHEED HIGHWAY BURNABY
0007681	13MAR27	6876 ROYAL OAK AVENUE BURNABY
0007726	04FEB06	6741 CARIBOO ROAD BURNABY
0007762	12SEP14	3664 & 3696 CORNETT ROAD VANCOUVER
0007811	13APR19	4, 6, 18 SPRUCE ST. AND FOOT OF SPRUCE ST. NEW WESTMINSTER
0007968	04AUG03	4440 EAST HASTINGS AND 4485 PENDER STREET BURNABY
0008044	03SEP23	5298 STILL CREEK AVENUE BURNABY

447 records selected for 5.0 km from latitude 49 deg, 15 min, 57.4 sec
and Longitude 122 deg, 57 min, 19.2 sec

Site Id	Lastupd	Address / City
0008153	03OCT21	5750 LOUGHEED HIGHWAY BURNABY
0008176	05JAN11	5650 LOUGHEED HIGHWAY BURNABY
0008248		7120-7180 PANDORA STREET BURNABY
0008274	03OCT30	237 EAST COLUMBIA NEW WESTMINSTER
0008277	05SEP19	4140 DAWSON STREET BURNABY
0008289		2916 NORLAND AVENUE BURNABY
0008364	04APR19	100 BLOCK OF WILLINGDON AVENUE BURNABY
0008503	12SEP28	2549, 2650 BETA AVENUE & 4855 STILL CREEK AVENUE BURNABY
0008577	04NOV30	6911 SALISBURY AVENUE BURNABY
0008589	04FEB19	5735 DORSET STREET BURNABY
0008685	05NOV04	3191 THUNDERBIRD CRESCENT BURNABY
0008728		9288 CAMERON STREET BURNABY
0008730		9444 CAMERON STREET BURNABY
0008831		7785 LEE STREET BURNABY
0008857	04JUN21	7710, 7760 AUBREY & 7741 KITCHENER STREET BURNABY
0008873	12MAR29	130 FORESTER STREET

Como Lake Avenue to 2nd Avenue (-122.9, 49.26)

		NORTH VANCOUVER
0008877	05JAN25	DOLLARTON HWY
		NORTH VANCOUVER
0008952	05SEP01	4180 DAWSON STREET
		BURNABY
0008959	04MAY26	4644 BRENTLAWN DRIVE
		BURNABY
0008966		3183 NORLAND AVENUE
		BURNABY
0008990	08DEC16	7009 EAST HASTINGS STREET
		BURNABY
0009020	05JUL26	2345 & 2355 MADISON AVENUE
		BURNABY
0009070		2280 - 2290 HOLDOM AVENUE
		BURNABY
0009101		5965 KINGSWAY AVENUE
		BURNABY
0009129	05SEP07	2150 BETA AVENUE
		BURNABY

447 records selected for 5.0 km from latitude 49 deg, 15 min, 57.4 sec
and Longitude 122 deg, 57 min, 19.2 sec

Site Id	Lastupd	Address / City
0009171	04NOV26	832 CHILLIWACK STREET
		NEW WESTMINSTER
0009176	04DEC03	3856 SUNSET STREET
		BURNABY
0009219	09JAN29	4789, 4805 & 4841 KINGSWAY; 6243 & 6255 MILLER AVE
		BURNABY
0009282		3807 HASTINGS STREET
		BURNABY
0009468	05NOV07	PORTIONS OF MADISON AVE AND STILL CREEK ROAD ROW
		BURNABY
0009548	13JAN17	4510, 4512, 4516, 4524, 4528, 4530 ALBERT STREET
		BURNABY
0009672	06APR03	7010 BUCHANAN STREET
		VANCOUVER
0009760	09FEB05	3807 CANADA WAY
		BURNABY
0009764	09FEB05	4859 LOUGHEED HIGHWAY
		BURNABY
0009775	12SEP11	411-419 EAST COLUMBIA STREET
		VANCOUVER
0009829	11MAR24	4692 IMPERIAL STREET
		BURNABY
0009868	13APR05	545 GARFIELD STREET
		NEW WESTMINSTER
0009929	06JUL07	4441 LOUGHEED HIGHWAY
		BURNABY
0009963	08JUL24	2751 UNDERHILL AVENUE
		BURNABY

Como Lake Avenue to 2nd Avenue (-122.9, 49.26)

0009966	07NOV30	428 BLAIR AVENUE NEW WESTMINSTER
0009971		2140 ALPHA STREET BURNABY
0009973	07JUL18	5720 HASTINGS STREET BURNABY
0010000	09FEB12	3495 NORTH ROAD BURNABY
0010007		311 8TH AVENUE NEW WESTMINSTER
0010017	12NOV15	7274 CANADA WAY BURNABY
0010032	07NOV30	6055 HALIFAX STREET BURNABY
0010059	07NOV30	530 EAST COLUMBIA STREET NEW WESTMINSTER
0010090		5229 CAPITOL DRIVE BURNABY
0010116	12JUN14	4806 EAST HASTINGS STREET BURNABY
0010188	09JAN30	4789 KINGSWAY BURNABY

447 records selected for 5.0 km from latitude 49 deg, 15 min, 57.4 sec
and Longitude 122 deg, 57 min, 19.2 sec

Site Id	Lastupd	Address / City
0010208	07JAN23	4556 VENABLES STREET BURNABY
0010243	09FEB05	8081 LOUGHEED HIGHWAY BURNABY
0010271		6004 AND 6006 WILSON AVENUE BURNABY
0010301	07MAR16	4190 HASTINGS STREET BURNABY
0010327	10OCT07	7738 EDMONDS STREET (FORMERLY 7762 EDMONDS) BURNABY
0010329		4440 BURKE STREET BURNABY
0010355		6939 BALMORAL STREET BURNABY
0010366	09JAN08	4412, 4422, 4432, 4442 AND 4452 BUCHANAN STREET BURNABY
0010368		5751 GRANT STREET BURNABY
0010406		3636 TRINITY STREET VANCOUVER
0010441	10DEC13	3665 - EAST 25TH AVENUE VANCOUVER
0010469		6355 ASHWORTH PLACE BURNABY
0010486		7894 CARIBOO ROAD

Como Lake Avenue to 2nd Avenue (-122.9, 49.26)

		BURNABY
0010509		3940 YALE STREET
		BURNABY
0010531	09DEC24	WESTRIDGE RELEASE
		BURNABY
0010572	12DEC20	4710 AND 4738 LOUGHEED HIGHWAY
		BURNABY
0010593		925 BURNABY ST NEW WESTMINSTER BC
		NEW WESTMINSTER
0010613	13FEB28	2133 DOUGLAS ROAD AND 4900 DAWSON STREET
		BURNABY
0010621	07NOV09	3267 / 3373 NORLAND AVENUE
		BURNABY
0010634		3976 YALE STREET
		BURNABY
0010647		4166 ETON STREET
		BURNABY
0010712		4735 NORTHLAWN DRIVE
		BURNABY
0010725	10NOV12	5961 HASTINGS STREET
		BURNABY
0010786	08JUL24	BC HYDRO RIGHT OF WAY
		BURNABY
0010813		4431 BURKE STREET
		BURNABY

447 records selected for 5.0 km from latitude 49 deg, 15 min, 57.4 sec
and Longitude 122 deg, 57 min, 19.2 sec

Site Id	Lastupd	Address / City
0010840	08MAY30	331 HOLMES STREET
		NEW WESTMINSTER
0010865	08MAY09	909 LADNER STREET
		NEW WESTMINSTER
0010866	08MAY09	4821 HIGHLAWN DRIVE
		BURNABY
0010956		3877 ETON STREET
		BURNABY
0010958		4761 HIGHLAWN DRIVE
		BURNABY
0011024		4091 YALE STREET
		BURNABY
0011034		6049 ELGIN AVENUE
		BURNABY
0011035		6407 BUCHANAN STREET
		BURNABY
0011036		4330 NAPIER STREET
		BURNABY
0011037		3844 LISTER STREET
		BURNABY
0011038		7391 NEWCOMBE STREET
		BURNABY

Como Lake Avenue to 2nd Avenue (-122.9, 49.26)

0011043		4381 WILDWOOD CRESENT BURNABY
0011044		3814 CAMBRIDGE STREET BURNABY
0011076		4228 OXFORD BURNABY
0011097	13FEB08	6888 ROYAL OAK AVENUE BURNABY
0011108	12AUG20	151 SPRUCE STREET NEW WESTMINSTER
0011141		7238 PANDORA STREET BURNABY
0011197	13APR25	3390 LAKE CITY WAY BURNABY
0011216		4357 FRANCES STREET BURNABY
0011222		819 CHERRY STREET NEW WESTMINSTER
0011229		6592 DUNBLANE AVENUE BURNABY
0011264		4248 VENABLES STREET BURNABY
0011283	13APR25	4420 AND 4444 LOUGHEED HIGHWAY, BURNABY
0011299		2131 WILLINGDON AVENUE BURNABY
0011324		453 FADER STREET NEW WESTMINSTER

447 records selected for 5.0 km from latitude 49 deg, 15 min, 57.4 sec
and Longitude 122 deg, 57 min, 19.2 sec

Site Id	Lastupd	Address / City
0011332	12NOV26	6979 HASTINGS STREET BURNABY
0011359	12MAY28	2338 MADISON AVENUE BURNABY
0011364	09MAY29	5401 LANE STREET BURNABY
0011397		587 HARRISON AVENUE COQUITLAM
0011406		8594 / 96 - 11TH AVENUE BURNABY
0011408		3814 OXFORD STREET BURNABY
0011412		9387 HOLMES STREET BURNABY
0011420	09JUL09	4855 SMITH AVENUE BURNABY
0011472	12SEP28	NORLAND LANDFILL BURNABY
0011500	09MAR13	3405 TO 3705 WILLINGDON AVENUE

		BURNABY
0011502		304 RICHMOND STREET
		NEW WESTMINSTER
0011517		3855 KITCHENER STREET
		BURNABY
0011558		468 KELLY STREET
		NEW WESTMINSTER
0011574		5380 GRIMMER STREET
		BURNABY
0011654		819 SURREY STREET
		NEW WESTMINSTER
0011664		4854 BOND STREET
		BURNABY
0011729		810 BURNABY STREET
		NEW WESTMINSTER
0011733		6855 & 6853 ELWELL STREET
		BURNABY
0011734		4676 BURKE STREET
		BURNABY
0011735		8704 CREST DRIVE
		BURNABY
0011745		226 CHURCHILL
		NEW WESTMINSTER
0011765	13APR04	2055 ROSSER AVENUE (FORMERLY 4388 LOUGHEED HWY))
		BURNABY
0011768	12SEP27	4090 FOREST STREET
		BURNABY
0011769		4696 WESTLAWN DRIVE
		BURNABY
0011793		6678 FULTON AVENUE
		BURNABY

447 records selected for 5.0 km from latitude 49 deg, 15 min, 57.4 sec
and Longitude 122 deg, 57 min, 19.2 sec

Site Id	Lastupd	Address / City
0011856	09OCT23	507 WILSON STREET
		NEW WESTMINSTER
0011864	09DEC18	5390 GRIMMER STREET
		BURNABY
0011891		640 ASPEN STREET
		COQUITLAM
0011957		8315 13TH AVENUE
		BURNABY
0011989		7611 MAYFIELD STREET
		BURNABY
0012042		8348 17TH AVENUE
		BURNABY
0012043		408 KELLY STREET
		NEW WESTMINSTER
0012050	10APR01	6108 EGLIN AVENUE
		BURNABY

Como Lake Avenue to 2nd Avenue (-122.9, 49.26)

0012051		4659 NORTHVIEW COURT BURNABY
0012055		559 APPIAN WAY COQUITLAM
0012117		4657 BRENTLAWN DRIVE BURNABY
0012119	10FEB19	6163 WALKER AVENUE BURNABY
0012147		6125 BERWICK BURNABY
0012154		3775 AVONDALE STREET BURNABY
0012176		910 CHILLIWACK STREET NEW WESTMINSTER
0012177	13APR05	7517 IMPERIAL STREET BURNABY
0012185		8560 KARRMAN AVENUE BURNABY
0012221		4070 NITHSDALE STREET BURNABY
0012278		8395 13TH AVENUE BURNABY
0012285	10JUL21	4400 STILL CREEK ROAD BURNABY
0012305		3883 LAUREL STREET BURNABY
0012308		4775 GILPIN COURT BURNABY
0012320		4836 BRENTLAWN DRIVE BURNABY
0012325		6408 HALIFAX STREET BURNABY
0012328		4707 BRRENTLAWN DRIVE BURNABY

447 records selected for 5.0 km from latitude 49 deg, 15 min, 57.4 sec
and Longitude 122 deg, 57 min, 19.2 sec

Site Id	Lastupd	Address / City
0012381		5480/5482 PANDORA STREET BURNABY
0012406		5930 BERWICK STREET BURNABY
0012410		8338 12TH AVENUE BURNABY
0012411		4418 VENABLES STREET BURNABY
0012420		341 SHERBROOKE STREET NEW WESTMINSTER
0012468		607 ALDERSON AVENUE COQUITLAM
0012469		140 EAST 10TH AVENUE

		NEW WESTMINSTER
0012495	11JUL07	7867 AND 7890 EXPRESS STREET
		BURNABY
0012547		610 AUSTIN STREET
		COQUITLAM
0012550		4128 YALE STREET
		BURNABY
0012551		7058 BELCARRA DRIVE
		BURNABY
0012552		6221 SUMAS STREET
		BURNABY
0012554		3630 E PENDER STREET
		VANCOUVER
0012583		8450 11TH AVENUE
		BURNABY
0012585		831 BURNABY STREET
		NEW WESTMINSTER
0012621		5191 CAMBRIDGE STREET
		BURNABY
0012627	12JUN26	4233 HASTINGS STREET
		BURNABY
0012648	11NOV25	604 & 606 COMO LAKE AVENUE
		COQUITLAM
0012653		89 GLOVER AVENUE
		NEW WESTMINSTER
0012658	12SEP14	8659 12TH AVENUE
		BURNABY
0012662		HIGHWAY 1 NORTH OF SPROTT STREET
		BURNABY
0012676		302 EAST 10TH AVENUE
		NEW WESTMINSTER
0012738	11FEB04	6320 DEER LAKE DRIVE
		BURNABY
0012740		4519 NAPIER STREET
		BURNABY
0012751		566 BROOKMERE AVENUE
		COQUITLAM

447 records selected for 5.0 km from latitude 49 deg, 15 min, 57.4 sec
and Longitude 122 deg, 57 min, 19.2 sec

Site Id	Lastupd	Address / City
0012761		3571 DIEPPE DRIVE
		VANCOUVER
0012766		6575 DUNBLANE AVENUE
		BURNABY
0012829		4427 BARKER AVENUE
		BURNABY
0012888	11APR20	404 GARRETT STREET
		NEW WESTMINSTER
0012906		5951 HALIFAX STREET
		BURNABY

Como Lake Avenue to 2nd Avenue (-122.9, 49.26)

0012922	12NOV26	9850 AUSTIN RD., 9858 & 9898 GATINEAU PL. BURNABY
0012924		6350 HALIFAX STREET BURNABY
0012950		8659 10TH AVENUE BURNABY
0012966		3778 BRANDON STREET BURNABY
0013044		4720 HIGHLAWN DRIVE BURNABY
0013055		4684 ALPHA DRIVE BURNABY
0013070		7743 ELFORD STREET BURNABY
0013091		6149 EMPRESS AVENUE BURNABY
0013099	12AUG20	603 CLARKE ROAD COQUITLAM
0013145	11AUG25	7317 IMPERIAL STREET BURNABY
0013152		4661 WESTLAWN DRIVE BURNABY
0013154		147 EAST 7TH AVENUE NEW WESTMINSTER
0013161		5610 DUNDAS STREET BURNABY
0013210		8731 CREST DRIVE BURNABY
0013220		4093 ETON STREET BURNABY
0013248		4060 ALBERT STREET, ALIAS: 4058 ALBERT STREET BURNABY
0013313		8623 11TH AVENUE BURNABY
0013326	12NOV26	7174 BARNET ROAD BURNABY
0013338		548 COCHRANE AVENUE COQUITLAM
0013342		115 NORTH HOWARD AVENUE BURNABY

447 records selected for 5.0 km from latitude 49 deg, 15 min, 57.4 sec
and Longitude 122 deg, 57 min, 19.2 sec

Site Id	Lastupd	Address / City
0013360	11OCT01	3785 EDINBURGH STREET BURNABY
0013384		7323 IMPERIAL STREET BURNABY
0013385		528 SPERLING AVENUE BURNABY
0013411		530 DELESTRE AVENUE

		COQUITLAM
0013424		4435 PANDORA STREET
		BURNABY
0013430	12AUG29	581 CLARKE ROAD
		COQUITLAM
0013442		8636 11TH AVENUE
		BURNABY
0013468	12APR05	41 OVENS AVENUE
		NEW WESTMINSTER
0013489		3858 KINCAID STREET
		BURNABY
0013490		4520 WILLIAM STREET
		BURNABY
0013526		4051 TRINITY STREET
		BURNABY
0013533		3776 YALE STREET
		BURNABY
0013622		3705 KINCAID STREET
		BURNABY
0013673	12JAN23	608 & 610 COMO LAKE AVENUE
		COQUITLAM
0013728	12MAR09	4344 GEORGIA STREET
		BURNABY
0013745	12JUN08	6830 BURLINGTON AVENUE
		BURNABY
0013752	12MAR07	951 BOUNDARY ROAD
		VANCOUVER
0013776		4439 BURKE STREET
		BURNABY
0013829	12OCT25	SIMON FRASER UNIVERSITY -SOUTH CAMPUS RD
		BURNABY
0013900	12JUN05	1771, 1779 AND 1791 DOUGLAS ROAD
		BURNABY
0013932	13APR17	4600 KINGSWAY
		BURNABY
0013939		4219 ETON STREET
		BURNABY
0013942		6667 HUMPHRIES AVENUE
		BURNABY
0013947		3914 NITHSDALE STREET
		BURNABY
0013950		7872 CARIBOO ROAD
		BURNABY

447 records selected for 5.0 km from latitude 49 deg, 15 min, 57.4 sec
and Longitude 122 deg, 57 min, 19.2 sec

Site Id	Lastupd	Address / City
0013975		4229 CASTLEWOOD CRESCENT
		BURNABY
0013990		4376 PRICE STREET
		BURNABY

Como Lake Avenue to 2nd Avenue (-122.9, 49.26)

0014024		6721 DOW AVENUE BURNABY
0014030		549 BROOKMERE AVENUE COQUITLAM
0014080	12AUG07	4056 YALE STREET VANCOUVER
0014082		6892 WILLINGDON AVENUE BURNABY
0014083		3878 BOND STREET BURNABY
0014128	12JUN22	4567 LOUGHEED HIGHWAY BURNABY
0014203		4649 BRENTLAWN DRIVE BURNABY
0014215		413 SCHOOL STREET NEW WESTMINSTER
0014229	12AUG16	5235 KINGSWAY BURNABY
0014237		4066 YALE STREET BURNABY
0014324		4393 WILDWOOD CRESCENT BURNABY
0014348	12SEP19	5550 GORING STREET BURNABY
0014352		142 EAST DURHAM STREET NEW WESTMINSTER
0014353		7065 BELCARRA DRIVE BURNABY
0014360		902 YORK STREET NEW WESTMINSTER
0014379	13APR11	8659 11TH AVENUE BURNABY
0014390	12NOV05	6333 SILVER AVENUE BURNABY
0014408	12OCT10	617 SMITH AVENUE COQUITLAM
0014456		3829 DOLLARTON HIGHWAY NORTH VANCOUVER
0014479	12NOV05	GLOVER AVENUE AND COLBORNE STREET NEW WESTMINSTER
0014488		8554 11TH AVENUE BURNABY
0014547		3655 ETON STREET VANCOUVER
0014595	13MAR19	325 EDWORTHY WAY NEW WESTMINSTER

447 records selected for 5.0 km from latitude 49 deg, 15 min, 57.4 sec
and Longitude 122 deg, 57 min, 19.2 sec

Site Id	Lastupd	Address / City
0014673		3723 PRICE STREET

		BURNABY
0014696		3128 WEST KING EDWARD AVENUE
		VANCOUVER
0014704		1870 SPERLING AVENUE
		BURNABY
0014706		4260 PRICE CRESCENT
		BURNABY
0014751		600 SYDNEY AVENUE
		COQUITLAM
0014824	13APR03	4209 EAST PENDER STREET
		BURNABY
0014825	13MAR27	4211 PENDER STREET
		BURNABY
0014838		5088 WILLINGDON AVENUE
		BURNABY
0014839		8226 13TH AVENUE
		BURNABY
0014856		2030 DUTHIE AVENUE
		BURNABY
0014862		6555 CHARLES STREET
		BURNABY
0014937	13APR03	6583 DUNBLANE AVENUE
		SURREY
0014944	13APR04	6593 DUNBLANE AVENUE
		BURNABY
0015042		4383 CAMBRIDGE STREET
		BURNABY
0015063		123 EAST DURHAM STREET
		NEW WESTMINSTER
0015064		3763 AVONDALE STREET
		BURNABY
0015092		4672 HIGHLAWN DRIVE
		BURNABY
0015098		315 EDWORTHY WAY
		NEW WESTMINSTER
0015145		4822 BOND STREET
		BURNABY
0015148		7214 NEWCOMBE STREET
		BURNABY
0015216		8623 12TH AVENUE
		BURNABY
0015226		ROSSER AVENUE AT SKYLINE DRIVE
		BURNABY

As Of: MAY 12, 2013 BC Online: Site Registry 13/05/16
For: PH45881 WEST COAST TITLE SEARCH LTD. 09:36:51
Folio: Page 1
1223 records selected for 5.0 km from latitude 49 deg, 14 min, 34.2 sec
and Longitude 123 deg, 2 min, 57.1 sec

Site Id	Lastupd	Address / City
0000013	13JAN25	51, 145, 151 WEST FIRST AVENUE VANCOUVER
0000015	02MAR22	525 WHEEL HOUSE ROAD VANCOUVER
0000019	02MAR22	UNKNOWN VANCOUVER
0000021	01NOV16	838 HAMILTON STREET AND ROBSON STREET VANCOUVER
0000023	07NOV30	5450 BYRNE ROAD BURNABY
0000024	06JUN27	2280 NEWPORT AVENUE VANCOUVER
0000025	04OCT28	8725 CAMBIE STREET VANCOUVER
0000026	12SEP19	1455 QUEBEC STREET VANCOUVER
0000027	12SEP19	140 KEEFER STREET VANCOUVER
0000031	02JAN17	540, 550, 580, 586 WEST 6TH AVENUE VANCOUVER
0000033	05OCT04	535-573 CARRALL STREET VANCOUVER
0000036	01NOV16	3189 GRANDVIEW HWY VANCOUVER
0000039	02JAN31	880 KINGSWAY VANCOUVER
0000041	01NOV16	101 NORTH VICTORIA DRIVE VANCOUVER
0000042	08NOV28	2150 CAMBIE VANCOUVER
0000045	01AUG15	1700 - 2100 EAST KENT AVENUE SOUTH VANCOUVER
0000046	10NOV11	941 MAIN STREET VANCOUVER
0000050	02MAR22	MOBERLEY ROAD VANCOUVER
0000056	02MAR22	500 BLOCK WEST 16TH AVENUE VANCOUVER
0000065	02JAN31	450 SOUTH EAST MARINE DRIVE VANCOUVER
0000069	01NOV16	1735 BOUNDARY ROAD VANCOUVER
0000070	02JAN31	720 BEATTY STREET VANCOUVER
0000072	13JAN16	1 KINGSWAY AVENUE VANCOUVER
0000073	02JAN31	790 CAMBIE STREET VANCOUVER
0000076	10NOV05	5650 BERESFORD STREET BURNABY

1223 records selected for 5.0 km from latitude 49 deg, 14 min, 34.2 sec
and Longitude 123 deg, 2 min, 57.1 sec

Site Id	Lastupd	Address / City
0000078	13APR04	2243 TRIUMPH STREET VANCOUVER
0000086	02MAY23	8240 MANITOBA STREET VANCOUVER
0000090	12SEP27	888 TERMINAL AVENUE VANCOUVER
0000095	02DEC02	2400 BOUNDARY ROAD BURNABY
0000097	13APR11	1026 POWELL STREET VANCOUVER
0000102	10NOV26	3777 LOUGHEED HIGHWAY BURNABY
0000103	05MAR07	EAST BROADWAY, EAST 10TH AND 2533 PENTICTON VANCOUVER
0000108	10JUL22	2910, 2998, 3010, 3030, 3098 EAST KENT SOUTH VANCOUVER
0000111	02APR12	NANAIMO AND 26TH STREETS VANCOUVER
0000115	10DEC23	822 SEYMOUR STREET VANCOUVER
0000117	01APR27	561 WEST 8TH AVENUE VANCOUVER
0000120	08JUN26	CORNER OF HAWKS AVENUE AND ALEXANDER STREET VANCOUVER
0000123	02JAN31	8555 GREENALL AVENUE BURNABY
0000130	01NOV16	901 WEST HASTINGS VANCOUVER
0000131	09JUN19	1636 PANDORA STREET VANCOUVER
0000132	02JAN31	45TH AND CAMBIE VANCOUVER
0000137	11SEP22	2010 GLEN DRIVE VANCOUVER
0000142	02FEB21	650 INDUSTRIAL AVENUE VANCOUVER
0000145	13FEB08	2895 & 2897 EAST HASTINGS STREET VANCOUVER
0000146	11MAR10	2801 MAIN STREET VANCOUVER
0000148	08FEB29	1616 RENFREW STREET VANCOUVER
0000149	02FEB21	925 VERNON DRIVE VANCOUVER
0000153	13MAY06	1026 POWELL STREET VANCOUVER
0000155	12JUN22	750 TERMINAL AVENUE VANCOUVER
0000158	11JUN23	1390 EAST 33RD AVENUE

2nd Ave to Marine Dr (-123.04, 49.2)
VANCOUVER

1223 records selected for 5.0 km from latitude 49 deg, 14 min, 34.2 sec
and Longitude 123 deg, 2 min, 57.1 sec

Site Id	Lastupd	Address / City
0000160	10DEC02	1880 NO. 4 ROAD AND 10071 RIVER DRIVE RICHMOND
0000165	12SEP13	8175 CAMBIE STREET VANCOUVER
0000171	03FEB27	1396 EAST 41ST AVENUE VANCOUVER
0000173	01NOV08	2950 SOUTH EAST MARINE DRIVE VANCOUVER
0000175	02FEB21	457 INDUSTRIAL AVENUE VANCOUVER
0000178	02FEB08	777 BEATTY ST VANCOUVER
0000179	01NOV16	3 CHARLES STREET VANCOUVER
0000189	01NOV08	1717 EAST HASTINGS STREET VANCOUVER
0000190	04FEB04	2390 SOUTH GRANDVIEW HIGHWAY VANCOUVER
0000191	13MAR06	2896 GRANDVIEW HIGHWAY VANCOUVER
0000193	02MAY23	524 HOMER STREET VANCOUVER
0000195	13MAR01	202 EAST 24TH AVENUE VANCOUVER
0000201	12OCT26	970 MALKIN AVENUE VANCOUVER
0000205	10NOV11	1700 BLOCK GLEN DRIVE VANCOUVER
0000213	02MAY29	8495 JELLICOE STREET VANCOUVER
0000220	02MAR20	2015 GLEN DRIVE VANCOUVER
0000221	03OCT09	920, 930, 950 CAMBIE & 186, 188, 190 SMITHE STREET VANCOUVER
0000222	02MAY29	733 BEATTY STREET VANCOUVER
0000230	11JUN07	1680 HASTINGS VANCOUVER
0000244	02MAR20	28 POWELL STREET VANCOUVER
0000247	10JAN07	1130 STATION STREET VANCOUVER
0000248	12APR30	8450 FRASER STREET VANCOUVER
0000250	09JAN09	688 SOUTH EAST MARINE DRIVE VANCOUVER

2nd Ave to Marine Dr (-123.04, 49.2)

0000251	02MAY29	3720 WELWYN STREET VANCOUVER
0000260	10NOV11	9198 GLENLYON PARKWAY, NORTH FRASER WAY BURNABY

1223 records selected for 5.0 km from latitude 49 deg, 14 min, 34.2 sec
and Longitude 123 deg, 2 min, 57.1 sec

Site Id	Lastupd	Address / City
0000263	02MAR20	111 DUNSMUIR VANCOUVER
0000268	03OCT09	OAKMOUNT CRESCENT AND OAKDALE ROAD BURNABY
0000270	01APR12	6645 VICTORIA DRIVE VANCOUVER
0000274	02DEC10	3490 PORTER STREET VANCOUVER
0000275	05JAN25	960, 980, 1002, 1004, 1006 MAIN STREET VANCOUVER
0000282	02MAY29	3318 MAIN STREET VANCOUVER
0000283	02MAY29	7525 CAMBIE STREET VANCOUVER
0000285	02APR19	315 TERMINAL AVENUE VANCOUVER
0000288	02MAY29	3434 MAIN STREET VANCOUVER
0000291	03JAN27	2582 EAST KENT AVENUE SOUTH VANCOUVER
0000292	03OCT06	365 WEST SECOND AVENUE VANCOUVER
0000294	04NOV23	7006 VICTORIA DRIVE VANCOUVER
0000301	03JAN28	2473-2475 KINGSWAY VANCOUVER
0000302	01NOV06	2580 SOUTH EAST MARINE DRIVE VANCOUVER
0000305	02APR19	55-99 KINGSWAY, 273-283 EAST BROADWAY STREET VANCOUVER
0000308	03JAN27	VANNESS, CROWLEY, JOYCE, GASTON, EUCLID STREETS VANCOUVER
0000313	01JUN20	WELLINGTON, YARDLEY, MCGEER , ASCOT PLACE VANCOUVER
0000314	11OCT06	4451 STILL CREEK DRIVE BURNABY
0000316		2803 KINGSWAY VANCOUVER
0000318	01APR20	5755 MARINE DRIVE BURNABY
0000319	13APR25	2060 ROSSER AVENUE BURNABY
0000322	12APR30	1675 RUPERT STREET

2nd Ave to Marine Dr (-123.04, 49.2)

		VANCOUVER
0000327	13JAN31	3110 EAST 54TH AVENUE
		VANCOUVER
0000330		CORNER OF 33RD AVENUE AND SOPHIA
		VANCOUVER
0000339	05JAN06	953 BEATTY STREET
		VANCOUVER

1223 records selected for 5.0 km from latitude 49 deg, 14 min, 34.2 sec
and Longitude 123 deg, 2 min, 57.1 sec

Site Id	Lastupd	Address / City
0000342	09JAN09	15100 RIVER ROAD
		RICHMOND
0000344	10NOV11	755 EVANS AVENUE
		VANCOUVER
0000345	02APR19	237 EAST FOURTH AVENUE
		VANCOUVER
0000353	02APR19	1526 KINGSWAY
		VANCOUVER
0000359	03FEB21	330 AND 350 EAST SECOND (2ND) AVENUE
		VANCOUVER
0000361	08MAY30	2605 - 2689 EAST 49TH AVENUE
		VANCOUVER
0000362	03JAN27	5638 CAMBIE
		VANCOUVER
0000367	05OCT25	141 E 4TH AVENUE
		VANCOUVER
0000372	01MAR22	3860 MAIN STREET
		VANCOUVER
0000376	01APR20	3312 GRANDVIEW
		VANCOUVER
0000400	06AUG15	2900 BLOCK KENT AVENUE SOUTH
		VANCOUVER
0000404	13APR11	5736 MAIN STREET
		VANCOUVER
0000413	03JAN30	1277 EAST GEORGIA STREET
		VANCOUVER
0000416	12MAY18	400 INDUSTRIAL AVENUE
		VANCOUVER
0000417	03JAN30	7326 ANTRIM AVENUE
		BURNABY
0000419	11DEC08	2555 GILMORE AVENUE
		BURNABY
0000423	05DEC12	521 WEST 6TH AVENUE
		VANCOUVER
0000425	02APR19	5850 SUNSET STREET
		BURNABY
0000426	02APR19	1950 BELLWOOD AVENUE
		BURNABY
0000431	01JUN20	2020 NO. 6 ROAD
		RICHMOND

2nd Ave to Marine Dr (-123.04, 49.2)

0000432	02APR12	8330 CHESTER VANCOUVER
0000439	12JAN27	MAIN STREET AND QUEBEC STREET VANCOUVER
0000441	06NOV09	975 WILLINGDON AVENUE BURNABY
0000442	12APR27	4301 EAST HASTINGS STREET BURNABY
0000445	13MAY08	MITCHELL ISLAND RICHMOND

1223 records selected for 5.0 km from latitude 49 deg, 14 min, 34.2 sec
and Longitude 123 deg, 2 min, 57.1 sec

Site Id	Lastupd	Address / City
0000447	02OCT24	1020 MALKIN AVENUE & 1399 CHESS STREET VANCOUVER
0000505	03JAN30	7233 FRASER STREET VANCOUVER
0000506	02FEB13	1285 NANAIMO STREET VANCOUVER
0000509	02DEC10	822 HOMER STREET VANCOUVER
0000729	06JAN23	1401/1402 TO 1436 KINGSWAY & 4050 KNIGHT STREET VANCOUVER
0000784		1212 EAST HASTINGS, AT VERNON DRIVE VANCOUVER
0000804	11DEC30	495 WEST 41ST AVENUE VANCOUVER
0000844	03JUL04	601& 615 TERMINAL AVENUE VANCOUVER
0000954		3695 GRANDVIEW HWY & 2755 BOUNDARY ROAD VANCOUVER
0000974	01APR27	1317 EAST 12TH AVENUE VANCOUVER
0000980	03OCT10	PACIFIC BOULEVARD VANCOUVER
0000983	02JUL11	PACIFIC BOULEVARD VANCOUVER
0000985	03FEB21	PACIFIC BOULEVARD VANCOUVER
0000986	02MAY29	PACIFIC BOULEVARD VANCOUVER
0000987	13FEB08	1716 CLARK DRIVE VANCOUVER
0000988	00OCT25	PACIFIC BOULEVARD VANCOUVER
0000989	09JAN15	PACIFIC BOULEVARD VANCOUVER
0000992	02FEB08	PACIFIC BOULEVARD VANCOUVER
0000995	03OCT09	PACIFIC BOULEVARD

2nd Ave to Marine Dr (-123.04, 49.2)

		VANCOUVER
0000997	00OCT25	PACIFIC BOULEVARD
		VANCOUVER
0000998	02FEB08	PACIFIC BOULEVARD
		VANCOUVER
0001001	01DEC21	PACIFIC BOULEVARD
		VANCOUVER
0001015	02FEB08	1995 KINGSWAY
		VANCOUVER
0001016	01APR27	2075 EAST HASTINGS STREET
		VANCOUVER
0001017	13FEB28	452 EAST BROADWAY
		VANCOUVER

1223 records selected for 5.0 km from latitude 49 deg, 14 min, 34.2 sec
and Longitude 123 deg, 2 min, 57.1 sec

Site Id	Lastupd	Address / City
0001021	06AUG15	3101 AND 3001 WAYBURNE DRIVE
		BURNABY
0001022	02MAY06	2150 CAMBIE STREET
		VANCOUVER
0001040	06APR03	2960 NANAIMO STREET
		VANCOUVER
0001042	01JAN17	900 EAST KENT AVENUE SOUTH
		VANCOUVER
0001051	03JAN31	5757 BERESFORD STREET
		BURNABY
0001055	02APR19	795 POWELL STREET
		VANCOUVER
0001067	01OCT18	3400 SE MARINE DR. AND 3402 - 3465 AMBERLY PL.
		VANCOUVER
0001069	01MAR14	8330 CHESTER STREET
		VANCOUVER
0001074	03JAN28	811 - 863 HAMILTON STREET
		VANCOUVER
0001075	03JAN31	4642, 4536, 4510 STILL CREEK AVENUE
		BURNABY
0001089	02JUN26	NW CORNER HASTINGS AND CASSIAR
		VANCOUVER
0001090	03FEB05	777 HOMER STREET
		VANCOUVER
0001097	02APR19	2475 DOUGLAS ROAD
		BURNABY
0001100	13MAR27	1002 STATION STREET (FORMERLY)
		VANCOUVER
0001128	03JAN29	2215 YUKON STREET
		VANCOUVER
0001141	03FEB06	5698 EAST HASTINGS STREET
		BURNABY
0001144	05FEB18	4506 RUPERT STREET
		VANCOUVER

2nd Ave to Marine Dr (-123.04, 49.2)

0001150	03MAR18	456 MOBERLY ROAD VANCOUVER
0001160	02APR19	2120 CAMBIE STREET VANCOUVER
0001168	03FEB06	2625 RUPERT STREET VANCOUVER
0001171	02MAR08	124 - 126 WEST 6TH AVENUE VANCOUVER
0001172	13APR05	721 MAIN STREET / 133 UNION STREET VANCOUVER
0001173	05JAN25	2206 EAST HASTINGS STREET VANCOUVER
0001186	09FEB13	5730 SOUTH EAST MARINE DRIVE BURNABY
0001207	12JUN26	900 / 950 TERMINAL AVENUE VANCOUVER

1223 records selected for 5.0 km from latitude 49 deg, 14 min, 34.2 sec
and Longitude 123 deg, 2 min, 57.1 sec

Site Id	Lastupd	Address / City
0001208	03FEB06	27/29 ALEXANDER STREET VANCOUVER
0001219	07JAN03	2895 EAST BROADWAY VANCOUVER
0001231	12SEP13	1720 RUPERT STREET VANCOUVER
0001232	00MAY12	5252 VICTORIA DRIVE VANCOUVER
0001234	01JAN26	3945 MYRTLE STREET BURNABY
0001237	02DEC10	1720 NANAIMO STREET VANCOUVER
0001238	03JAN31	586 GRANVILLE STREET VANCOUVER
0001240	03JAN28	1945/1955 MCLEAN DRIVE VANCOUVER
0001244	03OCT08	150 DUNSMUIR STREET VANCOUVER
0001246		639 EAST KING EDWARD VANCOUVER
0001250	04MAR30	3705 COMMERCIAL STREET VANCOUVER
0001253	03JAN28	1985 POWELL STREET VANCOUVER
0001257	05JAN26	1710 EAST KENT AVENUE SOUTH VANCOUVER
0001258	02APR25	439 RAILWAY STREET VANCOUVER
0001259	01JAN17	2503-2517 EAST BROADWAY STREET VANCOUVER
0001262	03JAN28	1387 EAST 41ST AVENUE

2nd Ave to Marine Dr (-123.04, 49.2)

		VANCOUVER
0001274	09JAN19	396 MARINE DRIVE SOUTHWEST
		VANCOUVER
0001276	02APR25	3330 MAIN STREET
		VANCOUVER
0001283	02JAN31	1445, 1447, 1459 KINGSWAY AVENUE
		VANCOUVER
0001286	00OCT20	5435 VICTORIA DRIVE
		VANCOUVER
0001289	01OCT18	2705 EAST KENT AVENUE
		VANCOUVER
0001290	01OCT18	2720 SE MARINE DRIVE
		VANCOUVER
0001291	07JAN03	653 - 689 WEST 7TH AVENUE
		VANCOUVER
0001292	01FEB09	3401 EAST HASTINGS STREET
		VANCOUVER
0001296	01MAR22	488 KINGSWAY & 515-15TH AVENUE EAST
		VANCOUVER

1223 records selected for 5.0 km from latitude 49 deg, 14 min, 34.2 sec
and Longitude 123 deg, 2 min, 57.1 sec

Site Id	Lastupd	Address / City
0001302	03FEB06	EAST KENT SOUTH ST, JELLICOE ST & LIGHTHOUSE WAY
		VANCOUVER
0001304	03FEB06	1001 DELTA AVENUE
		BURNABY
0001319	12NOV15	3550 LOUGHEED HIGHWAY
		VANCOUVER
0001324	10NOV18	301 INDUSTRIAL
		VANCOUVER
0001325	02FEB08	1126 SOUTH EAST MARINE DRIVE
		VANCOUVER
0001327		1070 SOUTH EAST MARINE DRIVE
		VANCOUVER
0001328	03FEB07	13911 VULCAN WAY
		RICHMOND
0001332	10APR01	2398 EAST 1ST AVENUE
		VANCOUVER
0001333	06MAR24	4805 & 4823 EAST HASTINGS STREET
		BURNABY
0001334		4905 JOYCE STREET
		VANCOUVER
0001337	03JAN31	4505 CANADA WAY
		BURNABY
0001342	13APR11	5749 MAIN STREET
		VANCOUVER
0001343	10SEP30	1213/1225 EAST PENDER STREET
		VANCOUVER
0001346	12APR30	268/272 EAST 2ND AVENUE
		VANCOUVER

2nd Ave to Marine Dr (-123.04, 49.2)

0001349		405 ALEXANDER STREET VANCOUVER
0001350	04AUG13	1896 EAST HASTINGS STREET VANCOUVER
0001353	02JAN31	1239/1249 ADANAC STREET VANCOUVER
0001356	01JUL12	130 WEST BROADWAY VANCOUVER
0001359	01NOV16	3791 KINGSWAY HIGHWAY BURNABY
0001364		1785 MAIN STREET VANCOUVER
0001366	07JUN21	5607 KEITH STREET BURNABY
0001369	10NOV11	325 EAST 5TH AVENUE VANCOUVER
0001371		1199 GRANT STREET VANCOUVER
0001375		2630 MAIN STREET VANCOUVER
0001381	98AUG01	7170 ANTRIM AVENUE BURNABY

1223 records selected for 5.0 km from latitude 49 deg, 14 min, 34.2 sec
and Longitude 123 deg, 2 min, 57.1 sec

Site Id	Lastupd	Address / City
0001383	08JUL24	1450 ADANAC STREET VANCOUVER
0001389	10NOV05	50 EAST PENDER STREET VANCOUVER
0001403	03JAN28	1725 QUEBEC STREET VANCOUVER
0001404		142 BROADWAY VANCOUVER
0001405	03OCT09	13611 MITCHELL ROAD RICHMOND
0001407		730 RAYMUR AVENUE VANCOUVER
0001410	05JUN10	1155 GREAT NORTHERN WAY VANCOUVER
0001411	09JAN29	1239 GLEN DRIVE VANCOUVER
0001413	03JAN30	2970 KINGSWAY VANCOUVER
0001417	04OCT29	1280 RAYMUR STREET VANCOUVER
0001420	12JUL26	1205 - 1221 GLEN DRIVE VANCOUVER
0001421	02FEB13	SITE 21 LANDFILL - DEER LAKE PARK BURNABY
0001423	03FEB07	57%

2nd Ave to Marine Dr (-123.04, 49.2)

		VANCOUVER
0001424	12JUL03	2902 GRANDVIEW HIGHWAY
		VANCOUVER
0001430	05AUG22	4050 FRASER STREET
		VANCOUVER
0001433		711 EAST 18TH AVENUE
		VANCOUVER
0001436	12JUN22	4450 STILL CREEK DRIVE
		BURNABY
0001437	12JUL23	3624 FRASER STREET
		VANCOUVER
0001438	02DEC10	8 EAST CORDOVA STREET
		VANCOUVER
0001442	03JAN29	912 CLARKE DRIVE
		VANCOUVER
0001444	97DEC04	1280 COMMERCIAL DRIVE
		VANCOUVER
0001448	00MAY04	VICTORIA DRIVE & EAST 47TH AVENUE
		VANCOUVER
0001449	01MAY22	3650 LOUGHEED HIGHWAY
		VANCOUVER
0001455	00MAY04	215 WEST BROADWAY
		VANCOUVER
0001457	04JAN20	375 TERMINAL AVENUE
		VANCOUVER

1223 records selected for 5.0 km from latitude 49 deg, 14 min, 34.2 sec
and Longitude 123 deg, 2 min, 57.1 sec

Site Id	Lastupd	Address / City
0001460	03OCT09	3055 CAMBIE STREET
		VANCOUVER
0001463	03JAN28	8250 FRASER STREET
		VANCOUVER
0001467	04AUG26	300 BLOCK RAILWAY STREET
		VANCOUVER
0001472	97DEC16	280 EAST 6TH AVENUE
		VANCOUVER
0001478	02FEB13	490 COMMERCIAL DRIVE
		VANCOUVER
0001481	97DEC04	2770 EAST KENT AVENUE SOUTH
		VANCOUVER
0001483		2155 ROSSER STREET
		BURNABY
0001486	03JAN28	336 EAST 1ST AVENUE
		VANCOUVER
0001487	97DEC04	300 WEST GEORGIA STREET
		VANCOUVER
0001491	02JUL04	5818 LINCOLN STREET
		VANCOUVER
0001499	02DEC10	4102 FRASER STREET
		VANCOUVER

2nd Ave to Marine Dr (-123.04, 49.2)

0001511	00DEC07	4862 TO 4888 FRASER STREET VANCOUVER
0001519	00APR14	2880 SOUTH EAST MARINE DRIVE VANCOUVER
0001520	12DEC03	1926 BROADWAY EAST VANCOUVER
0001528	03FEB07	100 EAST CORDOVA STREET VANCOUVER
0001529	03FEB07	205 KINGSWAY AVENUE VANCOUVER
0001530	03FEB07	2210 CAMBIE STREET VANCOUVER
0001536	04JUL02	5440 BERESFORD STREET BURNABY
0001545	03FEB07	8678 GREENALL AVENUE BURNABY
0001546	03JAN23	950 RAYMUR AVENUE VANCOUVER
0001613	03FEB07	3810 MAIN STREET VANCOUVER
0001677	13APR13	555 & 577 GREAT NORTHERN WAY VANCOUVER
0001682	03FEB07	1289 EAST BROADWAY VANCOUVER
0001982	06MAY24	600 - 636 WEST 6TH AVENUE VANCOUVER
0001991	13APR02	3450 AND 3512 EAST KENT AVENUE VANCOUVER

1223 records selected for 5.0 km from latitude 49 deg, 14 min, 34.2 sec
and Longitude 123 deg, 2 min, 57.1 sec

Site Id	Lastupd	Address / City
0002091	03JAN31	3975 MYRTLE STREET BURNABY
0002189	03JAN31	4905 MAIN STREET VANCOUVER
0002204	05JAN20	3811 NORTH FRASER WAY BURNABY
0002220	02FEB13	5590 GORING STREET BURNABY
0002221	02APR25	605 - 695 SOUTH EAST MARINE DRIVE VANCOUVER
0002368	06SEP06	9001 RIVERWAY PLACE BURNABY
0002391	07JUN08	3876 SMITH AVENUE BURNABY
0002394		WATER STREET LANEWAY/HOWE STREET VIADUCT VANCOUVER
0002511	06SEP06	2120 GRANDVIEW HIGHWAY VANCOUVER
0002549	00DEC01	1940 MAIN STREET

2nd Ave to Marine Dr (-123.04, 49.2)

		VANCOUVER
0002554	01MAY17	2236 KINGSWAY
		VANCOUVER
0002763	03FEB21	4888 STILL CREEK AVENUE
		BURNABY
0003079	04APR06	4507 EAST HASTINGS STREET
		BURNABY
0003120	13MAY09	CAMBIE AND 6TH AVENUE AND 301 WEST 1ST AVENUE
		VANCOUVER
0003153	97DEC04	3352 VANNESS AVENUE
		VANCOUVER
0003177	05JUN03	5550 BYRNE ROAD AND 5700 MARINE WAY
		BURNABY
0003249	01DEC19	4203 HASTINGS STREET
		BURNABY
0003251	10SEP30	5389 - 5577 BYRNE ROAD
		BURNABY
0003252	00MAY12	455 INDUSTRIAL AVENUE
		VANCOUVER
0003269		1177 KEEFER STREET
		VANCOUVER
0003292	03OCT09	4265 LOUGHEED HIGHWAY
		BURNABY
0003324	03OCT07	290 SW MARINE DRIVE
		VANCOUVER
0003325	00MAR17	4755 KINGSWAY AVENUE
		BURNABY
0003338	03JAN30	2955 KINGSWAY AVENUE
		VANCOUVER
0003351	02JUN26	418 EAST BROADWAY
		VANCOUVER

1223 records selected for 5.0 km from latitude 49 deg, 14 min, 34.2 sec
and Longitude 123 deg, 2 min, 57.1 sec

Site Id	Lastupd	Address / City
0003365	10JUN10	3826 CANADA WAY
		BURNABY
0003382	10OCT06	2400 BOUNDARY ROAD
		BURNABY
0003389	03OCT17	8351 ONTARIO STREET
		VANCOUVER
0003402	99JAN08	433 ROBSON STREET
		VANCOUVER
0003418	09JAN26	275 & 301 W 1ST AVENUE
		VANCOUVER
0003419	09SEP11	WEST 1ST AVENUE
		VANCOUVER
0003491	09JAN26	4472 EAST HASTINGS STREET
		BURNABY
0003504	05JAN21	4363 EAST HASTINGS STREET
		VANCOUVER

2nd Ave to Marine Dr (-123.04, 49.2)

0003511	03FEB24	746 POWELL STREET VANCOUVER
0003578	98FEB04	5775 KINGSWAY BURNABY
0003584	12OCT05	1460 EAST HASTINGS VANCOUVER
0003585	02APR12	800 KINGSWAY AVENUE VANCOUVER
0003588		5549 KINGSWAY BURNABY
0003594		4890 EAST HASTINGS BURNABY
0003598		1790 MAIN STREET VANCOUVER
0003602		5171 RUMBLE STREET BURNABY
0003604	13APR19	26 SW MARINE DRIVE VANCOUVER
0003606	00SEP15	4710 SLOCAN STREET VANCOUVER
0003626	06JAN31	2290 CAMBIE STREET VANCOUVER
0003627	00MAY04	5744 BYRNE ROAD BURNABY
0003643	02FEB13	4894 KNIGHT STREET VANCOUVER
0003652	03OCT17	1088 QUEBEC STREET VANCOUVER
0003655	01AUG15	3350 EAST BROADWAY VANCOUVER
0003666	02AUG08	68 EAST 1ST AVENUE VANCOUVER
0003726	13APR25	4490 LOUGHEED HIGHWAY BURNABY

1223 records selected for 5.0 km from latitude 49 deg, 14 min, 34.2 sec
and Longitude 123 deg, 2 min, 57.1 sec

Site Id	Lastupd	Address / City
0003727	12FEB10	11760 MITCHELL ROAD RICHMOND
0003773	00AUG04	533 POWELL STREET VANCOUVER
0003784	01JAN26	645 WEST 8TH AVENUE VANCOUVER
0003878	02MAR22	4705 - 4709 HASTINGS STREET BURNABY
0003890		222 MAIN STREET VANCOUVER
0003949	03OCT09	420 EAST KENT AVENUE VANCOUVER
0003952	01OCT18	2588 NANAIMO STREET

2nd Ave to Marine Dr (-123.04, 49.2)

		VANCOUVER
0003954	07JAN04	101 AND 149 WEST HASTINGS STREET
		VANCOUVER
0003958	12OCT26	4515 LOUGHEED HIGHWAY
		BURNABY
0003976	13APR20	285 EAST 1ST AVENUE
		VANCOUVER
0003998	10AUG11	696 CLARK DRIVE
		VANCOUVER
0004000	04AUG13	4530/4532 KINGSWAY
		BURNABY
0004030	04FEB04	3600 GILMORE WAY
		BURNABY
0004163	06JUL17	3205-3215, 3277 CAMBIE STREET & 3228 TUPPER STREET
		VANCOUVER
0004219	04OCT18	4550 LOUGHEED HIGHWAY
		BURNABY
0004313	99SEP16	196 KINGSWAY
		VANCOUVER
0004321	12SEP12	1967/1969 WILLINGDON AVENUE
		BURNABY
0004345	10OCT06	2338 GILMORE AVENUE
		BURNABY
0004401	03OCT09	679 EAST GEORGIA STREET
		VANCOUVER
0004421	02MAY23	288 EAST GEORGIA
		VANCOUVER
0004429	05FEB22	1901 EAST BROADWAY AVENUE
		VANCOUVER
0004444	03OCT10	2780 SE MARINE DRIVE
		VANCOUVER
0004491	98SEP30	569 - 581 HORNBY STREET
		VANCOUVER
0004556	04MAY19	1112 EAST HASTINGS STREET
		VANCOUVER
0004588	04MAR05	688 EAST 16TH AVENUE
		VANCOUVER

1223 records selected for 5.0 km from latitude 49 deg, 14 min, 34.2 sec
and Longitude 123 deg, 2 min, 57.1 sec

Site Id	Lastupd	Address / City
0004644	02JUL04	1216 EAST PENDER STREET
		VANCOUVER
0004677	03OCT10	4177 KINGSWAY
		BURNABY
0004697	12OCT26	95 EAST 1ST AVENUE
		VANCOUVER
0004703	04APR05	6991 VICTORIA DRIVE
		VANCOUVER
0004718		3755 KEITH STREET
		BURNABY

2nd Ave to Marine Dr (-123.04, 49.2)

0004720	01JUL27	20 WEST HASTINGS STREET VANCOUVER
0004741		710 SOUTHEAST MARINE DRIVE VANCOUVER
0004761	02JAN11	3295 EAST BROADWAY VANCOUVER
0004766	03OCT17	4401 STILL CREEK DRIVE BURNABY
0004790	10NOV07	735 GREAT NORTHERN WAY VANCOUVER
0004792	04JUN02	5639 VICTORIA DRIVE (WAS 5605) VANCOUVER
0004842	08JAN10	4444 KINGSWAY BURNABY
0004893	03FEB26	5717 MARINE DRIVE BURNABY
0004908	04FEB04	8265 FRASER STREET VANCOUVER
0004921	01MAR22	4200 NORTH FRASER WAY BURNABY
0004923	05JAN11	4132, 4150, 4196 HALIFAX STREET BURNABY
0004945	03FEB26	601 CANADA PLACE VANCOUVER
0005009	02JAN17	2894 EAST BROADWAY VANCOUVER
0005012	12APR17	600-960 EVANS AVENUE VANCOUVER
0005059	02JAN17	773 BEATTY STREET VANCOUVER
0005067	02JAN11	86 SE MARINE DRIVE VANCOUVER
0005078	05JAN27	118 WEST 2ND AVENUE VANCOUVER
0005089	10OCT07	149 WEST 4TH AVENUE VANCOUVER
0005096	01DEC19	3857 1ST AVENUE BURNABY
0005098	12JUN20	145/177 ROBSON STREET, 760/790 CAMBIE STREET VANCOUVER

1223 records selected for 5.0 km from latitude 49 deg, 14 min, 34.2 sec
and Longitude 123 deg, 2 min, 57.1 sec

Site Id	Lastupd	Address / City
0005109	01MAR22	4343 NORTH FRASER WAY BURNABY
0005134	13MAY02	4295 EAST HASTINGS VANCOUVER
0005164	03OCT17	14600 RIVER ROAD RICHMOND
0005166	11AUG12	2277 KINGSWAY

2nd Ave to Marine Dr (-123.04, 49.2)

		VANCOUVER
0005193	02AUG08	258 & 268 EAST 10TH AVENUE
		VANCOUVER
0005203	04FEB04	4553 KINGSWAY
		BURNABY
0005255	02MAR25	735 GREAT NORTHERN WAY
		VANCOUVER
0005305	01JUN01	1809, 1817 & 1835 EAST HASTINGS STREET
		VANCOUVER
0005308	10OCT07	345 EAST FIRST AVENUE
		VANCOUVER
0005345	03FEB26	436 EAST 48 AVENUE
		VANCOUVER
0005355	01AUG15	1710-1750 EAST KENT AVENUE
		VANCOUVER
0005364	06JUL18	4509 KINGSWAY
		BURNABY
0005402	02MAR25	655 GREAT NORTHERN WAY
		VANCOUVER
0005403	12DEC06	396 EAST FIRST AVENUE
		VANCOUVER
0005404	01APR06	EAST 1ST AVENUE
		VANCOUVER
0005452	00MAR16	421 KINGSWAY
		VANCOUVER
0005461	02JUN26	56 EAST 2ND AVENUE
		VANCOUVER
0005486	01AUG31	40 EAST HASTINGS STREET
		VANCOUVER
0005488	04APR27	4512 LOUGHEED HIGHWAY
		BURNABY
0005489	01APR20	12 & 22 EAST 8TH AVENUE
		VANCOUVER
0005499	98DEC04	1367 EAST KENT AVENUE NORTH
		VANCOUVER
0005530	11DEC22	2685 GILMORE AVENUE
		BURNABY
0005541	04FEB05	290 EAST 51ST AVENUE
		VANCOUVER
0005561	00JUN13	699 WEST CORDOVA STREET
		VANCOUVER
0005564	12OCT26	5300-5350 BYRNE ROAD
		BURNABY

1223 records selected for 5.0 km from latitude 49 deg, 14 min, 34.2 sec
and Longitude 123 deg, 2 min, 57.1 sec

Site Id	Lastupd	Address / City
0005589	03OCT10	1500 MAIN STREET
		VANCOUVER
0005596	10NOV26	430 GREAT NORTHERN WAY
		VANCOUVER

2nd Ave to Marine Dr (-123.04, 49.2)

0005597	04FEB05	3700 WILLINGDON AVENUE BURNABY
0005620	04JUN02	GEORGIA AND BEATTY STREET VANCOUVER
0005622	04FEB05	BEATTY STREET AND GEORGIA VANCOUVER
0005661	03FEB21	11488 EBURNE WAY RICHMOND
0005691	01MAR22	4300 NORTH FRASER WAY BURNABY
0005706	13APR16	1510 POWELL STREET VANCOUVER
0005715	99OCT22	4315 AND 4343 LOUGHEED HIGHWAY BURNABY
0005726	04FEB05	1196 POWELL STREET VANCOUVER
0005773	04FEB05	6808/6820 VICTORIA DRIVE VANCOUVER
0005808	04OCT21	6830 WAVERLEY AVENUE BURNABY
0005811	12NOV26	1660 STATION STREET VANCOUVER
0005826	04FEB05	4705 KINGSWAY BURNABY
0005875	10OCT20	1951 GLEN DRIVE VANCOUVER
0005880	05JAN26	6501 VICTORIA DRIVE VANCOUVER
0005881	00MAR17	289 ALEXANDER STREET VANCOUVER
0005882	05MAY27	1795 VICTORIA DRIVE VANCOUVER
0005888	00JUL07	4005 SECOND AVENUE BURNABY
0005915	10DEC03	939 MAIN STREET VANCOUVER
0005942	10NOV07	11631 TWIGG PLACE RICHMOND
0005944	05JAN26	5695 LOUGHEED HIGHWAY BURNABY
0005974	10NOV07	77 EAST BROADWAY VANCOUVER
0005996	04OCT21	3450 EAST HASTINGS STREET VANCOUVER
0006034	12OCT11	5608 KINGSWAY BURNABY

1223 records selected for 5.0 km from latitude 49 deg, 14 min, 34.2 sec
and Longitude 123 deg, 2 min, 57.1 sec

Site Id	Lastupd	Address / City
0006040	02DEC17	578 CARRALL STREET

2nd Ave to Marine Dr (-123.04, 49.2)

		VANCOUVER
0006066	03OCT10	33-37 WEST PENDER STREET
		VANCOUVER
0006092	02MAY10	1707 EAST 4TH AVENUE
		VANCOUVER
0006179	04FEB05	2015 MAIN STREET
		VANCOUVER
0006180	05MAR17	400 SOUTH EAST MARINE DRIVE
		VANCOUVER
0006202	04FEB05	700 WEST PENDER STREET
		VANCOUVER
0006244	12MAR23	4880 BENNETT STREET (WAS 4860 BENNETT STREET)
		BURNABY
0006248	01MAR22	250 WEST 70TH AVENUE
		VANCOUVER
0006261	04FEB05	2001 EAST 36TH AVENUE
		VANCOUVER
0006263	04FEB05	5665 5669 TYNE STREET
		VANCOUVER
0006277	09DEC18	368, 370, 380 & 388 WEST 1ST AVENUE
		VANCOUVER
0006294	00OCT20	1580 VERNON DRIVE
		VANCOUVER
0006301	03NOV25	2555 NOOTKA STREET
		VANCOUVER
0006357	04FEB05	445 KINGSWAY
		VANCOUVER
0006358	04DEC08	433 - 439 ALEXANDER STREET
		VANCOUVER
0006359	04FEB05	3766 EAST 1ST AVENUE
		BURNABY
0006363	03FEB25	2001 KINGSWAY
		VANCOUVER
0006365	04FEB05	401 KINGSWAY
		VANCOUVER
0006370	04FEB05	890 EAST HASTINGS STREET
		VANCOUVER
0006375	04FEB05	75 WEST 5TH AVENUE
		VANCOUVER
0006393	04FEB05	1705 EAST 12TH AVENUE
		VANCOUVER
0006394	05JAN07	376 EAST KENT AVENUE SOUTH
		VANCOUVER
0006402	04FEB06	4500 CANADA WAY
		BURNABY
0006404	04FEB06	200 BURRARD STREET
		VANCOUVER
0006417	04FEB06	3720 IMPERIAL STREET (SE CORNER)
		BURNABY

2nd Ave to Marine Dr (-123.04, 49.2)
and Longitude 123 deg, 2 min, 57.1 sec

Site Id	Lastupd	Address / City
0006420	04FEB06	1293 EAST 10TH AVENUE VANCOUVER
0006446	03JAN09	5005 NORTH FRASER WAY BURNABY
0006449	02JUL04	3541 CORNETT ROAD VANCOUVER
0006450	04FEB06	4293 SLOCAN STREET VANCOUVER
0006463	02FEB01	14431 RIVER ROAD RICHMOND
0006467	04FEB06	975 VERNON DRIVE VANCOUVER
0006472	09FEB10	4250 SOUTHEAST MARINE DRIVE BURNABY
0006477	13MAR27	310 PRIOR STREET VANCOUVER
0006478	13MAR27	250 PRIOR STREET VANCOUVER
0006494	10NOV18	1405 THORNTON STREET VANCOUVER
0006495	09APR23	1465 THORNTON STREET VANCOUVER
0006497	05JAN26	97 EAST 2ND AVENUE VANCOUVER
0006515	04FEB06	818 RICHARDS STREET VANCOUVER
0006531	04FEB06	3434 CORNETT ROAD VANCOUVER
0006546	01JAN17	196 SE MARINE DRIVE VANCOUVER
0006548	06MAY24	2812 MAIN STREET VANCOUVER
0006550	04FEB06	68 WEST 5TH AVENUE VANCOUVER
0006577	04FEB06	1570 KOOTENAY STREET VANCOUVER
0006581	07SEP12	5708 KINGSWAY BURNABY
0006587	02AUG08	3304 KINGSWAY VANCOUVER
0006700	10NOV18	330/680 TERMINAL, 455/649 INDUSTRIAL, 1755 COTRELL VANCOUVER
0006704	01NOV23	8390 MANITOBA STREET VANCOUVER
0006708	05MAR17	555 CARRALL STREET VANCOUVER
0006727	05FEB22	395-399 WEST 5 AVENUE VANCOUVER
0006735	02JUN26	4120, 4160, 4170 LOUGHEED HIGHWAY BURNABY

1223 records selected for 5.0 km from latitude 49 deg, 14 min, 34.2 sec
and Longitude 123 deg, 2 min, 57.1 sec

Site Id	Lastupd	Address / City
0006737	04OCT18	310 - 366 EAST KENT AVENUE SOUTH VANCOUVER
0006754	05JAN25	803 KEEFER STREET VANCOUVER
0006756	13APR23	1618 QUEBEC STREET (FORMERLY 1553-1615 MAIN STREET VANCOUVER
0006757	03JAN27	533 - 539 EAST HASTINGS STREET VANCOUVER
0006758	04FEB06	668 POWELL STREET VANCOUVER
0006759	04OCT18	65 WEST CORDOVA STREET VANCOUVER
0006769	10OCT20	460, 432 AND 494 RAILWAY STREET VANCOUVER
0006810	05JAN26	2730 EAST 41 AVENUE VANCOUVER
0006811	04OCT21	6857- 6891 ROYAL OAK AVENUE BURNABY
0006837	06MAR29	6502 VICTORIA DRIVE VANCOUVER
0006917	03JAN27	5000 NORTH FRASER WAY BURNABY
0006946	00NOV23	WILLINGDON AVENUE & LOUGHEED HIGHWAY BURNABY
0006948	05AUG19	102 AND 116 EAST 2ND AVENUE VANCOUVER
0006976	05FEB03	2470 COMMERCIAL DRIVE AND 1701-1759 EAST BROADWAY VANCOUVER
0007004	04MAY20	13511 VULCAN WAY RICHMOND
0007081	01APR20	2806 CAMBIE STREET VANCOUVER
0007082	12SEP14	1407 EAST 41 AVENUE VANCOUVER
0007084	03MAY20	361 HEATLEY AVENUE VANCOUVER
0007086	12JUL26	675 WEST 10TH AVENUE VANCOUVER
0007089	04DEC13	1375 VERNON DRIVE VANCOUVER
0007090	01FEB22	1502 BOUNDARY ROAD BURNABY
0007115	04FEB06	2010 COMMERCIAL DRIVE VANCOUVER
0007130	02DEC17	1519 EAST PENDER STREET VANCOUVER
0007143		3845-3847 KINGSWAY BURNABY
0007144	04NOV30	1927 KINGSWAY VANCOUVER

1223 records selected for 5.0 km from latitude 49 deg, 14 min, 34.2 sec
and Longitude 123 deg, 2 min, 57.1 sec

Site Id	Lastupd	Address / City
0007150		2835 SOPHIA STREET VANCOUVER
0007203	05JAN21	8-26 WEST BROADWAY VANCOUVER
0007230	10DEC31	2881 MAIN STREET VANCOUVER
0007240	04MAR08	946-948 MAIN STREET VANCOUVER
0007293	05JAN26	4349 DAWSON STREET BURNABY
0007296	12OCT26	4051 LOUGHEED HIGHWAY BURNABY
0007334	10NOV07	1200 RAYMUR AVENUE VANCOUVER
0007337	02MAY10	3521 & 3525 CORNETT ROAD VANCOUVER
0007343	04OCT28	500 DUNSMUIR STREET VANCOUVER
0007350	03JAN27	4950 IMPERIAL STREET BURNABY
0007373	04NOV01	4575 MAIN STREET VANCOUVER
0007375	05AUG31	4336 LOUGHEED HIGHWAY & 2151 ROSSER AVENUE BURNABY
0007386	12OCT01	2806 GRANDVIEW HIGHWAY VANCOUVER
0007402	01AUG29	295 TERMINAL AVENUE VANCOUVER
0007410	05MAR17	891 PRIOR STREET VANCOUVER
0007416	12DEC06	1833 CROWE STREET VANCOUVER
0007483	10DEC23	596 EAST HASTINGS STREET VANCOUVER
0007523	04FEB06	2089 COMMISSIONER STREET VANCOUVER
0007548	05AUG17	215 WEST 1 AVENUE VANCOUVER
0007577	04FEB06	15 & 25 WEST 5 AVENUE VANCOUVER
0007591	04OCT13	475 EAST HASTINGS STREET VANCOUVER
0007616	12OCT26	4453 MAIN STREET VANCOUVER
0007624	02FEB13	1196 EAST PENDER STREET VANCOUVER
0007643	02MAY10	2741 EAST HASTINGS STREET VANCOUVER
0007650		169 EAST 19 AVENUE VANCOUVER

As Of: MAY 12, 2013 BC Online: Site Registry 13/05/16
For: PH45881 WEST COAST TITLE SEARCH LTD. 09:36:51
Folio: Page 22
1223 records selected for 5.0 km from latitude 49 deg, 14 min, 34.2 sec
and Longitude 123 deg, 2 min, 57.1 sec

Site Id	Lastupd	Address / City
0007653	05MAR17	577, 655 & 735 GREAT NORTHERN WAY VANCOUVER
0007659	12OCT05	1056 AND 1060 EAST 14 AVENUE VANCOUVER
0007671		1436 EAST SECOND AVENUE VANCOUVER
0007681	13MAR27	6876 ROYAL OAK AVENUE BURNABY
0007732	03OCT30	941 MAIN STREET VANCOUVER
0007762	12SEP14	3664 & 3696 CORNETT ROAD VANCOUVER
0007771		3707 CAMBIE STREET VANCOUVER
0007772	02JUN07	600-640 GRANVILLE STREET VANCOUVER
0007797		3014 KINGSWAY VANCOUVER
0007841	04FEB06	3605 GRANDVIEW HIGHWAY VANCOUVER
0007859	03JAN10	578 CARRALL STREET VANCOUVER
0007908	05MAR23	3450 EAST KENT AVENUE VANCOUVER
0007910	12JAN12	3650 EAST KENT AVENUE VANCOUVER
0007911	06JUL18	3450 EAST KENT AVENUE VANCOUVER
0007968	04AUG03	4440 EAST HASTINGS AND 4485 PENDER STREET BURNABY
0008008	08JUN10	16 WEST 4TH AVUENUE & 2005 ONTARIO STREET VANCOUVER
0008016	04APR19	227 EAST GEORGIA STREET VANCOUVER
0008021	13APR04	2700 KINGSWAY VANCOUVER
0008044	03SEP23	5298 STILL CREEK AVENUE BURNABY
0008060		2010 - 2030 ALBERTA STREET VANCOUVER
0008070	10NOV10	2727 EAST 12TH AVENUE VANCOUVER
0008126	06JUL18	2300 CAMBIE STREET VANCOUVER
0008131	04OCT07	125 & 151 WEST CORDOVA STREET VANCOUVER
0008142		6162 - 6184 FRASER STREET VANCOUVER
0008153	03OCT21	5750 LOUGHEED HIGHWAY BURNABY

1223 records selected for 5.0 km from latitude 49 deg, 14 min, 34.2 sec
and Longitude 123 deg, 2 min, 57.1 sec

Site Id	Lastupd	Address / City
0008176	05JAN11	5650 LOUGHEED HIGHWAY BURNABY
0008194		224 WEST 5TH AVENUE VANCOUVER
0008213	06AUG16	700 HAMILTON STREET VANCOUVER
0008215	13FEB08	615/655 & 663 TERMINAL AVENUE VANCOUVER
0008222	04NOV02	910-914 MAIN STREET VANCOUVER
0008249		725 HOMER STREET VANCOUVER
0008271	07NOV13	2808 CAMBIE STREET VANCOUVER
0008275	03JUN03	2153-2157 KINGSWAY VANCOUVER
0008277	05SEP19	4140 DAWSON STREET BURNABY
0008325	09JAN22	9200 GLENLYON PARKWAY & A PORTION OF 9400 GLENLYON BURNABY
0008360	13APR19	888 SE MARINE DRIVE VANCOUVER
0008364	04APR19	100 BLOCK OF WILLINGDON AVENUE BURNABY
0008377	03OCT30	369 WEST 63RD AVENUE VANCOUVER
0008389	10JUN17	5100 NORTH FRASER WAY BURNABY
0008399	05DEC09	3502 EAST HASTINGS STREET VANCOUVER
0008406	04FEB25	708 EAST GEORGIA STREET VANCOUVER
0008408	05NOV01	111 EAST 3RD AVENUE (FORMERLY 123 E 3RD AVENUE) VANCOUVER
0008422	09JAN22	2943 RENFREW STREET VANCOUVER
0008450		110 EAST 12 AVENUE VANCOUVER
0008482	04JUL06	850 POWELL STREET VANCOUVER
0008483		8299 BORDEN VANCOUVER
0008485		806-808 RICHARDS STREET VANCOUVER
0008501	03OCT29	753 & 755 TERMINAL AVENUE VANCOUVER
0008503	12SEP28	2549, 2650 BETA AVENUE & 4855 STILL CREEK AVENUE BURNABY
0008532		373 KINGSWAY

2nd Ave to Marine Dr (-123.04, 49.2)
VANCOUVER

1223 records selected for 5.0 km from latitude 49 deg, 14 min, 34.2 sec
and Longitude 123 deg, 2 min, 57.1 sec

Site Id	Lastupd	Address / City
0008585	04FEB18	141 WEST 7TH AVENUE VANCOUVER
0008589	04FEB19	5735 DORSET STREET BURNABY
0008653	04JAN16	3705 COMMERCIAL STREET VANCOUVER
0008687	04MAR18	1361 EAST 49 AVENUE VANCOUVER
0008696	04NOV02	648 - 680 WEST 6TH AVENUE VANCOUVER
0008732		439 WEST 21ST AVENUE VANCOUVER
0008742		2548 EAST 23RD AVENUE VANCOUVER
0008753	04AUG03	7282 KNIGHT STREET VANCOUVER
0008756	04MAY26	400-436 (& 450) WEST 2 AVENUE VANCOUVER
0008926	10NOV26	1691 POWELL STREET VANCOUVER
0008930	07NOV14	7388 / 7310 MACPHERSON AVENUE BURNABY
0008941	12NOV26	1695 MAIN STREET VANCOUVER
0008952	05SEP01	4180 DAWSON STREET BURNABY
0008953		TROUT LAKE SANITARY TRUNK SEWER PROJECT VANCOUVER
0008957		2585 EAST 1ST AVENUE VANCOUVER
0008958		919 LILLOOET STREET VANCOUVER
0008959	04MAY26	4644 BRENTLAWN DRIVE BURNABY
0008964	04MAY03	5750 - 5772 FRASER STREET VANCOUVER
0008995		475 WEST 42ND AVENUE VANCOUVER
0009002	09JAN29	1155 EAST BROADWAY, 1111 E 7TH AVE, 2350 GLEN DR VANCOUVER
0009020	05JUL26	2345 & 2355 MADISON AVENUE BURNABY
0009024		5156 MAIN STREET VANCOUVER
0009037	07FEB02	2520 MANITOBA STREET VANCOUVER

2nd Ave to Marine Dr (-123.04, 49.2)

0009070		2280 - 2290 HOLDOM AVENUE BURNABY
0009073	13FEB08	105 KEEFER STREET AND 544 COLUMBIA STREET VANCOUVER

1223 records selected for 5.0 km from latitude 49 deg, 14 min, 34.2 sec
and Longitude 123 deg, 2 min, 57.1 sec

Site Id	Lastupd	Address / City
0009097	08JAN10	742, 746, 752 AND 788 RICHARDS STREET VANCOUVER
0009106	05JAN21	369 ALEXANDER STREET VANCOUVER
0009112	09JAN29	4192 MAIN STREET VANCOUVER
0009113	08APR11	505 & 525 WEST BROADWAY AND 2455 CAMBIE STREET VANCOUVER
0009114	13JAN25	107-155 COMMERCIAL DRIVE & VANCOUVER
0009129	05SEP07	2150 BETA AVENUE BURNABY
0009132	05JAN12	3704 WELWYN STREET VANCOUVER
0009153	06SEP20	180 COMMERCIAL DRIVE VANCOUVER
0009156	12OCT26	3541 FRASER STREET VANCOUVER
0009170	06MAR21	11580 MITCHELL ROAD RICHMOND
0009172	04DEC03	5878 ARLINGTON STREET VANCOUVER
0009173	05JAN12	2628 ADANAC STREET VANCOUVER
0009176	04DEC03	3856 SUNSET STREET BURNABY
0009178		1712 AND 1734 POWELL STREET VANCOUVER
0009181		5794 CHESTER STREET VANCOUVER
0009196	10NOV26	350 KINGSWAY/ 2710 SOPHIA STREET VANCOUVER
0009216	05MAY18	189 NATIONAL AVENUE VANCOUVER
0009217		305 DUNLEVY AVENUE VANCOUVER
0009219	09JAN29	4789, 4805 & 4841 KINGSWAY; 6243 & 6255 MILLER AVE BURNABY
0009273	10NOV26	1895 STAINSBURY AVENUE VANCOUVER
0009276		587 W 7TH AVENUE VANCOUVER
0009280		1353 MAIN STREET

2nd Ave to Marine Dr (-123.04, 49.2)

		VANCOUVER
0009282		3807 HASTINGS STREET
		BURNABY
0009300	09DEC24	12 AND 18/20 WATER STREET
		VANCOUVER
0009323	07MAR05	2134-2142 EAST HASTINGS STREET
		VANCOUVER

1223 records selected for 5.0 km from latitude 49 deg, 14 min, 34.2 sec
and Longitude 123 deg, 2 min, 57.1 sec

Site Id	Lastupd	Address / City
0009328	05OCT13	1407 GEORGIA STREET
		VANCOUVER
0009339	05JUN22	2402 EAST BROADWAY
		VANCOUVER
0009348	12OCT26	2743 TO 2745 EAST HASTINGS STREET
		VANCOUVER
0009357	12JUL23	2600 EAST BROADWAY, 2669 NORTH GRANDVIEW HIGHWAY
		VANCOUVER
0009468	05NOV07	PORTIONS OF MADISON AVE AND STILL CREEK ROAD ROW
		BURNABY
0009535	09JAN02	3377 GRANDVIEW HIGHWAY/2840 BENTALL STREET
		VANCOUVER
0009547		16160, 16240 RIVER ROAD
		RICHMOND
0009548	13JAN17	4510, 4512, 4516, 4524, 4528, 4530 ALBERT STREET
		BURNABY
0009562	06JUN09	111 COMMERCIAL STREET
		VANCOUVER
0009578		65 EAST 61ST AVENUE
		VANCOUVER
0009608	05DEC09	435 WEST 26TH AVENUE
		VANCOUVER
0009616	05DEC09	6556 INVERNESS STREET
		VANCOUVER
0009617	06MAY15	1408 EAST 61ST AVENUE
		VANCOUVER
0009628	05DEC09	531 BEATTY STREET
		VANCOUVER
0009630	05DEC09	7318 ONTARIO STREET
		VANCOUVER
0009651	12MAR26	7501 AND 7509 MARKET CROSS
		BURNABY
0009653	12DEC03	3869 AND 3891 MAIN STREET
		VANCOUVER
0009671	09FEB04	2003 EAST HASTINGS STREET
		VANCOUVER
0009672	06APR03	7010 BUCHANAN STREET
		VANCOUVER
0009688		3699 COMMERCIAL STREET
		VANCOUVER

2nd Ave to Marine Dr (-123.04, 49.2)

0009691	06JUN22	424 EAST 47TH AVENUE VANCOUVER
0009725	07SEP17	150 WEST CORDOVA STREET VANCOUVER
0009760	09FEB05	3807 CANADA WAY BURNABY
0009764	09FEB05	4859 LOUGHEED HIGHWAY BURNABY
0009765	13FEB28	102-160 WEST 1 AVENUE VANCOUVER

1223 records selected for 5.0 km from latitude 49 deg, 14 min, 34.2 sec
and Longitude 123 deg, 2 min, 57.1 sec

Site Id	Lastupd	Address / City
0009790	06APR28	12520 AND 12480 MITCHELL ROAD RICHMOND
0009799	06MAR30	7200 MARKET CROSSING BURNABY
0009813	06MAY01	2227 KINGSWAY VANCOUVER
0009829	11MAR24	4692 IMPERIAL STREET BURNABY
0009844	06MAY10	6495 MAIN STREET VANCOUVER
0009860	10NOV26	505 BURRARD STREET VANCOUVER
0009872	11AUG04	4669 EARLES STREET VANCOUVER
0009887	13MAR14	WEST 2ND AVE, WEST 1ST AVE AND EAST 1ST AVE VANCOUVER
0009894	06JUN28	598 EAST 22ND AVENUE SURREY
0009908	06AUG21	1155 POWELL STREET VANCOUVER
0009929	06JUL07	4441 LOUGHEED HIGHWAY BURNABY
0009938		5375 BERESFORD STREET BURNABY
0009941	07NOV30	121 WEST 17TH AVENUE VANCOUVER
0009952	06AUG21	2493 ETON STREET VANCOUVER
0009956	12OCT26	272-280 EAST 7TH AVENUE (2321 SCOTIA STREET) VANCOUVER
0009958		567 UNION STREET VANCOUVER
0009965	06AUG17	8652 JOFFRE AVENUE BURNABY
0009971		2140 ALPHA STREET BURNABY
0009972	12OCT26	1887 CROWE STREET

2nd Ave to Marine Dr (-123.04, 49.2)

		VANCOUVER
0009973	07JUL18	5720 HASTINGS STREET
		BURNABY
0009979	07MAR06	180 EAST 2ND AVENUE
		VANCOUVER
0010026		1967-1991 EAST HASTINGS STREET
		VANCOUVER
0010034	09FEB18	718 EAST PENDER STREET
		VANCOUVER
0010058	10FEB05	10091,10111,10131,10151 RIVER DRIVE
		RICHMOND
0010060	12OCT05	1955 WYLIE ST, 420 W. 1ST AVE, 415-455 W. 2ND AVE
		VANCOUVER

1223 records selected for 5.0 km from latitude 49 deg, 14 min, 34.2 sec
and Longitude 123 deg, 2 min, 57.1 sec

Site Id	Lastupd	Address / City
0010090		5229 CAPITOL DRIVE
		BURNABY
0010105	06DEC12	925-929 MAIN STREET
		VANCOUVER
0010107	08JAN10	3250 MARINE WAY
		VANCOUVER
0010116	12JUN14	4806 EAST HASTINGS STREET
		BURNABY
0010188	09JAN30	4789 KINGSWAY
		BURNABY
0010202	07NOV07	268 EAST KENT AVENUE SOUTH
		VANCOUVER
0010208	07JAN23	4556 VENABLES STREET
		BURNABY
0010228	09JUL23	700, 714, 718 AND 720 MAIN STREET
		VANCOUVER
0010271		6004 AND 6006 WILSON AVENUE
		BURNABY
0010278	07NOV30	4063 CAMBIE STREET
		VANCOUVER
0010281	07SEP27	3350 MARINE WAY
		VANCOUVER
0010295		95 WEST HASTINGS STREET
		VANCOUVER
0010301	07MAR16	4190 HASTINGS STREET
		BURNABY
0010312		790 POWELL STREET
		VANCOUVER
0010329		4440 BURKE STREET
		BURNABY
0010337	09JAN08	3699 MARINE WAY
		VANCOUVER
0010338	08SEP11	166 - 172 POWELL STREET
		VANCOUVER

2nd Ave to Marine Dr (-123.04, 49.2)

0010341	09JAN08	3520 TO 3680 MARINE WAY VANCOUVER
0010346		248 EAST SECOND AVENUE VANCOUVER
0010347	12SEP14	8228 CROMPTON STREET (WAS 1330 E 66TH AVENUE VANCOUVER
0010349	07MAY16	2515 EAST 27TH AVENUE VANCOUVER
0010352		2745 WEST 8TH AVENUE VANCOUVER
0010356		5606 COLUMBIA STREET VANCOUVER
0010366	09JAN08	4412, 4422, 4432, 4442 AND 4452 BUCHANAN STREET BURNABY
0010368		5751 GRANT STREET BURNABY

1223 records selected for 5.0 km from latitude 49 deg, 14 min, 34.2 sec
and Longitude 123 deg, 2 min, 57.1 sec

Site Id	Lastupd	Address / City
0010374		6908 - 6910 MAIN STREET VANCOUVER
0010379	12OCT26	670, 680 INDUSTRIAL AVENUE VANCOUVER
0010381	09JAN09	334 ALEXANDER STREET VANCOUVER
0010387	10NOV26	570 AND 620 EVANS AVENUE VANCOUVER
0010388	09JAN09	530 EVANS AVENUE VANCOUVER
0010400	12OCT26	288 WEST 1ST AVENUE VANCOUVER
0010407		2168 YUKON STREET VANCOUVER
0010441	10DEC13	3665 - EAST 25TH AVENUE VANCOUVER
0010457		833 HOMER STREET VANCOUVER
0010458	07JUL05	4575 CLANCY LORANGER WAY VANCOUVER
0010468	07NOV30	2764 EAST 49TH AVENUE VANCOUVER
0010476	13FEB01	63 WEST 2ND AVENUE (FORMERLY 27-99 WEST 2ND AVENUE VANCOUVER
0010477	13MAR14	2 - 26 EAST 1ST AVENUE VANCOUVER
0010497	07NOV30	138 WEST 45TH AVENUE VANCOUVER
0010499		3727 VICTORY STREET BURNABY
0010500	12OCT26	251 EAST 7TH AVENUE (FORMERLY 240 EAST 6TH AVE)

2nd Ave to Marine Dr (-123.04, 49.2)

		VANCOUVER
0010541	08JUN06	162 WEST 42ND AVENUE
		VANCOUVER
0010562	07NOV13	PORTION OF MARKET CROSSING ROAD ALLOWANCE
		BURNABY
0010572	12DEC20	4710 AND 4738 LOUGHEED HIGHWAY
		BURNABY
0010574	09JAN13	7811 & 7280 MACPHERSON AVENUE
		BURNABY
0010580		165 EAST 59TH AVENUE
		VANCOUVER
0010582		1815 EAST 37TH AVENUE
		VANCOUVER
0010584		3605 - EAST 25TH AVENUE
		VANCOUVER
0010586	12DEC06	650 EVANS AVENUE
		VANCOUVER
0010607	13FEB22	2547/2549 HASTINGS STREET EAST
		VANCOUVER

1223 records selected for 5.0 km from latitude 49 deg, 14 min, 34.2 sec
and Longitude 123 deg, 2 min, 57.1 sec

Site Id	Lastupd	Address / City
0010612		329-331 EAST 7TH AVENUE
		VANCOUVER
0010613	13FEB28	2133 DOUGLAS ROAD AND 4900 DAWSON STREET
		BURNABY
0010620		4547 CULLODEN STREET
		VANCOUVER
0010647		4166 ETON STREET
		BURNABY
0010655		252 WEST 23RD AVENUE
		VANCOUVER
0010666	07DEC06	12900, 12920, 12980, 13000, 13100 MITCHELL ROAD
		RICHMOND
0010674		4764 QUEBEC STREET
		VANCOUVER
0010700	07DEC13	7731 YUKON STREET
		VANCOUVER
0010704	07DEC21	1285 WILLIAM STREET
		VANCOUVER
0010712		4735 NORTHLAWN DRIVE
		BURNABY
0010750		2886 COMMERCIAL DRIVE
		VANCOUVER
0010773	09JAN30	663 TERMINAL AVE.
		VANCOUVER
0010775		221 UNION STREET
		VANCOUVER
0010786	08JUL24	BC HYDRO RIGHT OF WAY
		BURNABY

2nd Ave to Marine Dr (-123.04, 49.2)

0010802		38 39TH AVENUE WEST VANCOUVER
0010808		838 WEST HASTINGS STREET VANCOUVER
0010813		4431 BURKE STREET BURNABY
0010817	09JAN16	605 KASLO STREET VANCOUVER
0010826	08MAY30	339 EAST 57TH AVENUE VANCOUVER
0010843	12OCT26	188 EAST FIRST AVENUE VANCOUVER
0010852		173 WEST 22ND AVENUE VANCOUVER
0010866	08MAY09	4821 HIGHLAWN DRIVE BURNABY
0010873	08MAY09	1666 EAST 22ND AVENUE VANCOUVER
0010875	12NOV15	7087 MACPHERSON AVENUE BURNABY
0010958		4761 HIGHLAWN DRIVE BURNABY

1223 records selected for 5.0 km from latitude 49 deg, 14 min, 34.2 sec
and Longitude 123 deg, 2 min, 57.1 sec

Site Id	Lastupd	Address / City
0010961		7400 MACPHERSON STREET, 7411 & 7415 BULLER STREET BURNABY
0010973		1423 GRANT STREET VANCOUVER
0010978		135 KEEFER STREET VANCOUVER
0010982		1345 EAST 53RD AVENUE VANCOUVER
0010988		524 KASLO STREET VANCOUVER
0010991		138 WEST 22ND AVENUE VANCOUVER
0010995		1630 KAMLOOPS STREET VANCOUVER
0010996	12DEC03	LAND ADJACENT TO 5389 - 5577 BYRNE ROAD BURNABY
0010998		3530 CAMBIE STREET VANCOUVER
0011002		1285 EAST 19TH AVENUE VANCOUVER
0011003		280 EAST 37TH AVENUE VANCOUVER
0011009	12OCT26	215 EAST 33RD AND 4898 MAIN STREET VANCOUVER
0011034		6049 ELGIN AVENUE

2nd Ave to Marine Dr (-123.04, 49.2)

	BURNABY
0011036	4330 NAPIER STREET
	BURNABY
0011037	3844 LISTER STREET
	BURNABY
0011039	7980 GRAY AVENUE
	BURNABY
0011040	8049 GRAY AVENUE
	BURNABY
0011041	8268 PATTERSON AVENUE
	BURNABY
0011043	4381 WILDWOOD CRESENT
	BURNABY
0011044	3814 CAMBRIDGE STREET
	BURNABY
0011045	4566 CLINTON STREET
	BURNABY
0011069	11566 EBURNE WAY
	RICHMOND
0011072	1572 EAST 18TH AVENUE
	VANCOUVER
0011075	1643 KITCHENER STREET
	VANCOUVER
0011076	4228 OXFORD
	BURNABY

1223 records selected for 5.0 km from latitude 49 deg, 14 min, 34.2 sec
and Longitude 123 deg, 2 min, 57.1 sec

Site Id	Lastupd	Address / City
0011080	10FEB05	601 EAST HASTINGS STREET
		VANCOUVER
0011097	13FEB08	6888 ROYAL OAK AVENUE
		BURNABY
0011130		308 EAST 33RD AVENUE
		VANCOUVER
0011131		564 WEST 19TH AVENUE
		VANCOUVER
0011135		15360 KNOX WAY
		RICHMOND
0011147	08AUG29	426 EAST 20TH AVENUE
		VANCOUVER
0011148		5901 FRASER STREET
		VANCOUVER
0011169		7 WEST 22ND AVENUE
		VANCOUVER
0011173		2396 EAST 34TH AVENUE
		VANCOUVER
0011195		1304 COTTON DRIVE
		VANCOUVER
0011204		582 WEST 26TH AVENUE
		VANCOUVER

2nd Ave to Marine Dr (-123.04, 49.2)

0011211		315 WEST 45TH AVENUE VANCOUVER
0011214		410- 42ND AVENUE WEST VANCOUVER
0011216		4357 FRANCES STREET BURNABY
0011228	12APR05	215-225 WEST 2ND AVENUE VANCOUVER
0011229		6592 DUNBLANE AVENUE BURNABY
0011239	12OCT26	2855 PARKER STREET VANCOUVER
0011257	09JAN20	1850 SPYGLASS PLACE VANCOUVER
0011264		4248 VENABLES STREET BURNABY
0011277		144 WEST HASTINGS STREET VANCOUVER
0011280	10JUL16	4550 FRASER STREET VANCOUVER
0011283	13APR25	4420 AND 4444 LOUGHEED HIGHWAY, BURNABY
0011296		337 WEST PENDER STREET VANCOUVER
0011299		2131 WILLINGDON AVENUE BURNABY
0011302		104 PEVERIL AVENUE VANCOUVER

1223 records selected for 5.0 km from latitude 49 deg, 14 min, 34.2 sec
and Longitude 123 deg, 2 min, 57.1 sec

Site Id	Lastupd	Address / City
0011305	12DEC06	2743 SKEENA STREET VANCOUVER
0011316		2854 EAST 21ST AVENUE VANCOUVER
0011325	09MAR06	3505 & 3515 PRESTON AVENUE VANCOUVER
0011328		1648 EAST 10TH AVENUE VANCOUVER
0011329	09JAN21	430 EAST 48TH AVENUE VANCOUVER
0011334	10MAY07	2405 EAST BROADWAY VANCOUVER
0011359	12MAY28	2338 MADISON AVENUE BURNABY
0011364	09MAY29	5401 LANE STREET BURNABY
0011376		157 EAST 44TH AVENUE VANCOUVER
0011388		4636 CARSON STREET

2nd Ave to Marine Dr (-123.04, 49.2)

		BURNABY
0011405		365 EAST 14TH AVENUE
		VANCOUVER
0011408		3814 OXFORD STREET
		BURNABY
0011410		295 WEST 21ST AVENUE
		VANCOUVER
0011417		3585 GRANDVIEW HIGHWAY
		VANCOUVER
0011420	09JUL09	4855 SMITH AVENUE
		BURNABY
0011421		150 EAST 62ND AVENUE
		VANCOUVER
0011434		233 EAST 12TH AVENUE
		VANCOUVER
0011443		4696 TODD STREET
		VANCOUVER
0011458	10FEB18	4933 VICTORIA DRIVE
		VANCOUVER
0011478	09APR03	NATIONAL AVENUE NEAR MAIN STREET
		VANCOUVER
0011481		910 VICTORIA DRIVE
		VANCOUVER
0011487	10DEC03	207 WEST 13TH AVENUE
		VANCOUVER
0011493	11NOV10	50 WEST 2ND AVENUE
		VANCOUVER
0011500	09MAR13	3405 TO 3705 WILLINGDON AVENUE
		BURNABY
0011517		3855 KITCHENER STREET
		BURNABY

1223 records selected for 5.0 km from latitude 49 deg, 14 min, 34.2 sec
and Longitude 123 deg, 2 min, 57.1 sec

Site Id	Lastupd	Address / City
0011519		6090 INVERNESS STREET
		VANCOUVER
0011555		351 WEST 22ND AVENUE
		VANCOUVER
0011562		342 WATER STREET
		VANCOUVER
0011565		250-254 WEST 18TH AVENUE
		VANCOUVER
0011574		5380 GRIMMER STREET
		BURNABY
0011576		5894 SOPHIA STREET
		VANCOUVER
0011577	12SEP14	1239 KINGSWAY
		VANCOUVER
0011587	09MAY29	1198 EAST KENT AVENUE SOUTH
		VANCOUVER

2nd Ave to Marine Dr (-123.04, 49.2)

0011590		2438 GRANDVIEW HIGHWAY SOUTH VANCOUVER
0011591		10 EAST 11TH AVENUE VANCOUVER
0011600		4756 MOSS STREET VANCOUVER
0011601		3502 DUNDAS STREET VANCOUVER
0011602		4468 JOHN STREET VANCOUVER
0011616		1927 EAST 55TH AVENUE VANCOUVER
0011618		4029 IRMIN STREET BURNABY
0011624	09DEC18	426 WEST 19TH AVENUE VANCOUVER
0011632	13JAN25	755 EVANS AVE VANCOUVER
0011637		6368 MAIN STREET VANCOUVER
0011642		595 EAST 51ST AVENUE VANCOUVER
0011651	13APR05	4547 WELWYN STREET VANCOUVER
0011664		4854 BOND STREET BURNABY
0011690		15900 RIVER ROAD RICHMOND
0011695		3785 ARBOR STREET BURNABY
0011711		2742 EAST 8TH AVENUE VANCOUVER
0011713		3355 EAST 29TH AVENUE VANCOUVER

1223 records selected for 5.0 km from latitude 49 deg, 14 min, 34.2 sec
and Longitude 123 deg, 2 min, 57.1 sec

Site Id	Lastupd	Address / City
0011714		5120 ASH STREET VANCOUVER
0011716	09SEP04	2796 ADANAC STREET VANCOUVER
0011725		2590 EAST 15TH AVENUE VANCOUVER
0011734		4676 BURKE STREET BURNABY
0011736		4626 CARSON STREET BURNABY
0011740		3840 QUEBEC STREET VANCOUVER
0011741		52 WEST 13TH AVENUE

2nd Ave to Marine Dr (-123.04, 49.2)

		VANCOUVER
0011765	13APR04	2055 ROSSER AVENUE (FORMERLY 4388 LOUGHEED HWY))
		BURNABY
0011768	12SEP27	4090 FOREST STREET
		BURNABY
0011769		4696 WESTLAWN DRIVE
		BURNABY
0011773	12MAR09	890 MALKIN AVENUE
		VANCOUVER
0011821		43 WEST 49TH AVENUE
		VANCOUVER
0011845	12NOV26	111 PRINCESS AVENUE (FMRLY 522 & 590 ALEXANDER ST)
		VANCOUVER
0011851	09DEC31	3595 EAST 1ST AVENUE
		VANCOUVER
0011853	09OCT23	3630 TANNER STREET
		VANCOUVER
0011855		5454 SLOCAN STREET
		VANCOUVER
0011857		888 HOMER STREET
		VANCOUVER
0011864	09DEC18	5390 GRIMMER STREET
		BURNABY
0011872	12OCT26	3333 MAIN STREET
		VANCOUVER
0011914		2660 WESBROOK MALL
		VANCOUVER
0011933	12SEP14	3596 CORNETT ROAD
		VANCOUVER
0011956	09DEC04	3865 FLEMING STREET
		VANCOUVER
0011960	10MAR26	8717 JIM BAILEY CRES
		KELOWNA
0011961		605 ROBSON STREET
		VANCOUVER
0011971		1222 EAST 12TH AVENUE
		VANCOUVER

1223 records selected for 5.0 km from latitude 49 deg, 14 min, 34.2 sec
and Longitude 123 deg, 2 min, 57.1 sec

Site Id	Lastupd	Address / City
0011982		3149 IVANHOE STREET
		VANCOUVER
0012000	12MAY08	EASTERN PORTION OF 2010 GLEN DRIVE
		VANCOUVER
0012007	12NOV26	3003 EAST 22ND AVENUE
		VANCOUVER
0012020	12OCT26	222 30TH AVENUE EAST
		VANCOUVER
0012026	10APR01	16780 RIVER ROAD
		RICHMOND

2nd Ave to Marine Dr (-123.04, 49.2)

0012027	12DEC03	5605 BYRNE ROAD BURNABY
0012034		221 & 275 WEST 5TH AVENUE VANCOUVER
0012044	10DEC23	304,306,316,338,350 W 6TH AVENUE, 2221 VANCOUVER
0012048		553 WEST 63RD AVENUE VANCOUVER
0012050	10APR01	6108 EGLIN AVENUE BURNABY
0012051		4659 NORTHVIEW COURT BURNABY
0012054		4264 WINNEFRED STREET BURNABY
0012084		1389 VENABLES STREET VANCOUVER
0012104	12JUL18	1975 FERNDALE STREET VANCOUVER
0012116		7816 KAYMAR DRIVE BURNABY
0012117		4657 BRENTLAWN DRIVE BURNABY
0012118	10MAY13	2038 VICTORIA DRIVE VANCOUVER
0012127		2305 KITCHENER STREET VANCOUVER
0012129		8042 FRASER STREET VANCOUVER
0012143	11JAN20	580 MALKIN AVENUE VANCOUVER
0012146		428 WEST 58TH AVENUE VANCOUVER
0012154		3775 AVONDALE STREET BURNABY
0012170		NO 4 ROAD AND RIVER ROAD RICHMOND
0012179		1448 EAST 62ND AVENUE VANCOUVER
0012189		115 SOUTH WEST MARINE DRIVE VANCOUVER

1223 records selected for 5.0 km from latitude 49 deg, 14 min, 34.2 sec
and Longitude 123 deg, 2 min, 57.1 sec

Site Id	Lastupd	Address / City
0012200		115 WEST 49TH AVENUE VANCOUVER
0012201		835 EAST 7TH AVENUE VANCOUVER
0012214		6917 TYNE STREET VANCOUVER
0012216		8225 MAIN STREET

2nd Ave to Marine Dr (-123.04, 49.2)

		VANCOUVER
0012221		4070 NITHSDALE STREET BURNABY
0012245		4123 SOUTHWOOD STREET BURNABY
0012260		950 RENFREW STREET VANCOUVER
0012261		1543 FRANCES STREET VANCOUVER
0012262		1587 FRANCES STREET VANCOUVER
0012276	10MAY28	1700 & 1900 NO. 6 ROAD RICHMOND
0012285	10JUL21	4400 STILL CREEK ROAD BURNABY
0012296	11SEP01	2667 KINGSWAY VANCOUVER
0012305		3883 LAUREL STREET BURNABY
0012308		4775 GILPIN COURT BURNABY
0012313	10JUN10	782 EAST 22ND AVENUE VANCOUVER
0012314		405 WEST 26TH AVENUE VANCOUVER
0012320		4836 BRENTLAWN DRIVE BURNABY
0012324		2678 EAST 20TH AVENUE VANCOUVER
0012328		4707 BRRENTLAWN DRIVE BURNABY
0012337	10AUG13	688 EAST KENT AVENUE SOUTH VANCOUVER
0012346		3786 IRMIN STREET BURNABY
0012348	10JUL21	2215 EAST HASTINGS STREET VANCOUVER
0012349	10OCT07	5299 MAIN STREET VANCOUVER
0012350		3166 EAST 7TH AVENUE VANCOUVER
0012358	10JUL05	520 & 618 EAST KENT AVE., SOUTH VANCOUVER

1223 records selected for 5.0 km from latitude 49 deg, 14 min, 34.2 sec
and Longitude 123 deg, 2 min, 57.1 sec

Site Id	Lastupd	Address / City
0012361		476 WEST 40TH AVENUE VANCOUVER
0012363	13FEB28	1888 VICTORIA DIVERSION VANCOUVER

2nd Ave to Marine Dr (-123.04, 49.2)

0012379	12OCT26	3401 FRASER STREET VANCOUVER
0012380		74 WEST 20TH AVENUE VANCOUVER
0012381		5480/5482 PANDORA STREET BURNABY
0012408		4263 WINNIFRED STREET BURNABY
0012409		4539 NEVILLE STREET BURNABY
0012411		4418 VENABLES STREET BURNABY
0012412		2220 GARDEN DRIVE VANCOUVER
0012413		2757 EAST 53RD AVENUE VANCOUVER
0012417		1536 EAST 13TH AVENUE VANCOUVER
0012428		5576 PATRICK STREET BURNABY
0012476		2717 EAST 23RD AVENUE VANCOUVER
0012493	11APR21	3151 EAST KENT AVE NORTH AND 8450 KERR STREET VANCOUVER
0012494		187 WEST 48TH AVENUE VANCOUVER
0012496		2457 BROCK STREET VANCOUVER
0012524		2731 EAST 47TH AVENUE VANCOUVER
0012532	10NOV19	333 SEYMOUR STREET VANCOUVER
0012554		3630 E PENDER STREET VANCOUVER
0012562		179 PENTICTON STREET VANCOUVER
0012577	10OCT28	2486 GALT STREET VANCOUVER
0012588		15, 25 AND 29 EAST 2ND AVENUE VANCOUVER
0012600		1536 KAMLOOPS STREET VANCOUVER
0012603	12SEP14	1551 QUEBEC STREET VANCOUVER
0012605		918 VICTORIA DRIVE VANCOUVER

1223 records selected for 5.0 km from latitude 49 deg, 14 min, 34.2 sec
and Longitude 123 deg, 2 min, 57.1 sec

Site Id	Lastupd	Address / City
0012607	10DEC21	1595 EAST PENDER STREET

		VANCOUVER
0012608		6875 CULLODEN STREET
		VANCOUVER
0012611		990 EAST 24TH AVENUE
		VANCOUVER
0012621		5191 CAMBRIDGE STREET
		BURNABY
0012627	12JUN26	4233 HASTINGS STREET
		BURNABY
0012631		4556 NEVILLE STREET
		BURNABY
0012640	11JUL19	5067 MAIN STREET
		VANCOUVER
0012641		4622 SUNLAND PLACE
		BURNABY
0012656		3528 FRANKLIN STREET
		VANCOUVER
0012662		HIGHWAY 1 NORTH OF SPROTT STREET
		BURNABY
0012670		3040 EAST 16TH AVENUE
		VANCOUVER
0012675	13MAR18	104 - 150 EAST 1ST AVENUE
		VANCOUVER
0012694		2411 ADANAC STREET
		VANCOUVER
0012697		2603 TRIUMPH STREET
		VANCOUVER
0012706		229 EAST 23RD AVENUE
		VANCOUVER
0012711	11JAN27	305 WEST 12TH AVENUE
		VANCOUVER
0012713	13MAY02	4338 COMMERCIAL STREET
		VANCOUVER
0012716		3056 EAST 19TH AVENUE
		VANCOUVER
0012722	13JAN25	1650 QUEBEC STREET
		VANCOUVER
0012723		5075 CARSON STREET
		BURNABY
0012726		3184 EAST 23RD AVENUE
		VANCOUVER
0012740		4519 NAPIER STREET
		BURNABY
0012741	13APR08	2788 PRINCE EDWARD STREET
		VANCOUVER
0012754		441 EAST 36TH AVENUE
		VANCOUVER
0012761		3571 DIEPPE DRIVE
		VANCOUVER

2nd Ave to Marine Dr (-123.04, 49.2)
and Longitude 123 deg, 2 min, 57.1 sec

Site Id	Lastupd	Address / City
0012764		420 EAST 55TH AVENUE VANCOUVER
0012766		6575 DUNBLANE AVENUE BURNABY
0012767		4711 CAMBIE STREET VANCOUVER
0012771		2533 NAPIER STREET VANCOUVER
0012773	11FEB04	2775 EAST HASTINGS STREET VANCOUVER
0012776	11AUG12	25 WEST 12TH AVENUE VANCOUVER
0012792	12FEB09	553 WEST 7TH AVENUE VANCOUVER
0012795	12OCT26	2980 - 3012 NANAIMO STREET VANCOUVER
0012809		4773 ROSS STREET VANCOUVER
0012829		4427 BARKER AVENUE BURNABY
0012831		6350 YUKON STREET VANCOUVER
0012835		4408 FRASER STREET VANCOUVER
0012850		2636 NOOTKA STREET VANCOUVER
0012862		3067 COPLEY STREET VANCOUVER
0012863		56 WEST KING EDWARD AVENUE VANCOUVER
0012870		592 WEST 27TH AVENUE VANCOUVER
0012875		3114 EAST PENDER STREET VANCOUVER
0012894	11OCT20	932 CORDOVA STREET VANCOUVER
0012900	11APR15	404 WEST 17TH AVENUE VANCOUVER
0012910		4141 IRMIN STREET BURNABY
0012912		518 MOBERLY ROAD VANCOUVER
0012926	13FEB14	540 WEST 7TH AVENUE VANCOUVER
0012939	11APR28	2509 MAIN STREET VANCOUVER
0012956	12JUN22	677-691 EAST BROADWAY VANCOUVER
0012961		408 EAST 46TH AVENUE VANCOUVER

1223 records selected for 5.0 km from latitude 49 deg, 14 min, 34.2 sec
and Longitude 123 deg, 2 min, 57.1 sec

Site Id	Lastupd	Address / City
0012966		3778 BRANDON STREET BURNABY
0012967		1725 EAST 1ST AVENUE VANCOUVER
0012977		161 WEST 44TH AVENUE VANCOUVER
0012978		2627 WEST 7TH AVENUE VANCOUVER
0012983	12AUG08	1553, 1577 AND 1615 MAIN STREET VANCOUVER
0012994		2565 KITCHENER VANCOUVER
0012997	12SEP14	344 EAST 34TH AVENUE VANCOUVER
0013002		1233 EAST 18TH AVENUE VANCOUVER
0013008		82 WEST 18TH AVENUE VANCOUVER
0013021	12MAR22	557 GREAT NORTHERN WAY VANCOUVER
0013026		1175 EAST 17TH AVENUE VANCOUVER
0013040		2839 EAST BROADWAY VANCOUVER
0013044		4720 HIGHLAWN DRIVE BURNABY
0013055		4684 ALPHA DRIVE BURNABY
0013059	12FEB24	220 PRINCESS STREET, 606 POWELL STREET VANCOUVER
0013072		2128 EAST 45TH AVENUE VANCOUVER
0013082		7050 MARLBOROUGH AVENUE BURNABY
0013084		196 WEST 23RD AVENUE VANCOUVER
0013085		782 EAST 41ST AVENUE VANCOUVER
0013087		66 WEST 21ST AVENUE VANCOUVER
0013101		510 WEST 29TH AVENUE VANCOUVER
0013103		2116 EAST 7TH AVENUE VANCOUVER
0013108		7061 MCKAY AVENUE BURNABY
0013109		8083 JOFFRE AVENUE BURNABY
0013142	11SEP01	7707-7723 ROYAL OAK AVENUE BURNABY

As Of: MAY 12, 2013 BC Online: Site Registry 13/05/16
For: PH45881 WEST COAST TITLE SEARCH LTD. 09:36:51
Folio: Page 42
1223 records selected for 5.0 km from latitude 49 deg, 14 min, 34.2 sec
and Longitude 123 deg, 2 min, 57.1 sec

Site Id	Lastupd	Address / City
0013146	11SEP09	2149 PARKER STREET VANCOUVER
0013147		2151 PARKER STREET VANCOUVER
0013150		276 WEST 22ND AVENUE VANCOUVER
0013152		4661 WESTLAWN DRIVE BURNABY
0013161		5610 DUNDAS STREET BURNABY
0013163		2769 EUCLID AVENUE VANCOUVER
0013185		4565 CAMBIE STREET VANCOUVER
0013190	13JAN25	1077 GREAT NORTHERN WAY VANCOUVER
0013220		4093 ETON STREET BURNABY
0013223		531 WEST 27TH AVENUE VANCOUVER
0013231	11AUG15	1955 COLUMBIA STREET VANCOUVER
0013232	11AUG12	540 GRANVILLE STREET VANCOUVER
0013241		130 WEST 26TH AVENUE VANCOUVER
0013247		6386 BUTLER STREET VANCOUVER
0013248		4060 ALBERT STREET, ALIAS: 4058 ALBERT STREET BURNABY
0013263	11NOV17	459 WEST 20TH AVENUE VANCOUVER
0013272	12JAN12	4987 EARLES STREET VANCOUVER
0013315		4780 ELGIN STREET VANCOUVER
0013320		944 EAST 13TH AVENUE VANCOUVER
0013342		115 NORTH HOWARD AVENUE BURNABY
0013343		645 EAST 48TH AVENUE VANCOUVER
0013350		4702 HASTINGS STREET BURNABY
0013357	11SEP22	1817 MCSPADDEN AVENUE VANCOUVER
0013361	12OCT01	8920 FRASERTON COURT BURNABY
0013363		2579 EAST 6TH AVENUE VANCOUVER

As Of: MAY 12, 2013 BC Online: Site Registry 13/05/16
For: PH45881 WEST COAST TITLE SEARCH LTD. 09:36:51
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1223 records selected for 5.0 km from latitude 49 deg, 14 min, 34.2 sec
and Longitude 123 deg, 2 min, 57.1 sec

Site Id	Lastupd	Address / City
0013371		4361 CARSON STREET BURNABY
0013376		1012 LILLOOET STREET VANCOUVER
0013377	11OCT01	2650 NANAIMO STREET VANCOUVER
0013398		1806 EAST 52ND AVENUE VANCOUVER
0013412		550 EAST 58TH AVENUE VANCOUVER
0013415	12MAY24	5762 ONTARIO STREET VANCOUVER
0013424		4435 PANDORA STREET BURNABY
0013444		1437 EAST 10TH AVENUE VANCOUVER
0013447		1352 VERNON STREET VANCOUVER
0013460		518 EAST 11TH AVENUE VANCOUVER
0013476		454 EAST 60TH AVENUE VANCOUVER
0013489		3858 KINCAID STREET BURNABY
0013490		4520 WILLIAM STREET BURNABY
0013516		4995 ST CATHERINES STREET VANCOUVER
0013517		4535 CAMBIE STREET VANCOUVER
0013525		3144 EAST 45TH AVENUE VANCOUVER
0013530		5428 ELIZABETH STREET VANCOUVER
0013541		7677 YUKON STREET VANCOUVER
0013549		139 WEST 46TH AVENUE VANCOUVER
0013569	12SEP28	420 WEST 19TH AVENUE VANCOUVER
0013579		385 WEST 23RD AVENUE VANCOUVER
0013609	12JAN06	605 - 645 WEST 41ST AVENUE VANCOUVER
0013614	12OCT05	775 RICHARD STREET VANCOUVER
0013615	13APR05	520 AND 550 WEST GEORGIA STREET VANCOUVER
0013622		3705 KINCAID STREET BURNABY

1223 records selected for 5.0 km from latitude 49 deg, 14 min, 34.2 sec
and Longitude 123 deg, 2 min, 57.1 sec

Site Id	Lastupd	Address / City
0013636	12OCT26	545 POWELL STREET VANCOUVER
0013643	12JAN24	3239 EAST 3RD AVENUE VANCOUVER
0013644	13JAN17	105-167 WEST 2ND AVENUE VANCOUVER
0013645	12APR05	333 WOODLAND DRIVE VANCOUVER
0013648		3247 EAST 3RD AVENUE VANCOUVER
0013657		7045 QUEBEC STREET VANCOUVER
0013690		576 EAST 49TH AVENUE VANCOUVER
0013706		EAST SIDE OF KNIGHT ST SOUTH OF EAST 54TH AVE VANCOUVER
0013707		2631 DUKE STREET VANCOUVER
0013728	12MAR09	4344 GEORGIA STREET BURNABY
0013745	12JUN08	6830 BURLINGTON AVENUE BURNABY
0013752	12MAR07	951 BOUNDARY ROAD VANCOUVER
0013776		4439 BURKE STREET BURNABY
0013780		1667 KITCHENER STREET VANCOUVER
0013782	12MAY28	3970 MAIN STREET VANCOUVER
0013785	13MAY02	3470 AND 3520 COMMERCIAL STREET VANCOUVER
0013888	13FEB28	7301 MARKET CROSSING ROAD BURNABY
0013891		2758 EAST 24TH AVENUE VANCOUVER
0013892		4724 KILLARNEY STREET VANCOUVER
0013900	12JUN05	1771, 1779 AND 1791 DOUGLAS ROAD BURNABY
0013914	12JUN28	5750 ONTARIO STREET VANCOUVER
0013932	13APR17	4600 KINGSWAY BURNABY
0013935	12SEP14	4894 FRASER STREET VANCOUVER
0013939		4219 ETON STREET BURNABY
0013945		757 EAST 26TH AVENUE

2nd Ave to Marine Dr (-123.04, 49.2)
VANCOUVER

1223 records selected for 5.0 km from latitude 49 deg, 14 min, 34.2 sec
and Longitude 123 deg, 2 min, 57.1 sec

Site Id	Lastupd	Address / City
0013947		3914 NITHSDALE STREET BURNABY
0013948		176 TALISMAN AVENUE VANCOUVER
0013951		66 EAST 63RD AVENUE VANCOUVER
0013963		4547 CAMBIE STREET VANCOUVER
0013964		744 EAST GEORGIA STREET VANCOUVER
0013970		2622 CHARLES STREET VANCOUVER
0013975		4229 CASTLEWOOD CRESCENT BURNABY
0013976	12SEP28	222, 230, 236 WEST BROADWAY VANCOUVER
0013990		4376 PRICE STREET BURNABY
0014007	12MAY29	1021 WEST HASTINGS STREET VANCOUVER
0014011	12MAY16	302 - 318 INDUSTRIAL AVENUE VANCOUVER
0014024		6721 DOW AVENUE BURNABY
0014036		819-829 WEST PENDER STREET VANCOUVER
0014077		5229 ST CATHERINES STREET VANCOUVER
0014082		6892 WILLINGDON AVENUE BURNABY
0014083		3878 BOND STREET BURNABY
0014085		223 WEST 13TH AVENUE VANCOUVER
0014099		590 EAST 52ND AVENUE VANCOUVER
0014100	12JUL03	4580 ONTARIO STREET VANCOUVER
0014119		770 EAST 24TH AVENUE VANCOUVER
0014120	13FEB14	6391 FRASER STREET VANCOUVER
0014128	12JUN22	4567 LOUGHEED HIGHWAY BURNABY
0014147		3245 TURNER STREET VANCOUVER

2nd Ave to Marine Dr (-123.04, 49.2)

0014152	12NOV20	2220 KINGSWAY VANCOUVER
0014203		4649 BRENTLAWN DRIVE BURNABY

1223 records selected for 5.0 km from latitude 49 deg, 14 min, 34.2 sec
and Longitude 123 deg, 2 min, 57.1 sec

Site Id	Lastupd	Address / City
0014204		2950 GRAVELEY STREET VANCOUVER
0014226		412 WEST 19TH AVENUE VANCOUVER
0014229	12AUG16	5235 KINGSWAY BURNABY
0014233		5028 SHERBROOKE STREET VANCOUVER
0014288	13JAN24	549, 553, 557 EAST CORDOVA STREET VANCOUVER
0014290	12DEC04	310 EAST 2ND AVENUE VANCOUVER
0014299		470 WEST 22ND AVENUE VANCOUVER
0014306		481 EAST 11TH AVENUE VANCOUVER
0014324		4393 WILDWOOD CRESCENT BURNABY
0014333		2769 CAMBRIDGE STREET VANCOUVER
0014337		152 EAST 20TH AVENUE VANCOUVER
0014346		1496 EAST 20TH AENUE VANCOUVER
0014348	12SEP19	5550 GORING STREET BURNABY
0014349		150 WEST KING EDWARD AVENUE VANCOUVER
0014357		976 EAST 10TH AVENUE VANCOUVER
0014364		4847 HENRY STREET VANCOUVER
0014371		1439/1445 EAST 41ST AVENUE VANCOUVER
0014388		3170 QUEBEC STREET VANCOUVER
0014390	12NOV05	6333 SILVER AVENUE BURNABY
0014396		63 WEST 28TH AVENUE VANCOUVER
0014397		49 WEST 28TH AVENUE VANCOUVER
0014403	13APR10	3980 NORTH FRASER WAY

2nd Ave to Marine Dr (-123.04, 49.2)

		BURNABY
0014440	12OCT10	1908 PARKER STREET
		VANCOUVER
0014441	12OCT24	1014 VICTORIA DRIVE
		VANCOUVER
0014477	12NOV07	453 EAST 47TH AVENUE
		VANCOUVER

1223 records selected for 5.0 km from latitude 49 deg, 14 min, 34.2 sec
and Longitude 123 deg, 2 min, 57.1 sec

Site Id	Lastupd	Address / City
0014480	12OCT25	314 WEST 13TH AVENUE
		VANCOUVER
0014483	12OCT25	2828 ALEMEIN STREET
		VANCOUVER
0014511	12NOV16	495 SE MARINE DRIVE
		VANCOUVER
0014535	12NOV21	1415 EAST 14TH AVENUE
		VANCOUVER
0014537	12NOV21	7767 YUKON STREET
		VANCOUVER
0014550		5355 & 5347 CAMBIE STREET
		VANCOUVER
0014582	12DEC05	253 KEEFER STREET
		VANCOUVER
0014584	12DEC05	247 KEEFER STREET (BETWEEN KEEFER ST & BACK LANE)
		VANCOUVER
0014587	12DEC05	LANEWAY BEHIND 253 KEEFER STREET
		VANCOUVER
0014593	13MAR27	9980 RIVER DRIVE
		RICHMOND
0014598		650 WEST 41ST AVENUE
		VANCOUVER
0014613		5254 SPENCER STREET
		VANCOUVER
0014635		4320-4330 SLOCAN STREET
		VANCOUVER
0014649	12DEC17	50 EAST 30TH AVENUE
		VANCOUVER
0014672	13APR11	4226 FRASER STREET
		VANCOUVER
0014673		3723 PRICE STREET
		BURNABY
0014674		5040 ELGIN STREET
		VANCOUVER
0014686	12DEC20	225 KINGSWAY
		VANCOUVER
0014696		3128 WEST KING EDWARD AVENUE
		VANCOUVER
0014706		4260 PRICE CRESCENT
		BURNABY

2nd Ave to Marine Dr (-123.04, 49.2)

0014711		7855 WINDSOR STREET VANCOUVER
0014713	13FEB08	1636 CLARK DRIVE AND CITY OF VANCOUVER ROADWAYS VANCOUVER
0014747		987 EAST CORDOVA STREET VANCOUVER
0014749	13MAY06	992, 994 AND 996 POWELL STREET VANCOUVER
0014759		3567 HULL STREET VANCOUVER

1223 records selected for 5.0 km from latitude 49 deg, 14 min, 34.2 sec
and Longitude 123 deg, 2 min, 57.1 sec

Site Id	Lastupd	Address / City
0014824	13APR03	4209 EAST PENDER STREET BURNABY
0014825	13MAR27	4211 PENDER STREET BURNABY
0014835	13MAR27	7211 CHARLFORD AVENUE BURNABY
0014837		275 WEST 19TH AVENUE VANCOUVER
0014838		5088 WILLINGDON AVENUE BURNABY
0014842		784 POWELL STREET VANCOUVER
0014843		2415 EAST 29TH AVENUE VANCOUVER
0014845		5426 KEITH STREET BURNABY
0014853		165 WEST 21ST AVENUE VANCOUVER
0014854		573 EAST 29TH AVENUE VANCOUVER
0014871	13FEB28	CITY OF VANCOUVER ROADWAY VANCOUVER
0014882	13APR03	518 RICHARDS STREET VANCOUVER
0014905	13APR15	LANEWAY SOUTH OF 138 W 1ST AVENUE VANCOUVER
0014906	13FEB28	AREA SOUTH OF 138 WEST 1ST. AVENUE VANCOUVER
0014927		1663 EAST 11TH AVENUE VANCOUVER
0014928	13MAR13	1450 VENABLES STREET VANCOUVER
0014929	13MAR06	404 HAWKS AVENUE VANCOUVER
0014937	13APR03	6583 DUNBLANE AVENUE SURREY
0014939	13APR15	5009 ELGIN STREET

2nd Ave to Marine Dr (-123.04, 49.2)

		VANCOUVER
0014940	13APR15	5019 ELGIN STREET
		VANCOUVER
0014944	13APR04	6593 DUNBLANE AVENUE
		BURNABY
0015014	13APR19	MANAGEMENT AREA ADJACENT TO 2700 KINGSWAY
		VANCOUVER
0015037		2411 GEORGIA STREET
		VANCOUVER
0015042		4383 CAMBRIDGE STREET
		BURNABY
0015043	13APR04	7801 ARGYLE STREET
		VANCOUVER

1223 records selected for 5.0 km from latitude 49 deg, 14 min, 34.2 sec
and Longitude 123 deg, 2 min, 57.1 sec

Site Id	Lastupd	Address / City
0015064		3763 AVONDALE STREET
		BURNABY
0015076	13APR16	1130 - 1132 POWELL STREET
		VANCOUVER
0015082		2677 EAST 40TH AVENUE
		VANCOUVER
0015083	13APR05	1100 POWELL STREET
		VANCOUVER
0015089		2635 EAST 52ND AVENUE
		VANCOUVER
0015091	13APR05	1160-1196 POWELL STREET
		VANCOUVER
0015092		4672 HIGHLAWN DRIVE
		BURNABY
0015103	13APR05	3284-3298 E BROADWAY & 2521 RUPERT ST
		VANCOUVER
0015104	13APR05	LANEWAY 50 M SOUTH OF EAST BROADWAY
		VANCOUVER
0015114		241 EAST 64TH AVENUE
		VANCOUVER
0015125	13APR05	855 CENTENNIAL ROAD
		VANCOUVER
0015126	13APR05	CENTENNIAL ROAD AND WATER LOTS
		VANCOUVER
0015130		106 EAST 37TH AVENUE
		VANCOUVER
0015137		3510 OXFORD STREET
		VANCOUVER
0015138		55 WEST 45TH AVENUE
		VANCOUVER
0015145		4822 BOND STREET
		BURNABY
0015146		391 WEST KING EDWARD AVENUE
		VANCOUVER

2nd Ave to Marine Dr (-123.04, 49.2)

0015158		945 EAST 20TH AVENUE VANCOUVER
0015176		PART OF NORTH FRASER CRESCENT BURNABY
0015189		154 41ST AVENUE VANCOUVER
0015201	13MAY10	150 EAST CORDOVA STREET VANCOUVER
0015226		ROSSER AVENUE AT SKYLINE DRIVE BURNABY
0015236		1112 EAST 10TH AVENUE VANCOUVER

APPENDIX C
PHOTO LOG

Photo B1 – Spuraway Avenue facing southwest towards KP 0.0 at Coquitlam Station.

Photo B2 – Pipeline alignment along the north side of Gaglardi Way facing northeast towards KP 6.3.

Photo B3 – Pipeline alignment along the north side of Gaglardi Way facing southwest towards KP 6.4.

Photo B4 – Pipeline alignment facing southwest towards KP 6.5.

Photo B5 – Pipeline alignment facing northeast towards KP 6.6.

Photo B6 – Pipeline alignment facing southwest towards KP 6.7

Photos taken March 5, March 12 and May 22, 2014.

Photo B7 – Ramp to Forest Grove Drive from Broadway Avenue. Facing east towards KP 7.2.

Photo B8 – Ramp to Forest Grove Drive from Broadway Avenue. Facing west towards KP 7.3.

Photo B9 – Burnaby Mountain Urban Trail west of Production Way. Facing west towards KP 7.4.

Photo B10 – Burnaby Mountain Urban Trail facing east towards KP 7.7.

Photo B11. Underhill Avenue facing east towards Burnaby Mountain Urban Trail

Photo B12. Burnaby Mountain Urban Trail facing west towards Broadway Avenue at Underhill Avenue.

Photos taken March 5, March 12 and May 22, 2014.

Photo B13 – Broadway Avenue facing west towards KP 11.8.

Photo B14 – Broadway Avenue at Fell Avenue facing east towards KP 11.9.

Photo B15 – KP 12.0 facing west towards KP 12.1.

Photo B16 – Broadway Avenue facing southeast towards Beecher Creek and KP 12.6.

Photo B17 – Spring Avenue facing northwest towards KP 12.8.

Photo B18 – Halifax Street facing southeast towards KP 12.9.

Photos taken March 5, March 12 and May 22, 2014.

Photo B19 – Halifax Street facing west towards KP 13.2.

Photo B20 – Highlawn Drive facing west towards KP 13.6.

Photo B21 – Brentlawn Drive facing west towards K P 14.3.

Photo B22 – Graveley Street facing west towards KP 14.7.

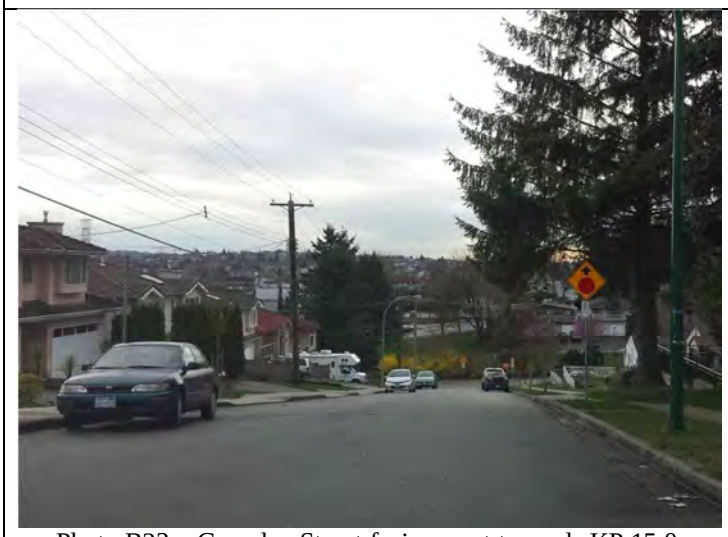


Photo B23 – Graveley Street facing west towards KP 15.0.

Photos taken March 5, March 12 and May 22, 2014.

Photo C1 – KP 1.3 facing southwest towards KP 1.2 and Lougheed Highway.

Photo C2 – KP 1.4 facing northeast towards KP 1.5.

Photo C3 – Pipeline alignment along hydro corridor alignment facing south towards KP 1.4.

Photo C4 – Pipeline alignment along hydro corridor alignment facing north towards KP 1.5.

Photo C5 – United Boulevard facing southwest towards KP 1.5.

Photo C6 – United Boulevard facing northeast towards KP 1.6.

Photo C7 – Ramp to United Boulevard facing west towards KP 1.7.

Photo C8 – Ramp to United Boulevard along original alignment facing north towards KP 1.8.

Photo C9 – Pipeline alignment along hydro corridor facing southwest towards KP 1.9.

Photo C10 – Pipeline alignment along hydro corridor facing southwest towards KP 2.0.

Photo C11 – Pipeline alignment along hydro corridor facing northeast towards KP 2.1.

Photo C12 – Mariner Way facing southwest towards KP 2.1.

Photo C13 – Mariner Way facing north towards KP 2.2.

Photo C14 – Cape Horn Water Pump Station facing south towards KP 2.2.

Photo C15 – Cape Horn Water Pump Station facing north towards KP 2.3.

Photo C16 – KP 2.5 facing south towards KP 2.4 along hydro corridor.

Photo C17 – KP 2.5 facing north towards KP 2.6 and Mariner Way Park along hydro corridor.

Photo C18 – Crawley Avenue facing south towards KP 2.8 and Mariner Way Park.

Photo C19 – Crawley Avenue facing north towards KP 2.9.

Photo C20 – Austin Avenue facing south towards KP 3.0 and commercial plaza.

Photo C21 – Austin Avenue facing north towards KP 3.1.

Photo C22 – Pipeline alignment facing south towards KP 3.1 along hydro corridor adjacent to recycling depot.

Photo C23 – Pipeline alignment facing north towards KP 3.2 along hydro corridor adjacent to recycling depot.

Photo C24 – Pipeline alignment adjacent to Mundy Park, facing south towards KP 3.4.

Photo C25 – Pipeline alignment adjacent to Mundy Park, facing north towards KP 3.5.

Photo C26 – Low lying wet areas along pipeline alignment, facing south towards KP 3.6.

Photo C27 – Lost Creek crossing pipeline alignment between KP 3.6 and KP 3.7. Facing north towards KP 3.7.

Photo C28 – Pipeline alignment adjacent to Mundy Park facing south towards KP 3.7.

Photo C29 – Pipeline alignment adjacent to Mundy Park facing north towards KP 3.8.

Photo C30 – Pipeline alignment adjacent to Mundy Park facing south towards KP 4.0.

Photo C31 – Pipeline alignment adjacent to Mundy Park facing north towards KP 4.1.

Photo C32 – Mundy Park Community Path adjacent to Mariner Way, facing south towards KP 4.2.

Photo C33 – Mariner Way, facing north towards KP 4.3.

Photo C34 – Spuraway Avenue facing south towards KP 4.475.

Photo D1 – KP 0.1 facing south towards KP 0.0

Photo D2 – KP 0.1 facing north towards KP 0.2

Photo D3 – 94a Ave facing north towards KP 0.3

Photo D4 – 94a Ave facing south towards KP 0.2

Photo D5 – 96 ave facing south towards KP 0.4

Photo D6 – KP 0.5 facing north

Photo D7 – KP 0.6 facing south towards KP 0.5

Photo D8 – Facing north from Quibble Creek towards KP 0.9

Photo D9 – KP 0.9 facing south towards Quibble Creek/KP 0.8

Photo D10 – KP 0.9 facing north towards KP 1.0

Photo D11 – Facing south along greenway towards KP 1.2

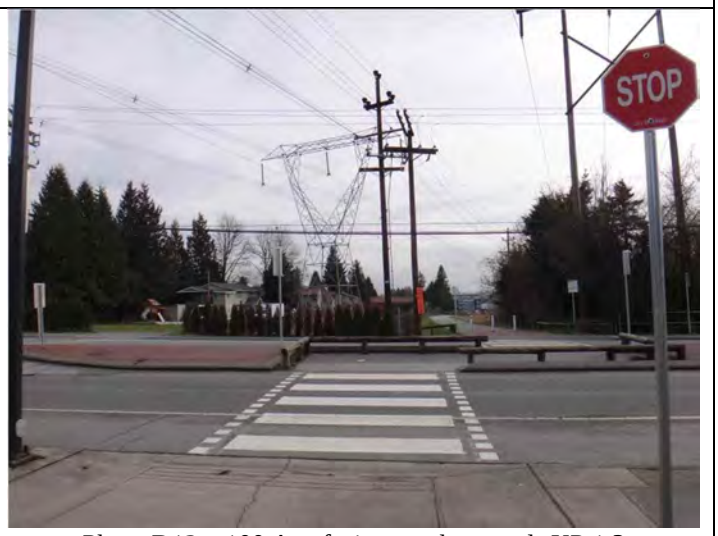


Photo D12 – 100 Ave facing south towards KP 1.3

Photo D13 – 100 Ave facing north towards KP 1.4

Photo D14 – 102 Ave facing south along greenway to KP 1.7

Photo D15 – KP 2.0 facing south towards KP 1.9

Photo D16 – KP 2.0 facing north towards KP 2.1

Photo D17 – 140 Ave facing south towards KP 2.2

Photo D18 – 140 Ave facing north towards KP 2.3

Photo D19 – 160 Ave facing south towards KP 2.6

Photo D20 – 160 Ave facing north towards KP 2.7

Photo D21 – KP 2.9 facing south towards KP 2.8

Photo D22 – KP 2.9 facing north towards KP 3.0

Photo D23 – 108 Ave facing south towards KP 3.0

Photo D24 – 108 Ave facing north towards KP 3.1

Photo D25 – 109 Ave facing south towards KP 3.2.

Photo D26 – 109 Ave facing north twoards KP 3.3.

Photo D27 –110 Ave facing south towards KP 3.4

Photo D28 – 110 Ave facing northeast towards KP 3.5

Photo D29 – 110 a Avenue facing southwest towards KP 3.5.

Photo D30 – 110 a Avenue facing northeast towards KP 3.6.

Photo D31 – Park Drive facing south towards KP 3.7

Photo D32 – Park Drive facing north towards KP 3.8.

Photo D33 – Melrose Drive facing south towards KP 3.9.

Photo D34 – Melrose Drive facing north towards KP 4.0.

Photo D35 – Currie Drive at KP 4.2 facing south towards KP 4.1.

Photo D36 – Currie Drive at KP 4.2 facing north towards KP 4.3.

Photo D37 –114 Avenue at KP 4.5 facing south towards KP 4.4.

Photo D38 – 114 Avenue at KP 4.5 facing north towards KP 4.6.

Photo D39 – 115 Avenue facing south towards KP 4.6.

Photo D40 –115 Avenue facing north towards KP 4.7.

Photo D41 – King Road facing south towards KP 4.8.

Photo D42 –King Road facing south towards KP 4.9.

APPENDIX D

ENVIRONMENTAL WATERCOURSE INFORMATION

Number	FortisBC Waterbody Number	FortisBC IP Referen Number	Pipe Size	Site Location, Site Access	Legal Description	GPS Location	Waterbody Name	Waterbody Classification (Waterbody Type)
BBY City of Burnaby, City of New Westminster, Annacis Island								
8	BBY-WB1.0	3.1	IP508	Broadway, E of Gaglardi Way, BBY	City of Burnaby	N49° 15.775' W122° 53.841'	Stoney Creek	red (stream)
9	BBY-WB2.0	3.2	IP508	Broadway, E of Gaglardi Way, BBY	City of Burnaby	N49° 15.775' W122° 53.841'	Stoney Creek tributary	significant/ not classified
10	BBY-WB3.0	3.4	IP508	Gaglardi Way, W of Broadway, BBY	City of Burnaby	N49° 15.778' W122° 54.178'	Stoney Creek tributary	significant/ not classified
11	BBY-WB4.0	3.7	IP508	Forest Grove Dr, BBY	City of Burnaby	N49° 15.745' W122° 54.330'	Stoney Creek tributary	significant/ not classified
12	BBY-WB5.0	3.12	IP508	Production Way, N of Eastlake Dr, BBY	City of Burnaby	N49° 15.645' W122° 54.896'	Stoney Creek tributary	significant/ not classified
13	BBY-WB6.0	3.14	IP508	Production Way, N of Eastlake Dr, BBY	City of Burnaby	N49° 15.658' W122° 54.968'	Stoney Creek tributary	significant/ not classified
14	BBY-WB7.0	3.16	IP508	Production Way, N of Eastlake Dr, BBY	City of Burnaby	N49° 15.645' W122° 55.225'	Silver Creek tributary	significant/ not classified
15	BBY-WB8.0	3.18	IP508	Production Way, N of Eastlake Dr, BBY	City of Burnaby	N49.260875° W122.922960°	Silver Creek	significant/ not classified
16	BBY-WB9.0	3.20	IP508	Underhill Ave, N of Eastlake Dr, BBY	City of Burnaby	N49.260903° W122.927279°	Silver Creek	significant/ not classified
18	BBY-WB11.0	3.21	IP508	Broadway, W of Lake City Way, BBY	City of Burnaby	N49° 15.660' W122° 56.380'	Eagle Creek	red (stream)
19	BBY-WB12.0	3.22	IP508	Halifax St, E of Delta Ave, BBY	City of Burnaby	N49° 16.085' W122° 59.447'	Beecher Creek (tributary)	significant/ not classified

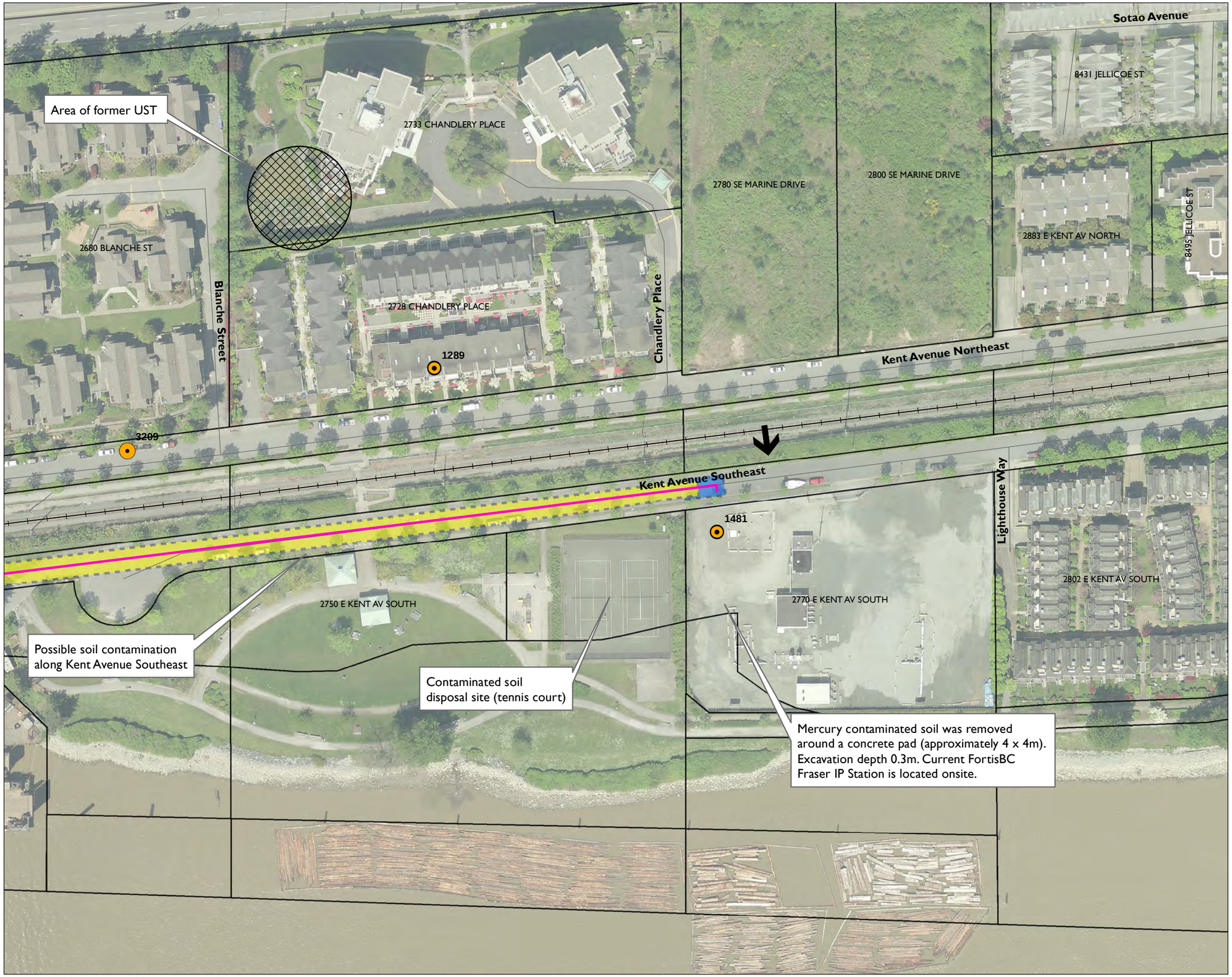
Ref. Number	FortisBC Waterbody Number	FortisBC File Number	Site Location, Site Access	Legal Description	GPS Location	Waterbody Name (Downstream Waterbody)	Waterbody Classification (Waterbody Type)
NP Nichol to Port Mann							
268	NP-WB1.0	NP007	9465 139 St, Surrey	PID: 008-542-805 L45 NW4 S33 T2 P38692 Posting Plan 1-52	N49 10.450 W122 50.401	Lay Creek (Bear Creek)	red (stream)
269	NP-WB2.0	NP010	13828 Fraser Hwy, Surrey	PID: 000-819-034 L2 PCL'E' S35 R2 P17876 EXC LMP89 Posting Plan 1-51	N49 10.804 W122 50.356	Lay Creek (Bear Creek)	red (stream)
270	NP-WB3.0	NP060	106 Ave, E of 140 St, Surrey	PID: 000-819-879 L20 B5 S24 R2 P16807 Posting Plan 1-49	N49 11.686 W122 49.932	Bon Accord Creek (Fraser River)	red (stream)
PC Port Mann to Coquitlam							
279	PC-WB0.3	PC12.01	United Blvd Exit (Hwy 1 E) Coquitlam	C P R Posting Plan 15012	N49 13.682 W122 49.570		significant/ classification not found (ditch)
280	PC-WB0.4	PC13.R	S of Rocket Way, W of Golden Dr Coquitlam	Trans Canada Hwy Coquitlam BC	N49 13.714 W122 49.560		significant/ classification not found (ditch)
281	PC-WB0.5	PC017	N of Rocket Way, NW of Golden Dr Coquitlam	Mile 3.16 Westminster Subdivision Posting Plan 1-76	N49 14.038 W122 49.545		significant/ classification not found (ditch)
282	PC-WB1.0	PC019	S of Mariner Way, N of Lougheed Hwy Coquitlam	PID: 014-528-924 L2 DL65/67 G1 NWD P81991 Posting Plan 1-77	N49 14.245 W122 49.333	Mundy Creek (Coquitlam River)	red (stream)
283	PC-WB2.0	PC041	Mariner Way, W of Chilko Dr Coquitlam	PID: 012-038-458 L4 DL360 P1230 Posting Plan 1-78	N49 15.286 W122 49.007	Lost Creek (Mundy Creek)	yellow (stream)

APPENDIX E

APEC Overview

APEC Information – Fraser Gate	
APEC A1	Site ID 1481– 2770 East Kent Avenue South, Vancouver – Figure A1
APEC Location	End of alignment south of Chandley Place
Length	10m
Groundwater Elevation (Flow Direction)	Tidally influenced 1-3 mbgs (South)
Site Details	
Site ID 1481 (Located hydraulically downgradient) Industrial site located south of the alignment. Current FortisBC Fraser IP Station is located onsite.	
Document Review Findings	
Site ID 1481 BC Gas letter to BC MOE - stating remediation of localized mercury contaminated soil at the Fraser Gate Station in Vancouver. A total of 1.53 m^3 of contaminated soil was removed around the concrete pad. soils were remediated to 10ppm	
Classification	Low Impact Site
Potential Contamination	Hydrocarbon and metals
Recommendation	Manage any subsurface contamination related issues during construction activities.
PCOCs	
Mercury and other metals	

See APEC Overview Figure APEC A1 for more information



FortisBC

FortisBC LMSU - Fraser Gate

APEC Overview

APEC A1

- Distance Posts
- Contaminated Sites
- Proposed Fraser IP
- Proposed Metro IP
- Proposed Cape Horn to Coquitlam
- Railways

Roads/Highways

- Highway/Freeway
- Arterial Streets
- Collector Street
- Local Streets
- Alley
- Ramp

APEC Classification

- Low Impact Site
- Medium to High Impact Site
- Parcels
- Inferred Ground Water Flow

SCALE 1:1,145

0 2.5 5 10 Meters

N W E S

Map Drawing Information: FortisBC, BC Site Registry, Dillon Consulting Limited

Map Created By: ECH
Map Checked By:
Map Projection: NAD 1983 UTM Zone 10N

DILLON CONSULTING

PROJECT: 14-8963

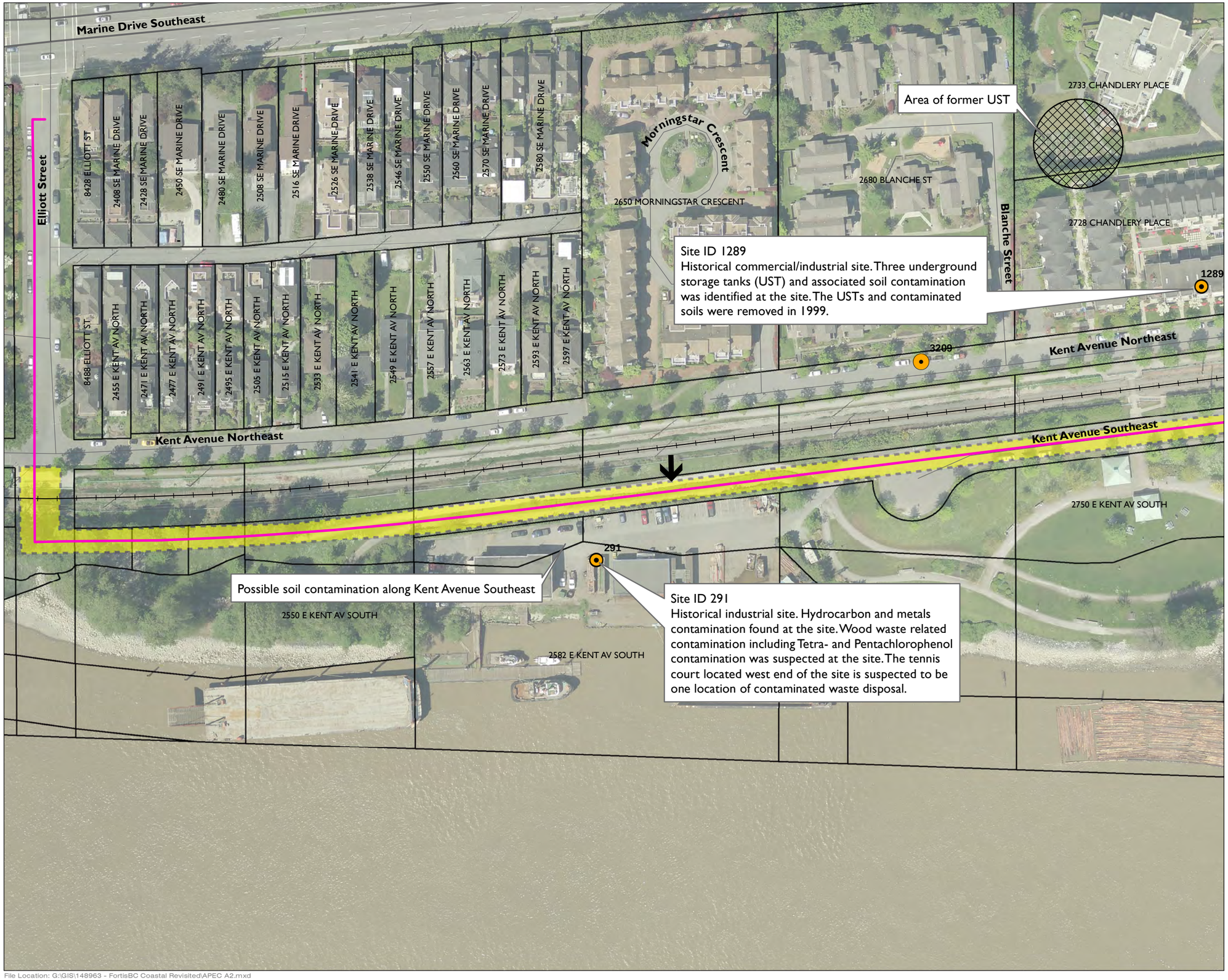
STATUS: FINAL

DATE: 5/2/2014

File Location: G:\GIS\148963 - FortisBC Coastal Revisited\APEC A1.mxd

APEC Information – Fraser Gate	
APEC A2	Site ID 291 - 2582 East Kent Avenue South, Vancouver – Figure A1 Site ID 1289 - 2705 East Kent Avenue, Vancouver – Figure A1
APEC Location	Along Kent Avenue south from Elliott Street up to APEC 1
Length	500 m
Groundwater Elevation (Flow Direction)	Tidally influenced 1-3 mbgs (South)
Site Details	
Site ID 291 (Located hydraulically downgradient) The site is located south of the alignment. Currently the site has been developed as Fraser Lands Riverpoint Park. Historical activities at the site included: • Lumber storage; • Mooring, provisioning and fueling of tug boats and barges; • Container repair and storage; • Repair and maintenance of marine and mobile equipment; • Concrete plant and related activities; and • Shipyard Site ID 1289 (Located hydraulically upgradient) Site includes addresses 2720-2740 SE Marine Drive as well. The site is located north of the alignment. Currently the site has been developed as residential housing. Prior to redevelopment the site was zoned as commercial/industrial. APEC 2 includes railroad crossing as well.	
Document Review Findings	
Site ID 291 Hydrocarbon and metals contamination found at the site. Wood waste related contamination including Tetra- and Pentachlorophenol contamination was suspected at the site. The tennis court located west end of the site is suspected to be one location of contaminated waste disposal.Site ID 1289 Three underground storage tanks (UST) and associated soil contamination was identified at the site. The USTs and contaminated soils were removed in 1999.	
Classification	Medium to High Impact Site
Potential Contamination	Hydrocarbon, metals and wood waste
Recommendation	Subsurface soil and groundwater investigation
PCOC s	
LEPH/HEPH, PAHs, VOCs including BTEX, Metals, Tetra and Pentachlorophenol and other wood waste related PCOCs, PCBs	

See APEC Overview Figures APEC A1 and A2 for more information



FortisBC

FortisBC LMSU - Fraser Gate

APEC Overview

APEC A2

- Distance Posts
- Contaminated Sites
- Proposed Fraser IP
- Proposed Metro IP
- Proposed Cape Horn to Coquitlam
- Railways

Roads/Highways

- Highway/Freeway
- Arterial Streets
- Collector Street
- Local Streets
- Alley
- Ramp

APEC Classification

- Low Impact Site
- Medium to High Impact Site
- Inferred Ground Water Flow

SCALE 1:1,250

0 12.5 25 50 Meters

N W E S

Map Drawing Information: FortisBC, BC Site Registry, Dillon Consulting Limited

Map Created By: ECH
Map Checked By:
Map Projection: NAD 1983 UTM Zone 10N

DILLON CONSULTING

PROJECT: 14- 8963

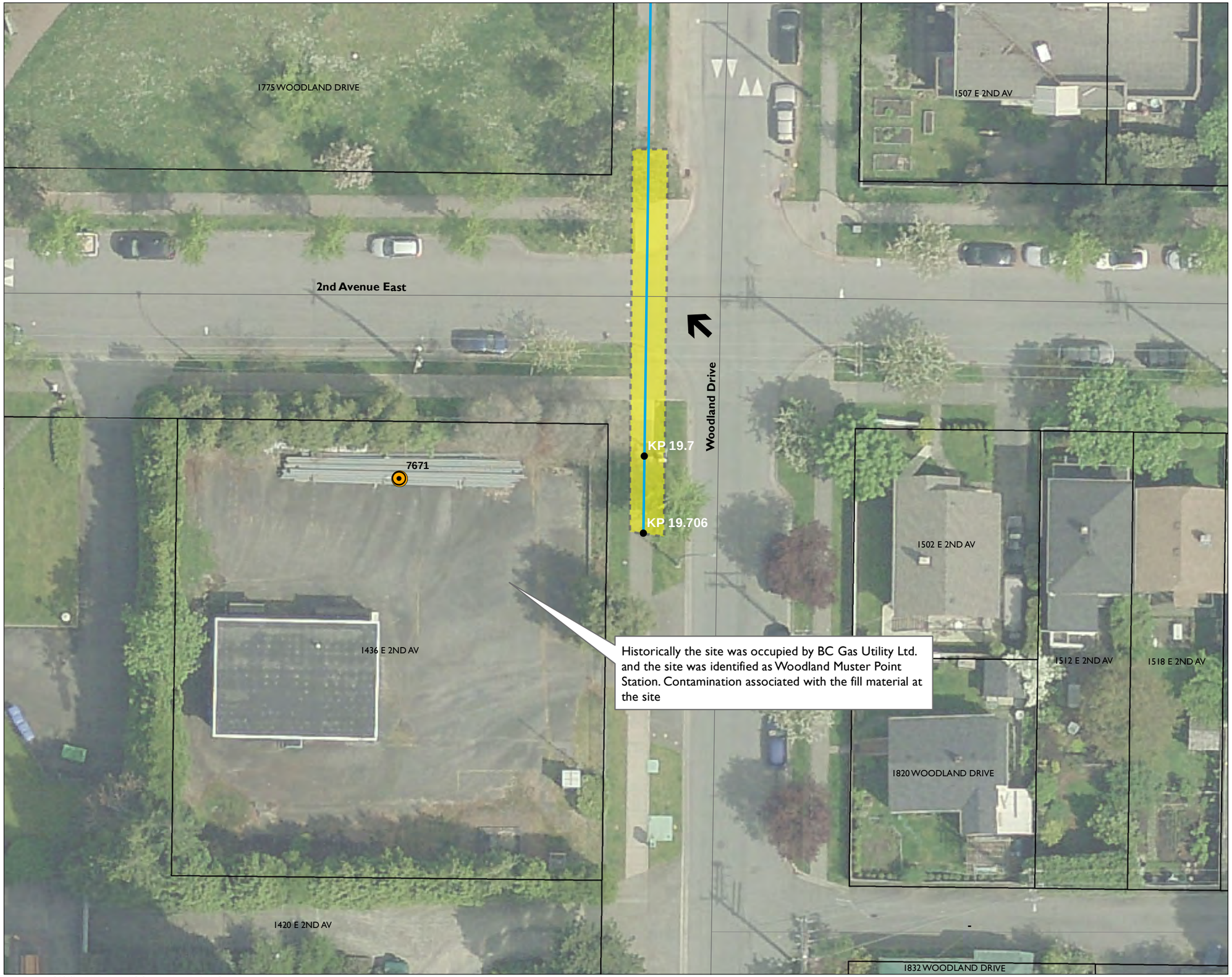
STATUS: FINAL

DATE: 5/2/2014

File Location: G:\GIS\148963 - FortisBC Coastal Revisited\APEC A2.mxd

APEC Information – Metro IP	
APEC B1	Site ID 7671 - 1436 East Second Avenue, Vancouver – Figure B1
APEC Location	At the intersection of Second Avenue and Woodland Drive
Length	31 m (KP 19.675-KP 19.706)
Groundwater Elevation (Flow Direction)	Reportedly shallow (Inferred Northwest)
Site Details	
Site ID 7671 (Located hydraulically upgradient) The site is and south of the alignment. The proposed alignment will end at the site. The site is currently owned by FortisBC. Historically the site was occupied by BC Gas Utility Ltd. and the site was identified as Woodland Muster Point Station (abandoned natural gas regulator station). Aerial photos show that the site was developed from 1946.	
Document Review Findings	
Site ID 7671 An independent remediation plan was submitted to MOE in 2001. There is no indication that the independent remediation was completed. The independent remediation plan was based on findings of Stage 1 and 2 Preliminary Site Investigations (PSIs) completed at this site prior to 2001. The contamination was identified as fill material related contamination. According to the independent remediation plan, contaminated soil and groundwater exist at the site. Polyaromatic hydrocarbons were identified as Chemicals of Potential Concern (COPCs).	
Classification	Medium to High Impact Site
Potential Contamination	Hydrocarbon and metals
Recommendation	Subsurface soil and groundwater investigation
PCOC s	
LEPH/HEPH, PAH, VOCs including BTEX, Metals	

See APEC Overview Figure APEC B1 for more information



FortisBC

FortisBC LMSU - Metro IP

APEC Overview

APEC B1

- Distance Posts
- Contaminated Sites
- Proposed Fraser IP
- Proposed Metro IP
- Proposed Cape Horn to Coquitlam
- Railways

Roads/Highways

- Highway/Freeway
- Arterial Streets
- Collector Street
- Local Streets
- Alley
- Ramp

APEC Classification

- Low Impact Site
- Medium to High Impact Site
- Parcels
- Inferred Ground Water Flow

SCALE 1:300

0 2.5 5 10 Meters

N W E S

Map Drawing Information: FortisBC, BC Site Registry, Dillon Consulting Limited

Map Created By: ECH
Map Checked By:
Map Projection: NAD 1983 UTM Zone 10N

DILLON CONSULTING

PROJECT: 14- 8963

STATUS: FINAL

DATE: 5/5/2014

File Location: G:\GIS\148963 - FortisBC Coastal Revisited\APEC B1.mxd

APEC Information – Metro IP	
APEC B2	Site ID 12967 - 1725 East First Avenue, Vancouver – Figure B1
APEC Location	On East First Avenue west of Commercial Drive
Length	20 m (KP 19.238-KP 19.258)
Groundwater Elevation (Flow Direction)	Unknown (Inferred Northwest)
Site Details	
Site ID 12967 (Located hydraulically downgradient) The site is a two storey residential property located north of the alignment at 1725 East First Avenue in Vancouver. Aerial photos show that the site was developed from 1946.	
Document Review Findings	
Site ID 12967 An independent remediation was completed in 2011. No further information is available.	
Classification	Low Impact Site
Potential Contamination	Unknown
Recommendation	Manage any subsurface contamination related issues during construction activities.
PCOC s	
Unknown	

See APEC Overview Figure APEC B2 for more information

FortisBC

FortisBC LMSU - Metro IP

APEC Overview

APEC B2

- Distance Posts
- Contaminated Sites
- Proposed Fraser IP
- Proposed Metro IP
- Proposed Cape Horn to Coquitlam
- Railways

Roads/Highways

- Highway/Freeway
- Arterial Streets
- Collector Street
- Local Streets
- Alley
- Ramp

APEC Classification

- Low Impact Site
- Medium to High Impact Site
- Parcels
- Inferred Ground Water Flow

SCALE 1:250

0 2.5 5 10 Meters

N W E S

Map Drawing Information: FortisBC, BC Site Registry, Dillon Consulting Limited

Map Created By: ECH
Map Checked By:
Map Projection: NAD 1983 UTM Zone 10N

DILLON CONSULTING

PROJECT: 14- 8963

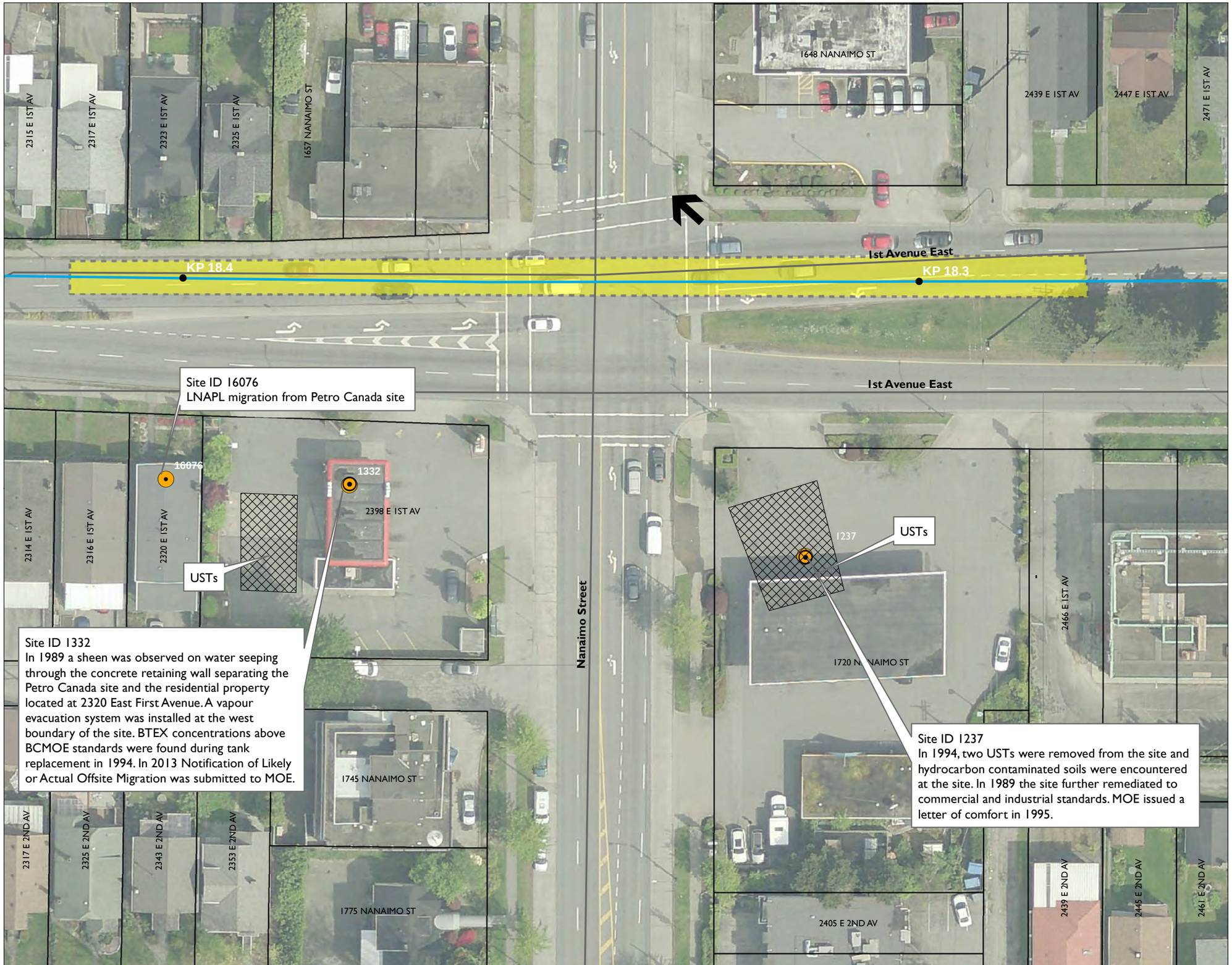
STATUS: FINAL

DATE: 5/5/2014

File Location: G:\GIS\148963 - FortisBC Coastal Revisited\APEC B2.mxd

APEC Information – Metro IP	
APEC B3	Site ID 1237 - 1720 Nanaimo Street, Vancouver – Figure B1 Site ID 1332 – 2398 East First Avenue, Vancouver – Figure B1 Site ID 16076 – 2320 East First Avenue, Vancouver – Figure B1
APEC Location	On East First Avenue west of Commercial Drive
Length	140 m (KP 18.280-KP 18.420)
Groundwater Elevation (Flow Direction)	1mbgs (Inferred Northwest)
Site Details	
Site ID 1237 (Located hydraulically upgradient) A commercial property located south of the alignment and currently Chevron Service Station occupies the property. Site ID 1332 (Located hydraulically upgradient) A commercial property located south of the alignment and currently Petro Canada Service Station occupies the property. Site ID 16076 Residential property located east of the Petro Canada gas station and south of the alignment Aerial photos show that the site was developed between 1946 and 1963.	
Document Review Findings	
Site ID 1237 In 1994, two USTs were removed from the site and an environmental site investigation was completed. During the tank removal hydrocarbon contaminated soils were encountered at the site. In 1989 the site further remediated to commercial and industrial standards. MOE issued a letter of comfort in 1995. Site ID 1332 A subsurface investigation was initiated in 1989 when a sheen was observed on water seeping through the concrete retaining wall separating the Petro Canada site and the residential property located at 2320 East First Avenue. Since LNAPL plume was found at the site, a vapour evacuation system was installed at the west boundary of the site. BTEX concentrations above BCMOE standards were found during tank replacement in 1994. In 2013 Notification of Likely or Actual Offsite Migration was submitted to MOE. Site ID 16076 LNAPL migration from Petro Canada site located at 2398 East First Avenue (Site ID 1332)	
Classification	Medium to High Impact Site
Potential Contamination	Hydrocarbon and metals
Recommendation	Subsurface soil and groundwater investigation
PCOC s	
LEPH/HEPH, PAH, VOCs including BTEX, Metals	

See APEC Overview Figure APEC B3 for more information



FortisBC

FortisBC LMSU - Metro IP

APEC Overview

APEC B3

- Distance Posts
- Contaminated Sites
- Proposed Fraser IP
- Proposed Metro IP
- Proposed Cape Horn to Coquitlam
- Railways

Roads/Highways

- Highway/Freeway
- Arterial Streets
- Collector Street
- Local Streets
- Alley
- Ramp

APEC Classification

- Low Impact Site
- Medium to High Impact Site
- Parcels
- Inferred Ground Water Flow

SCALE 1:500

0 5 10 20 Meters

N W E S

Map Drawing Information: FortisBC, BC Site Registry, Dillon Consulting Limited

Map Created By: ECH
Map Checked By:
Map Projection: NAD 1983 UTM Zone 10N

DILLON CONSULTING

PROJECT: 14- 8963

STATUS: FINAL

DATE: 5/2/2014

File Location: G:\GIS\148963 - FortisBC Coastal Revisited\APEC B3.mxd

APEC Information – Metro IP	
APEC B4	Site ID 8757 – 2585 East First Avenue, Vancouver – Figure B2
APEC Location	West of the intersection of Penticton Street and East First Avenue
Length	20 m (KP 18.035-KP 18.055)
Groundwater Elevation (Flow Direction)	Unknown (Inferred Northwest)
Site Details	
Site ID 8757 (Located hydraulically downgradient) The site is a single storey residential property located north of the alignment at 8757 East First Avenue in Vancouver. Aerial photos show that the buildings were built between 1946 and 1963.	
Document Review Findings	
Site ID 8757 An independent remediation was completed in 2004. It was noted that 15 tonnes of Light Extractable Petroleum Hydrocarbon soil was remediated and 1,500 liters of product/water was removed from the site. No other information was provided.	
Classification	Low Impact Site
Potential Contamination	Hydrocarbon and metals
Recommendation	Manage any subsurface contamination related issues during construction activities.
PCOC s	
LEPH/HEPH, PAH, VOCs including BTEX, Metals	

See APEC Overview Figure APEC B4 for more information

FortisBC

FortisBC LMSU - Metro IP

APEC Overview

APEC B4

- Distance Posts
- Contaminated Sites
- Proposed Fraser IP
- Proposed Metro IP
- Proposed Cape Horn to Coquitlam
- Railways

Roads/Highways

- Highway/Freeway
- Arterial Streets
- Collector Street
- Local Streets
- Alley
- Ramp

APEC Classification

- Low Impact Site
- Medium to High Impact Site
- Parcels
- Inferred Ground Water Flow

SCALE 1:250

0 2.5 5 10 Meters

N W E S

Map Drawing Information: FortisBC, BC Site Registry, Dillon Consulting Limited

Map Created By: ECH
Map Checked By:
Map Projection: NAD 1983 UTM Zone 10N

DILLON CONSULTING

PROJECT: 14- 8963

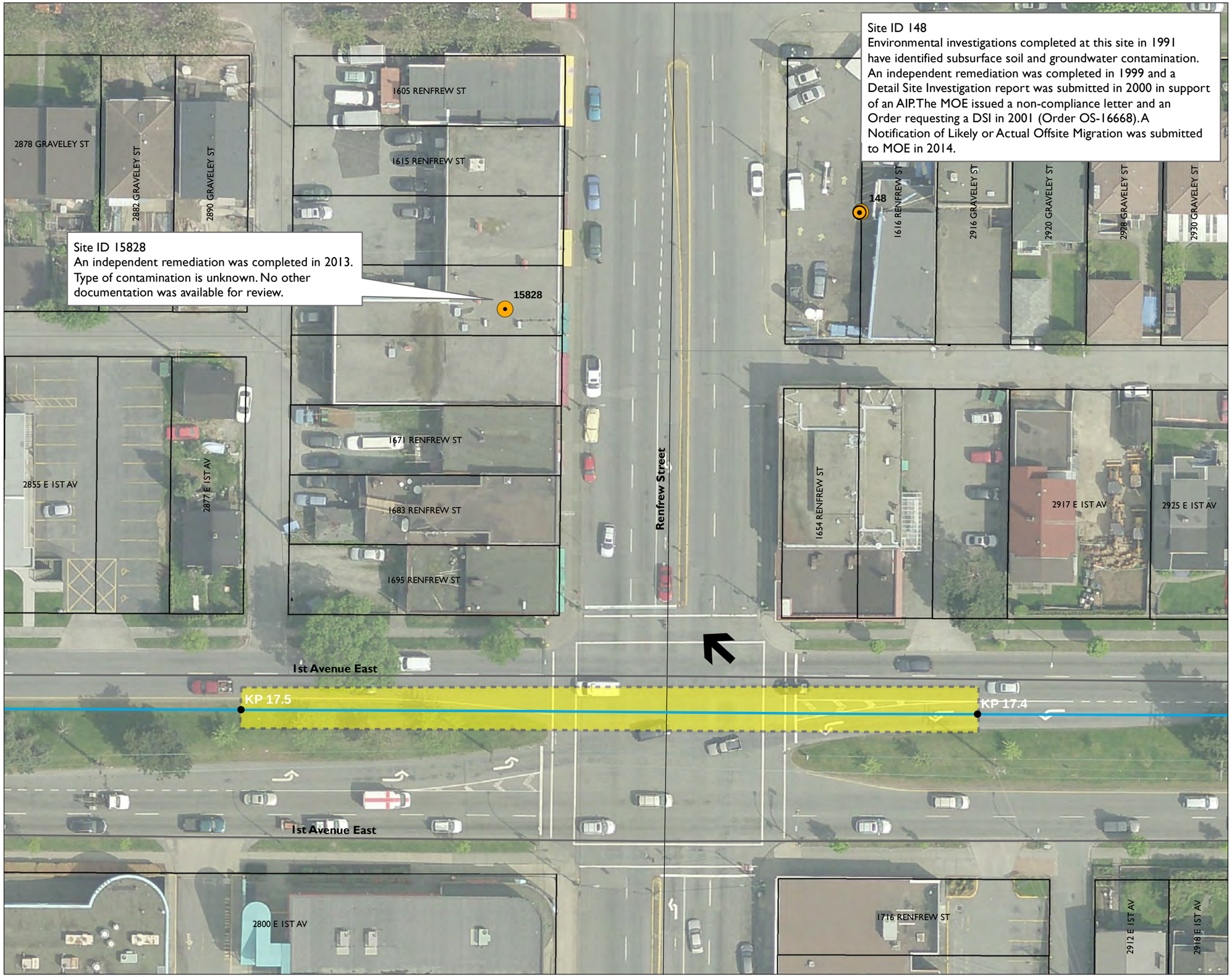
STATUS: FINAL

DATE: 5/2/2014

File Location: G:\GIS\148963 - FortisBC Coastal Revisited\APEC B4.mxd

APEC Information – Metro IP	
APEC B5	Site ID 148 – 1616 Renfrew Street, Vancouver – Figure B2 Site ID 15828 – 1615 Renfrew Street, Vancouver – Figure B2
APEC Location	Intersection of Renfrew Street and East First Avenue
Length	100 m (KP 17.4-KP 17.5)
Groundwater Elevation (Flow Direction)	Unknown (Inferred Northwest)
Site Details	
Site ID 148 (Located hydraulically downgradient) Commercial property located north of the alignment on Renfrew Street, currently Capanga Auto Service occupies the property. Historically Super-Save gas has occupied the site. Site ID 15828 (Located hydraulically downgradient) Commercial property located north of the alignment on Renfrew Street, currently Brush Dental Clinic occupies the property.	
Document Review Findings	
Site ID 148 Environmental investigations completed at this site in 1991 have identified subsurface soil and groundwater contamination. In 1997 MOE requested Super Saver Gas to notify all neighboring properties and the MOE of offsite migration based on the historical reports. An independent remediation was completed in 1999 and a Detail Site Investigation report was submitted in 2000 in support of an AIP. The MOE rejected the DSI in 2001 since the submitted information did not meet MOE requirements. The MOE issued a non-compliance letter and an Order requesting a DSI in 2001 (Order OS-16668). A site investigation report was submitted in 2003. A Notification of Likely or Actual Offsite Migration was submitted to MOE in 2014. Site ID 15828 An independent remediation was completed in 2013. Type of contamination is unknown. No other documentation was available for review. Aerial photos show that the buildings were built between 1946 and 1963.	
Classification	Medium to High Impact Site
Potential Contamination	Hydrocarbon and metals
Recommendation	Subsurface soil and groundwater investigation
PCOC s	
LEPH/HEPH, PAH, VOCs including BTEX, Metals	

See APEC Overview Figure APEC B5 for more information



FortisBC

FortisBC LMSU - Metro IP

APEC Overview

APEC B5

- Distance Posts
- Contaminated Sites
- Proposed Fraser IP
- Proposed Metro IP
- Proposed Cape Horn to Coquitlam
- Railways

Roads/Highways

- Highway/Freeway
- Arterial Streets
- Collector Street
- Local Streets
- Alley
- Ramp

APEC Classification

- Low Impact Site
- Medium to High Impact Site
- Parcels
- Inferred Ground Water Flow

SCALE 1:500

0 5 10 20 Meters

N W E S

Map Drawing Information: FortisBC, BC Site Registry, Dillon Consulting Limited

Map Created By: ECH
Map Checked By:
Map Projection: NAD 1983 UTM Zone 10N

DILLON CONSULTING

PROJECT: 14- 8963

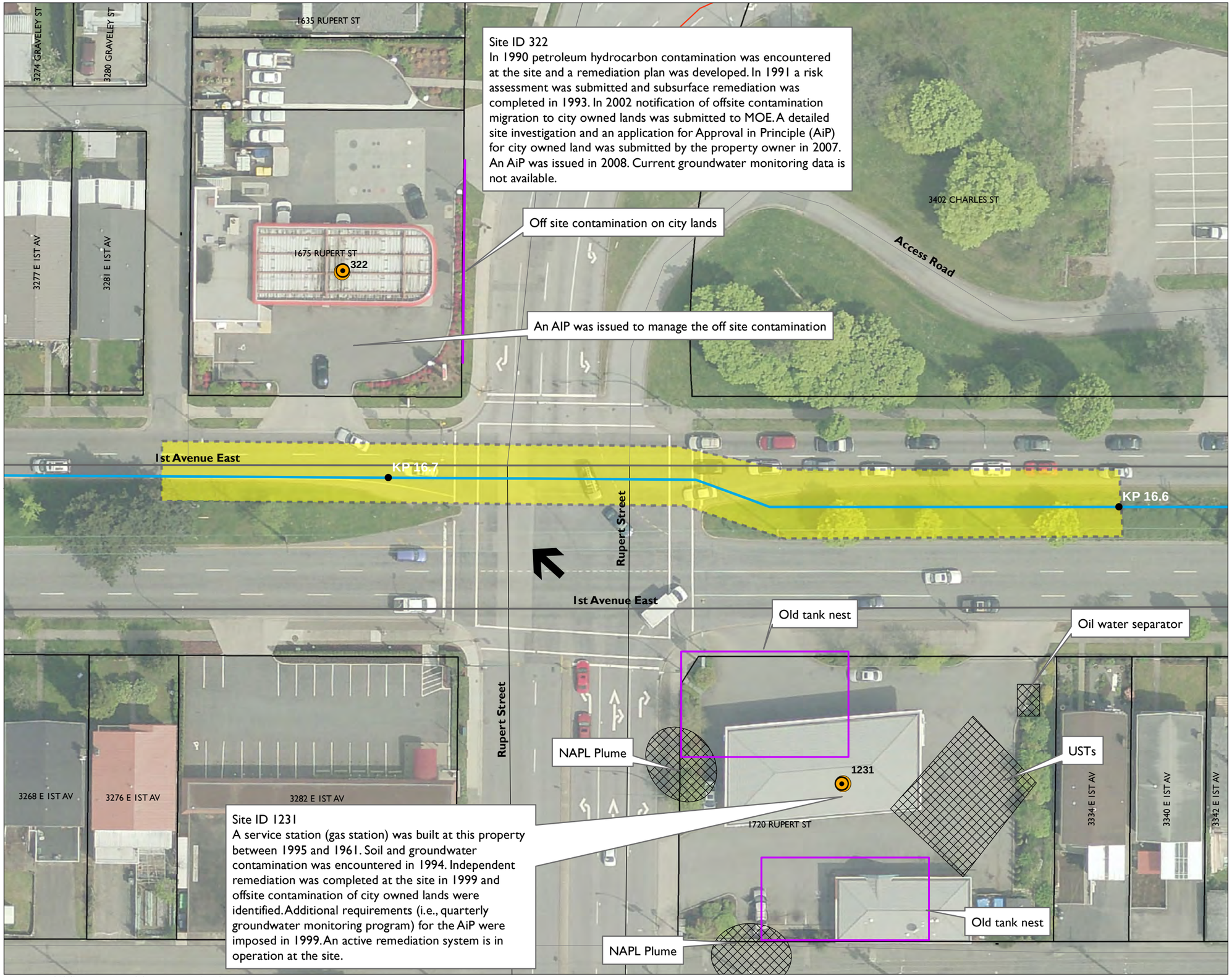
STATUS: FINAL

DATE: 5/2/2014

File Location: G:\GIS\148963 - FortisBC Coastal Revisited\APEC B5.mxd

APEC Information – Metro IP	
APEC B6	Site ID 322 – 1675 Rupert Street, Vancouver – Figure B2 Site ID 1231 – 1720 Rupert Street, Vancouver – Figure B2
APEC Location	Intersection of Rupert Street and East First Avenue
Length	140 m (KP 16.6-KP 16.740)
Groundwater Elevation (Flow Direction)	2mbgs (Inferred North-northeast)
Site Details	
Site ID 322 (Located hydraulically downgradient) A commercial property located north of the alignment and currently Petro Canada Service Station occupies the property. Site ID 1231 (Located hydraulically upgradient) A commercial property located south of the alignment and currently Petro Chevron Service Station occupies the property. Aerial photos show that significant changes occurred at this intersection in 1960s and in 1990s.	
Document Review Findings	
Site ID 322 In 1990 petroleum hydrocarbon contamination was encountered at the site and a remediation plan was developed. In 1991 a risk assessment was submitted and subsurface remediation was completed in 1993. In 2002 notification of offsite contamination migration to city owned lands was submitted to MOE. A detailed site investigation and an application for Approval in Principle (AiP) for city owned land was submitted by the property owner in 2007. An AiP was issued in 2008. Current groundwater monitoring data is not available. Site ID 1231 A service station (gas station) was built at this property between 1995 and 1961. Chevron has been operating this site from 1976. Soil and groundwater contamination was encountered in 1994. A remedial plan and an AiP was approved in 1996. Independent remediation was completed at the site in 1999 and offsite contamination of city owned lands were identified. Additional requirements (i.e., quarterly groundwater monitoring program) for the AiP were imposed in 1999. Groundwater monitoring data available from 1999. An active remediation system is in operation at the site. Groundwater elevation at the site is approximately 2 metres below ground surface (mbgs).	
Classification	Medium to High Impact Site
Potential Contamination	Hydrocarbon and metals
Recommendation	Subsurface soil and groundwater investigation
PCOC s	
LEPH/HEPH, PAH, VOCs including BTEX, Metals	

See APEC Overview Figure APEC B5 for more information



FortisBC

FortisBC LMSU - Metro IP

APEC Overview

APEC B6

- Distance Posts
- Contaminated Sites
- Proposed Fraser IP
- Proposed Metro IP
- Proposed Cape Horn to Coquitlam
- Railways

Roads/Highways

- Highway/Freeway
- Arterial Streets
- Collector Street
- Local Streets
- Alley
- Ramp

APEC Classification

- Low Impact Site
- Medium to High Impact Site
- Parcels
- Inferred Ground Water Flow

SCALE 1:500

0 5 10 20 Meters

N W E S

Map Drawing Information: FortisBC, BC Site Registry, Dillon Consulting Limited

Map Created By: ECH
Map Checked By:
Map Projection: NAD 1983 UTM Zone 10N

DILLON CONSULTING

PROJECT: 14- 8963

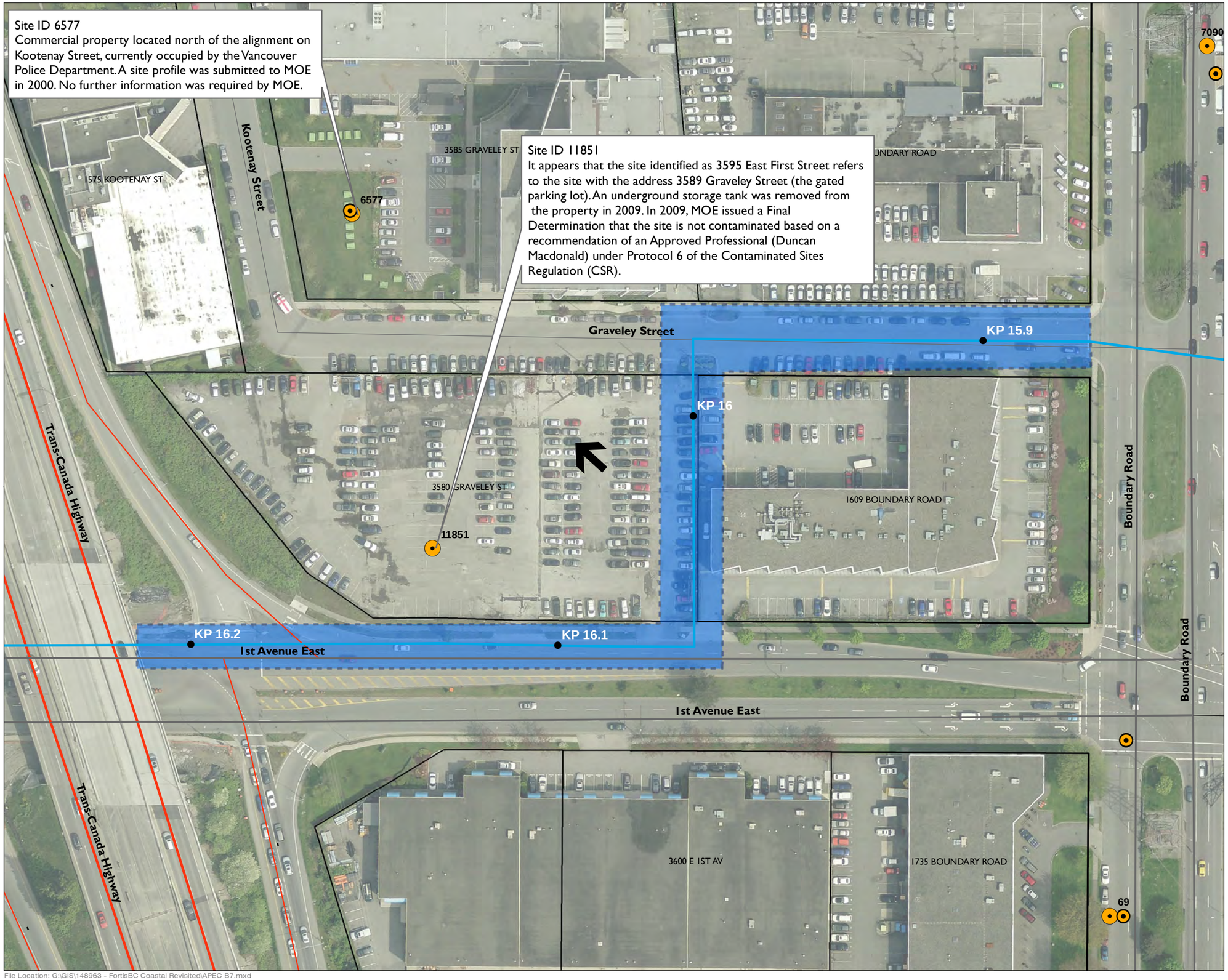
STATUS: FINAL

DATE: 5/5/2014

File Location: G:\GIS\148963 - FortisBC Coastal Revisited\APEC B6.mxd

APEC Information – Metro IP	
APEC B7	Site ID 6577 - 1570 Kootenay Street, Vancouver Site ID 11851 – 3595 East First Avenue, Vancouver – Figure B2 Gated Parking Lot (3580 Graveley Street, Vancouver) Mazda Dealership - 1595 Boundary Road, Vancouver
APEC Location	Section of alignment from overpass of Highway 1 and East First Avenue to the intersection of Graveley Street and Boundary Road as shown on Figure APEG B7
Length	300 m (KP 15.9-KP 16.2)
Groundwater Elevation (Flow Direction)	Unknown (Inferred Northwest)
Site Details	
Site ID 6577 (Located hydraulically downgradient) Commercial property located north of the alignment on Kootenay Street, currently occupied by the Vancouver Police Department. Site ID 11851 (Located hydraulically downgradient) It appears that the site identified as 3595 East First Street refers to the site with the address 3589 Graveley Street (the gated parking lot). The aerial photos show that these sites were developed between 1963 and 1969. In 1969 buildings can be seen on the current parking lot identified as 3595 East First Street and 3580 Graveley Street and continue to exist on the latest available aerial photo of 2004. Gated Parking Lot (Located hydraulically downgradient) Same as Site ID 11851 - 3595 East First Avenue, Vancouver Mazda Dealership (Located hydraulically downgradient)	
Document Review Findings	
Site ID 6577 A site profile was submitted to MOE in 2000. No further information was required by MOE. Site ID 11851 An underground storage tank was removed from the property in 2009. A pre demolition inspection and a risk assessment for suspect asbestos containing materials (ACM) was conducted in 2009. A Stage 1 and 2 Preliminary Site Investigations (PSI) and a Summary of Site Conditions were submitted to MOE. In 2009, MOE issued a Final Determination that the site is not contaminated based on a recommendation of an Approved Professional (Duncan Macdonald) under Protocol 6 of the Contaminated Sites Regulation (CSR).	
Classification	Low Impact Site (Since MOE has determined that the site is not contaminated the risk of finding contamination is low)
Potential Contamination	Hydrocarbon and metals
Recommendation	Manage any subsurface contamination related issues during construction activities.
PCOC s	
LEPH/HEPH, PAH, VOCs including BTEX, Metals	

See APEC Overview Figure APEC B7 for more information



FortisBC

FortisBC LMSU - Metro IP

APEC Overview

APEC B7

- Distance Posts
- Contaminated Sites
- Proposed Fraser IP
- Proposed Metro IP
- Proposed Cape Horn to Coquitlam
- Railways

Roads/Highways

- Highway/Freeway
- Arterial Streets
- Collector Street
- Local Streets
- Alley
- Ramp

APEC Classification

- Low Impact Site
- Medium to High Impact Site
- Parcels
- Inferred Ground Water Flow

SCALE 1:1,000

0 7.5 15 30 Meters

N W E S

Map Drawing Information: FortisBC, BC Site Registry, Dillon Consulting Limited

Map Created By: ECH
Map Checked By:
Map Projection: NAD 1983 UTM Zone 10N

DILLON CONSULTING

PROJECT: 14- 8963

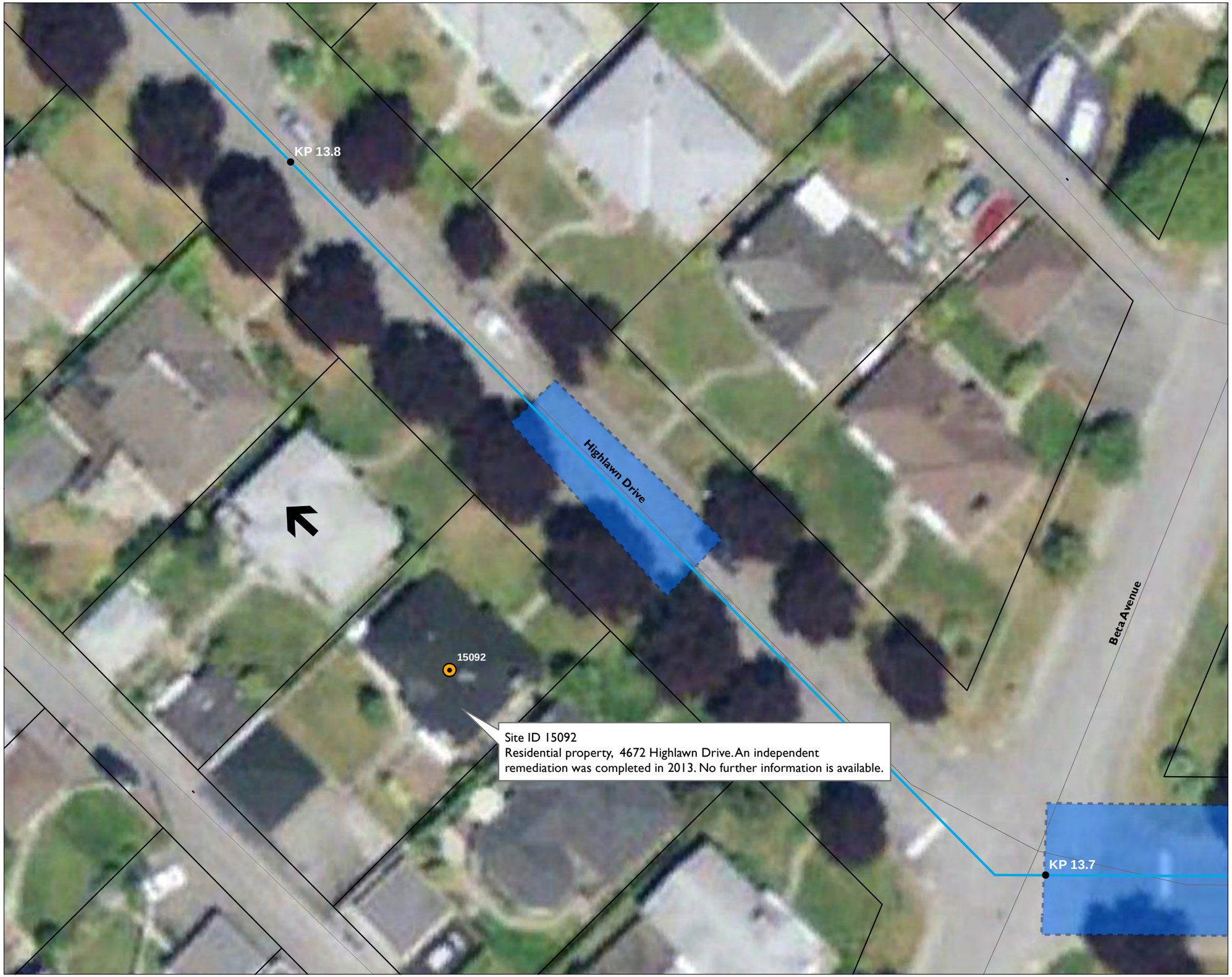
STATUS: FINAL

DATE: 5/2/2014

File Location: G:\GIS\148963 - FortisBC Coastal Revisited\APEC B7.mxd

APEC Information – Metro IP	
APEC B8	Site ID 15092 – 4672 Highlawn Drive, Burnaby – Figure B4
APEC Location	On Highlawn Drive west of Beta Avenue
Length	20 m (KP 13.745-KP 13.765)
Groundwater Elevation (Flow Direction)	Unknown (Inferred Northwest)
Site Details	
Site ID 15092 (Located hydraulically upgradient) The site is a single storey residential property located south of the alignment at 4672 Highlawn Drive in Burnaby. Aerial photos show that the site was developed between 1946 and 1963.	
Document Review Findings	
Site ID 15092 An independent remediation was completed in 2013. No further information is available.	
Classification	Low Impact Site
Potential Contamination	Unknown
Recommendation	Manage any subsurface contamination related issues during construction activities.
PCOC s	
Unknown	

See APEC Overview Figure APEC B8 for more information



FortisBC

FortisBC LMSU - Metro IP

APEC Overview

APEC B8

- Distance Posts
- Contaminated Sites
- Proposed Fraser IP
- Proposed Metro IP
- Proposed Cape Horn to Coquitlam
- Railways

Roads/Highways

- Highway/Freeway
- Arterial Streets
- Collector Street
- Local Streets
- Alley
- Ramp

APEC Classification

- Low Impact Site
- Medium to High Impact Site
- Parcels
- Inferred Ground Water Flow

SCALE 1:350

0 2.5 5 10 Meters

N W E S

Map Drawing Information: FortisBC, BC Site Registry, Dillon Consulting Limited

Map Created By: ECH
Map Checked By:
Map Projection: NAD 1983 UTM Zone 10N

DILLON CONSULTING

PROJECT: 14- 8963

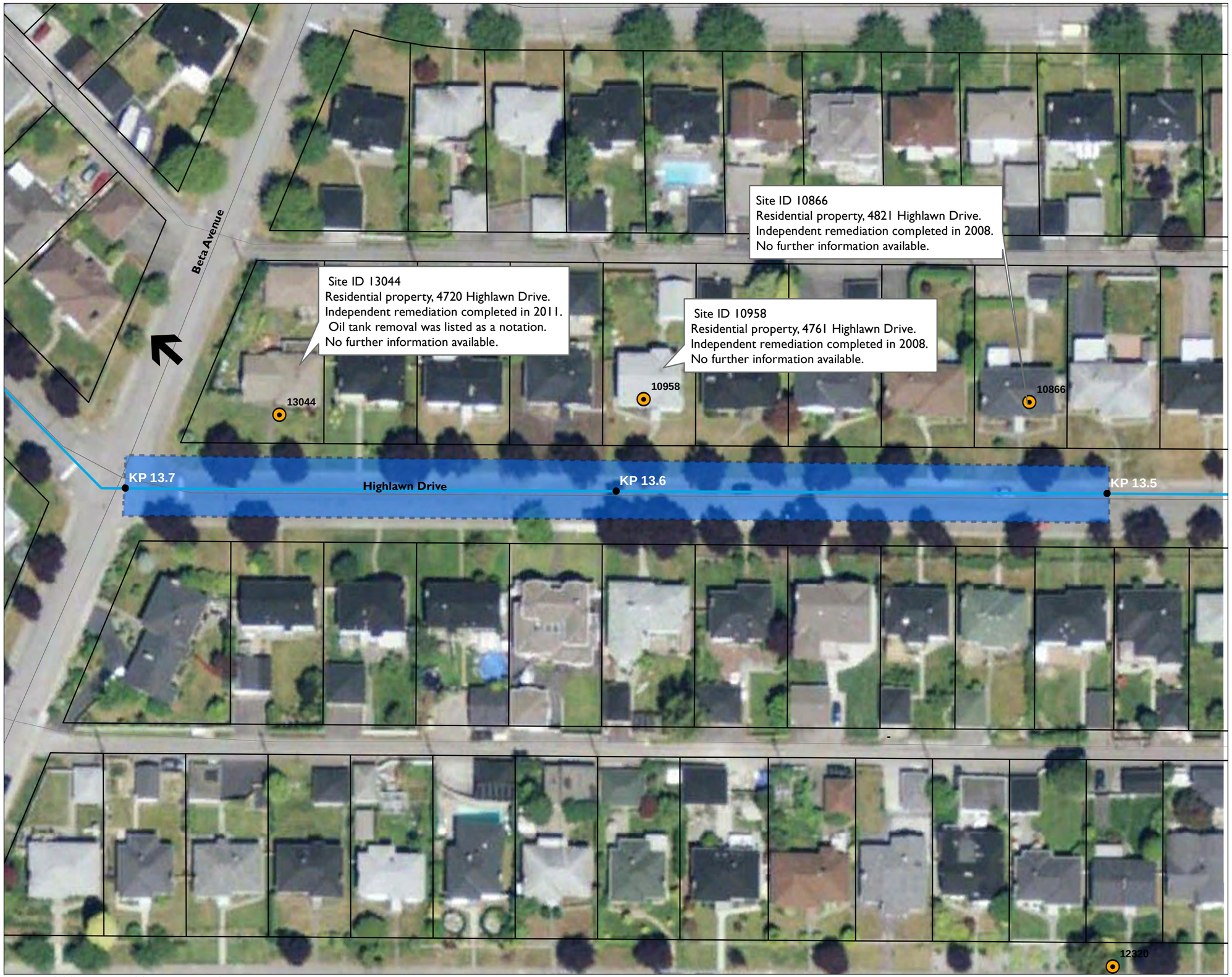
STATUS: FINAL

DATE: 5/2/2014

File Location: G:\GIS\148963 - FortisBC Coastal Revisited\APEC B8.mxd

APEC Information – Metro IP	
APEC B9	Site ID 10866 – 4821 Highlawn Drive, Burnaby – Figure B4 Site ID 10958 – 4761 Highlawn Drive, Burnaby – Figure B4 Site ID 13044 – 4720 Highlawn Drive, Burnaby – Figure B4
APEC Location	On Highlawn Drive east of Beta Avenue
Length	200 m (KP 13.5-KP 13.7)
Groundwater Elevation (Flow Direction)	Unknown (Inferred Northwest)
Site Details	
Site ID 10866 (Located hydraulically downgradient) The site is a single storey residential property located north of the alignment at 4821 Highlawn Drive in Burnaby. Site ID 10958 (Located hydraulically downgradient) The site is a single storey residential property located north of the alignment at 4761 Highlawn Drive in Burnaby. Site ID 13044 (Located hydraulically downgradient) The site is a single storey residential property located north of the alignment at 4720 Highlawn Drive in Burnaby. Aerial photos show that the site was developed between 1946 and 1963.	
Document Review Findings	
Site ID 10866 Independent remediation completed in 2008. No further information available. Site ID 10958 Independent remediation completed in 2008. No further information available. Site ID 13044 Independent remediation completed in 2011. Oil tank removal was listed as a notation. No further information available.	
Classification	Low Impact Site
Potential Contamination	Hydrocarbon and metals
Recommendation	Manage any subsurface contamination related issues during construction activities.
PCOC s	
LEPH/HEPH, PAH, VOCs including BTEX, Metals	

See APEC Overview Figure APEC B9 for more information



FortisBC

FortisBC LMSU - Metro IP

APEC Overview

APEC B9

- Distance Posts
- Contaminated Sites
- Proposed Fraser IP
- Proposed Metro IP
- Proposed Cape Horn to Coquitlam
- Railways

Roads/Highways

- Highway/Freeway
- Arterial Streets
- Collector Street
- Local Streets
- Alley
- Ramp

APEC Classification

- Low Impact Site
- Medium to High Impact Site
- Parcels
- Inferred Ground Water Flow

SCALE 1:750

0 7.5 15 30 Meters

N W E S

Map Drawing Information: FortisBC, BC Site Registry, Dillon Consulting Limited

Map Created By: ECH
Map Checked By:
Map Projection: NAD 1983 UTM Zone 10N

DILLON CONSULTING

PROJECT: 14- 8963

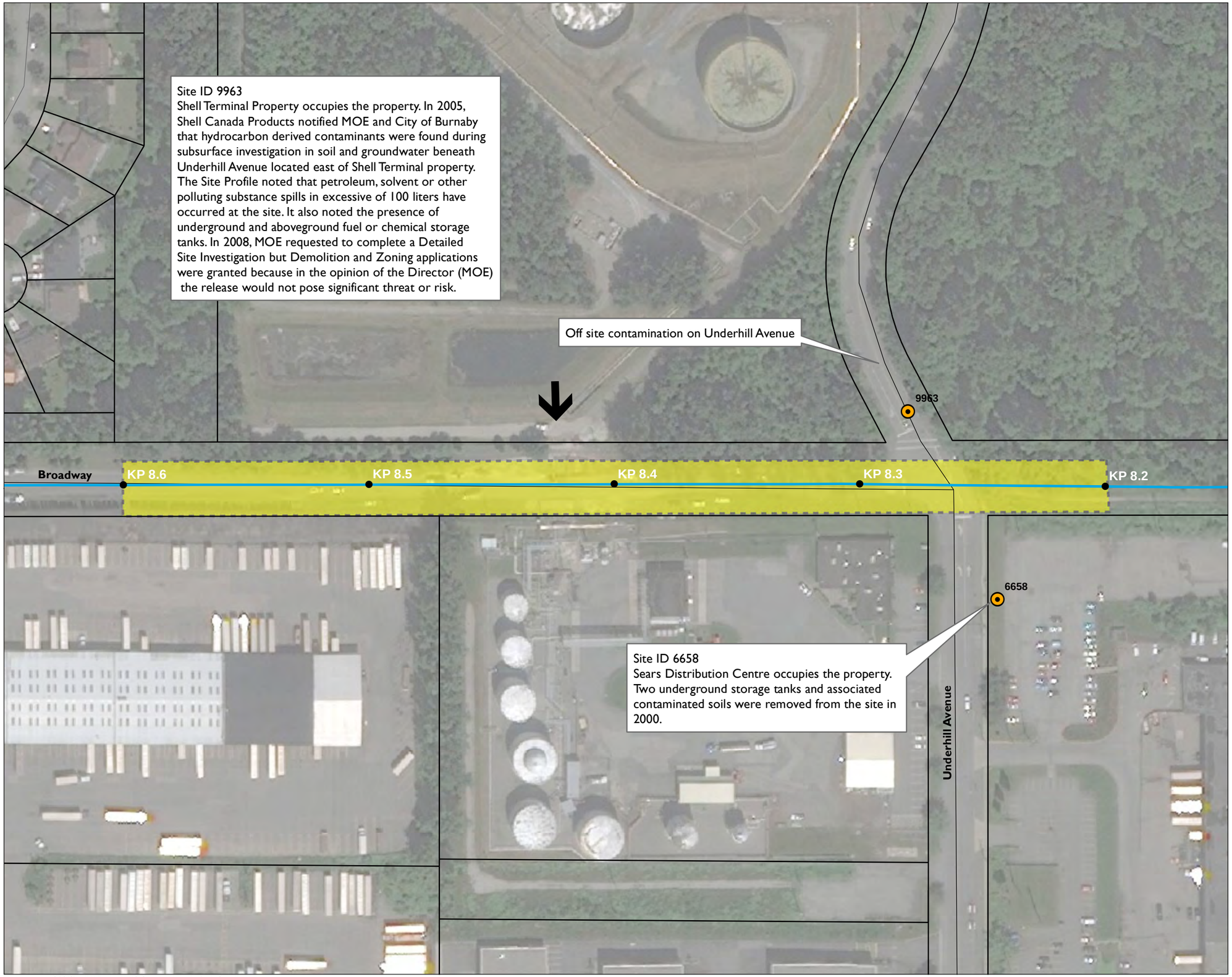
STATUS: FINAL

DATE: 5/2/2014

File Location: G:\GIS\148963 - FortisBC Coastal Revisited\APEC B9.mxd

APEC Information – Metro IP	
APEC B10	Site ID 6658 – 2820 Underhill Avenue, Burnaby – Figure B6 Site ID 9963 – 2751 Underhill Avenue, Burnaby – Figure B6
APEC Location	East and west of Underhill Avenue
Length	400 m (KP 8.2-KP 8.6)
Groundwater Elevation (Flow Direction)	Unknown (inferred South)
Site Details	
Site ID 6658 (Located hydraulically downgradient) A commercial property located south of the alignment and currently Sears Distribution Centre occupies the property. Site ID 9963 (Located hydraulically upgradient) An industrial property located north of the alignment and currently Shell Terminal Property occupies the property. The aerial photos show that the Shell Terminal was developed between 1946 and 1963. The Sears Distribution building was developed between 1969 and 1974.	
Document Review Findings	
Site ID 6658 Two underground storage tanks and associated contaminated soils were removed from the site in 2000. Site ID 9963 In 2005, Shell Canada Products notified MOE and City of Burnaby that hydrocarbon derived contaminants were found during subsurface investigation in soil and groundwater beneath Underhill Avenue located east of Shell Terminal property. In 2008, Shell Canada submitted a Site Profile to MOE. The Site Profile noted that petroleum, solvent or other polluting substance spills in excessive of 100 liters have occurred at the site. It also noted the presence of underground and aboveground fuel or chemical storage tanks. In 2008, MOE requested to complete a Detailed Site Investigation but Demolition and Zoning applications were granted because in the opinion of the Director (MOE) the release would not pose significant threat or risk.	
Classification	Medium to High Impact Site
Potential Contamination	Hydrocarbon and metals
Recommendation	Subsurface soil and groundwater investigation
PCOC s	
LEPH/HEPH, PAH, VOCs including BTEX, Metals	

See APEC Overview Figure APEC B10 for more information



FortisBC

FortisBC LMSU - Metro IP

APEC Overview

APEC B10

- Distance Posts
- Contaminated Sites
- Proposed Fraser IP
- Proposed Metro IP
- Proposed Cape Horn to Coquitlam
- Railways

Roads/Highways

- Highway/Freeway
- Arterial Streets
- Collector Street
- Local Streets
- Alley
- Ramp

APEC Classification

- Low Impact Site
- Medium to High Impact Site
- Parcels
- Inferred Ground Water Flow

SCALE 1:1,500

0 10 20 40 Meters

N W E S

Map Drawing Information: FortisBC, BC Site Registry, Dillon Consulting Limited

Map Created By: ECH
Map Checked By:
Map Projection: NAD 1983 UTM Zone 10N

DILLON CONSULTING

PROJECT: 14- 8963

STATUS: FINAL

DATE: 5/2/2014

File Location: G:\GIS\148963 - FortisBC Coastal Revisited\APEC B10.mxd

APEC Information – Metro IP	
APEC B11	Site ID 147 – 580, 584 & 590 Clarke Road, Coquitlam – Figure B7 Site ID 13430 – 581 Clarke Road, Coquitlam – Figure B7 Site ID 13099 – 603 Clarke Road, Coquitlam– Figure B7 Site ID 12673 – 604 & 606 Como Lake Avenue, Coquitlam – Figure B7 Site ID 13673 – 608 & 610 Como Lake Avenue, Coquitlam – Figure B7 Site ID 15298 – Como Lake Avenue Adjacent to 590 Clarke Road – Figure B7 Site ID 15860 – Como Lake Avenue and Clarke Road – Figure B7
APEC Location	East and west of Clarke Road
Length	310 m (KP 5.03-KP 5.34)
Groundwater Elevation (Flow Direction)	1-3mbgs (inferred North-Northwest)
Site Details	
Site ID 147 (Located hydraulically upgradient) Commercial property located south of the alignment (east of Clarke Road) and historically occupied by Shell service station (580 and 584 Clarke Road-from 1960 to 1980) and 590 Clarke Road occupied by Safeway Canada. Currently all buildings have been removed and the site is vacant. Site ID 13430 (Located hydraulically upgradient) Commercial property located south of the alignment (west of Clarke Road) historically occupied by Esso service station. Currently retail businesses occupy the building. Site ID 13099 (Located hydraulically downgradient) Commercial property located north of the alignment (west of Clarke Road) historically occupied by Mahawk Como Lake service station and a corner store. Currently all buildings have been removed and the site is vacant. Site ID 12673 and 13673 (Located hydraulically upgradient) Residential 4 storey condo located south of the alignment (east of Clarke Road) developed in 2012 Site ID 15298 and 15860 (Located hydraulically upgradient) Sections of the road on Clarke Road and Como Lake Avenue located south of the alignment The aerial photos show that the intersection existed prior to 1946 but fully developed in 1960s.	
Document Review Findings	
Site ID 147 Soil and groundwater contamination with hydrocarbons and metals were detected in 2007 during site decommissioning. Selected areas were remediated during gas station demolition in 2007 and 2008. Further findings in 2013 have identified soil, groundwater contamination (hydrocarbon and metals) along Como Lake Avenue. A study completed in 2012 identified historical dry-cleaning related contamination (Trichloroethylene (TCE) and perchloroethylene (PCE)) within the site. TCE and PCE have migrated from Morguard property (Rhondas Dry Cleaners) located upgradient of the site. There is no indication that the TCE and PCE contamination had reached Como Lake Avenue. However a Detailed Site Assessment suggested that the deep drinking water aquifer and Basal Aquitard (the water-bearing sands, gravel or fractured rock that is found at the bottom of a geological formation) is contaminated with TCE and PCE. In 2013, a 14 metre deep hydraulic barrier and a drainage system (HBDS) was installed along Clarke Road to prevent recontamination of previously remediated areas within the site from offsite hydrocarbon contamination generated at Site ID 13430 (former Esso station at 581 Clarke Road). Site ID 13430 In 2011 the property owners notified the City of Coquitlam that contamination (suspect hydrocarbon) has migrated offsite to the roadway at Como Lake and Clarke Road. In 2012 MOE classified the site as a High Risk site and requested to submit a schedule and a summary of remediation methods for high risk conditions. Site ID 13099 In 2011 offsite migration was identified at the site. The affected site was identified as roadway at Como Lake and Clarke Road. Independent remediation was completed in 2012. It is not clear whether offsite contamination was remediated in 2012. Site ID 12673 and 13673 Independent remediations were completed prior to the development of the condos to address hydrocarbon related contamination associated with Shell service station located at 580 and 584 Clarke Road (Site ID 147) Site ID 15298 and 15860 Two areas of the roadway were remediated to meet BC MOE Drinking Water and Aquatic Water standards in 2013.	
Classification	Medium to High Impact Site
Potential Contamination	Hydrocarbon, metals and historical dry cleaning related contamination
Recommendation	Subsurface soil and groundwater investigation
PCOC s	
LEPH/HEPH, PAH, VOCs including BTEX, Metals, TCE, PCE	

See APEC Overview Figure APEC B11 for more information

Site ID 13099
In 2011 offsite migration was identified at the site. The affected site was identified as roadway at Como Lake and Clarke Road. Independent remediation was completed in 2012. It is not clear whether offsite contamination was remediated in 2012.

Site ID 15298 and 15860
Two areas of the roadway were remediated to meet BC MOE Drinking Water and Aquatic Water standards in 2013.

Site ID 12673 and 13673
Independent remediations were completed prior to the development of the condos to address hydrocarbon related contamination associated with Shell service station located at 580 and 584 Clarke Road (Site ID 147)

Site ID 13430
In 2011 the property owners notified the City of Coquitlam that contamination (suspect hydrocarbon) has migrated offsite to the roadway at Como Lake and Clarke Road. In 2012 MOE classified the site as a High Risk site and requested to submit a schedule and a summary of remediation methods for high risk conditions.

Site ID 147
Soil and groundwater contamination with hydrocarbons and metals were detected in 2007 during site decommissioning. Selected areas were remediated during gas station demolition in 2007 and 2008. Further findings in 2013 have identified soil, groundwater contamination (hydrocarbon and metals) along Como Lake Avenue. A study completed in 2012 identified historical dry-cleaning related contamination (Trichloroethylene (TCE) and perchloroethylene (PCE)) within the site. TCE and PCE have migrated from Morguard property (Rhondas Dry Cleaners) located upgradient of the site. There is no indication that the TCE and PCE contamination had reached Como Lake Avenue. However a Detailed Site Assessment suggested that the deep drinking water aquifer and Basal Aquitard (the water-bearing sands, gravel or fractured rock that is found at the bottom of a geological formation) is contaminated with TCE and PCE. In 2013, a 14 metre deep hydraulic barrier and a drainage system (HBDS) was installed along Clarke Road to prevent recontamination of previously remediated areas within the site from offsite hydrocarbon contamination generated at Site ID 13430 (former Esso station at 581 Clarke Road).

Gardena Drive
Elmwood Street
Lea Avenue
Claremont Street
Como Lake Avenue
Emerson Street
Clarke Road
Breslay Street

KP 5.3
KP 5.2
KP 5.1
KP 5

13099
15860
15298
12648
13673
147
13430
7383

Former UST
?????
Former dry cleaner
Pump island
Former UST
Pump island
Former UST
Hydraulic barrier
Former Safeway
Former UST

FortisBC

FortisBC LMSU - Metro IP

APEC Overview

APEC B11

- Distance Posts
- Contaminated Sites
- Proposed Fraser IP
- Proposed Metro IP
- Proposed Cape Horn to Coquitlam
- Railways

Roads/Highways

- Highway/Freeway
- Arterial Streets
- Collector Street
- Local Streets
- Alley
- Ramp

APEC Classification

- Low Impact Site
- Medium to High Impact Site
- Parcels
- Inferred Ground Water Flow

SCALE 1:1,250

0 10 20 40 Meters

N W E S

Map Drawing Information: FortisBC, BC Site Registry, Dillon Consulting Limited

Map Created By: ECH
Map Checked By:
Map Projection: NAD 1983 UTM Zone 10N

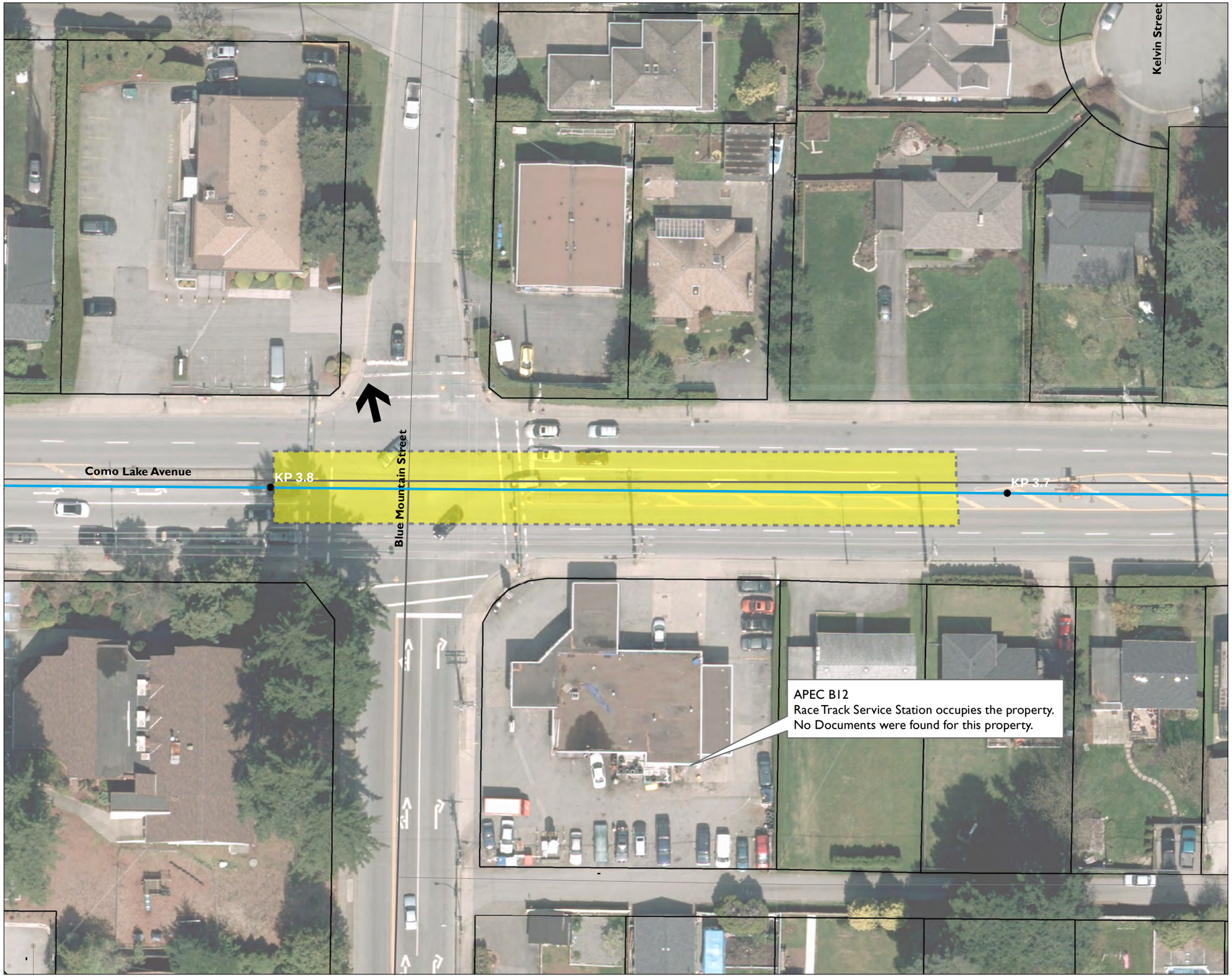
DILLON CONSULTING

PROJECT: 14- 8963
STATUS: FINAL
DATE: 5/5/2014

File Location: G:\GIS\148963 - FortisBC Coastal Revisited\APEC B11.mxd

APEC Information – Metro IP	
APEC B12	Race Trac Gas Station – 592 Como Lake Avenue, Coquitlam – Figure B8
APEC Location	Intersection of Blue Mountain Street and Como Lake Avenue
Length	400 m (KP 3.73-KP 3.8)
Groundwater Elevation (Flow Direction)	Unknown (inferred North-northwest)
Site Details	
Race Trac Service Station A commercial property located south of the alignment and currently Race Trac Service Station occupies the property. Aerial photos show that the site was developed between 1946 and 1963.	
Document Review Findings	
Race Trac Service Station No Documents were found for this property	
Classification	Medium to High Impact Site
Potential Contamination	Hydrocarbon and metals
Recommendation	Subsurface soil and groundwater investigation
PCOC s	
LEPH/HEPH, PAH, VOCs including BTEX, Metals	

See APEC Overview Figure APEC B12 for more information



FortisBC

FortisBC LMSU - Metro IP

APEC Overview

APEC B12

- Distance Posts
- Contaminated Sites
- Proposed Fraser IP
- Proposed Metro IP
- Proposed Cape Horn to Coquitlam
- Railways

Roads/Highways

- Highway/Freeway
- Arterial Streets
- Collector Street
- Local Streets
- Alley
- Ramp

APEC Classification

- Low Impact Site
- Medium to High Impact Site
- Parcels
- Inferred Ground Water Flow

SCALE 1:500

0 5 10 20 Meters

N W E S

Map Drawing Information: FortisBC, BC Site Registry, Dillon Consulting Limited

Map Created By: ECH
Map Checked By:
Map Projection: NAD 1983 UTM Zone 10N

DILLON CONSULTING

PROJECT: 14- 8963

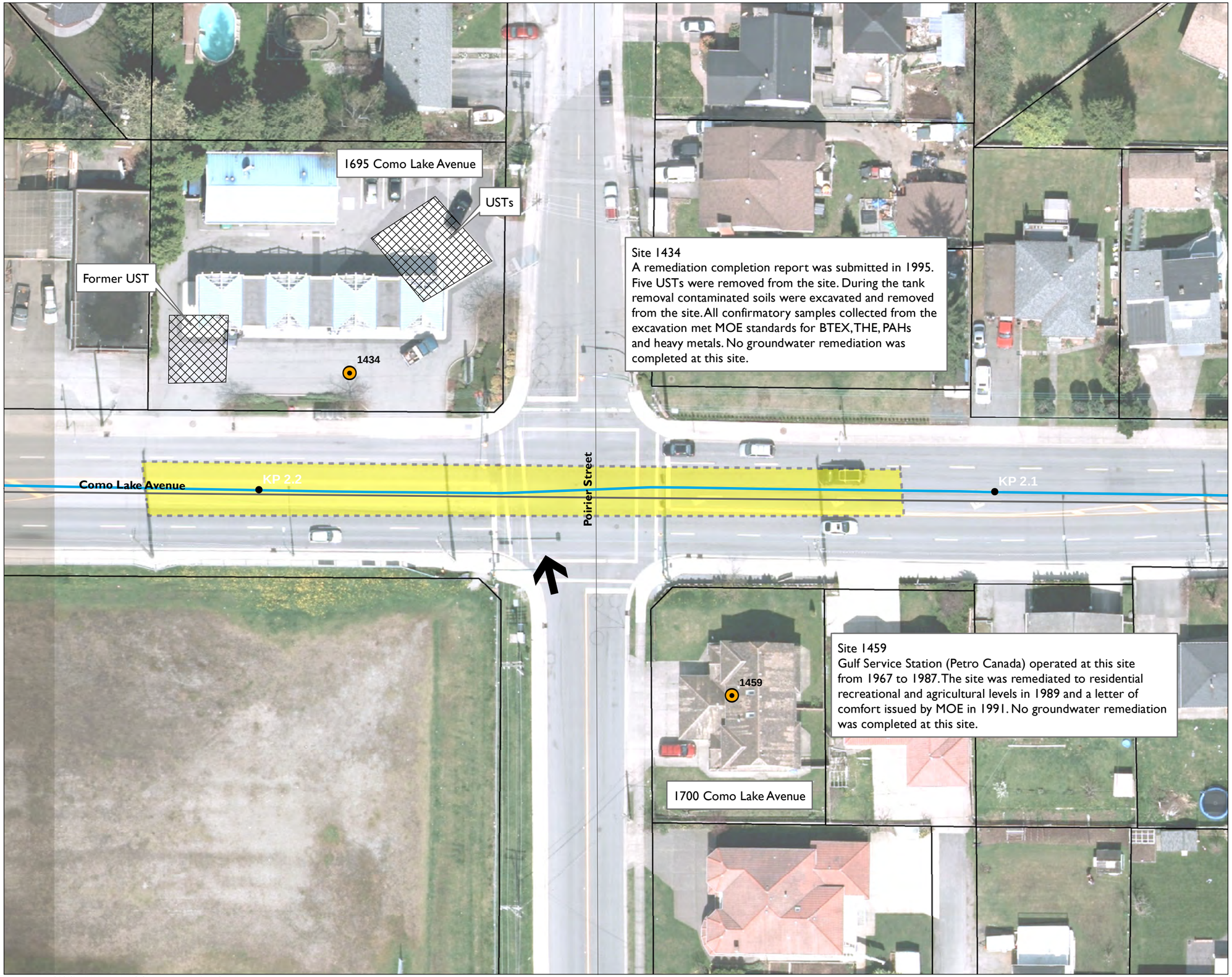
STATUS: FINAL

DATE: 5/2/2014

File Location: G:\GIS\148963 - FortisBC Coastal Revisited\APEC B12.mxd

APEC Information – Metro IP	
APEC B13	APEC 1434 – 1695 Como Lake Avenue, Coquitlam – Figure B8 APEC 1459 – 1700 Como Lake Avenue, Coquitlam – Figure B8
APEC Location	Intersection of Poirier Street and Como Lake Avenue
Length	100 m (KP 2.115-KP 2.215)
Groundwater Elevation (Flow Direction)	1-3mbgs (inferred North-Northwest)
Site Details	
APEC 1434 (Located hydraulically downgradient) Commercial property located north of the alignment (west of Poirier Street) and currently occupied by Chevron service station. APEC 1459 (Located hydraulically upgradient) A residential property located south of the alignment (east of Poirier Street). Historically the site has been a commercial property occupied by Petro Canada service station. Aerial photos show that the site was developed between 1946 and 1963. The residential building at 1700 Como Lake Avenue was built 1990s.	
Document Review Findings	
APEC 1434 A remediation completion report was submitted in 1995. Five USTs were removed from the site. During the tank removal contaminated soils were excavated and removed from the site. All confirmatory samples collected from the excavation met MOE standards for BTEX, THE, PAHs and heavy metals. No groundwater remediation was completed at this site. APEC 1459 Gulf Service Station (Petro Canada) operated at this site from 1967 to 1987. The site was remediated to residential, recreational and agricultural levels in 1989 and a letter of comfort issued by MOE in 1991. No groundwater remediation was completed at this site.	
Classification	Medium to High Impact Site
Potential Contamination	Hydrocarbon and metals
Recommendation	Subsurface soil and groundwater investigation
PCOC s	
LEPH/HEPH, PAH, VOCs including BTEX, Metals	

See APEC Overview Figure APEC B13 for more information



FortisBC

FortisBC LMSU - Metro IP

APEC Overview

APEC B13

- Distance Posts
- Contaminated Sites
- Proposed Fraser IP
- Proposed Metro IP
- Proposed Cape Horn to Coquitlam
- Railways

Roads/Highways

- Highway/Freeway
- Arterial Streets
- Collector Street
- Local Streets
- Alley
- Ramp

APEC Classification

- Low Impact Site
- Medium to High Impact Site
- Parcels
- Inferred Ground Water Flow

SCALE 1:500

0 5 10 20 Meters

N W E S

Map Drawing Information: FortisBC, BC Site Registry, Dillon Consulting Limited

Map Created By: ECH
Map Checked By:
Map Projection: NAD 1983 UTM Zone 10N

DILLON CONSULTING

PROJECT: 14- 8963

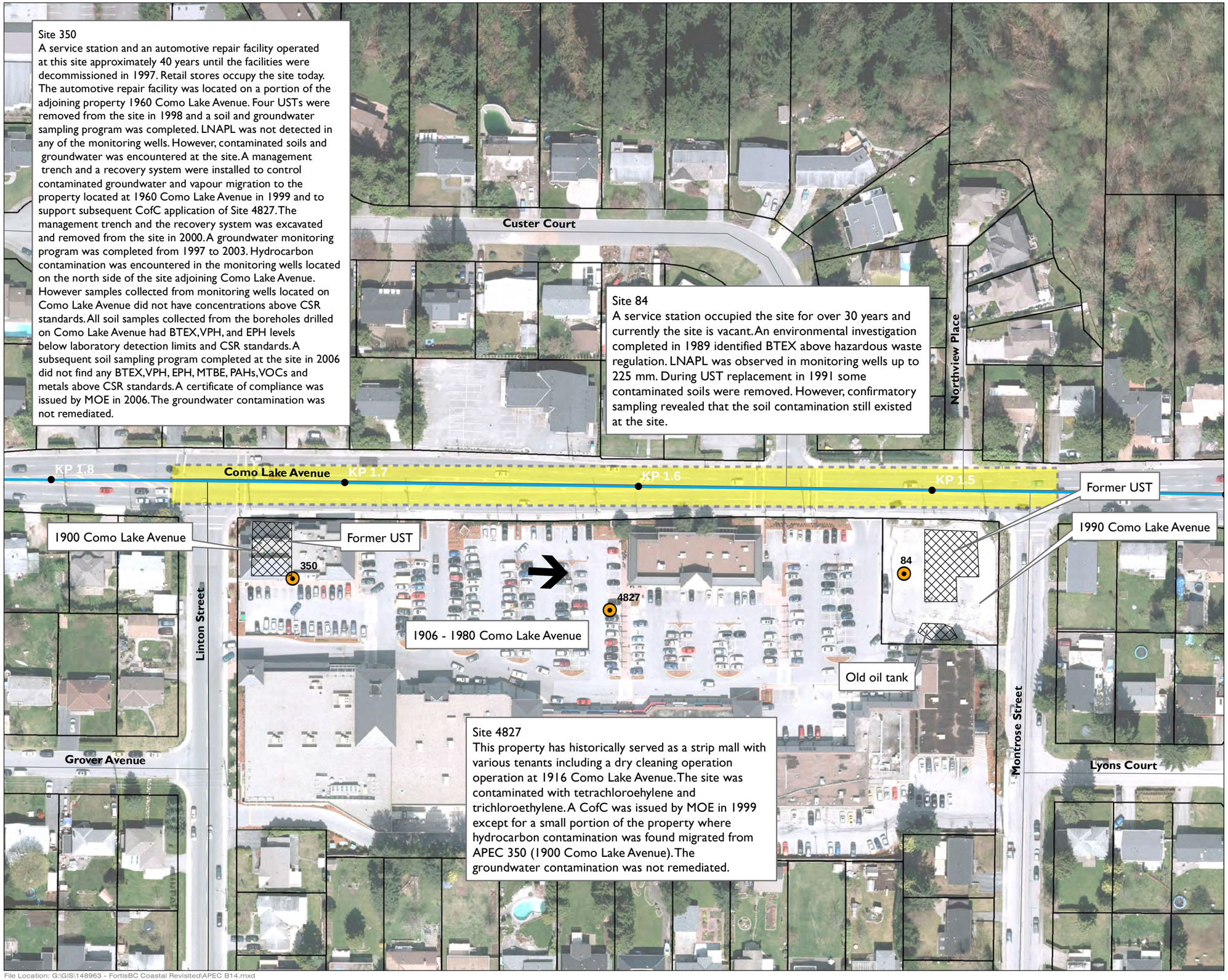
STATUS: FINAL

DATE: 5/2/2014

File Location: G:\GIS\148963 - FortisBC Coastal Revisited\APEC B13.mxd

APEC Information – Metro IP	
APEC B14	Site 84 – 1990 Como Lake Avenue, Coquitlam – Figure B8 Site 350 – 1900 Como Lake Avenue, Coquitlam – Figure B8 Site 4827 – 1960 Como Lake Avenue, Coquitlam – Figure B8
APEC Location	Intersection of Poirier Street and Como Lake Avenue
Length	300 m (KP 1.46-KP 1.76)
Groundwater Elevation (Flow Direction)	1.5 mbgs (inferred east)
Site Details	
Site 84 (Located hydraulically downgradient) Commercial property located south of the alignment (west of Montrose Street) historically occupied by Shell Canada service station. The gas station has been decommissioned, the buildings were removed and currently the site is vacant. Site 350 (Located hydraulically downgradient) Commercial property located south of the alignment (east of Montrose Street) historically occupied by Petro Canada service station. The gas station has been decommissioned and retail stores occupy the site today. Site 4827 Commercial property. This property has historically served as a strip mall with various tenants. The site addresses include 1906-1980 Como Lake Avenue. The site extends from Linton Street to Montrose Street. Aerial photos show that the site was developed between 1946 and 1963.	
Document Review Findings	
Site 84 A service station occupied the site for over 30 years. An environmental investigation completed in 1989 identified BTEX above hazardous waste regulation. LNAPL was observed in monitoring wells up to 225 mm. In 1991 three steel product (gasoline or diesel) USTs and three steel heating oil USTs were replaced with fibreglass tanks. The USTs with product were found intact, however the waste oil UST had evidence of damage. During UST replacement some contaminated soils were removed. However, confirmatory sampling revealed that the soil contamination still existed at the site. Site 350 A service station and an automotive repair facility operated at this site approximately 40 years until the facilities were decommissioned in 1997. The automotive repair facility was located on a portion of the adjoining property 1960 Como Lake Avenue. Four USTs were removed from the site in 1998 and a soil and groundwater sampling program was completed. LNAPL was not detected in any of the monitoring wells. However, contaminated soils and groundwater was encountered at the site. A management trench and a recovery system were installed to control contaminated groundwater and vapour migration to the property located at 1960 Como Lake Avenue in 1999 and to support subsequent CofC application of Site 4827. The management trench and the recovery system was excavated and removed from the site in 2000. A groundwater monitoring program was completed from 1997 to 2003. Not all wells were monitored regularly. Hydrocarbon contamination was encountered in the monitoring wells located on the north side of the site adjoining Como Lake Avenue. However samples collected from monitoring wells located on Como Lake Avenue did not have concentrations above CSR standards. All soil samples collected from the boreholes drilled on Como Lake Avenue had BTEX, VPH, and EPH levels below laboratory detection limits and CSR standards. A subsequent soil sampling program completed at the site in 2006 did not find any BTEX, VPH, EPH, MTBE, PAHs, VOCs and metals above CSR standards. A certificate of compliance was issued by MOE in 2006. The groundwater contamination was not remediated. Site 4827 This property has historically served as a strip mall with various tenants including a dry cleaning operation operation at 1916 Como Lake Avenue. The site was contaminated with tetrachloroehylene and trichloroethylene. A CofC was issued by MOE in 1999 except for a small portion of the property where hydrocarbon contamination was found migrated from APEC 350 (1900 Como Lake Avenue). The groundwater contamination was not remediated.	
Classification	Medium to High Impact Site
Potential Contamination	Hydrocarbon, metals and historical dry cleaning related contamination
Recommendation	Subsurface soil and groundwater investigation
PCOC s	
LEPH/HEPH, PAH, VOCs including BTEX, Metals, TCE, PCE	

See APEC Overview Figure APEC B14 for more information



Site 350
A service station and an automotive repair facility operated at this site approximately 40 years until the facilities were decommissioned in 1997. Retail stores occupy the site today. The automotive repair facility was located on a portion of the adjoining property 1960 Como Lake Avenue. Four USTs were removed from the site in 1998 and a soil and groundwater sampling program was completed. LNAPL was not detected in any of the monitoring wells. However, contaminated soils and groundwater was encountered at the site. A management trench and a recovery system were installed to control contaminated groundwater and vapour migration to the property located at 1960 Como Lake Avenue in 1999 and to support subsequent CofC application of Site 4827. The management trench and the recovery system was excavated and removed from the site in 2000. A groundwater monitoring program was completed from 1997 to 2003. Hydrocarbon contamination was encountered in the monitoring wells located on the north side of the site adjoining Como Lake Avenue. However samples collected from monitoring wells located on Como Lake Avenue did not have concentrations above CSR standards. All soil samples collected from the boreholes drilled on Como Lake Avenue had BTEX, VPH, and EPH levels below laboratory detection limits and CSR standards. A subsequent soil sampling program completed at the site in 2006 did not find any BTEX, VPH, EPH, MTBE, PAHs, VOCs and metals above CSR standards. A certificate of compliance was issued by MOE in 2006. The groundwater contamination was not remediated.

Site 84
A service station occupied the site for over 30 years and currently the site is vacant. An environmental investigation completed in 1989 identified BTEX above hazardous waste regulation. LNAPL was observed in monitoring wells up to 225 mm. During UST replacement in 1991 some contaminated soils were removed. However, confirmatory sampling revealed that the soil contamination still existed at the site.

Site 4827
This property has historically served as a strip mall with various tenants including a dry cleaning operation operation at 1916 Como Lake Avenue. The site was contaminated with tetrachloroehylene and trichloroethylene. A CofC was issued by MOE in 1999 except for a small portion of the property where hydrocarbon contamination was found migrated from APEC 350 (1900 Como Lake Avenue). The groundwater contamination was not remediated.

FortisBC

FortisBC LMSU - Metro IP

APEC Overview

APEC B14

- Distance Posts
- Contaminated Sites
- Proposed Fraser IP
- Proposed Metro IP
- Proposed Cape Horn to Coquitlam
- Railways

Roads/Highways

- Highway/Freeway
- Arterial Streets
- Collector Street
- Local Streets
- Alley
- Ramp

APEC Classification

- Low Impact Site
- Medium to High Impact Site
- Parcels
- Inferred Ground Water Flow

SCALE 1:1,250

0 10 20 40 Meters

N W E S

Map Drawing Information: FortisBC, BC Site Registry, Dillon Consulting Limited

Map Created By: ECH
Map Checked By:
Map Projection: NAD 1983 UTM Zone 10N

DILLON CONSULTING

PROJECT: 14- 8963

STATUS: FINAL

DATE: 5/2/2014

File Location: G:\GIS\148963 - FortisBC Coastal Revisited\APEC B14.mxd

APEC Information – Cape Horn to Coquitlam	
APEC C1	Mariner Fire Hall (#2 Fire Hall) – 775 Mariner Way, Coquitlam – Figure C1
APEC Location	On Mariner Way south of Spuraway Avenue
Length	100 m (KP 4.4-KP 4.5)
Groundwater Elevation (Flow Direction)	Unknown (Inferred Southeast)
Site Details	
Mariner Fire Hall (#2 Fire Hall) (Located hydraulically upgradient) A Fire Station located west of the alignment	
Document Review Findings	
No documents were available. Some firefighting foams contained Perfluorooctane Sulfonate (PFOS) a synthetic (man-made) chemical substance belonging to a large family of compounds known as perfluorinated chemicals which was phased-out of the production in 2000. The Perfluorooctane Sulfonate and its Salts and Certain Other Compounds Regulations (PFOS Regulations) which limits the use of PFOS came into effect in Canada in 2013. The Fire Halls may have USTs for fuel storage as well. The aerial photos show that the Fire Station was built between 1986 and 1991.	
Classification	Low Impact Site
Potential Contamination	Hydrocarbon and metals
Recommendation	Manage any subsurface contamination related issues during construction activities.
PCOC s	
LEPH/HEPH, PAH, VOCs including BTEX, Metals and PFOS	

See APEC Overview Figure APEC C1 for more information

FortisBC

FortisBC LMSU - Cape Horn to Coquitlam

APEC Overview

APEC C1

- Distance Posts
- Contaminated Sites
- Proposed Fraser IP
- Proposed Metro IP
- Proposed Cape Horn to Coquitlam
- Railways

Roads/Highways

- Highway/Freeway
- Arterial Streets
- Collector Street
- Local Streets
- Alley
- Ramp

APEC Classification

- Low Impact Site
- Medium to High Impact Site
- Parcels
- Inferred Ground Water Flow

SCALE 1:1,250

0 7.5 15 30 Meters

N W E S

Map Drawing Information: FortisBC, BC Site Registry, Dillon Consulting Limited

Map Created By: ECH
Map Checked By:
Map Projection: NAD 1983 UTM Zone 10N

DILLON CONSULTING

PROJECT: 14- 8963

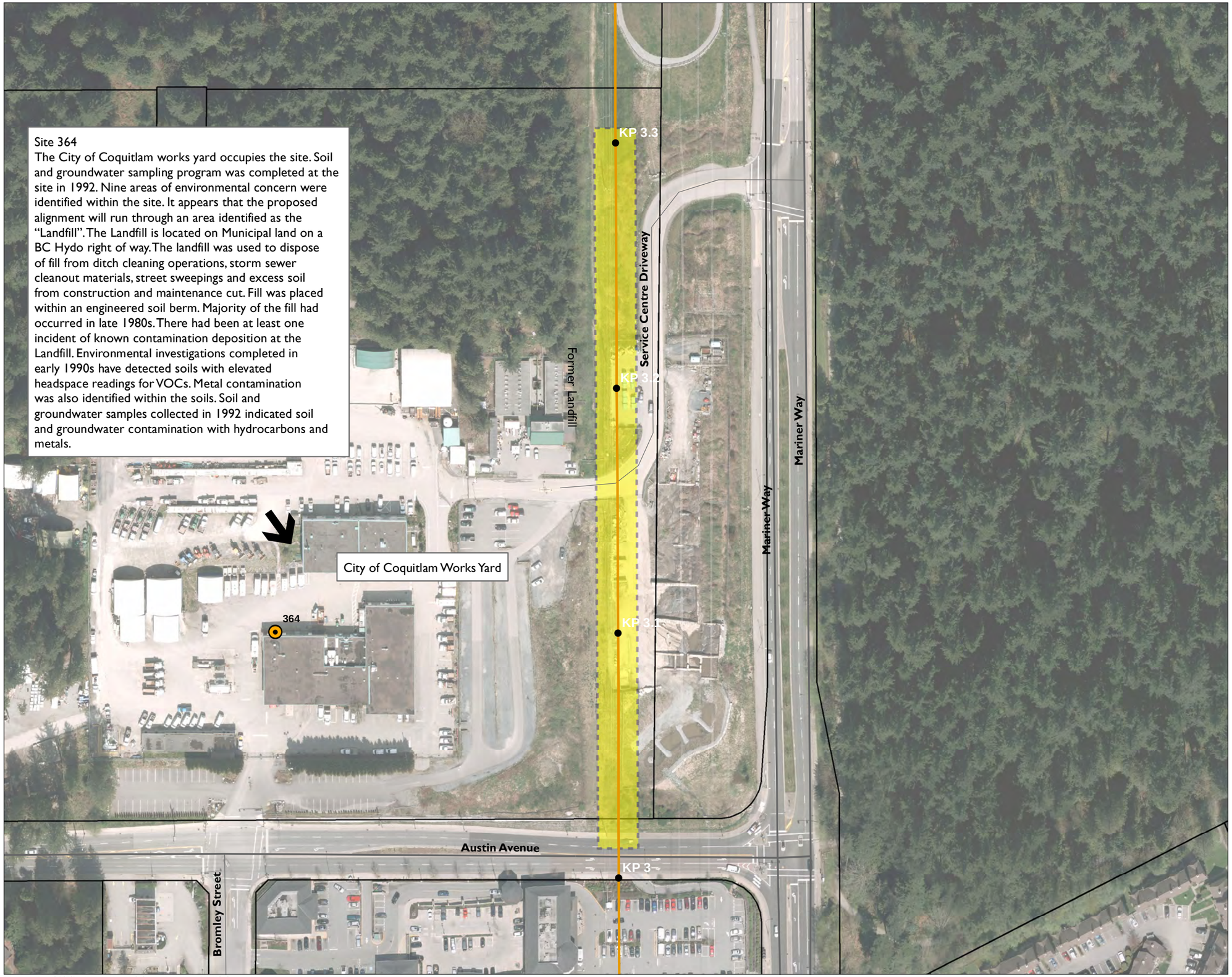
STATUS: FINAL

DATE: 5/2/2014

File Location: G:\GIS\148963 - FortisBC Coastal Revisited\APEC C1.mxd

APEC Information – Cape Horn to Coquitlam	
APEC C2	Site 364 – 2647 Austin Avenue (500 Mariner Way), Coquitlam – Figure C1
APEC Location	North of Austin Avenue
Length	310 m (KP 3.02-KP 3.33)
Groundwater Elevation (Flow Direction)	2-3 mbgs (inferred Southeast)
Site Details	
Site 364 (Located hydraulically upgradient) City of Coquitlam works yard is located west of the alignment. The aerial photos show that the site was developed between 1963 and 1969.	
Document Review Findings	
Site 84 Soil and groundwater sampling program was completed at the site in 1992. Nine areas of environmental concern were identified within the site. It appears that the proposed alignment will run through an area identified as the "Landfill". The Landfill is located on Municipal land on a BC Hydo right of way. The landfill was used to dispose of fill from ditch cleaning operations, storm sewer cleanout materials, street sweepings and excess soil from construction and maintenance cut. Fill was placed within an engineered soil berm. Majority of the fill had occurred in late 1980s. There had been at least one incident of known contamination deposition at the Landfill. Environmental investigations completed in early 1990s have detected soils with elevated headspace readings for VOCs. Metal contamination was also identified within the soils. Soil and groundwater samples collected in 1992 indicated soil and groundwater contamination with hydrocarbons and metals.	
Classification	Medium to High Impact Site
Potential Contamination	Hydrocarbon and metals
Recommendation	Subsurface soil and groundwater investigation
PCOC s	
LEPH/HEPH, PAH, VOCs including BTEX, Metals, and PCBs	

See APEC Overview Figure APEC C2 for more information



Site 364
The City of Coquitlam works yard occupies the site. Soil and groundwater sampling program was completed at the site in 1992. Nine areas of environmental concern were identified within the site. It appears that the proposed alignment will run through an area identified as the "Landfill". The Landfill is located on Municipal land on a BC Hydo right of way. The landfill was used to dispose of fill from ditch cleaning operations, storm sewer cleanout materials, street sweepings and excess soil from construction and maintenance cut. Fill was placed within an engineered soil berm. Majority of the fill had occurred in late 1980s. There had been at least one incident of known contamination deposition at the Landfill. Environmental investigations completed in early 1990s have detected soils with elevated headspace readings for VOCs. Metal contamination was also identified within the soils. Soil and groundwater samples collected in 1992 indicated soil and groundwater contamination with hydrocarbons and metals.

FortisBC

FortisBC LMSU - Cape Horn to Coquitlam

APEC Overview

APEC C2

- Distance Posts
- Contaminated Sites
- Proposed Fraser IP
- Proposed Metro IP
- Proposed Cape Horn to Coquitlam
- Railways

Roads/Highways

- Highway/Freeway
- Arterial Streets
- Collector Street
- Local Streets
- Alley
- Ramp

APEC Classification

- Low Impact Site
- Medium to High Impact Site
- Parcels
- Inferred Ground Water Flow

SCALE 1:1,500

0 12.5 25 50 Meters

N W E S

Map Drawing Information: FortisBC, BC Site Registry, Dillon Consulting Limited

Map Created By: ECH
Map Checked By:
Map Projection: NAD 1983 UTM Zone 10N

DILLON CONSULTING

PROJECT: 14- 8963

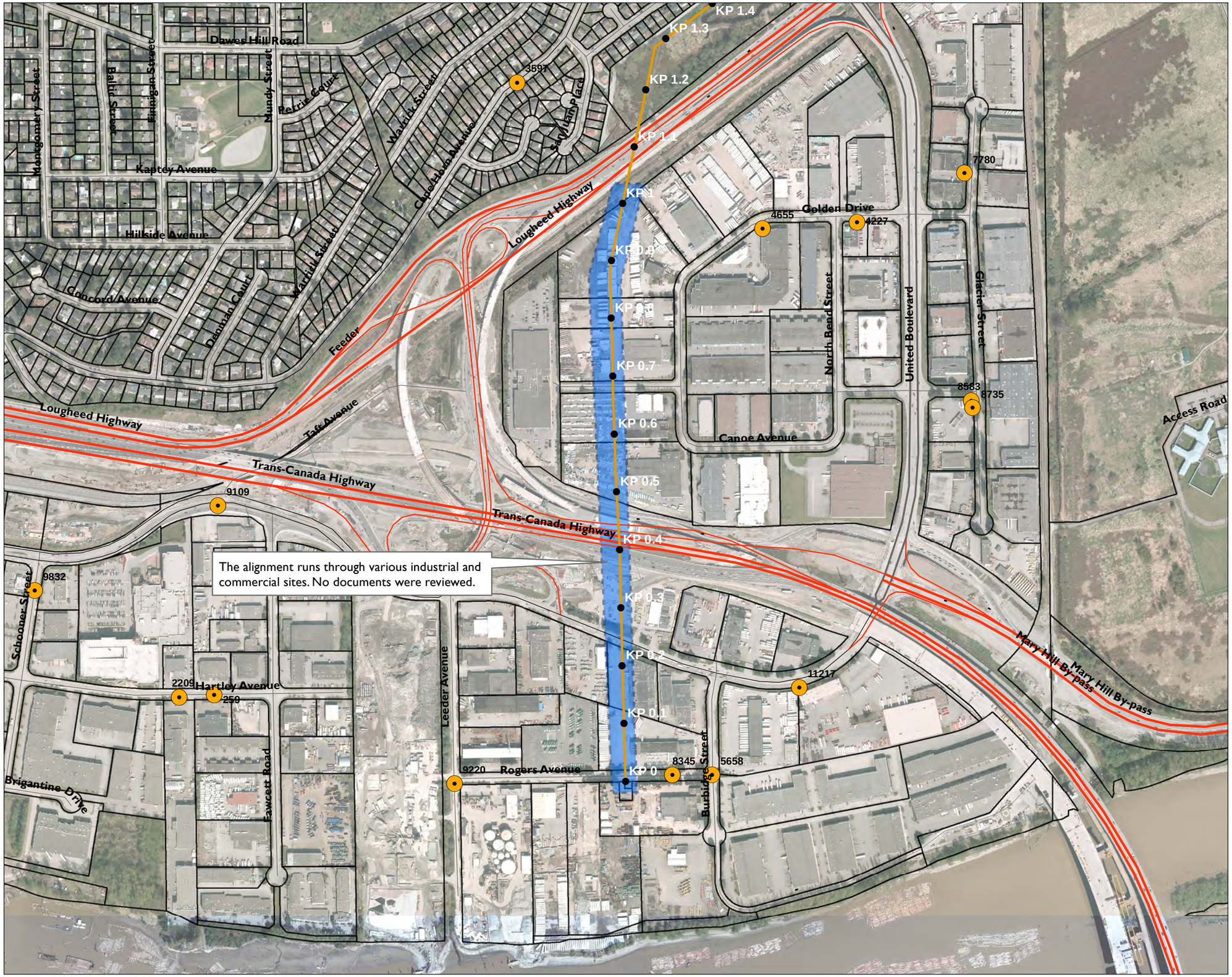
STATUS: FINAL

DATE: 5/5/2014

File Location: G:\GIS\148963 - FortisBC Coastal Revisited\APEC C2.mxd

APEC Information – Cape Horn to Coquitlam	
APEC C3	Various Sites, Coquitlam – Figure C2
APEC Location	First kilometre of the alignment
Length	1000 m (KP 0.0-KP 1.0)
Groundwater Elevation (Flow Direction)	Unknown (South)
Site Details	
The alignment runs through various industrial and commercial sites with long term truck and flatbed storage. The sites include Kiewit storage site, a product distribution centre, landscape commercial yard, Smithrite Disposal and truck and lumber yards. The aerial photos show that the site was developed in late 1970s.	
Document Review Findings	
No documents were available.	
Classification	Low Impact Site
Potential Contamination	Hydrocarbon and metals
Recommendation	Manage any subsurface contamination related issues during construction activities.
PCOC s	
LEPH/HEPH, PAH, VOCs including BTEX, Metals	

See APEC Overview Figure APEC C2 for more information



FortisBC

FortisBC LMSU - Cape Horn to Coquitlam

APEC Overview

APEC C3

- Distance Posts
- Proposed Fraser IP
- Proposed Metro IP
- Proposed Cape Horn to Coquitlam
- Railways

Roads/Highways

- Highway/Freeway
- Arterial Streets
- Collector Street
- Local Streets
- Alley
- Ramp

APEC Classification

- Low Impact Site
- Medium to High Impact Site
- Parcels
- Inferred Ground Water Flow

SCALE 1:6,358

0 50 100 200 Meters

N W E S

Map Drawing Information: FortisBC, BC Site Registry, Dillon Consulting Limited

Map Created By: ECH
Map Checked By:
Map Projection: NAD 1983 UTM Zone 10N

DILLON CONSULTING

PROJECT: 14- 8963

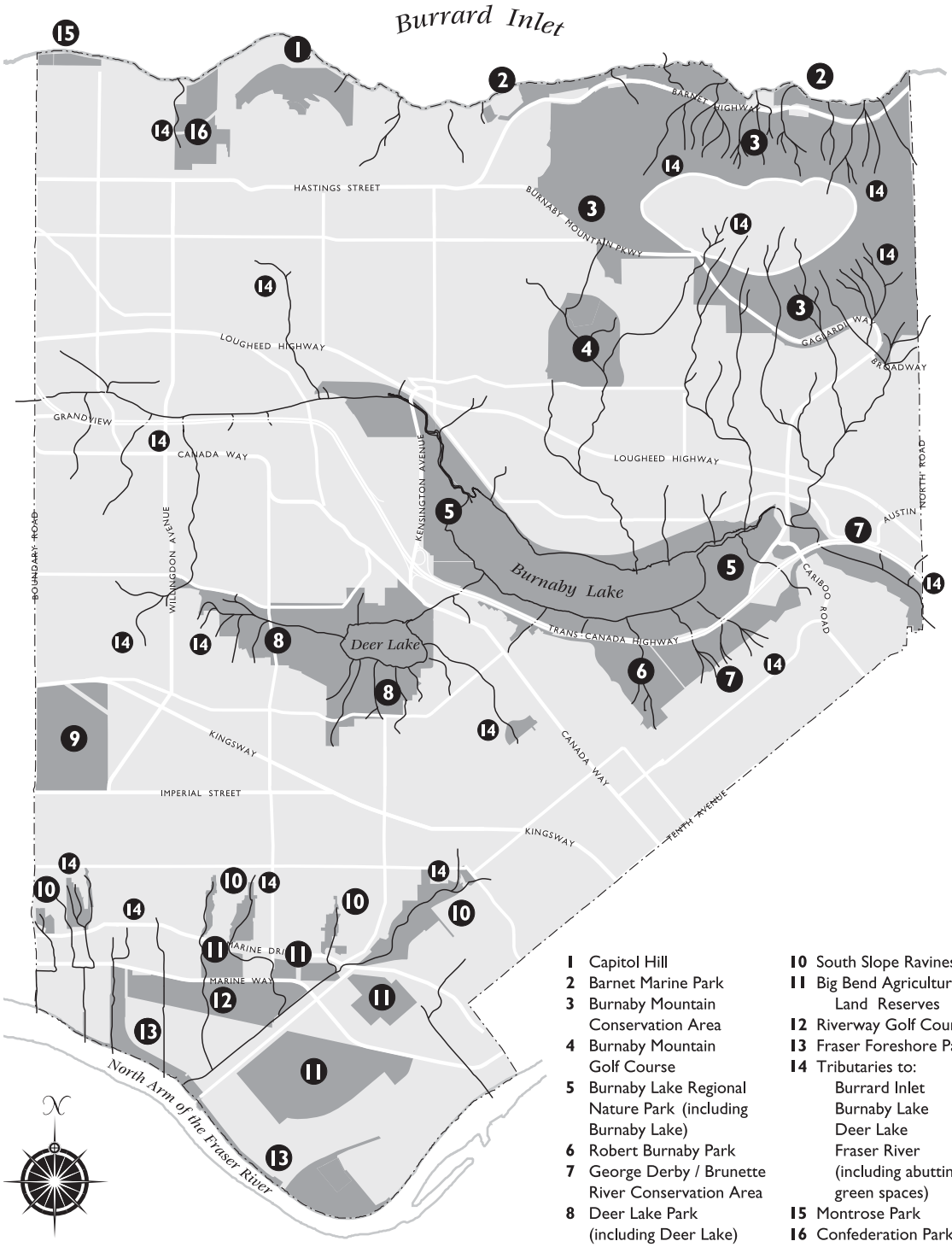
STATUS: FINAL

DATE: 5/2/2014

File Location: G:\GIS\148963 - FortisBC Coastal Revisited\APEC C3.mxd

APPENDIX F

City of Burnaby OCP Figures



1 Capitol Hill
2 Barnet Marine Park
3 Burnaby Mountain Conservation Area
4 Burnaby Mountain Golf Course
5 Burnaby Lake Regional Nature Park (including Burnaby Lake)
6 Robert Burnaby Park
7 George Derby / Brunette River Conservation Area
8 Deer Lake Park (including Deer Lake)
9 Central Park
10 South Slope Ravines
11 Big Bend Agricultural Land Reserves
12 Riverway Golf Course
13 Fraser Foreshore Park
14 Tributaries to:
Burrard Inlet
Burnaby Lake
Deer Lake
Fraser River
(including abutting green spaces)
15 Montrose Park
16 Confederation Park

Green Zone Lands

Appendix B-2

ARCHAEOLOGICAL OVERVIEW ASSESSMENT

Archaeological Overview Assessment

Metro Vancouver Reinforcements
Vancouver, Burnaby, Coquitlam and Surrey, BC

Prepared for:
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Final

Project No.: 1232-10387

August 22, 2014

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PERMITS

Kwantlen Heritage Investigation Permit 2014-0012

Stó:lō Heritage Investigation Permit 2013-0065

Tsleil-Waututh Cultural Heritage Investigation Permit 2013-0231

Executive Summary

At the request of FortisBC Energy Inc. (FortisBC), Stantec Consulting Ltd. (Stantec) conducted an archaeological overview assessment (AOA) for the proposed pipeline upgrade associated with the Metro Vancouver Reinforcements Project (the Project; Figure 1). This upgrade is part of FortisBC's Lower Mainland Natural Gas System Upgrade Projects (LMSU) program, a long-term infrastructure improvement project. The AOA is produced in support of a BC Utilities Commission Certificate of Public Concern and Necessity application.

The Project includes upgrades to ~30,700 m of existing Transmission Pressure (TP) and Intermediate Pressure (IP) pipelines across four municipalities in the Lower Mainland (Figure 1). The upgrades will be conducted on the Metro IP Pipeline Replacement through Vancouver, Burnaby, and Coquitlam, the Fraser Gate IP Replacement in south Vancouver, the Cape Horn to Coquitlam TP Pipeline Loop in Coquitlam, and the Nichol to Port Mann TP Pipeline Loop in north Surrey. The study was initiated to evaluate archaeological potential within the Project and provide recommendations for additional archaeological investigations, as required.

According to a review of the provincially maintained Consultative Areas Database, an online database used to identify First Nations with treaty rights or asserted or proven rights to title, the Project falls within the asserted traditional territories of the member groups of the Hul'qumi'num Treaty Group (including Cowichan Tribes, Halalt First Nation, Lake Cowichan First Nation, Lyackson First Nation, Penelakut Tribe, and Stz'uminus First Nation), Katzie First Nation, Kwantlen First Nation, Kwikwetlem First Nation, Musqueam Nation, Semiahmoo First Nation, Squamish Nation, the Stó:lō Tribal Council (representing Seabird Island First Nation, Shxw'owhamel First Nation, and Soowahlie First Nation), Stó:lō Nation (representing Skawahlook First Nation), Tsawwassen First Nation, and Tsleil-Waututh Nation.

Kwantlen Heritage Investigation Permit 2014-0012, Stó:lō Heritage Inspection Permits 2013-0065, and Tsleil-Waututh Cultural Heritage Investigation Permit 2013-0231 were issued for the AOA. A permit application was submitted to the Musqueam Nation, but no permit had been issued by the Musqueam at the time of writing this AOA.

There are no recorded archaeological sites within 50 m of the Project. A total of six sites are located within 500 m of the Project including three near or within the historic Port Mann town vicinity (DhRq-37, 38 and 76) and three on the adjacent north bank of the Fraser River (DhRq-70, 80 and 81). Additionally, DgRr-60 is located ~550 m east of the southeast extent of the Project.

Areas along the project route that have been previously disturbed by development activities and are at a distance from the Fraser River or other hydrological or resource features were assessed as having low archaeological potential.

Nine areas close to the Fraser River, to streams and lakes, or to recorded archaeological sites are assessed as having high archaeological potential and an AIA is recommended for these areas prior to development. These areas are as follows:

- Metro IP Pipeline Replacement in Burnaby: the four unnamed creek crossings at the south base of Burnaby Mountain at KPs 6.9, 7.4, 7.7 and 8.0
- Cape Horn to Coquitlam TP Pipeline Loop alignment: the ~400 m long portion of the alignment located east of Lost Lake in Mundy Park between KPs ~3.6 and ~4.0
- Nichol to Port Mann TP Pipeline Loop in north Surrey: the three unnamed creek crossings at KPs 0.1, 0.8 and 2.6., and the Fraser River terrace at King Road between KP 4.7 and the north end of the pipeline loop at KP 4.97

An AIA involves the subsurface testing of the Project. Small diameter auger and shovel tests would be excavated and mapped with all information presented in a final report. Any artifacts and/or faunal materials recovered during the testing program would be analyzed. Complete photographic and written documentation of the Project would be maintained with all pertinent records provided to the official artifact repository as appropriate. Any archaeological sites identified would be recorded on appropriate government inventory forms. A detailed management plan in the form of a series of recommendations would be provided, as necessary. All work would be conducted in accordance with Provincial archaeological guidelines administered by the Archaeology Branch.

Acquisition of an *HCA* Section 14 Heritage Inspection Permit will be required prior to AIA field work.

For areas assessed as having low archaeological potential, no further archaeological work is recommended. However, in the unlikely event that archaeological materials are uncovered during any future ground altering activity, all work in the vicinity of the finds should cease and the Archaeology Branch, a professional archaeologist, and the appropriate First Nations be notified. Historic and prehistoric materials older than AD 1846 are protected by legislation.

These recommendations applies solely to physical archaeological evidence of past human activity and in no way attempts to encompass any heritage concerns of the various First Nations people with asserted traditional territories in the project area.

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APPENDIX A SRRMC TRADITIONAL USE DATABASE SEARCH RESULT--DATA SHEET

1.0 Introduction

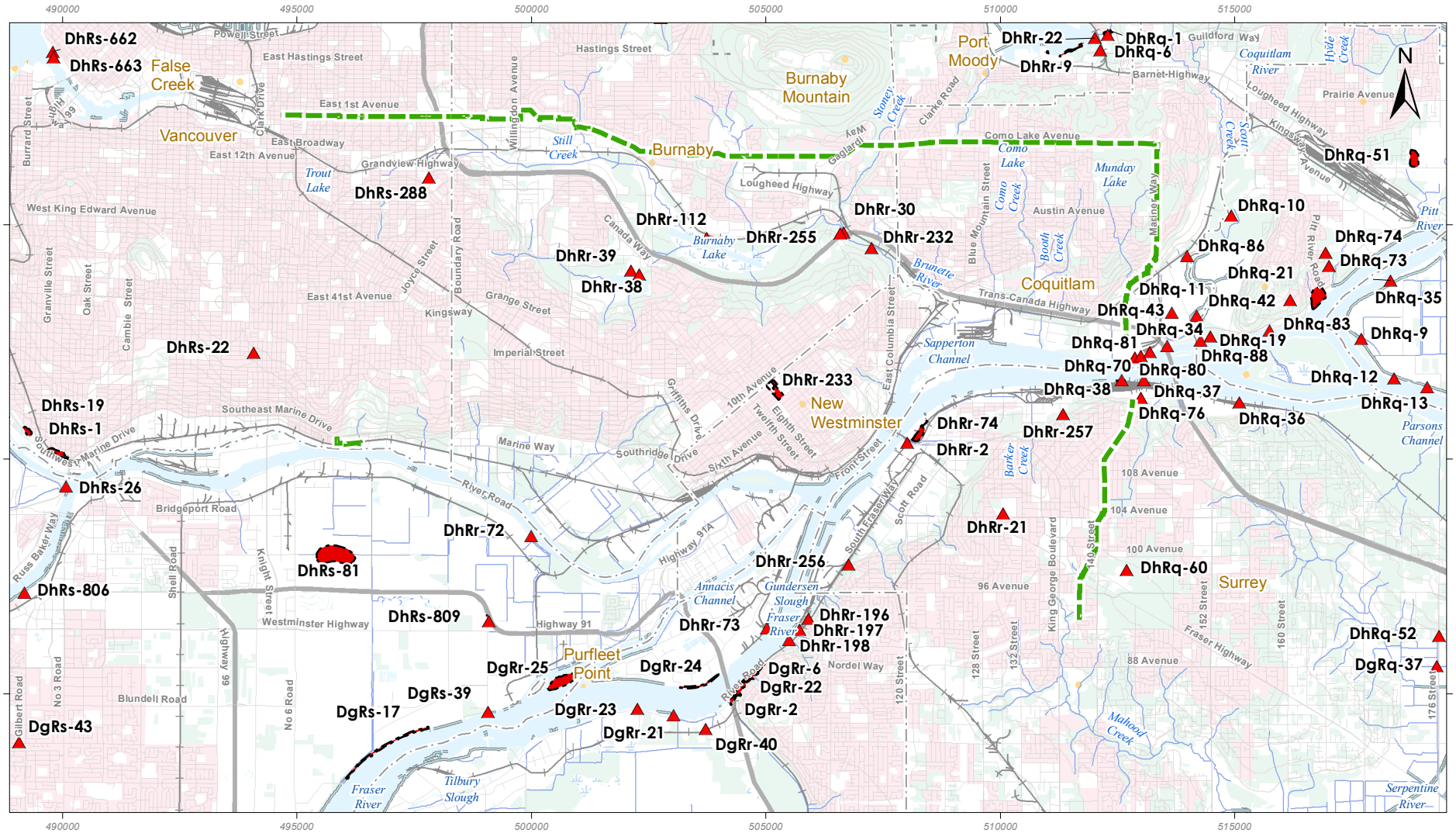
At the request of FortisBC Energy Inc. (FortisBC), Stantec Consulting Ltd. (Stantec) conducted an archaeological overview assessment (AOA) for the proposed pipeline upgrade associated with the Metro Vancouver Reinforcements Project (the Project; Figures 1-4). This upgrade is part of FortisBC's Lower Mainland Natural Gas Upgrade Projects (LMSU) program, a long-term infrastructure improvement project. The AOA is produced in support of a BC Utilities Commission Certificate of Public Concern and Necessity application.

The Project includes upgrades to ~30,700 m of existing Transmission Pressure (TP) and Intermediate Pressure (IP) pipelines across four municipalities in the Lower Mainland (Figures 1-4). The upgrades will be conducted on the Metro IP Pipeline Replacement through Vancouver, Burnaby, and Coquitlam, the Fraser Gate IP Replacement in south Vancouver, the Cape Horn to Coquitlam TP Pipeline Loop in Coquitlam, and the Nichol to Port Mann TP Pipeline Loop in north Surrey. The study was initiated to evaluate archaeological potential within the Project and provide recommendations for additional archaeological investigations, as required.

According to a review of the provincially maintained Consultative Areas Database, an online database used to identify First Nations with treaty rights or asserted or proven rights to title, the Project falls within the asserted traditional territories of the member groups of the Hul'qumi'num Treaty Group (including Cowichan Tribes, Halalt First Nation, Lake Cowichan First Nation, Lyackson First Nation, Penelakut Tribe, and Stz'uminus First Nation), Katzie First Nation, Kwantlen First Nation, Kwikwetlem First Nation, Musqueam Nation, Semiahmoo First Nation, Squamish Nation, the Stó:lō Tribal Council (representing Seabird Island First Nation, Shxw'owhamel First Nation, and Soowahlie First Nation), Stó:lō Nation (representing Skawahlook First Nation), Tsawwassen First Nation, and Tsleil-Waututh Nation.

Kwantlen Heritage Investigation Permit 2014-0012, Stó:lō Heritage Inspection Permits 2013-0065, and Tsleil-Waututh Cultural Heritage Investigation Permit 2013-0231 were issued for the AOA. A permit application was submitted to the Musqueam Nation, but no permit had been issued by the Musqueam at the time of writing this AOA.

Heritage sites and objects on private and Provincial Crown Land in British Columbia that predate AD 1846 are protected under the *Heritage Conservation Act* (*HCA*), which is administered by the Archaeology Branch of the Ministry of Forests, Lands and Natural Resource Operations. Heritage resources specifically protected by the *Act* include Provincial heritage sites, burial places with historical or archaeological value, aboriginal rock paintings or carvings, sites with evidence of human habitation or use before 1846 and heritage wrecks. The Lieutenant-Governor-in-Council may also make regulations to define the extent of types of sites protected by the Act.



Legend

- Archaeological Site
- Project Area
- Archaeological Site
- Municipal Boundary

0 1 2 3 4 5 km

1:125,000

Archaeological Overview Assessment
Lower Mainland Natural Gas Systems Upgrades

Metro Vancouver Reinforcements Project Area

Sources: FortisBC, BC Government

Although there is no reason to believe that there are any errors associated with the data used to generate this product or in the product itself, users of these data are advised that errors in the data may be present.

DATE: 08/22/14	PROJECTION: UTM - ZONE 10	DRAWN BY: K. JAMES
FIGURE ID: 123210387-1	DATUM: NAD 83	CHECKED BY: S. KALTENRIEDER

PREPARED BY: Stantec

PREPARED FOR: FORTIS BC

FIGURE NO: 1

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Heritage resources can be prehistoric in age (the time before written records) or they can be historic. They can be of First Nations, European, Euro-Canadian or other ethnic affiliation. Ethnographic heritage sites are locations reported as having been used or occupied by Aboriginal people in the past, which may or may not contain any physical evidence for such an occupation or use. A reported ethnographic site found to contain physical evidence changes the site to an archaeological site enhanced by ethnographic information. Ethnographic sites with no corroborative physical evidence are not treated as heritage sites according to present heritage legislation. However, all ethnographic sites should be managed as a responsibility of developers.

There are usually three stages to the heritage resource impact assessment and review process including: an overview assessment (AOA), a detailed impact assessment (AIA), and impact mitigation. The AOA is intended to identify and assess heritage resource potential, or the likelihood that sites are present. The objectives of the AIA are the identification and evaluation of heritage resources within a proposed development area, and also an assessment of possible impacts by the development on these sites. Impact mitigation is any course of action that results in the reduction or the elimination of the adverse impacts of a development. Mitigation, where required, usually involves site protection, project redesign or systematic data recovery, and normally involves archaeological excavation.

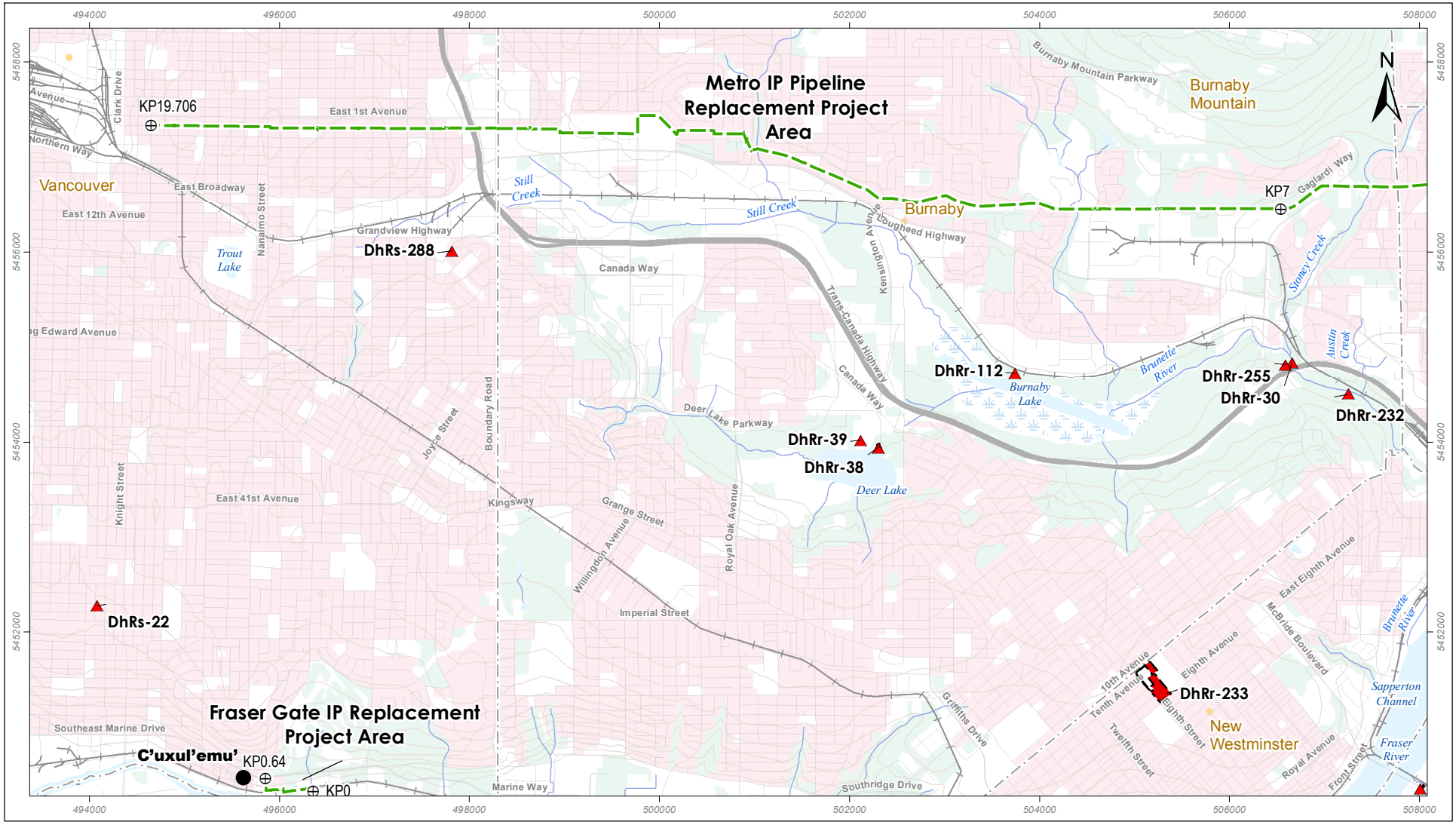
The present study was designed to satisfy the objectives of an AOA. The following results are based on desktop analysis and the findings from a preliminary field reconnaissance (PFR).

The study was conducted without prejudice to First Nations treaty negotiations, aboriginal rights or aboriginal title.

2.0 Proposed Project

The proposed Project includes (Figures 2–4):

- Metro IP Pipeline Replacement: A 30” IP pipeline replacement from Coquitlam Station at Como Lake Avenue and Mariner Way west to East 2nd Avenue at Woodland Drive through Coquitlam, Burnaby and Vancouver
- Fraser Gate IP Replacement: A 30” IP pipeline replacement along a 700 m section from the Fraser Gate Station to the intersection of Marine Drive and Elliot Street in Vancouver
- Cape Horn to Coquitlam TP Pipeline Loop: A 36” TP pipeline installation along a 4.6 km section from 2340 Rogers Avenue, following the SRW north to Mariner Way and Como Lake Avenue
- Nichol to Port Mann TP Pipeline Loop: A 36” TP pipeline installation along a 5.4 km section from 93A Avenue and 138A Street, following the FortisBC Statutory Right-of-Way (SRW) north to the South Fraser Perimeter Road



Legend

- Archaeological Site
- Kilometre Post
- Stó:lō Place Names
- Project Area
- Archaeological Site
- Municipal Boundary

0 1 2 3 km

1:60,000

Archaeological Overview Assessment
Lower Mainland Natural Gas System Upgrades

Metro Vancouver Reinforcements
Fraser Gate IP Replacement and
Metro IP Pipeline Replacement Project Areas

Sources: FortisBC, BC Government, McHalsie (2001)

Although there is no reason to believe that there are any errors associated with the data used to generate this product or in the product itself, users of these data are advised that errors in the data may be present.

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PREPARED BY: Stantec

PREPARED FOR: FORTIS BC

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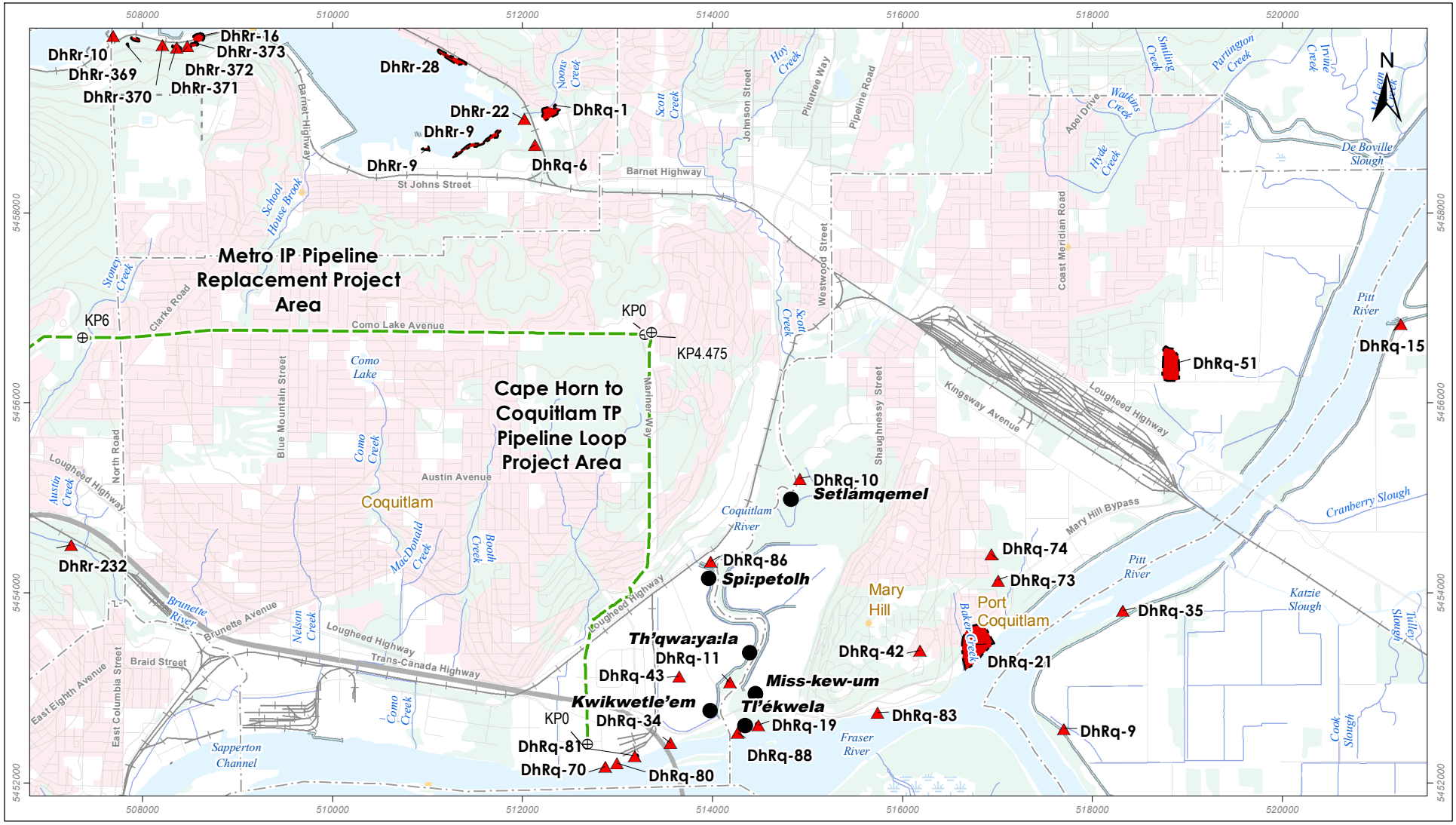

Legend

- Archaeological Site
- Archaeological Site
- Kilometre Post
- Municipal Boundary
- Stó:lō Place Names
- Project Area

0 1 2 3 km

1:60,000

Archaeological Overview Assessment
Lower Mainland Natural Gas System Upgrades

Metro Vancouver Reinforcements - Metro IP Pipeline Replacement and Cape Horn to Coquitlam TP Pipeline Loop Project Area

Sources: FortisBC, BC Government, McHalsie (2001)

Although there is no reason to believe that there are any errors associated with the data used to generate this product or in the product itself, users of these data are advised that errors in the data may be present.

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PREPARED BY: Stantec

PREPARED FOR: FORTIS BC

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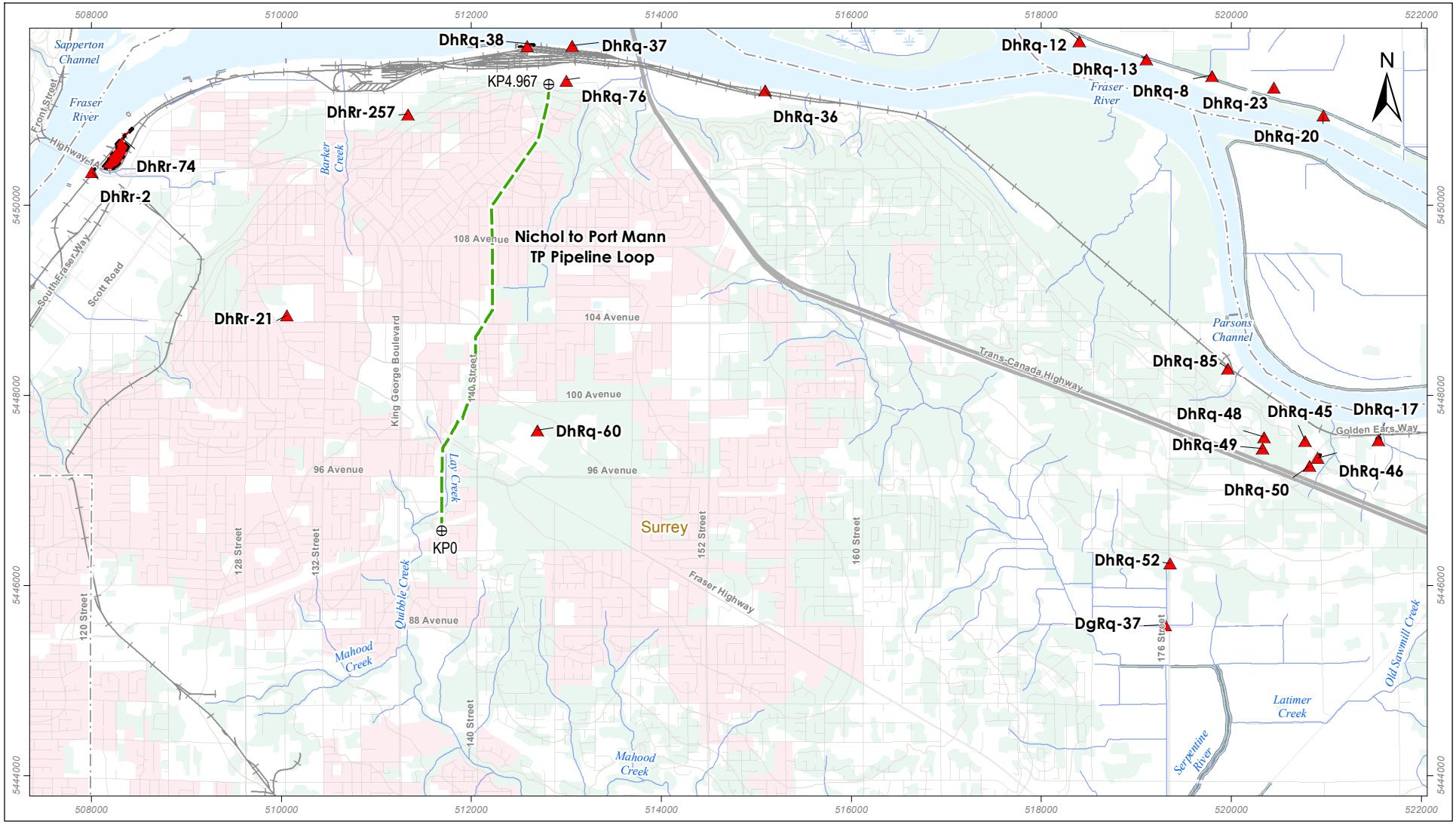

Legend

- Archaeological Site
- Archaeological Site
- Kilometre Post
- Municipal Boundary
- Project Area

0 1 2 3 km

1:60,000

Archaeological Overview Assessment
Lower Mainland Natural Gas System Upgrades

Metro Vancouver Reinforcements
Nichol to Port Mann TP Pipeline Loop
Project Area

Sources: FortisBC, BC Government

Although there is no reason to believe that there are any errors associated with the data used to generate this product or in the product itself, users of these data are advised that errors in the data may be present.

DATE: 08/22/14	PROJECTION: UTM - ZONE 10	DRAWN BY: K. JAMES
FIGURE ID: 123210387-4	DATUM: NAD 83	CHECKED BY: S. KALTENRIEDER

PREPARED BY: Stantec

PREPARED FOR: FORTIS BC

FIGURE NO: **4**

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The dimensions for shored trench excavation are proposed to be at maximum no deeper than ~2.8 m and no wider than ~1.6 m. The dimensions for sloped trench excavation are proposed to be at maximum no deeper than ~2.8 m and no wider than ~7 m at the top and ~1.6 m at the bottom. Exact dimensions have not been defined at this time.

Horizontal directional drilling (HDD) may be utilized rather than trenching at creek crossings. In order to avoid impacts to streams, HDD may be used to bore the pipeline under steams to minimize environmental impacts. HDD is a steerable trenchless method of installing underground pipelines in an arch along a prescribed bore path (Lubrecht 2012; Short 1993). Depending on the boring requirements, one of three locating systems will be used in the HDD process: the walk-over locating system, wire-line locating system and gyro-based locating system (Short 1993).

3.0 Methods

Available information concerning the location, nature and distribution of known prehistoric and historic resources in the vicinity of the Project was acquired using the Remote Access to Archaeological Data (RAAD) application maintained by the Archaeology Branch of the Ministry of Forests, Lands and Natural Resource Operations. A review of previous archaeological assessments in the vicinity of the Project was also completed. A review of background literature dealing with anthropology, history, archaeology and palaeoenvironment of the project area was conducted to place the Project in cultural context. A review of ethnographic literature and traditional use studies was also conducted.

A PFR was conducted to further refine the archaeological potential assessment of the Project. The study area was assessed by both vehicle and pedestrian survey.

4.0 Project Area

A review of local and regional natural history can provide insight into past environmental conditions that may have influenced cultural adaptations. These palaeoecological studies, in concert with ethnographic, historical and archaeological data, help determine the types of site and the general archaeological nature of remains that may be present in a given area.

4.1 NATURAL HISTORY

The Project lies within the Fraser Lowland, a region characterized by low-lying and gently rolling hills of glacial drift separated by wide alluvium filled valleys. The Fraser Lowland is bounded by the Coast Mountains to the north, the Cascade Mountains to the east and southeast and Georgia Strait to the west. The dominant watercourse, the Fraser River, assumed its modern channel ~10,800 years BP (before present) and had begun building the Fraser delta by 8,000 years BP (Armstrong 1981).

The Project is situated within the Coastal Western Hemlock (CWH) zone. On average, the CWH zone is the rainiest biogeoclimatic zone in British Columbia with typically cool summers, with some hot spells and generally mild winters. The CWH zone tends to be dominated by western hemlock (*Tsuga heterophylla*) with western red cedar (*Thuja plicata*) and Douglas-fir (*Pseudotsuga menziesii*) also being widespread. The poorly to moderately developed shrub layer consists mostly of salal (*Gaultheria shallon*), dull Oregon grape (*Mahonia nervosa*) and red huckleberry (*Vaccinium parvifolium*). The well-developed moss layer consists of Oregon beaked moss (*Kindbergia oregana*), step moss (*Hylocomium splendens*), lanky moss (*Rhytidiadelphus loreus*) and wavy-leaved cotton moss, which is also known as flat moss (*Plasiothecium indulatum*) (Pojar et al. 1991). Pojar et al. (1991) provide a comprehensive list of avian and mammalian species that are commonly found in the project area.

The Late Wisconsinan glaciation of the Fraser Lowland is called the Fraser glaciation. The Fraser glaciation was preceded by the Olympia Non-glacial Interval (Booth 1987; Clague et al. 1987). Olympia non-glacial deposits are overlain by widespread advance outwash sands, called the Quadra Sands, which were deposited as outwash aprons in front of alpine glaciers moving south down the Strait of Georgia in early Fraser times (Booth 1994; Ryder and Clague 1989; Ryder et al. 1991).

This early Fraser alpine advance is called the Coquitlam stade (Booth 1987; Mathewes 1991). Mountain ice-caps in southwest BC expanded and coalesced, and advanced slowly down the Georgia depression (Booth 1987). The maximum extent of Coquitlam ice is dated to about 21,500 years BP but had receded from the western Fraser lowlands by 18,700 years BP when forests became re-established in the area (Blaise et al. 1990; Clague et al. 1980; Ryder and Clague 1989; Ryder et al. 1991).

The climactic advance of the Fraser glaciation was the Vashon stade, during which valley glaciers moved into the Fraser lowland and coalesced, forming a large piedmont glacier (Clague et al. 1987). The maximum accumulation of Vashon ice in the Fraser lowland occurred between about 16,000 and 14,500 years BP, and involved the accumulation of ice to depths of more than 1,800 m (Clague et al. 1988; Mathewes 1991).

The subsequent decay of Vashon glacier ice was also rapid. Deglaciation of the Strait of Georgia was in effect at about 13,500 years BP, and parts of the coastal lowland of southwestern British Columbia were ice-free by about the same time (Ryder and Clague 1989; Ryder et al. 1991). Simple plants had recolonized parts of the study region by about 13,500 years BP; trees re-established in the area about 500 years later (Mann and Hamilton 1995). Deglaciation was close to complete by 11,500 years BP (Ryder et al. 1991).

Late glacial deposits known as the Sumas drift represent a brief late Fraser re-advance called the Sumas stade localized to the Fraser Lowland and nearby valleys. The Sumas maximum occurred at approximately 11,500 years BP, with complete recession of ice from the lowlands by about 11,000 years BP (Booth 1987; Clague et al. 1987; Hicock et al. 1982; Ryder and Clague 1989; Ryder et al. 1991).

Late Wisconsinan sea-levels in the region varied in a complex fashion relating primarily to local variation in isostatic depression and eustatic sea levels (Mann and Hamilton 1995). At about 13,000 years BP, sea-levels were approximately 200 m above present as a result of very significant isostatic depression. Subsequent isostatic rebound caused the rapid emergence of submerged coastal lowlands, and relative sea-levels reached modern levels by about 10,500 years BP. The sea kept falling relative to the land, albeit at a progressively slower rate, until a lowstand at about 12 m below present was reached around 8,000 years BP (Clague et al. 1982). Subsequently, relative sea levels rose at a relatively steady rate to modern levels. Some reconstructions of local relative sea levels indicate that there was a still stand at about 4 m below present at about 6,000 years ago (Williams and Roberts 1989).

A review of the surficial geology was conducted for the study area. The Project on the north side of the Fraser River primarily falls within Vashon Drift and Capilano Sediments, described as "glacial drift: including lodgement and minor flow till, lenses and interbeds of substratified glaciofluvial sand to gravel lenses and interbeds of glaciolacustrine laminated stony silt up to 25 m thick" (Armstrong and Hickok 1976a). The Project on the south side of the Fraser River primarily falls within Capilano Sediments, described as raised marine, deltaic and fluvial deposits. The area is further described as "marine and glaciomarine stony (including till-like deposits to stoneless silt loam to clay loam with minor sand and silt normally less than 3 m thick but up to 30 m thick, containing marine shells" (Armstrong and Hickok 1976b).

4.2 ETHNOGRAPHY

The central Coast Salish groups described in this report are speakers of Downriver Halq'eméylem dialects, with the exception of the Squamish who speak a separate but related Salishan language (Smith 2001; Suttles 1990; Thompson and Kinkaid 1990).

Prior to European contact, the Coast Salish used rectangular cedar plank houses as permanent dwellings with villages consisting of one or more of these houses as well as a number of smaller buildings. Permanent plank or bark-covered houses were constructed at well-established resource procurement locations. Temporary shelters of rush mats were used in areas utilized for shorter periods of time (Barnett 1955; Suttles 1974, 1979, 1990).

A wide variety of objects including woodworking tools, weapons and hunting and fishing gear were manufactured by flaking stone, grinding slate and working bone, antler and shell. Plant materials were extremely important, with red cedar (*Thuja plicata*) being used for houses, canoes, boxes, clothing, bags, baskets and mats. Blankets and clothing were sometimes woven from materials which included the hair of dogs (*Canis familiaris*) and mountain goats (*Oreamnos americanus*) (Schulting 1994; Wells 1966).

Fishing, particularly of salmon (*Oncorhynchus* sp.), was the principal economic activity among the Coast Salish. Both land and sea mammals were taken by a variety of methods. Birds were also taken. Plant foods, particularly blueberry (*Cyanococcus*), cranberry (*Vaccinium oxycoccus*) and braken ferns (*Pteridium aquilinum*), were also gathered for subsistence (Pojar and Mackinnon 1994; Suttles 1990; Turner 1974).

4.3 ARCHAEOLOGY

A great deal of archaeological research has been focused on the Coast Salish and a generally accepted culture history has been formulated. The following generalized sequence is based primarily upon the works of Borden (1970, 1975); Ham (1982); Ham et al. (1984); Matson (1976, 1992) and Mitchell (1971, 1990).

The earliest culture type identified is variously referred to as Old Cordilleran (Matson 1976, 1992), the Lithic culture type (Mitchell 1971), the Pebble tool tradition (Carlson 1990) or the Protowestern tradition (Ham 1982). This little known period, which extends from about 8,500 to 5,500 BP, is characterized by an artifact assemblage consisting of abundant chipped stone artifacts, including cobble tools and leaf-shaped bifaces, along with bone and antler tools (Carlson 1990; Matson 1992).

Faunal remains from the Old Cordilleran component at the Glenrose Cannery site (DgRr-6), located on the South Arm of the Fraser River south of Annacis Island, reflect an economic pattern directed toward the hunting of land mammals with deer (*Odocoileus hemionus*) and wapiti (*Cervus elaphus*) the two most important animals. Seals, salmon (*Oncorhynchus* sp.), sticklebacks (*Gasterosteus aculeatus*), eulachon (*Thaleichthys pacificus*), flatfish and bay mussel (*Mytilus edulis*) were also present (Matson 1976, 1992).

The Charles culture type (5,500-3,300 BP) may be the earliest archaeological phase directly ancestral to the ethnographically documented Northwest Coast pattern. This period saw a continuation of some tool types from the previous culture type and the introduction of new types. New tool types include chipped stone scrapers, drills, stemmed bifaces as well as ground slate, bone and antler implements (Ham et al. 1984).

A well-developed woodworking technology is inferred from the presence of adzes and wedges and the remains of several large residential structures located along the Fraser River at Agassiz and Hatzic and possibly at Fort Langley (James 1990; LeClair 1976; Mason 1994; Schaepe 1998).

Pratt (1992) suggests that Charles culture faunal remains are indicative of a mixed economy where land and sea mammals were exploited. Although salmon were exploited to some extent, specialization had not yet begun (Pratt 1992; Matson 1992). Thus, Pratt (1992) views the Charles culture as essentially a hunting population. Mason (1994) has argued that the presence of several large residential structures at sites located along the Fraser River suggests that specialized salmon exploitation had occurred by this period. It is doubtful that a hunting population would have required, or invested the necessary time and energy into the large structures found at the Hatzic Rock (DgRn-23) and Maurer (DhRk-8) sites (Mason 1994; LeClair 1976).

Eldridge (1991) argues for intensive salmon harvesting, processing and storage at the mouth of the Fraser River by 4,600 BP based on the presence of intertidal stakes at the Glenrose Cannery site, thought to represent the remains of fish weirs. Eldridge further suggests that the Northwest Coast pattern was likely well established during the Charles culture, and elements such as massive architecture, wealth accumulation, hereditary status and social ranking were in place at this time. Cannon (1993) has argued for the presence of salmon specialization and storage technology at Namu on the central coast prior to 6,000 BP suggesting that similar data are waiting to be uncovered along the Fraser River.

Ham et al. (1984) suggest a broader economic base may have led to a stratification in social status as evidenced by burial practices, use of labrets and possibly cranial deformation. In contrast, Pratt (1992) suggests the existence of an egalitarian society despite the possible presence of status differentiation reflected in burial remains at Tsawwassen and possibly Pender Canal.

The Locarno Beach phase or culture type (ca. 3,500/3,300-2,500 BP) is typified by a varied resource base showing a greater reliance on shellfish, birds and sea mammals, although land mammals and fish still are of prime importance. Tool types show continuity from earlier periods but reflect changing styles and different relative frequencies. Evidence of cordage, basketry and other wood items have been recovered from water saturated sites in the Lower Mainland (Archer and Bernick 1990; Bernick 1991; Borden 1976; Patenaude 1985).

The only evidence of housing dating to the Locarno period is two small pithouse structures from Crescent Beach (Matson et al. 1991; Matson 1992) and Sequim in Washington state (Morgan 1998, 1999) and possible postmold features from Shoemaker Bay on Vancouver Island (McMillan and St. Claire 1982) and Long Harbour on Saltspring Island (Johnstone 1991). Evidence of large residential structures is lacking, but these dwellings likely existed based on the nature of tools found in artifact assemblages and the evidence of large Charles culture dwellings. The distribution of sites shows a strong orientation to offshore rather than riverine resources.

The Marpole culture type (Burley 1980; Clark 2000; Mitchell 1971) spans the period between 2,000 and 1,500/1,100 B.P. Marpole artifact assemblages mark a shift away from chipped stone to ground and pecked stone. There is also a noticeable rise in nonlithic, bone and antler industries and increasing reliance on composite tools. Important artifact types are handmauls, unilaterally barbed non-toggling harpoons, pecked stone zoomorphic bowls and thin ground slate knives. During Marpole, a rich artistic tradition develops which is expressed in stone and antler sculpture, slate and shell disc beads and decorated items of native copper.

Marpole settlement is relatively well known. Large house platforms have been discovered at Garrison (Kornbacher 1989), Beach Grove (Matson et al. 1980), False Narrows (Burley 1989), Whalen Farm (Matson and Coupland 1995), Dionisio Point (Mitchell 1971), and possibly Tualdad Altu (Chatters 1989). Site distribution generally shifts to riverine locations, many of which are located on the Fraser River.

Conversely, elevated inland shell midden sites have been identified on the Gulf Islands and on the mainland that contain artifacts commonly associated with Marpole assemblages. This move to inland locations could be attributed to increased warfare and raiding, or other population pressures that influenced small groups to move inland to less desirable locations (Wilson 1988b). Archaeological studies at inland shell midden sites have been conducted at DeRu-44 on Saltspring Island (Wilson 1988b) and on Gabriola Island at DgRw-200 and DgRw-196 (Wilson 1987). Wilson offers another explanation for inland shell middens during the Marpole phase; the zoomorphic bowl found at DiRw-16, clearly dating to the Marpole phase, is identified as part of a shaman's retreat–offering yet another explanation for elevated inland shell midden sites (Wilson 2000b).

Past studies (Burley 1980; Clark 2000; Matson et al. 1980) have shown significant geographic and temporal variation within the Marpole culture type. Two subphases of Marpole have been proposed to explain this diversity. These subphases have been interpreted as a result of unequal access to the Fraser River fishery (Clark 2000).

Ascribed status differentiation is clearly present with the rise of cranial deformation around 2,000 B.P. (Burley and Knüsel 1989). Rich burial inclusions are also present during Marpole times (Burley and Knüsel 1989; Matson 1976).

The Developed Coast Salish tradition (Borden 1962; Ham 1982) (1,400 BP to European contact) is directly ancestral to present Coast Salish culture and contains a single culture type, though several regional variants have been proposed. These include Late (Fladmark 1982; Matson 1992), San Juan (Carlson 1960), Strait of Georgia (Mitchell 1971, 1990), Gulf of Georgia (Ham 1982) and Stselax (Borden 1954). This culture type is characterized by a marked decrease in chipped stone and a concomitant increase in ground stone and bone artifacts. Large village sites with longhouse platforms oriented towards riverine resources continue from Marpole. The economy continues to be directed towards intensive salmon processing and storage.

4.4 HISTORY

The earliest written history of European arrivals to the study area begins with the Spanish and British explorers who arrived by ship on the west coast of British Columbia in the late 18th century. Explorers also investigated the interior of the province, coming over the Rocky Mountains. Fur trade posts were established by explorers in the early 19th century along rivers in British Columbia, including Fort Langley on the Fraser River in 1827. The gold rush in the 1850s in the Fraser canyon saw the influx of miners seeking their fortunes.

Initial settlements in the lower mainland area were at New Westminster and Burrard Inlet in the 1860s. The region saw increased clearing of land and settlement through the 19th century, including the establishment of farms.

Settlements in Burrard Inlet were made near the new sawmills beginning in the 1860s. Captain Edward Stamp built a sawmill c. 1965 on the south side of Burrard Inlet but it closed down in 1867, reopening as the Hastings Mill in 1870 after it was sold to new owners (Hayes 2012: 92). A settlement expanded surrounding the mill, and John "Gassy Jack" Deighton built the Globe Saloon in 1867 in today's Gastown neighborhood (ibid.). Another settlement also called Hastings was established in 1869 to the east of Gastown. Two hotels were built there as resorts for residents of nearby New Westminster, to escape the buggy Fraser River in the summertime.

During construction of the Canadian Pacific Railway, it was decided to end the line in Burrard Inlet near the Granville town site, which arrived in 1887 (Hayes 2012: 132). The population of Burrard Inlet was ~900 inhabitants at that time (Hayes 2012:138). A street car system was established by the Vancouver Electric Railway and Light Company by 1890 running through Vancouver (Hayes 2012:140). The street cars ran until 1955, when they were replaced by buses.

Municipalities were established to the east of Vancouver and New Westminster, including Coquitlam in 1891 (Hayes 2012:142) and Burnaby in 1892 (Davis 2011:31). By this time, canneries were at their height along the Fraser River. Vancouver's population grew substantially in the early 20th century, from 26,000 in 1901 to 100,000 in 1911 (Hayes 2012: 236). Port Coquitlam was established in 1913. There was a real estate boom at this time and residential development occurred quickly throughout the lower mainland, with the clearing of forests. Roads were built during this time and mostly paved after World War II. Simon Fraser University began construction of its Burnaby campus in 1963, following earlier timber harvesting activities on the mountain. The lower mainland saw continued residential development and expansion of municipalities during the 20th century.

The municipality of Surrey was incorporated in 1879. Logging and agriculture took place in Surrey after this time. Various town centers were established prior to 1900, including Elgin-Mud Bay, Halls Prairie/Hazelmere, Bothwell/Tynehead, Brownsville, Surrey Centre, Port Kells, Kensington Prairie, East Kensington, Johnston Settlement/Sullivan, and Bon Accord/Port Mann (Brown 2014). The construction of the Pattullo Bridge in 1937 allowed Surrey to grow. From the mid-20th century, residential development of single family homes was widespread, leading to the densely populated neighborhoods of today.

The proposed project segments are to be installed or replaced within the existing SRW and along roadways. The entire project area has been highly to moderately disturbed by road, railway, industrial and residential construction.

4.5 SITE TYPES

Site types commonly recorded in the project area include shell midden, lithic scatters, subsistence features, burials, trails and historic sites. Sites may also be made up of one or several of these components. In the immediate vicinity of the Project, archaeological sites would most likely be limited to lithic scatters or isolated finds. Brief descriptions of these site types are provided.

4.5.1 Shell Midden

Shell midden is typified by the presence of shellfish (clam, mussel, scallop, etc.) shells discarded after the consumption of shellfish. Shell midden also commonly contains charcoal, ash and burnt sediments, fire-broken rock, and stone, bone, antler, and shell artifacts. Shell midden deposits vary from small pockets to very large sites many hundreds of metres long. They are usually but not only found along or near marine and riverine shorelines. Shell midden sites often represent villages or seasonal encampments where shellfish were consumed in quantity. Shell midden deposits are unique inasmuch as the shells neutralize soil acidity, such that archaeological materials that usually degrade quickly are preserved. Artifacts of bone and antler, faunal remains, and human bone all preserve in shell midden.

4.5.2 Lithic Scatters and Isolated Lithic Finds

Lithic scatter sites consist of surface and/or subsurface scatters of stone tools and/or flakes, the result of lithic raw material processing and tool production and/or tool maintenance. Isolated lithic artifact finds consisting of single artifacts are included in this category. These sites lack structural remains and often reflect little diversity in their artifact assemblages, the result of less intensive and more specialized activities than are reflected at village sites. Lithic scatters are frequently identified in surface exposures, although archaeological subsurface testing is required to establish their boundaries and depths. They can reflect activities such as procurement and/or processing of food or raw materials. They can also reflect seasonal or short-term campsites, lookouts or various other activities.

4.5.3 Subsistence Features

Subsistence features are related to the collection, processing or storage of food, and are often found in the vicinity of water sources and are often a component of larger, multi-function sites. Subsistence features may also be associated with temporary hunting or fishing camps away from principal habitation sites. Subsistence features can include roasting areas and shellfish processing areas among a wide variety of other functions.

4.5.4 Human Burials

This category includes sites which contain material remains and features associated with prehistoric mortuary practices. Interments in the historic period can also be reported in association with recorded archaeological sites. Information about historic cemeteries or individual or family interments can often be acquired through documentary research and consultation with local residents. Prehistoric burials are difficult to identify because of their generally unmarked nature, although cairns and other visible related structures can be associated with burials.

4.5.5 Trails

Trails are transportation corridors frequently following well-traveled game trails around and to lakes, rivers, creeks and other geographical features. Because of their typically ambiguous nature, trails are rarely identified as archaeological sites, but instead are noted as historic and/or traditional land use features. It is assumed that historic and traditional use trails were present in the project area although disturbances due to industrial development would have obscured most, if not all, physical evidence of trail locations.

4.5.6 Historic Sites

Historic sites relate to human activities during the time period documented by written records. Historic sites in the project area relate primarily to resource extraction such as logging and agriculture, but also include ranching and small scale hunting and fishing.

Sites can range from large complex sites which represent a wide range of activities to task specific sites which evidence little diversity in activity. Thus, the scientific, historic, and ethnic significance of this site type varies greatly and should be assessed on an individual basis. Such research should take into account archaeological remains, standing structures, documentary evidence, historic significance (links to important events, individuals and developments in local, regional and national history), ethnic and economic significance.

Current British Columbia legislation requires archaeological evaluation of all sites older than AD 1846 and allows added flexibility with more recent resources. However, post-1846 sites may also require archaeological work and may be protected by legislation depending on the nature and significance of the site.

5.0 Results

5.1 PREVIOUS ARCHAEOLOGICAL STUDIES

A large number and variety of archaeological studies have been conducted in the Fraser Lowland. A summary and review of these studies can be found in Kristensen et al. (2009).

Closer to the Project, major archaeological investigations have been conducted at the St. Mungo Cannery Site (DgRr-2) and the Glenrose Cannery Site (DgRr-6) located ~7 km and 6.5 km southwest of the southeastern extent of the Project respectively.

The St. Mungo Cannery Site, once a large salmon fishing village (Ham et al. 1984), is a highly significant site beginning ~50 m southwest of the Alex Fraser Bridge and extending northeast along the Fraser River for ~600 m. The site's width is recorded as 190 m although its southern extent has never been clearly defined (Owens and Vincent 1999). The depths of cultural deposits vary considerably but excavations completed in 1981 in response to the proposed Alex

Fraser Bridge crossing encountered deposits up to 3 m deep (Archer and Mackie 1981). A wet site component is also present at the site in the intertidal zone of the Fraser River.

Since 1969, a number of archaeological studies have taken place at DgRr-2. Many of the excavations have been conducted in response to the Alex Fraser Bridge component of the Annacis Island Highway Crossing (Apland 1981; Archer and Mackie 1981; Eldridge 1983, 1984; Ham et al. 1984). Calvert's (1969) study marks the first formal excavation at the site, consisting of four data recovery units excavated to a depth of ~2 m, from which basal dates of 4,310 and 4,240 BP were established. Approximately 1,700 artifacts were recovered during this project. Archer and Mackie (1981) excavated eleven 1 x 1 m units (eight to sterile deposits) and Eldridge (1984) excavated an additional eight 1 x 1 m units.

To date, the largest archaeological study at DgRr-2 has been conducted by Ham et al. (1984). Excavation included 190 m of backhoe testing followed by hand-excavation of five small block areas measuring between 1 x 2 m and 2 x 5 m, resulting in the controlled excavation of 36.63 m^3 of cultural deposits. A total of 1,115 artifacts were recovered. Radiocarbon dates of 3,370 to 4,480 years BP were obtained, firmly linking site occupation and use to the Charles Period (4,500–3,500/3,300 BP). This Period includes a St. Mungo Phase which is represented at both DgRr-2 and DgRr-6. Human remains are also known from DgRr-2, specifically from Marpole components (Calvert 1969) as well as other levels. Ham et al. (1984) recovered scattered human remains from three units in the western portion of his excavation area. On River Road, Oliver (1995) recovered several isolated bone fragments from disturbed contexts following house demolition and removal.

Cultural periods identified at DgRr-2 include Charles; as noted above, Marpole (2,500–1,500/1,100 BP); as described by Calvert (1969) and Eldridge (1984), and Gulf of Georgia or Developed Coast Salish (1,500/1,100–200 BP); as also noted by Calvert (1969). A fourth, older component, the Old Cordilleran or Lithic culture period (8,500–5,000/4,500 BP), has also been suggested by Mackie (1982). The oldest radiocarbon date for the site is 4,490 years BP, established from the wet site component (Eldridge and Fisher 1997).

To date approximately 120 m^3 of DgRr-2 deposits have been subject to controlled excavation (Mason et al. 2006), including intact deposits (Archer and Mackie 1981, Calvert 1969, Eldridge 1984). Intact deposits have also been noted by Howe (1980) and Ball and Bereziuk (1998) on River Road, and by Apland (1981) and Ham et al. (1984) in the Alex Fraser Bridge right-of-way.

The Glenrose Cannery site, one of the oldest and most significant archaeological sites recorded in the Pacific Northwest, contains deposits over 4 m thick which, from its lowest levels, date to 8,150 years BP. The site begins ~30 m northeast of the northeast end of DgRr-2 and extends northeast along the Fraser River for ~350 m. A wet site component is also present at this site dating to 4,500 years BP, just slightly older than that at DgRr-2, making it the oldest known wet site component on the Northwest Coast (Eldridge 1991).

DgRr-6 has been subjected to substantive disturbance from most of the same destructive agencies as the St. Mungo Cannery site. In 1979, it was suggested by Yip and Gose (1979) that fully a third (~7,500 m^2) of the site area had been lost as a result of development operations of the Glenrose Cannery from its initial construction, general residential and commercial development, riverbank erosion, and "pot-hunting". Pot hunting has been noted as early as 1972 and is responsible for the destruction of "over 650 cubic feet of cultural deposits" (Loy 1972). Twenty years later, the site was described as still "heavily pot-hunted every weekend" (Eldridge and Mackie 1993).

Excavations at DgRr-6 were first undertaken in 1969 (Percy 1972). Four 2 x 2 m units were excavated during this study to depths of ~2.5 m in response to proposed cannery expansion, resulting in the recovery of almost 200 artifacts from the units and another ~300 artifacts from the beach. The largest study carried out at DgRr-6 was completed by UBC between 1971 and 1973 during which 12 units were excavated to 4 m or more below surface, but only seven to completion (Limer et al. 1972; Loy 1972; Matson 1973, 1976; Pearson 1974). Two backhoe trenches were also excavated by UBC at this time to up to a depth of ~2.2 m (Mason et al. 2006). Mason et al. (2006) note that almost 1,500 artifacts were recovered from six units during the UBC study.

Human remains have been recovered from DgRr-6 in a variety of contexts, with the majority found during the UBC excavations (Loy 1972) from Marpole and Charles Phase components (Styles 1976). Scattered or disturbed human remains are also noted by Limer et al. (1972), Percy (1972) and Eldridge (1991).

To date ~89 m^3 of DgRr-6 deposits have been subject to controlled excavation (Mason et al. 2006), including intact deposits (Garvin et al. 1993; Loy 1972; Percy 1972).

Other work conducted in the vicinity of the Project have occurred near the Fraser River and were driven by AIAs associated with construction of the South Fraser Perimeter Road (DhRq-76, DhRq-196, -197, -198 and DhRr-257 detailed site forms [final report copyright not available]), a Fraser River intertidal study (Eldridge and Mackie 1993), a Fraser Valley planning study (Yip and Gose 1979), a Fraser River flood protection study for Terasen Gas (DhRr-2 and DhRr-74 detailed site forms) and a highway expansion project (Rousseau et al. 2007). Sites recorded as a result of these studies include fish weirs (DhRq-37 and DhRq-38), subsurface lithics (DhRq-52, DhRr-197 and DhRr-257), surface lithics (DhRr-196 and DhRr-198) and a Kwantlen fishing village site comprised of subsurface lithics, rock art and faunal remains (DhRr-2 and DhRr-74).

Some sites north of the Fraser River have been recorded in association with existing green spaces or in the vicinity of bodies of water. Sites DhRq-11 and DhRq-86 are located east of the Project along the Coquitlam River. DhRq-11 is a pre-contact habitation site (the Coquitlam Indian Reserve #1) recorded in 1953 during a survey of the Lower Fraser Valley (DhRq-11 site inventory form), revisited as part of the Fraser River intertidal survey (Eldridge and Mackie 1993) and again visited in 1996 as part of an AOA for Riverview Hospital Lands (Simonsen 1996). DhRq-

86 is a pre-contact surface lithic and fire broken rock site recorded in 2012 (DhRq-86 site inventory form). Further west, along the Brunette River, DhRr-30 (a pre-contact petroglyph), DhRr-232 (a pre-contact subsurface lithic site), and DhRr-255 (possible mound/cairn site) have been recorded as a result of an AIA for the Upper Brunette habitat enhancement area and the Port Mann Highway (DhRr-30, DhRr-232 and DhRr-255 site inventory forms). An undefined cultural depression (DhRr-112) was recorded in the wooded area immediately north of Burnaby Lake during a survey for the Burnaby Lake rejuvenation project (Brolly 2001). Surface lithics (DhRr-38 and DhRr-39) were recorded on the north side of Deer Lake, southwest of Burnaby Lake, as a result of a 1987 heritage study of Deer Lake Park (Wilson 1987).

Other sites have been recorded in largely developed areas and include a pre-contact roasting pit (DhRq-43) identified in a residential area during waterline excavation (DhRq-43 site inventory form) and surface lithics (DhRs-288) located in a residential garden (DhRs-288 site inventory form).

5.2 RECORDED ARCHAEOLOGICAL SITES

There are no recorded archaeological sites within 50 m of the Project but six sites are located within 500 m including three near or within the historic Port Mann town vicinity (DhRq-37, DhRq-38 and DhRq-76) and three on the adjacent north bank of the Fraser River (DhRq-70, DhRq-80 and DhRq-81). Additionally, DgRr-60 is located ~550 m east of the southeastern extent of the Project. A brief description of the nearby archaeological sites is as follows:

- **DhRq-37** is a pre-contact fishing weir site located in a peat deposit on the south bank of the Fraser River, ~265 m east of the Project. It was recorded in 1993 during a survey for Fraser River intertidal wet sites (Eldridge and Mackie 1993).
- **DhRq-38** is a pre-contact surface lithic and fishing weir site located in the intertidal zone on the south bank of the Fraser River, ~125 m west of the Project. It was first recorded during the 1993 survey for Fraser River wet sites (Eldridge and Mackie 1993) and revisited during an AIA of the Fraser East Dyke improvement works project (DhRq-38 site form; report not yet available).
- **DhRq-70** is a post-contact marine shipwreck consisting of the remains of a wooden steam-powered sternwheeler located on the north bank of the Fraser River just west of the entrance to Maquebeak Park in Coquitlam and ~55 m east of the Project. It was recorded in 2005 (DhRq-70 site form).
- **DhRq-76** is a pre-contact subsurface deposit of charcoal and fire broken rock dating to the Marpole period. It is located on the south bank of the Fraser River, ~104 m east of the Project. The site was first recorded in 2007 as part of a South Fraser Perimeter Road study (DhRq-76 site form; final report copyright not available).
- **DhRq-80** and **-81** are pre-contact surface lithic sites respectively located ~160 m and 336 m east of the Project, on the north bank of the Fraser River. They were recorded in 2009 as part of an AIA for the Port Mann Highway (DhRq-80 site form; final report copyright not available).

- **DgRr-60**, a surface lithic site, is located ~550 m east of the southeastern extent of the Project (McLaren 2005). DgRr-60 was first recorded in 2005 consisting of an isolated cobble chopper located, but not recovered, in a disturbed context. It is thought to have been piled with other rocks cleared from nearby nursing facility fields.

5.3 TRADITIONAL USE

A number of traditional use sites have been documented in the Fraser Lowland. Most represent geographical features, habitation sites, resource procurement sites or places of mythological significance. The most frequently documented traditional use sites in the vicinity of the Project are settlements or transformation sites.

Tobias (2000:3) defines traditional use as follows:

> Use refers to activities involving the harvest of traditional resources; things like hunting, trapping, fishing, gathering of medicinal plants and berry picking, and travelling to engage in these activities. For any given community or nation, use occurs over a specific geographic area…Use mapping documents the locations where activities like hunting, fishing and travelling occur.

These types of sites can also be defined as ethnographic heritage sites; though this term is more commonly associated with sites identified with specific place names or documented ethnohistoric sources.

There are a number of recorded place names in the vicinity of the Project. Table 1 outlines their names, significance and location (information summarized from McHalsie 2001).

Table 1 Stó:lō Place Name, Significance and Location in the Project Area

Place Name	Significance	Location
Kwikwetle'em • "stinking of something"; "smelly fish slime"	Fishing site	Near the confluence of Coquitlam and Fraser Rivers.
Tl'ékwela • "deaf"	A transformation site where a deaf warrior was transformed to stone by *Xá:ls*	Near the confluence of Coquitlam and Fraser Rivers.
Miss-kew-um	Settlement site	Near the confluence of Coquitlam and Fraser Rivers.
Th'qwa:ya:la • "any fish container"	Settlement site	Near confluence of Coquitlam and Fraser Rivers, ~ 1 km ups the Coquitlam River.
Spi:petolh • "baby vision seer"	Transformation site at location of whirlpool in Coquitlam River	Near confluence of Coquitlam and Fraser Rivers, ~2 km up the Coquitlam River.

Table 1 Stó:lō Place Name, Significance and Location in the Project Area

Place Name	Significance	Location
Setlámqemel • "when the tide is high, we can go"	Settlement site	Near confluence of Coquitlam and Fraser Rivers, ~3 km up the Coquitlam River.
C'uxul'emu'	Unknown	On the north bank of the Fraser River near the southwestern extent of the Project.

A database query performed by the Stó:lō Research and Resource Management Centre (SRRMC) did not identify any further place names than those identified in the table above. Their results revealed one cultural landscape feature, five historic sites, four documented travel routes and three GIS-modeled travel routes in the project area (Stó:lō Research and Resource Management Centre 2013; Appendix A[1]). Many of these are in proximity to the project area.

- The Fraser River is known to the Stó:lō people as Stó:lō and is an important cultural landscape feature central to Stó:lō identity.
- A single heritage site is located within 100 m of the Project—the historic Cristiano House.
- Documented travel routes intersect the Metro IP Pipeline project area, overlap the Fraser Gate IP Replacement project area, and abut the south end of the Nichol to Port Mann TP Pipeline Loop project area.
- GIS-modeled travel routes intersect the Metro IP Pipeline project area and the south end of the Nichol to Port Mann TP Pipeline Loop project area.

The SRRMC assessed the Project as having high cultural significance because of its location on the Fraser Valley floodplain and its proximity to previously recorded archaeological sites (Stó:lō Research and Resource Management Centre 2013; Appendix A).

5.4 PRELIMINARY FIELD RECONNAISSANCE

A PFR of the entire Project was conducted on April 15 and 16, 2014. Stantec archaeologist Nicholas Chesworth and Musqueam First Nation representative Wayne Point conducted a pedestrian survey of the Cape Horn to Coquitlam TP Pipeline Loop and a pedestrian and vehicle survey of the Metro IP Pipeline Replacement project areas on April 15 with Stantec archaeologist Simon Kaltenrieder joining in the survey of the Metro IP Pipeline Replacement alignment. Nicholas Chesworth alone conducted pedestrian surveys of the Nichol to Port Mann TP Pipeline Loop and Fraser Gate Station study areas on April 16. The details of the PFR results for each study area are listed below:

[1] the Stó:lō Research and Resource Management Centre database query attached as Appendix A does not accurately depict the FortisBC Metro Vancouver reinforcements Project areas – see Figures 1-4

5.4.1 Fraser Gate IP Replacement

A PFR was conducted on the entire ~700 m section of the Fraser Gate IP Replacement alignment beginning at KP 0 located at the FortisBC facility on East Kent Street south to KP 0.64 located along Elliot Street north of the intersection of Elliot Street and East Kent Avenue N. (Figure 2). No areas of archaeological potential were identified as the area has been very significantly previously disturbed, and is comprised of leveled, terraformed terrain. The terrain is heavily impacted due to construction activities related to residential developments, railroad construction and the design of Riverfront Park where sections of the study area have been built up with fill to a depth greater that the impact of the proposed development (Photos 1 and 2). Vegetation within the study area consists primarily of planted trees and grasses.

Photo 1 View of the deep fill deposits within the study area at Riverfront Park

Photo 2 View of residential and railroad developments located within the study area.

5.4.2 Metro IP Pipeline Replacement

A PFR was conducted on the entire ~19.7 km section of the Metro IP Pipeline Replacement alignment beginning at KP 0 located at the intersection of Mariner Way and Como Lake Road to KP 19.70 located to the west, at the intersection of Woodland Drive and East 2nd Avenue (Figures 2 and 3). The study area crosses Coquitlam, Burnaby and Vancouver. The significant majority of the Metro IP Pipeline Replacement alignment is proposed for construction within built roads. Significant portions of the PFR were conducted by vehicle; the crew parked often to inspect portions of the alignment on foot.

Between KPs 0 and 6.15 and KPs 8.2 and 19.7 the terrain is level to moderately sloped and heavily disturbed by the previous road construction and nearby urban infrastructure and commercial, residential and industrial developments. These areas have been so significantly impacted by previous construction and development that they are evaluated as lacking significant archaeological site potential.

Between KPs 6.15 and 7.0 and 7.3 and 8.25, the pipeline alignment is proposed for construction outside built roads, in areas exhibiting less evidence of previous disturbances. The vegetation in the right-of-way in these areas consists of cedar and Douglas-fir and an understory of blackberry, salmonberry, and salal. These areas have been logged once or more.

Four areas adjacent to extant streams were evaluated as having high potential to contain archaeological sites (Figure 5). All area located in Burnaby at the base of Burnaby Mountain. They include:

- The relatively level north and south banks of an unnamed creek at KP 6.9, ~80 m north of the intersection of Galardi Way and Broadway
- The level, well-defined ~50 m wide terraces on the east and west banks of an unnamed south-trending creek at KP ~7.41
- The 30-40 m wide level areas on the east and west banks of an unnamed south-trending creek at KP ~7.73
- The 30-40 m wide level areas on the east and west banks of an unnamed south-trending creek just east of KP 8.0

5.4.3 Cape Horn to Coquitlam TP Pipeline Loop

A PFR was conducted on significant portions of the ~4.6 km Cape Horn to Coquitlam TP Pipeline Loop alignment in Coquitlam, which extends north from KP 0, located at 2340 Rogers Avenue, to KP 4.475, located east of Mundy Park and ~1.2 km southeast of the intersection of Mariner Way and Como Lake Avenue (Figure 3).

A pedestrian survey was completed along the northern portion of the alignment from KP 4.475 to KP ~2.2. It follows and existing utilities corridor that has been previous-disturbed by the construction and installation of electrical and natural gas infrastructure. This corridor passes along the eastern margin of Mundy Park, and then passes through commercial, residential, and industrial areas. There is a berm in the middle of the entire, level to moderately sloping corridor, indicating that it has being leveled in the recent past (Photo 3).

Pedestrian access was limited in the portions of the alignment south of KP ~2.2, due to the presence of highways and highway interchanges, and privately-held industrial and commercial developments. Those areas that could be accessed were, and good vantages were available of some inaccessible areas.

Three archaeological sites (DhRq-70, DhRq-80 and DhRq-81) have been recorded along the north bank of the Fraser River, south of the project area at KP 0 (Figure 3). Typically, areas close to the Fraser River and/or recorded archaeological sites are assessed as having high archaeological potential but in this instance, the PFR confirmed that this portion of the alignment is located on highly-disturbed lands of low archaeological potential. Between KPs 0 and 2.9 the alignment is located in commercial and industrial spaces, crossing major roads and industrial areas exhibiting moderate ground disturbance due to past construction activities. Between KPs 0 and 1.2 the study area is situated in a paved and levelled industrial area. The study area is inaccessible between KPs 1.2 to 1.5 due to its location in low-lying, swampy terrain which is likely the product of recent diversions of water from Lougheed Highway located ~100 m to the south.

Photo 3 View of the right-of-way corridor along which the study is located. Note the typical vegetation and the large berm (right) which is located along the middle of the entire corridor

A single area of high archaeological potential was identified within the Cape Horn to Coquitlam TP Pipeline Loop alignment. It is comprised of the portion of the alignment located east of Lost Lake in Mundy Park, extending north along level terrain from Lost Lake's unnamed outflow stream at KP ~3.6 to KP ~4.0 (Figure 6).

5.4.4 Nichol to Port Mann TP Pipeline Loop

A pedestrian survey was conducted on the majority of the ~5.4 km Nichol to Port Mann TP Pipeline Loop in Surrey, which extends from KP 0 near the intersection of 93A Avenue and 138A Street north to KP 4.97 at the South Fraser Perimeter Road just north of King Road (Figure 4). Three archaeological sites (DhRq-37, DhRq-38 and DhRq-76) have been recorded along the south north bank of the Fraser River, immediately north of the project area (Figure 4). Pedestrian survey could not be completed between KPs ~3 and ~4, as this portion is situated in a number of fenced private properties. A visual inspection from the public roads did not identify landforms or features of archaeological potential.

The entire alignment is heavily impacted by commercial, residential and industrial developments and is situated within the existing rights-of-way of existing high pressure gas and power lines.

Generally, areas in proximity to the Fraser River and/or recorded archaeological sites are assessed as having high archaeological potential. However, the PFR indicated that the Nichol to Port Mann TP Pipeline Loop project area extends through lands so significantly disturbed as to be deemed as having low archaeological potential. The significant majority of the alignment has

been heavily impacted by commercial, residential and industrial developments (Photos 4 and 5), and is located on undifferentiated terrain; no landforms typically associated with archaeological site potential were identified.

However, several locations along the alignment were identified as having high archaeological potential (Figures 7-9):

- The relatively level, ~50 m wide south bank of Lay Creek at KP ~0.1, ~120 m south of the intersection of 94A Avenue and 138 Street, at the very southern end of the project area (Figure 7).
- The relatively level north and south banks of Lay Creek, ~50 m in width, situated at KP ~0.8, ~80 m south of 97 Ave (Fraser Highway) (Figure 7).
- The level, ~30 m wide north and south banks of an unnamed stream at KP ~2.6, east of Hawthorne Park and ~35 m south of 106 Avenue near 141 Street (Figure 8)
- The heavily impacted section of Fraser River terrace at King Road between KP ~4.7 and the north end of the pipeline loop at KP 4.97 (Photo 4; Figure 9).

Photo 4 View facing north toward the Fraser River form the north end of the Nichol to Port Mann TP Pipeline Loop alignment

Photo 5 View of the typical terrain and vegetation located within the right-of-way

5.5 EVALUATION OF ARCHAEOLOGICAL POTENTIAL

Areas along the project route that have been previously disturbed by development activities and are at a distance from the Fraser River or other hydrological or resource features are assessed as having low archaeological potential. This comprises the majority of the Project.

Nine areas close to the Fraser River, to streams and lakes, or to recorded archaeological sites are assessed as having high archaeological potential and an AIA is recommended for these areas prior to development (Figures 5-8). These areas are:

- Metro IP Pipeline Replacement in Coquitlam, Burnaby and Vancouver:
  - the four unnamed creek crossings at the south base of Burnaby Mountain at KPs 6.9, 7.4, 7.7, and 8.0
- Cape Horn to Coquitlam TP Pipeline Loop alignment in Coquitlam:
  - The ~400 m long portion of the alignment located east of Lost Lake in Mundy Park between KPs ~3.6 and ~4.0
- Nichol to Port Mann TP Pipeline Loop in north Surrey:
  - The three unnamed creek crossings at KPs 0.1, 0.8 and 2.6
  - The Fraser River terrace at King Road between KP 4.7 and the north end of the pipeline loop at KP 4.97

No areas of high archaeological potential were identified within the Fraser Gate Station IP Pipeline replacement in Vancouver.

Legend

- ⊕ Kilometre Post
- Project Area
- High Archaeological Potential

0 150 300 450 Meters

1:10,000

Archaeological Overview Assessment
Lower Mainland Natural Gas System Upgrades

Metro Vancouver Reinforcements
Metro IP Pipeline Replacement Project Area - High Archaeological Potential Locations

Sources: FortisBC, BC Government

Although there is no reason to believe that there are any errors associated with the data used to generate this product or in the product itself, users of these data are advised that errors in the data may be present.

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PREPARED BY: Stantec

PREPARED FOR: FORTIS BC

FIGURE NO: 5

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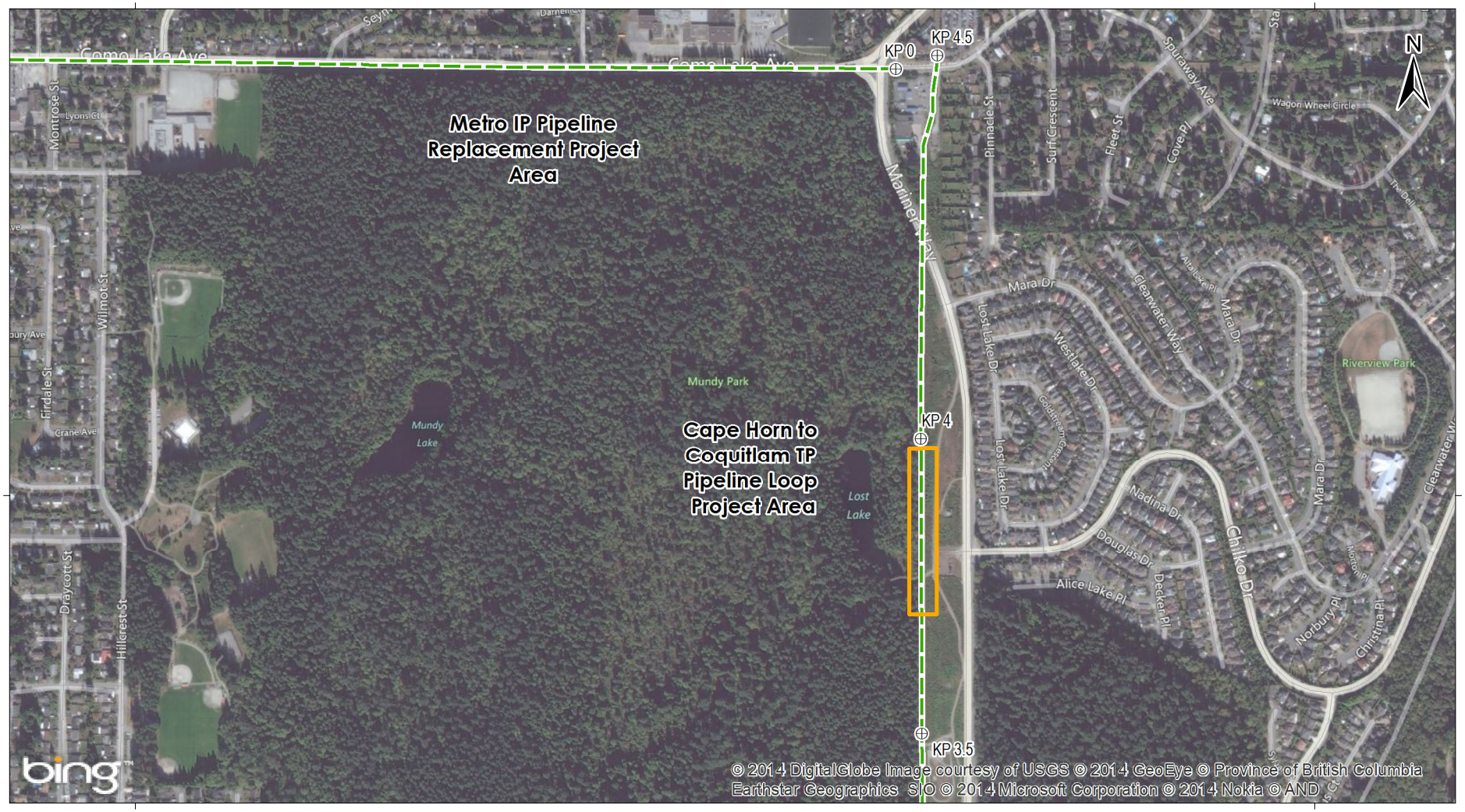

Legend

- ⊕ Kilometre Post
- Project Area
- High Archaeological Potential

0 150 300 450 Meters

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Archaeological Overview Assessment
Lower Mainland Natural Gas System Upgrades

Metro Vancouver Reinforcements
Metro Cape Horn to Coquitlam Loop Project Area - High Archaeological Potential Locations

Sources: FortisBC, BC Government

Although there is no reason to believe that there are any errors associated with the data used to generate this product or in the product itself, users of these data are advised that errors in the data may be present.

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PREPARED BY: Stantec

PREPARED FOR: FORTIS BC

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- ⊕ Kilometre Post
- Project Area
- High Archaeological Potential

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Archaeological Overview Assessment
Lower Mainland Natural Gas System Upgrades

Metro Vancouver Reinforcements
Nichol to Port Mann TP Pipeline Loop Project Area -
High Archaeological Potential Locations

Sources: FortisBC, BC Government

Although there is no reason to believe that there are any errors associated with the data used to generate this product or in the product itself, users of these data are advised that errors in the data may be present.

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PREPARED BY: Stantec

PREPARED FOR: FORTIS BC

FIGURE NO: 7

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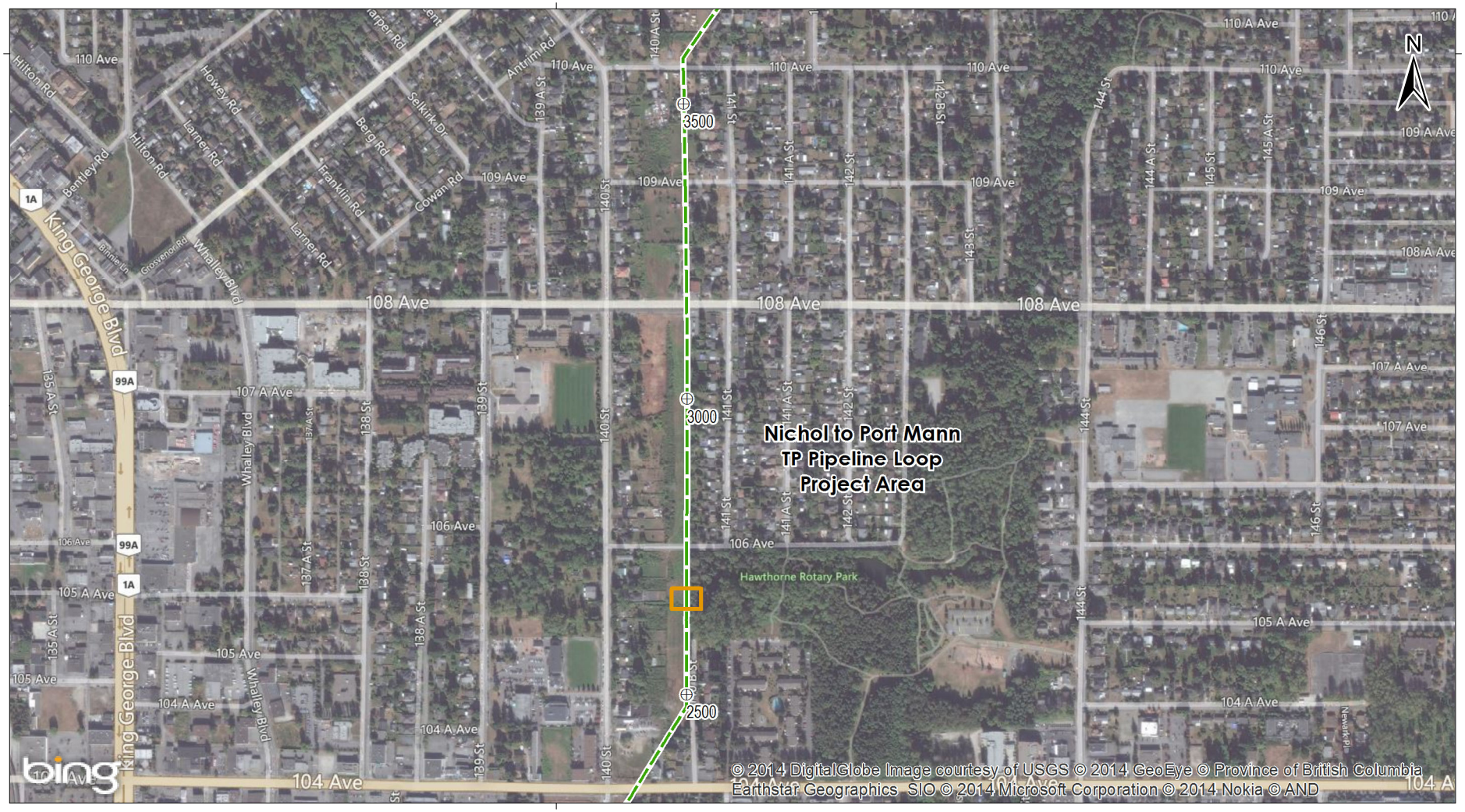

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- ⊕ Kilometre Post
- Project Area
- High Archaeological Potential

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Archaeological Overview Assessment
Lower Mainland Natural Gas System Upgrades

Metro Vancouver Reinforcements
Nichol to Port Mann TP Pipeline Loop Project Area -
High Archaeological Potential Locations

Sources: FortisBC, BC Government

Although there is no reason to believe that there are any errors associated with the data used to generate this product or in the product itself, users of these data are advised that errors in the data may be present.

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PREPARED BY: Stantec

PREPARED FOR: FORTIS BC

FIGURE NO: **8**

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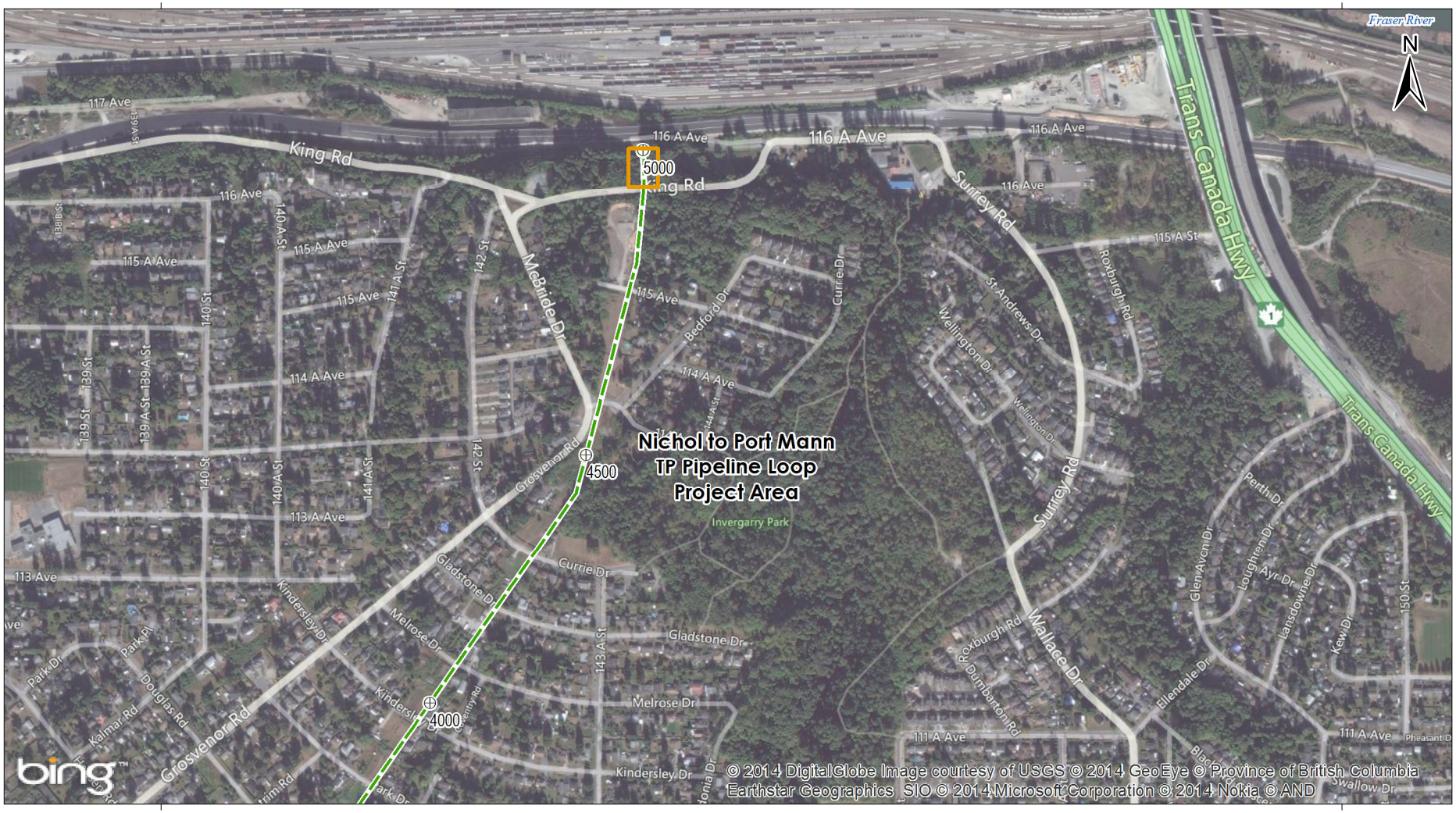

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- ⊕ Kilometre Post
- Project Area
- High Archaeological Potential

0 150 300 450 Meters

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Archaeological Overview Assessment
Lower Mainland Natural Gas System Upgrades

Metro Vancouver Reinforcements
Nichol to Port Mann TP Pipeline Loop Project Area -
High Archaeological Potential Locations

Sources: FortisBC, BC Government

Although there is no reason to believe that there are any errors associated with the data used to generate this product or in the product itself, users of these data are advised that errors in the data may be present.

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PREPARED BY: Stantec

PREPARED FOR: FORTIS BC

FIGURE NO: 9

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6.0 Recommendations

Nine areas of high archaeological potential were identified along the Metro Vancouver Reinforcements project alignment (Figures 5-9). They are described in Section 5.5 above. An AIA is recommended for these areas prior to the commencement of pipeline construction.

For areas assessed as having low archaeological potential, no further archaeological work is recommended. However, in the unlikely event that archaeological materials are uncovered during any future ground altering activity, all work in the vicinity of the finds should cease and the Archaeology Branch, a qualified archaeologist, and the appropriate First Nations be notified. Historic and prehistoric materials older than AD 1846 are protected by legislation.

AIAs are field-based assessments conducted where potential impacts to archaeological and heritage resources are anticipated. They are conducted under the authority of a Heritage Inspection Permit issued by the Archaeology Branch pursuant to Section 14 of the HCA. AIAs are designed to:

- Gain a comprehensive understanding of archaeological and heritage resources that may be threatened by the proposed development.
- Inventory the archaeological and heritage resources in the study area.
- Assess the significance of identified archaeological and heritage resources.
- Assess potential conflicts posed to archaeological and heritage resources by the proposed development.
- Provide recommendations regarding the most appropriate management of archaeological and heritage resources. These commonly involve project redesign or relocation to avoid archaeological sites, or a mitigation program.

AIA fieldwork involves:

- The intensive pedestrian survey of the study area to search for archaeological materials and features evident on the ground surface, and to further evaluate the archaeological potential of the project area.
- Sub-surface testing to search for buried archaeological and heritage sites. This commonly involves shovel testing, auguring, and/or soil probing, but may also involve the use of machine excavators where surface fills or pavement prevent hand testing or where deeply-buried archaeological deposits are anticipated.
- The assessment of identified sites. This involves the collection of baseline data about the sites, their mapping and photography, and the delineation of their spatial extent.

Upon completion of AIA fieldwork, a comprehensive AIA report will be produced, detailing the work conducted, the sites identified and their significance, the conflicts identified between proposed development activities and archaeological and heritage sites, and the management recommendations which are proposed to alleviate or eliminate these conflicts.

Alternatively, FortisBC has indicated that they will consider avoiding areas assessed as having high archaeological potential by using HDD to install their pipeline under these areas. This approach may allow for the avoidance of impacts to the buried archaeological and heritage resources potentially present in these locations. If this approach is adopted, it may be possible to forgo the AIA of these locations, if the following conditions are met:

- The bore entry and exit locations are situated outside areas assessed as having high archaeological potential.
- The depth of archaeologically-sterile sedimentary deposits (such as glacial till or other drift deposits) must be identified in order to plot boring arcs deep enough for the HDD to avoid potential archaeological deposits. The depth of sterile deposits may be confirmed by reviewing existing geotechnical records for these locations (if available), or through a limited program of AIA sub-surface testing conducted under the authority of a heritage inspection permit.

The Archaeology Branch should be consulted to ensure that this approach is acceptable.

Lastly, if Metro Vancouver Reinforcements project construction is to impact any previously-unrecorded archaeological sites found during the AIA, FortisBC will require a Section 12 HCA alteration permit to allow construction of the proposed gas line through these sites.

These recommendations applies solely to physical archaeological evidence of past human activity and in no way attempts to encompass any heritage concerns of the various First Nations people with asserted traditional territories in the project area.

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Appendix A
SRRMC Traditional Use Database Search Result – Data Sheet

SRRMC TUS Database Search Result – Data Sheet
PROJECT: SHIP 2013-065 Kaltenrieder – FortisBC Lower Mainland Gas Pipeline Upgrade AOA
REQUESTED: Simon Kaltenrieder / Stantec Consulting Ltd.
DATE: November 4, 2013

The information provided in this report is the result of a digital database review for the above referenced project conducted by the Stó:lō Research and Resource Management Centre (SRRMC) on behalf of Stantec Consulting Ltd. This review is limited in scope and is not to be considered a comprehensive treatment of First Nations interests or concerns associated with the proposed project. This assessment focuses on the relationship between cultural heritage resources defined in the Stó:lō Heritage Policy and the proposed project plan(s). This report is intended to provide information useful to Stantec Consulting Ltd. and FortisBC Energy Inc. in the archaeological overview assessment process. This report does not constitute consultation and does not in any way satisfy or complete the First Nation consultation requirements of Stantec Consulting Ltd. and FortisBC Energy Inc. with the Stó:lō Nation, the Stó:lō Tribal Council, or any other First Nations or First Nations organizations.

***Findings*:**

1. Cultural Landscape Feature
2. Historic Sites
3. Documented Travel Routes
4. GIS-modeled Travel Routes
5. High Archaeological Potential

Cultural Landscape Feature: 1 within 100 m of Study Area (as depicted)

Feature	Name	Significance	Proximity
Fraser River	Stó:lō	transformer site	50 m

Cultural Landscape Features are important areas of the landscape that are central to the Stó:lō cultural identity. Often these places are directly related to the Transformer Narratives (the "First People", or Creation stories). Avoidance and/or no impact are the only acceptable management recommendations for sites of this type. "Impact" can be construed to indicate either direct or indirect adverse effects.

Historic Sites: 5 within 100 m of Study Area (as depicted)

Borden ID	Site Type	Proximity
DhRq-24	Historic hospital	95 m
DhRq-57	Lorne Circus	within
DhRs-337	Historic habitation	70 m
DhRs-815	Cristiano House	45 m
DhRs-824	John Tibb House	adjacent

10-7201 Vedder Road
Chilliwack, BC V2R 4G5
604.824.2420 phone
604.824.0278 fax

www.srrmcentre.com
admin@srrmcentre.com

Documented Travel Routes: 4 within 100 m of Study Area (as depicted)

DOC ID	Location	Proximity
135	runs E-W across Fraser River floodplain	within
138	runs E-W along north bank of Fraser River	within
140	runs NW-SE across Fraser River floodplain	within
184	runs E-W across Fraser River floodplain	within

Documented Travel Routes are considered indicators of past land and resource use and, as such, recognition of these places is an important component in the context of aboriginal rights and title. Travel routes in this category have either been ground-truthed or verified to have been used. Documented trails indicated may or may not be presently discernable. In cases where physical evidence of historic trails is still present, the trail itself may be subject to protection under the Stó:lō Heritage Policy (2003) and the provincial Heritage Conservation Act.

GIS-modeled Travel Routes: 3 within 100 m of Study Area (as depicted)

PRJ ID	Location	Proximity
81	runs NW-SE along Mahood Creek	within
82	runs NE-SW across Fraser River floodplain	within
282	runs across Fraser River floodplain	within

GIS-modeled trails are travel routes that are either thought to exist, but their existence has not been verified, or modeled to exist based on other known factors such as the movement of people in a specific area. GIS-modeled trails require ground-truthing.

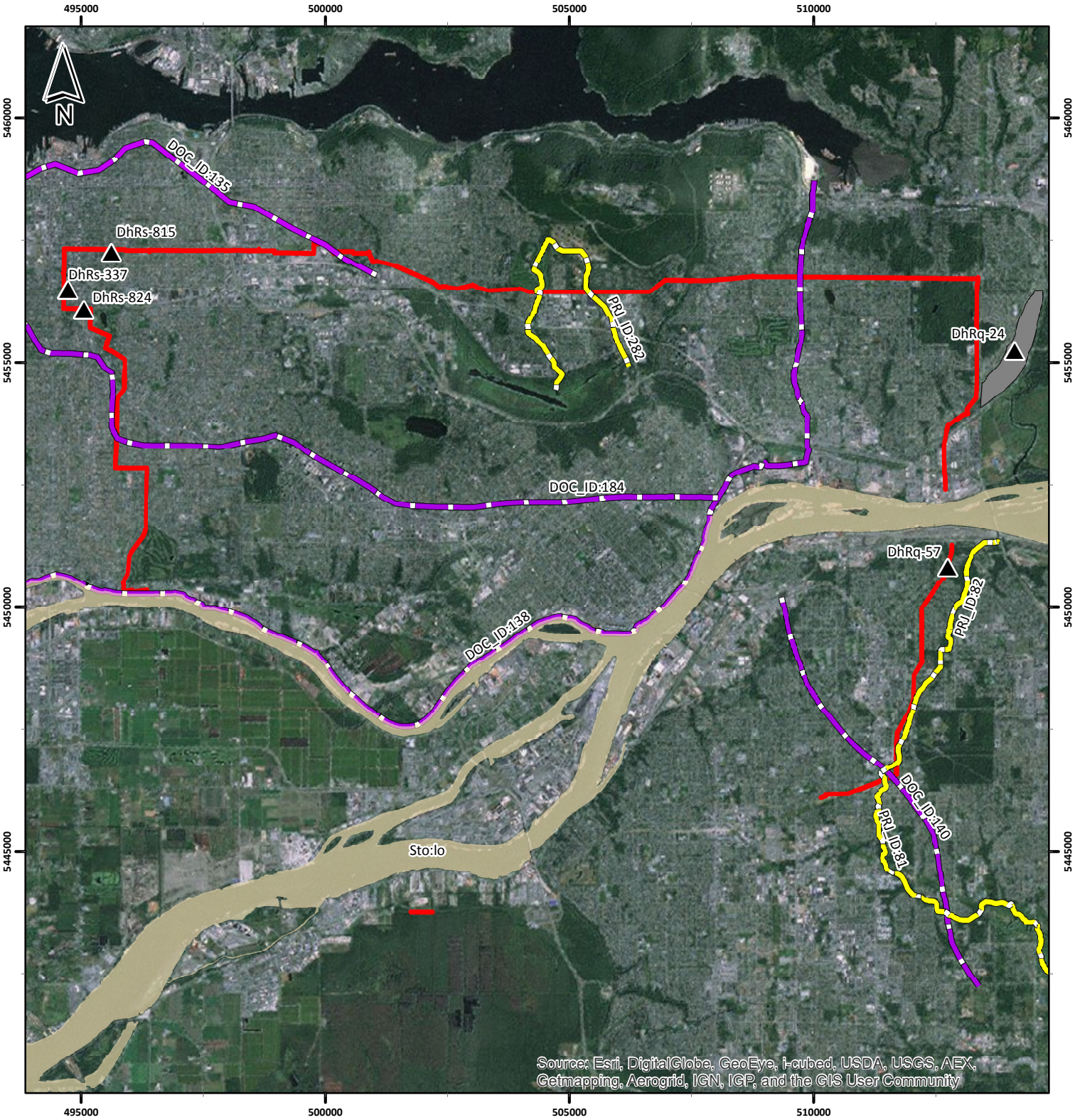
High Archaeological Potential

The Study Area has high archaeological potential because of its location on the Fraser Valley floodplain and its proximity to previously recorded archaeological sites.

If you have any questions about the content of this report, the Stó:lō Heritage Policy and/or its implementation, please contact me at (w) 604-824-5107, (c) 604-791-1982 or email at cara.brendzy@srrmcentre.com. Additional information regarding specific sites identified in this database evaluation is available for review in the archives on-site at the SRRMC in the Stó:lō Resource Management Centre office in Chilliwack.

Sincerely,

Cara Brendzy, B.A., B.App.GIS, RPCA
Lead Project Archaeologist / GIS Specialist
Stó:lō Research and Resource Management Centre



Study Area
Documented Travel Route
Archaeological Site
Cultural Landscape Feature
GIS-Modeled Travel Route

SRRMC TUS Database Search Result
PROJECT: SHIP 2013-065 Kaltenrieder
FortisBC Lower Mainland Gas Pipeline Upgrade AOA
REQUESTED: S. Kaltenrieder / Stantec

GIS: LMD
November 4, 2013

0 3,000
Meters

Stó:lō Research and Resource Management Centre

Appendix B-3

SOCIO-ECONOMIC OVERVIEW ASSESSMENT

FORTIS BC

FortisBC - Lower Mainland Natural Gas System Upgrades

Socio-Economic Overview Assessment

September 30, 2014

Submitted to:
FortisBC
16705 Fraser Highway
Surrey, BC
V4N 5R8
Attention: Gord Schoberg

Submitted by:
Dillon Consulting Limited
3820 Cessna Drive
Suite 510
Richmond, BC
V7B 0A2
Contact: Andrea Nokleby

DILLON CONSULTING

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FortisBC - LMSU

EXECUTIVE SUMMARY

FortisBC Energy Inc. (FortisBC) is proposing to upgrade approximately 32,400 metres (m) of existing Transmission Pressure (TP) and Intermediate Pressure (IP) pipelines as part of FortisBC's long-term infrastructure projects titled, "Lower Mainland Natural Gas System Upgrades" (LMSU). The existing TP and IP pipelines extend across four municipalities in the Lower Mainland, including the cities of Surrey, Coquitlam, Burnaby and Vancouver. Dillon Consulting Limited (Dillon) was retained by FortisBC to undertake a socio-economic impact assessment study (the Study) of the proposed routes for the five pipeline sections that form the LMSU projects including:

Intermediate Pressure Pipelines

Section 1: Fraser IP Pipeline Replacement - 500 m, Vancouver, BC.

Section 2: Coquitlamo IP Pipeline Replacement - 20,000 m, Vancouver, Burnaby, and Coquitlam, BC.

Transmission Pressure Pipelines

Section 3: Cape Horn to Coquitlam TP Pipeline Loop- 4,600 m, Coquitlam, BC.

Section 4: Nichol to Port Mann TP Pipeline Loop - 5,400 m, Surrey, BC.

Section 5: Nichol to Roebuck TP Loop - 1,700 m, Surrey, BC.

For the most part the proposed alignments for the pipeline sections are within either existing roads right-of-ways and/or existing joint FortisBC-Hydro BC rights-of-way. Land uses adjacent to the project sections are largely urban and include residential (high to low density), commercial, institutional (*e.g.*, schools, churches), parks/open space, recreation (*e.g.*, golf courses). Linear features crossed include: roads, rail lines (2 crossings) and underground municipal infrastructure. Section 2.0 of this report provides a detailed description of local land uses. A map set is also included that illustrates the pipeline locations and land uses. A review of applicable mapping revealed no First Nation reserves or Métis communities area located in the study area. It is understood that FortisBC is engaging aboriginal communities that could have an interest in the project.

The potential for effects is most likely during the project construction period. Construction activities have the potential to disturb nearby residents and users of recreation space/institutions. Construction noise is the most likely disturbance. Sensitive land uses include residences, schools, community facilities, parks, and recreation areas. Of the five pipeline sections, the Coquitlam IP Replacement, Nichol to Port Mann and Coquitlam to Cape Horn sections have the greatest interface with sensitive land uses, particularly residential. The Nichol to Roebuck section also passes some sensitive land uses, including recreational

areas, and the Fraser Gate IP has minimal length adjacent to sensitive land uses. Construction noise could dissuade people from using outdoor living space for some periods of time. The operation of the pipeline will not impact sensitive receptors from a noise perspective.

There are approximately 12 different business, commercial, and industrial areas along the project sections. These include large malls, small retail clusters, service stations, and commercial strips. Related potential construction effects to business activity include general disturbances, delays to road traffic, access impacts, and loss of on-street parking.

To minimize and manage potential project effects, this report makes several mitigation and monitoring recommendations. As an example, to mitigate potential noise effects, all construction activities will be carried out in compliance with municipal noise by-laws. No construction activities will occur on Statutory Holidays, Sundays and at night as stipulated in respective noise by-laws without applicable by-law exemptions. FortisBC will endeavour to limit access restrictions to businesses as much as possible, even if for short durations. Section 3.0 of this report should be consulted for a full list of the recommended mitigation measures.

The construction of the project also has the potential for positive employment impacts and contribute to the local economy in Metro Vancouver. The project may generate new jobs during the construction period as well as create economic "spin-offs" such as increased demand for local hospitality services such as hotels and restaurants for employees working on the construction sites.

The potential for cumulative effects have been considered. As an example there is the potential for the construction of these projects to overlap with the construction of the Kinder Morgan - Trans Mountain Expansion Pipeline Project. This project crosses the FortisBC project at two points including the Coquitlam IP and Nichol to Port Mann sections. It is recommended that FortisBC and Kinder Morgan consult with each other so that the potential for any cumulative effects are recognized and managed appropriately.

The report makes several project inspection and monitoring recommendations (Sections 4.0) as well as recommendations for community/land owner outreach and consultation activities.

This assessment of socio-economic effects of the LMSU projects proposed by FortisBC confirms that with the implementation of the proposed mitigation measures, monitoring and reporting plans, the projects are expected to have no negative, long-term effects on the socio-economic conditions in the Study Area. However, at selected locations (primarily associated with the Coquitlam IP Section) the project will result in temporary disturbance to vehicular traffic and will temporarily eliminate

areas of residential and commercial on-street parking. Temporary disturbances will be mitigated implementation of a Traffic Management Plan. Assessed environmental effects are expected to be temporary and managed through implementation of appropriate mitigation measures.

In conclusion, this Study considered the existing and planned socio-economic environment and how the construction and operation activities related to the proposed LMSU Projects would interact and affect those conditions. The resulting recommendations for mitigation efforts, monitoring and reporting are based on industry best practices and applicable requirements of local regulations. FortisBC will continue to work with the local stakeholders, agencies and the public to effectively understand and address the needs of the community and coordinate the construction and operation plans.

1.0 INTRODUCTION

FortisBC Energy Inc. (FortisBC) is proposing to upgrade approximately 32,400 metres (m) of existing Transmission Pressure (TP) and Intermediate Pressure (IP) pipelines as part of FortisBC's long-term infrastructure projects titled, "Lower Mainland Natural Gas System Upgrades" (LMSU). The existing TP and IP pipelines extend across four municipalities in the Lower Mainland, including the cities of Surrey, Coquitlam, Burnaby and Vancouver.

The FortisBC LMSU Project is proposed as a means to improve the natural gas supply system for British Columbia's Lower Mainland, providing a reliable gas supply to meet forecast future growth, security of supply and operational flexibility.

The LMSU project meets the long term projected gas supply requirements for the Lower Mainland area that result from increased population growth and residential, commercial and industrial natural gas demand growth. The project also addresses pipeline safety and integrity issues by replacing one pipeline that has reached the end of its service life and must be replaced given the inability to prevent leaks through maintenance activities, and another pipeline that has been assessed as being highly vulnerable to a 1:2475 year seismic event and must be upgraded to address this risk.

Dillon Consulting Limited (Dillon) was retained by FortisBC to undertake a socio-economic impact assessment study (the Study) of the proposed routes for the five pipeline sections that form the LMSU projects. This Study identifies potential impacts that the five proposed pipeline sections (referred to as the "Projects") could have on the socio-economic environment. Mitigation measures to minimize negative impacts (and enhance project benefits) have also been proposed and are described in Section 3.2. The Study has been completed in conformance with the B.C. Utilities Commission Act (the UCA). Pursuant to Sections 45 and 46 of the UCA, the Study accords with the guidelines set out in the B.C. Utility Commission's 2010 Certificates of Public Convenience and Necessity Application Guidelines (CPCN Application Guidelines).

The CPCN Application Guidelines require the identification of the social setting in which the Projects (and their feasible alternatives) will be constructed and operated, and the public who may be directly impacted by the Projects (and their feasible alternatives). The Guidelines also require the identification of the potential effects of the Projects on the social environment and proposals for reducing potentially negative effects and maximizing benefits from positive effects. As such, the scope of this Study is comprised of the following key elements:

- Identification of the existing socio-economic conditions within 500 m of the Projects;

- Identification of potential impacts (including cumulative effects) to the socio-economic conditions from construction, operation or maintenance activities associated with the Projects;
- Identification of mitigation and environmental management measures to limit impacts;
- Identification of potential net effects following the implementation of the mitigation and management measures; and
- Recommendations for monitoring activities.

This analysis is based primarily on secondary data sources. And, while it is typical to include in a socio-economic impact analysis information collected through consultation activities, this information was not available at the time of this Study. It is understood that FortisBC is in the process of undertaking consultation activities with local stakeholders. Feedback received from the consultation activities will be considered by Fortis BC in the planning and design of the system upgrades and will be documented in Section 5 of the CPCN (Public Consultation).

The five sections of pipeline discussed within this report are as follows:

Intermediate Pressure Pipelines

Section 1: Fraser IP Pipeline Replacement - 500 m, Vancouver, BC.
Section 2: Coquitlam IP Pipeline Replacement - 20,000 m, Vancouver, Burnaby, and Coquitlam, BC.

Transmission Pressure Pipelines

Section 3: Cape Horn to Coquitlam TP Pipeline Loop- 4,600 m, Coquitlam, BC.
Section 4: Nichol to Port Mann TP Pipeline Loop - 5,400 m, Surrey, BC.
Section 5: Nichol to Roebuck TP Loop - 1,700 m, Surrey, BC.

Each of these pipeline sections is shown in **Figure 1** in a regional context. According to Section 46(1) of the *Utilities Commission Act* (1996), the LMSU will require a Certificate of Public Convenience and Necessity (CPCN). Dillon was retained by FortisBC to undertake a high-level socio-economic assessment to support FortisBC's CPCN application. The 2010 *CPCN Application Guidelines* document was used to scope this report.

1.1 Description of Projects

Section 1: Fraser IP Replacement

The Fraser Gate IP Pipeline runs approximately 500 m along East Kent Street from Fraser Gate Station to the south-east corner of Marine Drive and Elliott Street intersection in Vancouver. The existing 762 mm outside diameter (OD) pipeline will be replaced with a 762 mm OD pipeline which meets FortisBC's adopted seismic standard. Most of the length of this

FortisBC - LMSU

pipeline is within the existing roads rights-of-way including East Kent Avenue South and Elliot Street (***Figure A1)***.

Section 2: Coquitlam IP Replacement

Section 2 runs approximately 20,000 m through three cities: 6,000 m through Coquitlam, 10,000 m through Burnaby, and 4,000 m through Vancouver. The Section commences near Coquitlam Gate Station, and ends at the intersection of Woodland Drive and 2nd Avenue in Vancouver. Much of the planned route for this proposed pipeline is within existing road rights-of-ways including: Como Lake Avenue, Broadway, Gravely Street, and East First Avenue. The LMSU proposes to replace the existing 508 mm OD pipeline in all three cities with a 762 mm pipeline ***(Figures B1-B9)***.

Section 3: Cape Horn to Coquitlam TP Loop

This section of pipeline is located entirely within the City of Coquitlam and runs north/south approximately 4,600 m between Coquitlam Gate Station (Mariner Way and Como Lake Avenue intersection) to Cape Horn Valve Station (Rogers Avenue), generally following the joint FortisBC pipeline-BC Hydro high voltage power transmission line corridor. The LMSU proposes to loop the existing 508 mm OD pipeline with a 914 mm OD pipeline ***(Figures C1 and C2)***.

Section 4: Nichol to Port Mann TP Loop

This section of pipeline is located entirely within the City of Surrey and commences on the south side of the Fraser River, immediately opposite the southern terminus of the Cape Horn to Coquitlam pipeline alignment (**Section 3**). The section is 5,400 m long and runs from the Nichol Vale Assembly (138th Street and 93rd Avenue) to Port Mann (King Road). The LMSU proposes to loop the existing 610 mm OD pipeline with a 914 mm OD pipeline ***(Figures D1, D2, and D3)***. The planned route for this pipeline is largely located within a joint FortisBC pipeline-BC Hydro high voltage electrical transmission right-of-way.

Section 5: Nichol to Roebuck TP Loop

This proposed section of TP pipeline runs through the City of Surrey from the Nichol Valve Assembly (93A Avenue and 138A Street) to the Roebuck Valve Assembly (1900 Block and 132 Street). The proposed pipeline upgrade will loop (*i.e.*, twin) approximately 1,700 m of the existing 1067 mm OD pipeline ***(Figure E1)***. The planned route for this pipeline is largely located within a joint FortisBC pipeline-BC Hydro high voltage electrical transmission right-of-way.

1.2 Study Areas & Data Sources

The Study area for data collection (spatial boundary) considered in the socio-economic assessment of the Projects included a 500 m area surrounding each of the five proposed pipeline sections. Each of the

routes was driven and/or walked by Dillon staff. The following data sources were used to complete the assessment:

Spatial Data Sources

- City of Vancouver - Open Data Catalogue;
- City of Surrey - Open Data;
- Province of British Columbia - Data Distribution Service, GeoBC, and OpenData BC;
- Government of Canada, CanVec;
- City of Coquitlam - GIS Data; and
- ESRI - Base Imagery Data.

Demographic and Economic Data

- Statistics Canada 2011 - National Household Survey (NHS) and Census of Canada; and
- Statistics Canada 2012 - National Household Survey (NHS) and Census of Canada.

1.3 Regulatory Framework

The following describes the applicable regulations and policies that this study recognized.

1.3.1 Federal Environmental Assessment

Federal government involvement under the Canadian Environmental Assessment Act (CEAA) is sometimes required for pipeline projects. CEAA was not triggered for this Study as the Projects are not designated projects under CEAA 2012. Further, cadastral information did not indicate the Projects cross over federally-owned lands, as such, the B.C. *Land Act* does not apply and no permits for License of Occupation of Crown Lands would be required.

1.3.2 Transport Canada

Transport Canada is responsible for the administration of the *Railway Safety Act* to ensure the safe operation of railways. The Act addresses the construction and alteration of railway works, the operation and maintenance of railway equipment and certain non-railway operations affecting railway safety. Pursuant to the Notice of Railway Works Regulations, FortisBC may be required to give notice of the proposed project to the:

- Railway whose line is to be crossed;
- Municipality in which the crossing works are to be located; and
- Authority having responsibility for roads that may be impacted.

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An approval may be required for certain railway works that depart from engineering standards set under the regulations or where an objection has been filed against the work.

Of the Projects in this Study, the Fraser Gate IP and Capehorn to Coquitlam sections cross rail lines and will be required to meet the *Railway Safety Act* and the Notice of Railway Works Regulations.

1.3.3 British Columbia Utilities Commission

In order to proceed with the proposed LMSU Projects, approval is required from the British Columbia Utilities Commission (BCUC). The BCUC is a regulatory agency of the B.C. Provincial Government, operating under and administering the *Utilities Commission Act* (UCA). The BCUC is responsible for approving the construction of new facilities planned by utilities and their issuance of securities. The BCUC oversees the review and approval of CPCN Applications.

Prior to obtaining CPCN Application approval for construction of new facilities, the BCUC requires the identification of measures that will be implemented for the Projects to reduce potentially negative socio-economic effects and maximize benefits from positive effects. In terms of maximizing the benefits from positive effects, this may include the identification of employment opportunities as a result of construction, operation and maintenance of the Projects, or the identification of opportunities to source construction materials from local suppliers to support the local economy.

1.3.4 B.C. Hydro

BC Hydro is regulated by the BCUC, under the UCA. Several of the Projects are either located adjacent to or within BC Hydro transmission line designated utility corridors. FortisBC will be required to coordinate with BC Hydro to cross transmission corridors and obtain lands for construction, operation and maintenance of the proposed Projects. This includes coordination of construction work with appropriate set-backs from existing transmission lines operated by BC Hydro. The BCUC will be reviewing the CPCN Application for the Projects to ensure coordination with BC Hydro.

1.3.5 B.C. Oil and Gas Commission

In addition to the CPCN Application under the UCA, the construction and operation of the Projects are governed by the *Oil and Gas Activities Act* and are subject to the Oil and Gas Commission (OGC) Regulation. The Projects require a Pipeline Application with OGC. A Pipeline Application is a significant process with considerable technical scrutiny on the Projects by the OGC. Public and First Nations Consultation, ROW acquisition, archaeological requirements, design reviews, environmental permits/approvals for work in and around fish-bearing streams are all

components of the Pipeline Application. Each component must receive OGC approval prior to the start of construction.

The Pipeline Application needs to address components of the socio-economic environment including, but not limited to, a construction plan, health and safety and emergency management plans, completion of consultation programs, and landowner agreements where easements are required.

The OGC Pipeline Application review is a significant regulatory process in addition to the CPCN approval by the BCUC. Once the application is submitted, OGC determines if the application is complete. If it is, then OGC enters into a process of reviewing the application and conducting project-specific First Nations consultation, if necessary, as well as completing a review of any unresolved stakeholder concerns. A Pipeline Application can take up to one year for approval.

1.3.6 B.C. Ministry of Transportation

Under the *Transportation Act*, the Ministry of Transportation (MoT) oversees "the use, occupation, plan, design, acquisition, hold, construction in any manner or place, operation, upgrade, alteration, expansion, extension, maintenance, repair, rehabilitation, protection, removal, discontinuation, close and disposal of provincial highways". MoT holds all highway users accountable for the actions they take on and around the right-of-way. The Projects include crossings of provincial highways. As such, work around the highways will require MoT review and approval. This includes review of construction and staging plans for highway crossings. Traffic management plans are required to ensure limited impacts on highway traffic and safety.

FortisBC will be required to consult with MoT in preparing construction, maintenance and operation plans around provincial highways for the Projects.

1.3.7 Relevant Municipal Permits

At the local government level, the Projects will require municipal reviews and permitting prior to construction. The Projects run through four municipalities in Metro Vancouver: City of Vancouver, City of Burnaby, City of Coquitlam, and the City of Surrey. Coordination with municipal departments includes Engineering and Infrastructure, Parks and Recreation, Planning and Development, and Transportation Planning where applicable.

All of the Projects require access to construct pipelines along/within road rights-of-way (ROWs). Pipeline installation and maintenance work on municipal streets will be subject to all applicable municipal standards, policies and codes for each of the Projects. Each municipality has similar requirements for reviewing utility permit drawings, construction plans and providing permits to secure easements for installation of

utilities in designated road ROWs and for crossing of other infrastructure, such as water mains and sewers.

Permitting requires construction drawings and plans, traffic management/control plans, requests to close roads during construction, and road restoration plans. The traffic control plans must be in compliance with the B.C. MoT Traffic Control Manual for Work on Roadways. Construction projects requiring lane closures must be approved in writing by the municipalities.

Municipalities also require local neighbourhood notifications of construction prior to commencement to ensure public awareness of traffic disruptions and construction schedules. Where the Projects cross through or beside public parks and recreation areas, Parks and Recreation departments will need to be consulted to manage impacts to park operations and activities, including disruption to trails.

Restoration of disrupted areas is of interest to every municipality. It will be important for FortisBC to work with the municipalities to agree on appropriate restoration standards. This includes restoration of any park trails or recreation areas disturbed by construction.

Noise Control By-Laws will also need to be reviewed by FortisBC prior to construction. Permits for Noise By-Law exemptions will require approval should work need to be completed outside of permitted hours specified in Noise By-Laws.

There are no Metro Vancouver Permits required except related to any portion of the Projects that may run through or adjacent to a Regional Park that the Metro Vancouver Regional District administers. Should the Projects impact a regional park, the construction, maintenance and operation of the Projects must comply with the Regional Parks Regulation By-Law 2013. Regarding the crossing of City underground infrastructure (e.g. water mains/sewers), while there is no specific permit required if the infrastructure is not to be directly impacted by the pipeline, the City will expect the proponent to present the proposed facility design and inform them of where the pipeline is expected to come in proximity of City infrastructure.

Municipal approvals related to tree removal or injuries to trees are required. The details of these permit requirements are provided in the environmental assessment for the Projects.

1.4 Stakeholder Consultation

It is understood that FortisBC is in the process of undertaking consultation activities with local stakeholders including local

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residents, residents associations, businesses, Business Improvement Areas (BIAs), the local municipalities and aboriginal communities.

Feedback received from the consultation activities will be considered by Fortis BC in the planning and design of the system upgrades and will be documented in Section 5 of the CPCN (Public Consultation).

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2.0 SOCIO-ECONOMIC ENVIRONMENT BASELINE DESCRIPTION

For each of the five pipeline route sections, a description of the following socio-economic components is provided. Socio-Economic conditions were examined within a Study Area of 500 m on either side of each pipeline section.

- Planning Policies;
- Land Use;
- Linear Infrastructure and Other Infrastructure;
- Population and Demographics;
- Economic Activities, Employment and Labour Force;
- Tourism and Recreation;
- First Nations and Métis Communities; and
- Community Services.

It is noted that a description of archaeological resources is covered under a separate report. Further, it is understood that known and potential contaminated sites are addressed through other studies commissioned by FortisBC.

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2.1 Section 1: Fraser IP Replacement

As previously noted, this section runs approximately 500 m along East Kent Street from Fraser Gate Station to the south-east corner of Marine Drive and Elliott Street intersection in Vancouver. The existing 762 mm outside diameter (OD) pipeline will be replaced with a 762 mm OD pipeline which meets FortisBC's adopted seismic standard. Most of the length of this pipeline is within the existing roads rights-of-way including East Kent Avenue South and Elliot Street ***(Figure A1)***.

Planning Policies

The following planning policies were reviewed for this pipeline section:

Provincial Secondary Sources

- BC Hydro Rights of Way Guidelines.

Regional Secondary Sources

- Metro Vancouver Regional Growth Strategy (Bylaw No. 1136), 2010.

Vancouver Municipal Sources

- Vancouver Zoning and Development Bylaw 3575, 1997; and
- Victoria-Fraserview-Killarney Community Vision Plan.

The Fraser IP section is located adjacent to 69 kV BC Hydro transmission lines and travels adjacent to various land use zones as defined by the City of Vancouver Zoning and Development Bylaw. These include Commercial Development (CD-1), Industrial (M-2), One-family Residential (RS-1), and Riverside One family Residential (RS-1B). Planning policies relevant to the LMSU within this pipeline section are consistent with those outlined for the Vancouver portion of the Coquitlam IP pipeline section.

Land Use

The Fraser IP section is located within the Vancouver neighbourhood of Killarney. Socio-economic land uses and features vary within the Fraser IP study area and include both residential and industrial land uses, a golf course, and several park and trail features ***(Figure A1)***. The majority of the pipeline section travels south of a Canadian Pacific railway ROW. Land use North of the pipeline is primarily high-density residential and includes a mix of low-rise, mid-rise, townhouse, and duplex residential occupancies. A lower-density residential area, consisting primarily of single-detached occupancies, is located between Morningstar Crescent and Elliot Street at the western end of the pipeline. Lands adjacent to the south of the pipeline consist of a riverfront industrial area, and several parks and green spaces. No institutional land uses or heritage sites were identified within the Fraser IP Study Area.

Linear Infrastructure and Other Infrastructure

Several existing linear infrastructure corridors are located within the Fraser Gate to Marine Drive IP Replacement Study Area ***(Figure A1)***. These include hydro transmission lines, rail lines, and other transportation networks. Each is discussed below in more detail.

Utility corridors containing hydro transmission lines

- 69 kV BC Hydro east-west hydro transmission lines running parallel to the IP section for the entire length of the Study Area.

Rail

- Canadian Pacific rail line traveling parallel to the north side of the IP section for the entire length of the Study Area.

Major Roads

- Kent Avenue (travels east-west through entire Study Area);
- Marine Drive Southeast (travels east west through entire Study Area, approximately 160 m north of the IP section; and
- Elliot Street (travels north-south through study area, parallel to western end of the IP section.

Bus Routes

- 100 22nd Street Station / Marpole Loop.

Population and Demographics

An understanding of the Study Area's demographic and socio-economic characteristics provides an understanding of the local populations. Mapping analysis indicates that the population within the Fraser IP Study Area has increased by approximately 24% between 2006 (4,311) and 2011 (5,345) (**Table 2** and **3**). Population growth statistics for the City of Vancouver are outlined in Section 2 (Coquitlam IP Replacement).

Table 1 provides a summary of demographic information of the Study Area in comparison to the City of Vancouver and the Province of British Columbia.

Table 1: Fraser IP Demographic Summary

	Population	Total Dwellings	Immigrant Population	Visible Minorities	Average Income
Fraser IP Study Area	5,345	2,328	47%	65%	$37,826
City of Vancouver	603,502	286,742	44%	52%	$43,058
British Columbia	4,400,057	1,945,365	27.6%	27.3%	$39,415

Source: 2011 National Household Survey, Statistics Canada

Economic Activities, Employment and Labour Force

Analysis of Statistics Canada (2011) Census Tract data indicates that the Fraser IP Study Area has a labour participation rate of approximately 64%

and an unemployment rate of approximately 7.0%. Retail trade; professional, scientific, and technical services; and health care and social assistance are the top three industries employing Study Area population. Comparatively, the approximate labour participation rate in 2006 was 65%. The top three industries were retail trade; professional, scientific, and technical services; and food and accommodation services.

Tourism and Recreation

The Fraser IP Study Area contains municipal parklands and trails that are used by both local residents and tourists ***(Figure A1)***. Parks located within the Study Area include:

- Gladstone Riverside Park (2500 East Kent Street South, adjacent to the pipeline ROW along the western portion of the route); and
- Riverfront Park (2750 East Kent Street South, adjacent to the pipeline ROW in the eastern portion of the route).

In addition, mapping analysis revealed the following trails within close-proximity to the pipeline section:

- Fraser River Trail (multi-use pathway traveling parallel to the south of the pipeline section through entire length of Study Area).

Gladstone and Riverside Park provide a variety of uses within the community, including tennis and basketball courts, playgrounds, and picnic sites. The parks provide a buffer between riverside industrial lands and residential areas. The Fraser River trail provides a connection between the various park sections in the Study Area. The Study Area also includes Fraserview Golf Course, which is located approximately 180 m north of the pipeline section (north of Marine Drive Southeast, and east of Elliot Street) ***(Figure A1)***.

First Nations and Métis Communities

A review of applicable mapping revealed no First Nation reserves or Métis communities located in the study area. It is understood that FortisBC is engaging aboriginal communities that could have an interest in the project. Through these engagement activities additional information may become available and will be included in Section 6 of the CPCN (First Nations Consultations).

Community Services

A review of applicable mapping revealed no community service facilities located in the Study Area.

2.2 Section 2: Coquitlam IP Replacement

As previously noted, this section runs approximately 20,000 m through three cities: 6,000 m through Coquitlam, 10,000 m through Burnaby, and 4,000 m through Vancouver. The section commences near Coquitlam Gate Station, and ends at the intersection of Woodland Drive and 2nd Avenue in Vancouver. Much of the planned route for this proposed pipeline is within existing road alignments including: Como Lake Avenue, Broadway, Gravely Street, and East First Avenue. The LMSU proposes to replace the existing 508 mm OD pipeline in all three cities with a 762 mm pipeline ***(Figures B1-B9)***.

Planning Policies

The following planning policies were reviewed for this pipeline section:

Provincial Secondary Sources

- BC Hydro Rights of Way Guidelines.

Regional Secondary Sources

- Metro Vancouver Regional Growth Strategy (Bylaw No. 1136), 2010.

Coquitlam Municipal Sources

- Citywide Official Community Plan (Bylaw No. 3479), 2001;
- Burquitlam Area Plan; and
- Coquitlam Zoning Bylaw No. 3000, 1996.

Burnaby Municipal sources

- Burnaby Official Community Plan (1998);
- Burnaby Zoning Bylaw No. 4742;
- Brentwood Town Centre Development Plan, 1996;
- Holdom Station Area Guide Plan;
- Lake City Business Centre Guide Plan;
- Forest Grove Community Plan; and
- Lougheed Town Centre Plan.

Vancouver Municipal Sources

- Vancouver Zoning and Development Bylaw 3575, 1997.

The Coquitlam IP pipeline section passes by multiple land use zones within the cities of Coquitlam, Burnaby, and Vancouver. The City of Coquitlam Zoning Bylaw (1996) outlines in *Part 5-General Regulations*, the following that relates to linear facilities and or utilities:

> ***502. Uses Permitted in All Zones***
> *(1) Land in any zone may be used for highways, utility poles, transmission towers, wires, traffic controls, telephone*

booths, bus benches and shelters, directional signs and underground utility systems, except where prohibited by this or another bylaw.
(2) Except where specifically permitted in a zone or permitted as a public service use in a zone, an underground utility system must not include buildings or structures for compressor stations or pumping stations.

Section 5 of the Vancouver Zoning and Development Bylaw relates to linear facilities and or utilities within the City of Vancouver as follows:

A person who complies in all other respects with this By-law, the Parking By-law, other City by-laws, any official Development Plan, and any development permit, to the extent any of them apply to that person's site, need not obtain a development permit for the following development and uses:

5.4 The installation, inspection, repair or renewal of sewers, mains, pipes, cables, wires or other similar apparatus required in connection with any lawful use of buildings or land.

5.5 The construction and maintenance of that part of a public utility placed in or upon a public thoroughfare or public utility easement.

No applicable planning policies were identified for linear facilities and or utilities within the City of Burnaby.

Land Use

The Coquitlam IP section passes through the cities of Coquitlam, Burnaby, and Vancouver; and includes a variety of socio-economic features and land uses. The eastern portion of this pipeline section (between Mariner Way and North Road) passes through the Coquitlam Neighbourhood of Burquitlam. Land use adjacent to this section of the pipeline is primarily medium-density residential area containing single-detached dwellings. ***(Figures B7, B8, and B9).***

The central portion of this pipeline section (between North Road and Boundary Road) continues, from the intersection of Como Lake Road and North Road, through the City of Burnaby. Lands adjacent to this portion of the pipeline include a variety of uses. The majority of land use north of this portion of the pipeline is medium density residential, while to the south land use includes a mix of single-detached and multi-family residential areas ***(Figures B3-B6).*** For the Burnaby portion of the pipeline, adjacent lands are mixed-use Commercial - Residential areas between Holdom Avenue and Willingdon Avenue. Much of the future commercial and residential development along this portion of the pipeline route is anticipated to focus in these areas, which surround the Holdom SkyTrain Station.

The western portion of this pipeline section (between Boundary Road and Clark Drive) passes along East First Avenue, through the neighbourhoods

of Hastings-Sunrise, and Grandview-Woodland, in Vancouver. Socio-economic land uses adjacent to this portion of the pipeline are primarily residential, but also include industrial, commercial, and parks and greenspace areas ***(Figures B1 and B2)***. High-density residential areas, containing primarily single-detached houses makes up the majority of adjacent land use between Rupert Street and Clark Drive, while industrial uses are concentrated at both the eastern and western extents of this portion of the pipeline section. These industrial areas are situated along Vancouver's eastern border (between Boundary Road and Trans-Canada Highway), and at the western end of the pipeline alignment (west of Clark Drive). Commercial area within the Vancouver portion of the Study Area is concentrated near the eastern end of the pipeline, along Commercial Drive ***(Figure B1)***. The majority these commercial uses are retail stores, coffee shops, and small restaurants.

There are several Institutional land uses within the Study Area including several schools that are part of the Coquitlam, Burnaby, and Vancouver School Districts ***(Figures B1-B9)***. There are also several privately-owned schools that operate within the Study Area. Colleges, Churches, cemeteries, libraries, and municipal facilities also operate as institutional land uses within the Study area. The following schools were identified:

Coquitlam Schools ***(Figures B7-B9)***

- Ranch Park Elementary (2701 Spuraway Avenue, approximately 360 m from the eastern end of the pipeline);
- Dr. Charles Best Secondary (2525 Como Lake Avenue approximately 50 m north of the eastern end of the pipeline);
- Hillcrest Middle School (2161 Regan Avenue, approximately 50 m south of the pipeline);
- Parkland Elementary (1563 Regan Avenue, approximately 65 m south of the pipeline);
- Queen of All Saints Elementary (1405 Como Lake Avenue, adjacent to the north of the pipeline);
- Porter Street Elementary (728 Porter Street, approximately 140 m south of the pipeline);
- Banting Middle School (820 Banting Street, approximately 100 m north of the pipeline); and
- Miller Park Community School (800 Egmont Avenue, approximately 250 m north of the pipeline).

Burnaby Schools ***(Figures B3-B6)***

- Lyndhurst Elementary (Lyndhurst Street, approximately 390 m south of the pipeline);
- Stoney Creek Elementary (2740 Beaverbrook Crescent, approximately 380 m south of the pipeline);

- Forest Grove Elementary (8525 Forest Grove Drive, approximately 40 m north of the pipeline;
- Montecito Elementary (2176 Duthie Avenue, approximately 350 m north of the pipeline);
- Sperling Elementary (2200 Sperling Avenue, approximately 250 m north of the pipeline);
- Parkcrest Elementary (6055 Halifax Street, approximately 390 m north of the pipeline);
- Brentwood Park Elementary (1455 Delta Avenue, approximately 240 m north of the pipeline);
- Holy Cross Elementary (1450 Delta Avenue, approximately 240 m north of the pipeline); and
- Kitchener Elementary (1351 Gilmore Avenue, approximately 240 m north of the pipeline).

Vancouver Schools (Figures B1 and B2)

- Begbie Elementary (1430 Lillooet St, approximately 200 m north of the pipeline);
- Grandview Elementary (2055 Woodland Drive, approximately 240 m southwest of pipeline);
- Chief Maquinna Elementary (2684 E 2nd Avenue, approximately 325 m south of the alignment);
- Queen Victoria Annex (1850 E 3rd Avenue, approximately 250 m south of the pipeline);
- Chief Maquinna Annex (2882 E 4th Avenue, approximately 100 m south of the pipeline); and
- Lord Nelson Elementary (2235 Kitchener Street, approximately 30 m north of the pipeline).

In addition, there are several heritage sites, parks, and green spaces that were identified in the Study Area. There are approximately 71 heritage sites. The majority of which are buildings located west of Nanaimo Street, in Vancouver ***(Figures B1 and B2)***. These sites are registered by the City of Vancouver in order to preserve their historical, cultural, scientific, and/or educational significance. Parks and Green Spaces within the Study Area are discussed in more detail under the *Tourism and Recreation* section further below.

Linear Infrastructure and Other Infrastructure

Several existing linear infrastructure corridors are located within the Coquitlam IP Study Area ***(Figures B1-B9)***. These include utility corridors, rail lines, and transportation networks. Each is discussed below in more detail.

Utility corridors containing hydro transmission lines

- 69 kV BC Hydro east-west hydro transmission lines traveling along Como Lake Road, adjacent to the Coquitlam portion of the pipeline.

Rail

- SkyTrain (travelling between Commercial Drive and Clark Drive, approximately 400 m south of the pipeline); and
- SkyTrain (traveling along Lougheed Hwy between Phillips Avenue and Gilmore Avenue, Ranging from 80-400 m south of pipeline).

Major Roads

- Mariner Way (travels north-south through eastern end of the pipeline section);
- Schoolhouse Street (travels north-south through eastern end of pipeline section);
- Clarke Road (travels north-east from North Road and intersects the pipeline at Como Lake Road);
- North Road (travels north-south through pipeline section at Coquitlam-Burnaby border);
- Gaglardi Way (travels adjacent to pipeline for approximately 500 m before intersecting pipeline at Broadway in east Burnaby);
- Brighton Avenue (travels north-south through central portion of pipeline section);
- Sperling Avenue (travels north-south through central portion of pipeline section);
- Holdom Avenue (travels north-south through central portion of pipeline section);
- Willingdon Avenue (travels north-south through central portion of pipeline section);
- Gilmore Avenue (travels north-south through central portion of pipeline section);
- Boundary Road (travels north-south through pipeline section at Burnaby-Vancouver border);
- Rupert Street (travels north-south through western portion of pipeline section);
- Renfrew Street (travels north-south through western portion of pipeline section);
- Nanaimo Street (travels north-south through western portion of pipeline section);
- Commercial Drive (travels north-south through western portion of pipeline section);
- Clarke Drive (travels north-south approximately 250 m from western end of pipeline);
- Lougheed Highway (travels-east west between Phillips Avenue and Gilmore Avenue);

- Como Lake Road (travels adjacent to pipeline through the City of Coquitlam);
- Broadway Street (travels adjacent to pipeline through the City of Burnaby); and
- East First Avenue (travels adjacent to pipeline through the City of Vancouver).

Bus Routes

- 156 Braid Station Via Coquitlam Rec Centre;
- 152 Coquitlam Station Via Chilko;
- 151 Coquitlam Station Via Coquitlam Rec Centre;
- 91 Coquitlam Station B-Line;
- 29 Phibbs Exchange;
- 129 Edmonds Station;
- 130 Capilano U;
- 134 Lake City Station;
- 136 Lougheed Station;
- 143 Coquitlam Station;
- 144 SFU;
- 145 SFU;
- 7 Nanaimo Station;
- 16 29th Ave Station;
- 20 Downtown;
- 27 Kootenay Loop;
- 28 Phibbs Exchange;
- N16 Renfrew to Kingsway Nightbus; and
- N20 Downtown Nightbus.

Non-Linear Facilities

- Holdom SkyTrain Station (Holdom Avenue and Lougheed Highway, approximately 100 m south of the Burnaby portion of the pipeline).

Population and Demographics

Demographic and socio-economic data can help characterize local populations. According to Statistics Canada (2012), the three cities experienced population increases between 2006 and 2011 as follows (**Table 2**):

- Coquitlam -10% (114,565 to 126,456);
- Burnaby -10% (202,799 to 223,218); and

- Vancouver -5% (578,041 to 603,502).

Comparatively, British Columbia experienced a population growth of 7% between 2006 and 2011, while Canada experienced a population increase of approximately 6% during the same period. Mapping analysis indicates that the population within Coquitlam IP Study Area has increased by approximately 12% between 2006 (63,867) and 2011 (71,618).

Population growth is expected to continue in the Cities of Coquitlam, Burnaby, and Vancouver. Growth forecasts for Coquitlam, in comparison to Metro Vancouver, are summarized as follows.

Table 2: Cities of Coquitlam, Burnaby, and Vancouver Population Growth Estimate

	2006*	2011*	2021**	2031**	2011-2031 Growth %age
City of Coquitlam	114,565	126,456	176,000	213,000	86.0%
City of Burnaby	202,799	223,218	277,000	314,000	41.0%
City of Vancouver	578,041	603,502	673,000	705,000	22.0%
Metro Vancouver	2,116,581	2,313,328	2,780,000	3,129,000	48.0%

*Actual based on Statistics Canada, 2012

**Forecasted based on City of Surrey Planning and Development population projects.

Table 3 provides a summary of demographic information of the Study Area in comparison to the cities of Coquitlam, Burnaby, and Vancouver; and the Province of British Columbia.

Table 3: Coquitlam IP Demographic Summary

	Population	Total Dwellings	Immigrant Population	Visible Minorities	Average Income
Coquitlam IP Study Area	71,618	29,550	42%	49%	$37,255
City of Coquitlam	126,456	48,083	41.6%	43.8%	$39,072
City of Burnaby	223,218	91,383	50.4%	59.5%	$35,120
City of Vancouver	603,502	286,742	44%	52%	$43,058
British Columbia	4,400,057	1,945,365	27.6%	27.3%	$39,415

Source: 2011 National Household Survey, Statistics Canada

Economic Activities, Employment and Labour Force

Analysis of Statistics Canada (2011) Census Tract data, indicates that the Coquitlam IP Study Area has a labour participation rate of approximately 67% and an unemployment rate of approximately 7.0%. Retail trade; educational services; and professional, scientific, and technical services are the top three industries employing study area population. Comparatively, the approximate labour participation rate in 2006 was 67% and top three industries were manufacturing, retail trade, and educational services.

The Commercial Drive BIA operates along Commercial Drive in the eastern portion of the Study Area ***(Figure B1)***. This BIA provides a way for property owners and businesses to promote and improve the economic vitality of the Commercial Drive corridor.

Tourism and Recreation

The Coquitlam IP Study Area contains several municipal parks, trails, and open space used by both locals and tourists ***(Figures B1-B9)***. Parks within the Study Area are used for both passive and active recreation, and include features such as baseball diamonds, soccer fields, playgrounds, picnic facilities, campgrounds, lakes, gardens, and large extents of forest area. Parks and recreation areas located within the Study Area include:

- Mundy Park (641 Hillcrest Street, adjacent to south side of pipeline for 1 km west of Mariner Way);
- Como Lake Park (686 Gatensbury Street, approximately 200 km south of eastern portion of pipeline);
- Burnaby Mountain Golf Course (7600 Halifax Street, Adjacent to north side of pipeline in Burnaby);
- Camrose Park (2766 Phillips Avenue, approximately 250 m south of the pipeline in Burnaby);
- Sunrise Park (Rupert Street, approximately 200 m south of pipeline in Vancouver);
- Rupert Park Baseball Diamond (Rupert Street and First Avenue East, adjacent to pipeline in Vancouver);
- Clinton Park (First Avenue East and Slocan Street, adjacent to pipeline in Vancouver);
- McSpadden Park (Victoria Drive, approximately 300 m south of pipeline in Vancouver);
- Garden Park (Templeton Drive, approximately 100 m south of pipeline in Vancouver);
- Grandview Park (Commercial Drive, approximately 400 m north of pipeline in Vancouver); and
- Alice Townley Park (Woodland Drive, adjacent to western end of pipeline in Vancouver).

In addition, the Coquitlam IP pipeline intersects or travels in close proximity to a number of trails and municipal pathways (***Figures B***). These include bicycle routes in the City of Vancouver, which travel along local roads throughout the City. The following trails were identified:

- Mundy Park Trails (mixed-use trail system through Mundy Park, adjacent to eastern end of pipeline);
- Sunrise Bicycle Route (shared local route along Slocan Street, intersecting pipeline in Vancouver);

- Lakewood Bicycle Route (shared local route along Lakewood Drive, intersecting pipeline in Vancouver); and
- Mosaic Bicycle Route (shared local route along Woodland Drive, intersecting pipeline in Vancouver).

First Nations and Métis Communities

A review of applicable mapping revealed no First Nation reserves or Métis communities located in the study area. It is understood that FortisBC is engaging aboriginal communities that could have an interest in the project. Through these engagement activities additional information may become available and will be included in Section 6 of the CPCN (First Nations Consultations).

Community Services

A review of applicable mapping revealed the following community services and facilities within the study area:

- Mariner Fire Hall, Coquitlam Fire Department (775 Mariner Way, approximately 35 m east of the eastern end of the pipeline) ***(Figure B9)***; and
- Fire Hall No. 9, Vancouver Fire Department (1805 Victoria Drive, approximately 150 m south of the western portion of the pipeline) ***(Figure B1)***.

2.3 Section 3: Cape Horn to Coquitlam TP Loop

As previously noted, this section of pipeline is located within the City of Coquitlam and runs north/south for approximately 4,600 m between Coquitlam Gate Station (Mariner Way and Como Lake Avenue intersection) and Cape Horn Valve Station (Rogers Avenue). The pipeline section is located within an existing joint FortisBC pipeline-BC Hydro transmission ROW ***(Figures C1 and C2)***.

Planning Policies

The following planning policies were reviewed for this pipeline section:

Provincial Secondary Sources

- BC Hydro Rights of Way Guidelines.

Regional Secondary Sources

- Metro Vancouver Regional Growth Strategy (Bylaw No. 1136), 2010.

Coquitlam Municipal Sources

- Citywide Official Community Plan (Bylaw No. 3479), 2001;
- Southwest Coquitlam Area Plan; and
- Coquitlam Zoning Bylaw No. 3000, 1996.

The majority of the Cape Horn to Coquitlam TP pipeline section is to be located within an existing joint FortisBC pipeline-BC Hydro transmission ROW. BC Hydro Rights of Way Guidelines are outlined previously in this report in the Nichol to Roebuck section.

Land Use

There is a variety of existing socio-economic land uses along the length of the Cape Horn to Coquitlam TP loop ***(Figures C1 and C2)***. The Study Area for the northern portion of the route (north of the Lougheed Highway) contains residential uses primarily consisting of single-detached residences and some townhouses ***(Figures C1 and C2)***. This portion of the ROW also extends adjacent to large extents of parkland between Austin Avenue and Como Lake Road ***(Figure C1)***. The southern portion of the pipeline ROW (south of the Lougheed Highway) travels through the Fraser Gateway industrial area, which is located along the northern shore of the Fraser River ***(Figure C2)***. In addition, there are small sections of commercial and institutional land uses located throughout the Study Area.

Institutional land uses located within the Study Area include three public schools that form part of the Coquitlam School District (BC School District No. 43), churches, and municipal facilities (outlined in community services) ***Figures C1 and C2*** outline the following schools located within the study area:

Public Schools

- RC Macdonald Elementary School (2550 Leduc Avenue, approximately 400 west of pipeline);
- Ranch Park Elementary (2701 Spuraway Avenue, approximately 300 m northeast of northern end of pipeline); and
- Dr. Charles Best Secondary (2525 Como Lake Avenue, approximately 400 m northwest of northern end of pipeline).

Linear Infrastructure and Other Infrastructure

Several existing linear infrastructure corridors are located within the Cape Horn to Coquitlam TP Loop Study Area ***(Figures C1 and C2)***. These include utility corridors, rail lines, and transportation networks. Each is discussed below in more detail.

Utility corridors containing hydro transmission lines

- 500 kV and 230 kV BC Hydro transmission lines within a joint FortisBC pipeline RoW that extends north-south for the entire length of the Study Area; and
- 69 kV BC Hydro east-west hydro transmission line that is approximately 100 m north of the end of the pipeline section.

Rail

- Canadian Pacific Railway line intersecting the southern section of the pipeline at the Lougheed Highway.

Major Roads

- Trans-Canada Highway (travels east-west through southern end of pipeline section);
- Lougheed Highway (travels east-west through southern end of pipeline section, north of the Trans-Canada Highway);
- United Boulevard (travels-east west through southern end of pipeline section, south of the Trans-Canada Highway);
- Mariner Way (travels north-south through Study Area, north of Lougheed Highway); and
- Austin Avenue (travels east-west through central area of pipeline section).

Bus Routes

- 143 Coquitlam Station;
- 151 Coquitlam Station Via Coquitlam Recreation Centre;
- 152 Coquitlam Station via Chilko;
- 159 POCO Station;
- 169 Coquitlam Station;
- 555 Port Mann Express / Carvolth Exchange; and
- 791 Haney Place.

Population and Demographics

Demographic and socio-economic data can help characterize local populations. According to Statistics Canada (2012), The City of Coquitlam experienced a population increase of approximately 10% between 2006 (114,565) and 2011 (126,456) (**Table 4**). Comparatively, the Province of British Columbia experienced a population growth of 7% between 2006 (4,113,487) and 2011 (4,400,057), while Canada experienced a population increase of approximately 6% during the same period. Mapping analysis indicates that the population within Cape Horn to Coquitlam TP Study Area has increased by approximately 13% between 2006 (7,890) and 2011 (8,944).

Population growth is expected to continue in the City of Coquitlam. Growth forecasts for Coquitlam, in comparison to Metro Vancouver, are summarized as follows.

Table 4: City of Coquitlam Population Growth Estimate

	2006*	2011*	2021**	2031**	2011-2031 Growth %Age
City of Coquitlam	114,565	126,456	176,000	213,000	86.0%
Metro Vancouver	2,116,581	2,313,328	2,780,000	3,129,000	48.0%

*Actual based on Statistics Canada, 2012

**Forecasted based on City of Surrey Planning and Development population projects.

Table 5 provides a summary of demographic information of the Study Area in comparison to the City of Coquitlam and the Province of British Columbia.

Table 5: Cape Horn to Coquitlam Demographic Summary

	Population	Total Dwellings	Immigrant Population	Visible Minorities	Average Income
Cape Horn to Coquitlam Study Area	8,944	3,160	32.0%	32.0%	$44,873
City of Coquitlam	126,456	48,083	41.6%	43.8%	$39,072
British Columbia	4,400,057	1,945,365	27.6%	27.3%	$39,415

Source: 2011 National Household Survey, Statistics Canada

Economic Activities, Employment and Labour Force

Analysis of Statistics Canada (2011) Census Tract data indicates that Cape Horn to Coquitlam IP Study Area has a labour participation rate of approximately 71% and an unemployment rate of approximately 6.6%. Retail trade, health care and social assistance, and educational services are the top three industries employing study area population. Comparatively, the approximate labor participation rate in 2006 was 69%. The top three industries were retail trade; professional, scientific and technical services; and health care and social assistance.

Tourism and Recreation

The majority of tourism and recreational areas located within the Study Area are concentrated within Mundy Park, which is located adjacent to the

northwest portion of the pipeline ROW ***(Figure C1)***. Mundy Park is a 178 hectare urban forest that provides a number of recreational amenities to both locals and tourists. These amenities include a pool, sports fields, baseball diamonds, playgrounds, disc-golf course, and an extensive trail system. Other tourism features within the Study Area include a series of multi-use pathways traveling along the BC Hydro ROW and an off-leash dog park.

First Nations and Métis Communities

A review of applicable mapping revealed no First Nation reserves or Métis communities located in the Study Area. It is understood that FortisBC is engaging aboriginal communities that could have an interest in the project. Through these engagement activities additional information may become available and will be included in Section 6 of the CPCN (First Nations Consultations).

Community Services

A review of applicable mapping indicated the following community services and facilities within the Study Area ***(Figures C1 and C2)***:

- Mariner Fire Hall (775 Mariner Way, Approximately 35 m west of the northern end of the pipeline section);
- Municipal works yard (adjacent to pipeline at Austin Avenue);
- Metro Vancouver Hickey Tennis Reservoir (adjacent to pipeline at Hickey Drive);
- Metro Vancouver water pump station (adjacent to pipeline at Hickey Drive); and
- Municipal water pump station located (within Hydro ROW, approximately 150 m south of Hickey Drive).

2.4 Section 4: Nichol to Port Mann TP Loop

As previously noted, this section of pipeline is located within the City of Surrey and commences on the south side of the Fraser River, immediately opposite the southern terminus of the Cape Horn to Coquitlam pipeline alignment (Section 3). The section is 5,400 m long and runs from the Nichol Vale Assembly (138th Street and 93rd Avenue) to Port Mann (King Road). The LMSU proposes to loop the existing 610 mm OD pipeline with a 914 mm OD pipeline ***(Figures D1, D2, and D3)***. The planned route for this pipeline is largely located within an existing joint FortisBC pipeline-BC Hydro high voltage electrical transmission right-of-way.

Planning Policies

The following planning policies were reviewed for this pipeline section.

Provincial Secondary Sources

- BC Hydro Rights of Way Guidelines.

Regional Secondary Sources

- Metro Vancouver Regional Growth Strategy (Bylaw No. 1136), 2010.

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Surrey Municipal Sources

- Surrey Official Community Plan (Bylaw 12900), 1996;
- Surrey Sustainability Charter;
- Surrey Greenways Plan, 2012; and
- Surrey Zoning By-Law 1993, No. 12000.

The Nichol to Portman TP section is located within an existing joint FortisBC pipeline-BC Hydro transmission ROW and travels adjacent to lands with various land use zones including: Community Commercial Zone (C8), Duplex Residential Zone (RM-D), Comprehensive Development Zone (CD), Downtown Commercial Zone (C-35), One Acre Residential Zone (RA), and Single Family Residential Zone (RF).

BC Hydro Rights of Way Guidelines outline the following in regards to pipeline projects:

BC Hydro must receive a detailed proposal (to be reviewed and accepted) for any pipeline works proposed within 30 m of BC Hydro works or ROW. Installation and operation of the pipeline must be in accordance with CAN/CSA-22.3 No. 6-M9I—Principles and Practices of Electrical Coordination between Pipelines and Electrical Supply Lines. Pipelines must not negatively impact BC Hydro's ability to access, maintain and operate its ROW and works. Permanent crossings within/across access roads and tracks may need to be provided.

Land Use

There are a variety of existing socio-economic features and land uses along the length of the Nichol to Port Mann TP Loop. Adjacent land use is primarily residential, but also includes some commercial, industrial, and several institutional land uses ***(Figures D1, D2, and D3)***. . The Study Area also includes parks and green spaces that are both adjacent and within the pipeline section ROW.

The Study Area falls within the town of Whalley (North Surrey) and portions of Surrey City Centre. Some of the larger residential neighbourhoods that are crossed or are in proximity to the pipeline route include: Bolivar Heights in the north portion of the Study Area; Johnston Heights in the central Study Area; and Green Timbers and Cedar Hill in the southern portion. These neighbourhoods are intensely developed single-family and low-medium rise developments. The northern portion of the Study Area also passes through Surrey City Centre, which is situated south of 112 Ave and north of 94 Avenue. Surrey City Centre includes many low, mid, and high rise residential buildings that surround the City Centre commercial area. Industrial areas within the Study Area include the Bridgeview and Port Mann Industrial areas, which are located at the northern end of the pipeline section.

Future development in the northern portion of the Study Area is anticipated to be primarily single detached, duplex, and townhouse residential developments. South of 108 Avenue, in areas surrounding the City Centre, future development is anticipated to focus primarily on higher-density multi-residential occupancies.

There are several institutional land uses within the Study Area. These include four public schools that form part of the Surrey School District (BC School District No. 36), two schools that are privately-owned and operated, and one adolescent psychiatric school. There are also two hospitals within the southern portion of Study Area: Surrey Memorial Hospital, and Jim Pattison Outpatient Care and Surgery Centre. In addition, there are several adult education centres, and churches also located within the Study Area. ***Figures D1, D2,*** and ***D3*** outline the location of the facilities. The following lists the schools located within the Study Area:

Public Schools (from north to south)

- Forsyth Road Elementary School (139 Avenue and 108 Avenue, approximately 200 m east of pipeline);
- Simon Cunningham Elementary School (140 Street and 93A Avenue, approximately 450 m east of southern end of pipeline);
- Surrey Connect (K-12) (140 Street and 92 Avenue, approximately 490 m south-east of southern end of pipeline); and
- North Surrey Learning Centre (140 Street and 92 Avenue, approximately 500 m south-east of southern end of pipeline).

Private Schools (from north to south)

- Iqra Islamic School (south of 116A Avenue - approximately 400 m west of the pipeline); and
- Our Lady of Good Counsel (north of 104 Avenue on 140 Avenue, - approximately 200 m west of pipeline).

Other Schools

- Fraser Health Adolescent Psychiatric Unit (13750 96 Avenue, approximately 100 m west of southern end of pipeline.

There are also five heritage sites that are crossed or in close proximity to the pipeline ***(Figures D1, D2, and D3)***. These sites include (from north to south):

- Lorne Circus Traffic Circle (Intersection of McBride Drive, Grosvenor Road and Bedford Drive, within the pipeline ROW;
- Ferguson House (14048 113A Avenue, approximately 400 m west of the pipeline);
- Reverend Thomas Haddon House (14040 113A Avenue, approximately 420 m west of the pipeline);
- Roll's Carpenter Shop (13946 Fraser Highway, approximately 280 m east of the pipeline); and
- Green Timbers - English Oaks Grove (14266 96 Avenue, approximately 450 m east of the pipeline).

Recreational features present in the Study Area include local municipal parks and trails. More detailed information of parks in the Study Area can be found in the Tourism and Recreation section further below.

Linear Infrastructure and Other Infrastructure

Several existing linear infrastructure corridors are located within the Nichol to Port Mann TP Loop Study area ***(Figures D1, D2, and D3)***. These include utility corridors, oil and gas pipelines, rail lines and transportation networks. Each is discussed below in more detail.

Utility corridors containing hydro transmission lines

- 500 kV and 230 kV BC Hydro transmission lines within a joint FortisBC pipeline RoW that extends north-south for the entire length of the Study Area; and
- 69 kV BC Hydro east-west transmission lines intersecting the southern end of the pipeline section.

Oil and gas pipeline rights-of-way

- Kinder-Morgan Oil pipeline intersecting TP section at 110 Avenue and 140A Street.

Major roads

- 108 Avenue (travels east-west through central area of Study Area);
- 104 Avenue (travels east-west through centre of Study Area);

- 100 Avenue (travels east-west through south end of Study Area);
- 96 Avenue (travels east-west through south end of Study Area);
- 140 Street (travels north-south through entire Study Area); and
- Fraser Highway (travels east-west through south end of Study Area).

Bus routes

- 096 Guildford Exchange;
- 320 Langley Centre;
- 325 Surrey Central Station;
- 326 Guildford;
- 335 Guildford Exchange;
- 337 Fraser Heights;
- 345 King George Station;
- 395 Willowbrook;
- 501 Surrey Central Station;
- 502 Aldergrove via Langley Centre;
- 509 Walnut Grove;
- 590 Surrey Central Station;
- Kwantlen Park School Special; and
- C73 Guildford.

Non-Linear Facilities

- BC Hydro Whalley Substation (located at the north end of 139A Street, approximately 40 m west of the pipeline.

Population and Demographics

Demographic and socio-economic data can help characterize a local population. Mapping Analysis indicates that the population within the Nichol to Port Mann TP Study Area (within 500 m of the route) has increased by approximately 14% between 2006 (14,832) and 2011 (16,953). Population growth statistics for the City of Surrey and Town of Whalley are outlined within the Nichol to Roebuck Section 2.5 (**Table 7**).

Table 6 provides a summary of the demographic information of the Study Area in comparison to the City of Surrey and the Province of British Columbia.

Table 6: Nichol to Port Mann Demographic Summary

	Population	Total Dwellings	Immigrant Population	Visible Minorities	Average Income
Nichol to Port Mann Study Area	16,953	7,299	39%	48%	$29,000

City of Surrey	468, 251	163, 986	40%	52%	$36,243
British Columbia	4,400,057	1,945,365	27.6%	27.3%	-

Source: 2011 National Household Survey, Statistics Canada

Economic Activities, Employment and Labour Force

Analysis of Statistics Canada (2011) Census Tract data indicates that the Nichol to Port Mann TP Study Area has a labour participation rate of approximately 67% and an unemployment rate of approximately 11%. Manufacturing, Construction, and Retail Trade are the top three industries employing Study Area population. These labour statistics are consistent with those identified from 2006 census tract data of the Study Area

The Downtown Surrey Business Improvement Association (BIA) operates west of the pipeline section within the central portion of the Study Area, in Surrey City Centre ***(Figures D1, D2, and D3)***. It is understood that FortisBC is consulting with BIAs active in the Study Area. Through these consultations, additional information regarding business activity in the Study Area may become available and will be documented in Section 5 of the CPCN (Public Consultation).

Tourism and Recreation

The Section also contains several municipal parks, trails, and open space used by both locals and tourists ***(Figures D1, D2, and D3)***. . Parks located within the Study Area include:

- Invergarry Park (14400 Currie Drive, adjacent to the pipeline ROW in north-east portion of study area);
- Hawthorne Park (10503 144 Street, approximately 140 m east of the pipeline);
- Cedar Grove Park (10222 141 Street, approximately 400 m east of the pipeline);
- Forsythe Park (10730 139 Street, approximately 280 m west of the pipeline);
- Victoria Park (14310 King Road, adjacent to the pipeline ROW at northern end of pipeline); and
- Green Timbers Urban Forest Park (14698 96 Avenue, approximately 200 m east of the pipeline).

In addition, mapping analysis revealed the following trails intersecting the Nichol to Port Mann TP section ***(Figures D1, D2, and D3)***:

- Quibble Creek Greenway - multi use path traveling along hydro corridor from 106 Avenue to 140B Street;
- Off-street bike route travelling south from 94A Avenue along Quibble Creek Greenway;

- Off-street bike route traveling south along Quibble Creek Greenway between 106 Avenue and 104 Avenue;
- Off-street bike route traveling south along Quibble Creek Greenway between 102 Avenue and 100 Avenue;
- Off-street bike route traveling south along Quibble Creek Greenway between 138A Avenue and Fraser Highway;
- Shared-local rode bike route traveling east-west, intersecting TP ROW at 106 Avenue; and
- Shared-local rode bike route traveling east-west, intersecting TP ROW at 94A Avenue.

First Nations and Métis Communities

A review of applicable mapping revealed no First Nation reserves or Métis communities located in the Study Area. It is understood that FortisBC is engaging aboriginal communities that could have an interest in the project. Through these engagement activities additional information may become available and will be included in Section 6 of the CPCN (First Nations Consultations).

Community Services

A review of applicable mapping revealed one community service facility located within the Study Area ***(Figures D1, D2, and D3)***:

- BC Ambulance Services (within the Study Area near Surrey Memorial Hospital, at the corner of 96 Avenue and 137 Street).

2.5 Section 5: Nichol to Roebuck TP Loop

As previously noted, this proposed section of TP pipeline runs through the City of Surrey from the Nichol Valve Assembly (93A Avenue and 138A Street) to the Roebuck Valve Assembly (1900 Block and 132 Street). The proposed pipeline upgrade will loop approximately 1,700 m of the existing 1067 mm OD pipeline ***(Figure E1)***. The planned route for this pipeline is largely located within a joint FortisBC pipeline-BC Hydro high voltage electrical transmission right-of-way.

Planning Policies

The following planning policies were reviewed for this pipeline section.

Provincial Secondary Sources

- BC Hydro Rights of Way Guidelines.

Regional Secondary Sources

- Metro Vancouver Regional Growth Strategy (Bylaw No. 1136), 2010.

Surrey Municipal Sources

- Surrey Official Community Plan (Bylaw 12900), 1996;
- Surrey Sustainability Charter;
- Surrey Greenways Plan, 2012; and
- Surrey Zoning By-Law No. 12000, 1993.

The Nichol to Roebuck TP Section is to be located within an existing joint FortisBC pipeline- BC Hydro transmission ROW ***(Figure E1)***. BC Hydro Rights of Way Guidelines outline the following in regards to pipeline projects:

BC Hydro must receive a detailed proposal (to be reviewed and accepted) for any pipeline works proposed within 30 m of BC Hydro works or ROW. Installation and operation of the pipeline must be in accordance with CAN/CSA-22.3 No. 6-M9I—Principles and Practices of Electrical Coordination between Pipelines and Electrical Supply Lines. Pipelines must not negatively impact BC Hydro's ability to access, maintain and operate its ROW and works. Permanent crossings within/across access roads and tracks may need to be provided.

Land Use

There is a variety of existing socio economic land uses along the length of the Nichol to Roebuck TP Loop. Adjacent land use is primarily residential, but also includes small areas of parks and green space, and commercial land use ***(Figure E1)***. A variety of institutional land uses are also located throughout the Study Area.

A large majority of the Study Area falls within the Surrey town of Whalley and passes through the neighbourhood of Green Timbers in the

east, and the neighbourhood of Cedar Heights in the west. These are medium to high-density residential neighbourhoods that primarily consist of single-detached, duplex, and townhouse occupancies. A small portion in the north-east of the Study Area, approximately 100 m from the pipeline ROW, is located within Surrey City Centre and contains a mix of multi-storey residential, and commercial occupancies. The majority of future development in the Study Area is anticipated at the north-east end of the pipeline section, in areas within close proximity to Surrey City Centre. These future development lands are designated in the City's Official Community Plan as 'urban,' 'multi-residential,' and 'commercial' areas.

There are several institutional land uses within the Study Area, including hospitals, churches, schools, and adult education centres. Surrey Memorial Hospital is located at the eastern end of the Study Area, south of 96 Avenue and north of 94A Avenue ***(Figure E1)***. The hospital is located approximately 300 m north of the pipeline. Institutional land uses also include the following five public schools that form part of the Surrey School District (BC School District No. 36):

- Simon Cunningham Elementary School (140 Street and 93A Avenue, approximately 450 m east of eastern end of the pipeline);
- Queen Elizabeth Secondary School (136 Street and 93A Avenue , approximately 350 m north of the pipeline);
- Surrey Connect (K-12) (140 Street and 92 Avenue, approximately 490 m south-east of eastern end of pipeline);
- North Surrey Learning Centre (140 Street and 92 Avenue, approximately 500 m south-east of eastern end of pipeline); and
- Cindrich Elementary School (134 Street and 91 Avenue, approximately 250 m south of the pipeline).

In addition, there is one heritage site, and a number of parks and green spaces located within the Study Area. The 'Red Cedar Stump' Heritage Site is located at 8920 Queen Mary Boulevard, approximately 400 m from the south-east end of the pipeline. Parks and Green spaces are discussed in more detail under the *Tourism and Recreation section further below*.

Linear Infrastructure and Other Infrastructure

Several existing linear infrastructure corridors are located within the Nichol to Port Mann TP Loop Study Area ***(Figure E1)***. These include utility corridors, gas pipelines, rail lines and transportation networks. Each is discussed below in more detail.

Utility Corridors containing hydro transmission lines

- 230 kV BC Hydro east-west hydro transmission line running parallel to the pipeline section for the entire length of the study area;
- 500 kV BC Hydro east-west hydro transmission line running parallel to the pipeline section for the entire length of the study area;

- 69 kV BC Hydro east-west transmission line running parallel to the pipeline section for the entire length of the study area;
- 230 kV BC Hydro north-south hydro transmission line intersecting the eastern end of the pipeline section; and
- 500 kV BC Hydro north-south hydro transmission line intersecting the eastern end of the pipeline section.

Gas Pipeline Rights of Way

- FortisBC north-south ROW intersection western end of pipeline section.

Major Roads

- 138 Street (travels north-south through eastern end of the pipeline);
- King George Boulevard (travels north-south through eastern section of the pipeline);
- 134 Street (travels north-south through centre of the pipeline section);
- 132 Street (travels north-south through western end of the pipeline section); and
- 92 Avenue (travels east-west, intersecting pipeline at 134 Street).

Bus Routes

- 96 Guildford Exchange;
- 321 Surrey Central Station;
- 324 Surrey Central Station; and
- 394 King George Station.

Population and Demographics

Demographic and socio-economic data can help characterize a local population. According to Statistics Canada (2012), the City of Surrey experienced a population increase of approximately 18.6 % between 2006 (394,976) and 2011 (468,251) (**Table 7**). Comparatively, the province of British Columbia experienced a population growth of 7.0 % between 2006 (4,113,487) and 2011 (4,400,057), while Canada experienced a population increase of approximately 6% during the same period.

The Surrey Planning Department (2014) indicates that the population of Whalley, including Surrey City Centre, grew by approximately 40% between 2006 (68,320) and 2011 (95,980), and is projected to reach a population of 101,580 in 2014. Mapping analysis indicates that the population within the Nichol to Roebuck Study Area has increased by approximately 14% between 2006 (10,400) and 2011 (11,815).

Population Growth is expected to continue in the City of Surrey, and community of Whalley. Population growth forecasts into 2021 and 2031 are summarized as follows.

Table 7: City of Surrey Population Growth

	2011	2021**	2031**	2011-2031 Growth %age
City of Surrey	468,251*	572,750	681,400	46%
Whalley (including City Centre)	95,980**	112,760	135,920	42%

*Actual based on Statistics Canada, 2012

**Forecasted based on City of Surrey Planning and Development population projects.

Table 8 provides a summary of the demographic information of the Study Area in comparison to the City of Surrey and the Province of British Columbia.

Table 8: Nichol to Roebuck Demographic Summary

	Population	Total Dwellings	Immigrant Population	Visible Minorities	Average Income
Nichol to Roebuck Study Area	11,815	3,323	56%	82%	$26,230
City of Surrey	468, 251	163, 986	40%	52%	$36,243
British Columbia	4,400,057	1,945,365	27.6%	27.3%	

Source: 2011 National Household Survey, Statistics Canada

Economic Activities, Employment and Labour Force

According to the Metro Vancouver Regional Growth Strategy, employment in the Greater Vancouver Regional District, including the cities of Surrey, Vancouver, Coquitlam, and Burnaby is expected to grow by approximately 40% from 2006 (1,158,000) to 2031 (1,622,000). Employment in the City of Surrey is expected to increase by approximately 81% between 2006 (143,000) and 2011 (259,000) **(Table 9)**.

Table 9: Metro Vancouver Employment Projections

	2006*	2021**	2031**
City of Surrey	143,000	217,000	259,000
City of Vancouver	393,000	441,000	464,000
City of Coquitlam	46,000	70,000	86,000
City of Burnaby	136,000	169,000	189,000
Metro Vancouver Total	1,158,000	1,448,000	1,622,000

*Actual based on Statistics Canada, 2012

**Forecasted based on Metro Vancouver Regional Growth Strategy, 2011

Analysis of Statistics Canada (2011) Census Tract data indicates that the Nichol to Roebuck TP Study Area has a labour participation rate of approximately 68% and an unemployment rate of 10.6%. Manufacturing, Construction, and Transportation and Warehousing are the top three industries employing the Study Area population. Comparatively, the approximate labor participation rate in 2006 was 64%. The top three industries were manufacturing, transportation and warehousing, and construction.

The Downtown Surrey Business Improvement Association (BIA) operates within the north-east portion of the Study Area, in Surrey City Centre ***(Figure E1)***. The purpose of this BIA is to facilitate businesses improvement and community economic development, and to promote and encourage the development of a livable downtown. It is understood that FortisBC is consulting with BIAs active in the Study Area. Through these consultations, additional information regarding business activity in the Study Area may become available and will be documented in Section 5 of the CPCN (Public Consultation).

Tourism and Recreation

The Nichol to Roebuck Study Area contains several municipal parks, trails, and open space used by both locals and tourists ***(Figure E1)***. Parks within the Study Area serve a variety of recreational purposes, and include amenities such as baseball diamonds, soccer fields, playgrounds, picnic facilities, gardens, and open green space. Parks located within the Study area include:

- Queen Elizabeth Meadows Park (9374 134 Street, approximately 250 m north of the pipeline);
- Cottontail Tot-Lot (9352 132A Street, approximately 400 m north of the pipeline);
- Queen Mary Park (8972 Queen Mary Boulevard, approximately 300 m south of the pipeline); and
- William Beagle Park (12944 92A Avenue, approximately 260 m north of the pipeline).

A network of trails connects Surrey's parks and neighbourhoods and is actively used by cyclists, hikers, and other recreationalists. Many of the trails located within the City travel along and adjacent to the Nichol to Roebuck TP Pipeline ROW. Preliminary mapping revealed the following trails intersecting the pipeline section within the Study Area:

- Wildflower Greenway - multi use path traveling along ROW east of 134 Street;
- Wildflower Greenway entrance trail - multi use path intersecting pipeline east of 132 street; and
- Quibble Creek Greenway - multi use path traveling north-south through eastern end of ROW.

First Nations and Métis Communities

A review of applicable mapping revealed no First Nation reserves or Métis communities located in the Study Area. It is understood that FortisBC is engaging aboriginal communities that could have an interest in the project. Through these engagement activities additional information may become available and will be included in Section 6 of the CPCN (First Nations Consultations).

Community Services

Police, Fire, and Emergency Medical Services (EMS) in the City of Surrey are operated, respectively, by the Royal Canadian Mounted Police, City of Surrey Fire Department, and BC Ambulance Services. There are no local police, fire, or EMS facilities located within the Nichol to Roebuck Study Area.

Stormwater, water supply, and wastewater treatment are managed by both the local and regional governments. The City of Surrey is responsible for drainage, water, stormwater, and sanitary sewers. Surrey is a municipal member of the Greater Vancouver Sewerage and Drainage District (GVSDD) of

the Regional Government (Metro Vancouver). The GVSDD is responsible for collecting, treating, and discharging wastewater from Surrey. No stormwater, water, or wastewater treatment facilities were identifies within the Nichol to Roebuck Study Area.

3.0 POTENTIAL IMPACTS AND MITIGATION MEASURES

This section provides a detailed assessment of the potential impacts associated with construction and operation of the proposed pipeline on the socio-economic environment. Recommended mitigation measures are also described in this section.

The mitigation measures described in this report conform to *FortisBC Construction and Maintenance Practices*.

Also considered in the development of the mitigation measures was Dillon's professional experience with pipeline projects and feedback received from the engagement of various stakeholders by FortisBC (to be completed by FortisBC).

Socio-economic impacts have been minimized by locating the proposed pipeline within designated utility corridors and in previously disturbed areas. Mitigation measures, however, must be implemented to protect against potential adverse socio-economic effects along the preferred routes for the projects.

3.1 Construction Activities

FortisBC plans to begin construction of the projects in 2017. Construction for each segment will likely take between 12 to 18 months from ground preparation to clean-up and testing, weather permitting. Construction will involve a number of distinct steps that may have the potential for effects on the socio-economic conditions including:

- **Right-Of-Way Preparation:** involves surveying and staking the pipeline location, identifying where other utilities are located, clearing vegetation (only as required), and grading to allow for the movement of equipment and preparation of workspace. In vegetated areas, topsoil along the right-of-way is stripped and stored in piles for replacement after construction. Crews re-stake the centre point of trench line/route.
- **Pipe Delivery and Pipe Preparation:** Trucks will deliver pipes in sections to avoid having to stack large quantities of pipe. Crews layout or string sections of the pipe along the right-of-way.
- **Joining Pipe Sections:** Pipes are then welded into one long piece, following the contour of the land. X-rays will be undertaken and crews will inspect the joints to confirm the integrity of the welding and the welded joints are coated.
- **Trenching/Horizontal Directional Drilling (HDD):** Pipeline is installed via open-trench or trenchless construction methods. Backhoes and/or excavators are used to dig trenches along staked routes. Entry and exit pits will be identified for specific trenchless construction activities.
- **Pipe Placement:** Crews use side booms/cranes to lower the pipe into the trench or through the drilled passage. Pipe is placed on trench bottom prepared with structural bedding material.

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- **Backfilling:** Excavated material is replaced and large stones are removed from the backfill material to prevent pipeline damage. Structural subsoil then topsoil are placed over the pipe, filling the trench. Anything disturbed by the construction (such as fences and pavement) is repaired or replaced. Vegetative cover or previous road surface is replaced.
- **Testing:** The new pipeline will be hydrostatically tested. The pipeline is sealed then filled with water and tested at a pressure higher than actual operating pressures. Hydrostatic tests check for leaks and confirm pipeline integrity. Water for the test may be obtained from the local municipality that can support the withdrawal with minimal environmental impact.
- **Clean-up:** The construction area is carefully cleaned up after the trench/drill hole is completed or backfilled. All construction materials and equipment is removed when construction is completed. A final grading of the area is done and excess soil is also removed. Slope stability and re-establishment of vegetation is carefully monitored following construction. FortisBC will do the remedial work necessary following pipeline construction.

3.2 Construction Effects on Socio-Economic Environment

Considering the baseline conditions of the Study Area and planned project activities, the following provides an overview description of potential project effects and recommended mitigation measures to minimize these effects. The following potential effects were considered:

- Noise;
- Vibration;
- Air Emissions and Dust;
- Traffic Congestion;
- Construction Waste;
- Land Use;
- Access;
- Landscape and Aesthetics;
- Other Infrastructure;
- Population;
- Economic Activity and Employment;
- Tourism and Recreation; and
- Aboriginal Communities.

3.2.1 Noise

Existing Condition

The preferred routes are located primarily in designated utility corridors and along road rights-of-way. The utility corridors are shared by FortisBC pipeline and by BC Hydro high voltage power transmission

lines. The alignment of the pipeline is in close proximity to residences and businesses at various points along the routes. Proximity to sensitive receptors occurs most frequently where the pipeline is within a densely populated road right-of-way or where the pipeline is on the edge of a utility corridor that is adjacent to residential and community uses.

Sensitive land uses include residences, schools, community facilities (libraries, recreation centres, etc.), parks and recreation areas. The location of these features are described in **Section 2** of this report and presented in the baseline conditions map set. Of the five pipeline sections, the Coquitlam IP Replacement, Nichol to Port Mann and Coquitlam to Cape Horn sections have the greatest interface with sensitive land uses, particularly residential. The Nichol to Roebuck section passes some sensitive land uses, including recreational areas, and the Fraser Gate IP has minimal length adjacent to sensitive land uses.

Potential Effect during Construction and Operation

Construction activities have the potential to disturb nearby residents, especially those living in close proximity to the routes. While construction noise impacts will be temporary and localized, they could be disruptive to residents and users of park space. Construction noise could dissuade people from using outdoor living space for short periods of time. For locations where trenchless technology (*e.g.*, HDD) will be used, the construction noise impacts are localized to the start and end points where the drilling rigs are located. Between the start and end points, where the line is underground, there will be little to no noise impacts. For locations where open trenches are used to lay the pipe, the construction noise impacts can affect a greater number of receptors as the trench is open; however, the construction duration would be shorter which limits impacts to sensitive receptors. The operation of the pipeline will not impact sensitive receptors from a noise perspective.

Proposed Mitigation

All construction activities will be carried out in compliance with municipal noise by-laws with respect to construction equipment usage. No construction activities will occur on Statutory Holidays, Sundays or at night, as stipulated in respective noise by-laws without applicable by-law exemptions. General noise control measures will be implemented during construction, including but not limited to:

- Scheduling construction at noise-sensitive locations during non-sensitive times, to limit disruption to sensitive receptors, including wildlife;
- Maintaining equipment prior to use and ensuring equipment is in good working order;
- Using noise abatement equipment including mufflers that are in good working order;

- Turning off equipment when not in use;
- Enclosing noisy equipment and use noise barriers, where warranted, to limit the transmission of noise beyond the construction site;
- Locating stationary equipment, such as compressors and generators, away from noise receptors;
- Replacing or repairing equipment parts generating excessive noise;
- Informing truck drivers and mobile equipment operators that the use of engine retarder brakes will not be permitted in previously identified noise-sensitive locations;
- Maintaining access roads to limit vehicle noise and noise from vibration; and
- Advising municipalities and the community of construction periods.

Net Effect

Construction noise impacts will generally be minor, temporary and localized.

3.2.2 Vibration

Existing Condition

Proximity of the pipeline route to sensitive receptors including residences occurs most frequently where the pipeline is within a densely populated road right-of-way or where the pipeline is on the edge of a utility corridor that is adjacent to residential and community uses.

Potential Effect during Construction and Operation

Vibration may be produced by heavy equipment movement along the pipeline route, soil excavation, and HDD activities. However it is expected to be minimal and will likely not exceed vibration caused by typical land development construction activities. No vibration impacts are anticipated during the operation of the pipelines.

Proposed Mitigation

FortisBC will monitor areas considered to be susceptible to vibration damage and take appropriate steps if required. Access routes will be identified to limit truck traffic near locations that are susceptible to vibration damage.

Net Effect

No significant net effect is anticipated should the proposed mitigation measures be implemented.

3.2.3 Air Emissions and Dust

Existing Condition

Metro Vancouver monitors air quality in the region, controls industrial, commercial and some residential emissions, creates long-term plans and compiles emission inventories. The Air Quality Policy and Management Division of Metro Vancouver produces an annual air quality monitoring

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report for the Lower Fraser Valley. Long-term trends show that concentrations of common air contaminants have been declining over the last two decades. The improvements are due to emission reductions across a variety of sectors, improved vehicle emission standards and the AirCare program in BC.

Potential Effect during Construction and Operation

Air emissions associated with construction generally include carbon monoxide and carbon dioxide from construction equipment exhaust and dust (total suspended particulate) emission from earth excavation activities. Air emissions may also be produced through pipeline welding activities. No air emissions impacts are anticipated during the operation of the pipelines.

Proposed Mitigation

Good equipment maintenance practices will be encouraged during construction. Emissions produced through welding cannot be mitigated; however, they will be short-term and localized. It is not anticipated that this would be a significant impact to residences and businesses along the routes.

Construction dust should be mitigated by limiting the area of open trenches (where possible) and protecting spoil piles appropriately. It is noted that for the Coquitlam IP Section, excavated soil will be hauled away during trenching activity; there will be no spoil piles. Water and other environmentally-friendly suppressants are recommended to control dust during dry and windy conditions. The amount of excavated soil remaining should be minimized and cleaned up immediately following construction. Dust control measures should be monitored regularly. Additional mitigation measures include:

- Equipping vehicles and construction equipment with emission controls, as applicable, and operate within regulatory requirements;
- Requiring regular equipment maintenance;
- Limiting long-term idling;
- Limiting construction activities during high wind events;
- Using multi-passenger vehicles (*e.g.*, crew trucks) to transport crews to the site to the extent practical and limit the amount of traffic and accompanying emissions;
- Controlling construction-related road dust near residential areas and other areas as advised by an environmental monitor/inspector; and
- Using dust control practices including wetting the construction right-of-way with water.

Net Effect

Air emissions and dust impacts will be localized and temporary. Assuming all the mitigation measures are put in place, the proposed work should not result in any significant impact on local sensitive uses such as residents and users of open space areas.

3.2.4 Traffic Congestion

Existing Condition

Traffic volumes are anticipated to be impacted by the project where the routes are located within road rights-of-way. There is also the potential for traffic interruption where the segments of the routes located within utility corridors intersect roads. All of the routes have segments that either run along or cross existing roads. In particular, the Coquitlam IP Replacement Route has the greatest extent of pipeline proposed along a road right-of-way. Existing traffic conditions along certain segments of the proposed routes are moderate to heavy and in some locations include transit routes.

Potential Effect during Construction and Operation

Generally, trenchless technologies will be used when crossing heavily travelled roads (highways and major commuter roads). Thus significant traffic disruptions are not anticipated to these roads during construction of the crossings. Where open-cut construction will be used along road rights-of-way, traffic disruptions are anticipated. Traffic reductions to one-lane or detours for roads that will be open-cut may be necessary during construction. Traffic impacts will be managed in consultation with local municipalities, in accordance with permit requirements, and are expected to be localized and temporary.

There will also be some increase in the amount of truck traffic during the pipeline construction along the designated haul routes. These effects will be temporary. Parking on the affected roads will be limited during construction, which may be of concern to nearby residents and businesses. While in operation, the pipeline will not have any impacts, or act as a barrier, to any vehicular traffic as it will be buried underground.

Proposed Mitigation

Traffic flow will be maintained where possible during construction. However, lane closure and traffic detours may be required to allow construction equipment and materials passage, or where open cut construction is planned. Good management and best practices will be implemented during construction to minimize traffic disruption. If required, alternative routes will be created and identified with appropriate signage.

Traffic Management Plans will be prepared in consultation with the local municipalities to assist in maintaining traffic flow (including for transit and school buses). These will conform to municipal requirements

for traffic management during construction. Where appropriate, efforts will be made to limit construction during peak traffic periods and to stage construction so as to reduce the impacted areas of the road rights-of-way. FortisBC and the contractor will work with municipalities to manage traffic delays and inform local residences and businesses of temporary traffic delays as appropriate. Clean-up and restoration of roadways will be undertaken immediately upon completion of construction to support the commencement of regular traffic flow.

Designated parking areas may be established for construction crews to help manage parking congestion in residential areas. The contractor will be encouraged to transport construction staff to site from a central collection point via bus or other method to reduce the potential of parking issues and traffic congestion from arising.

FortisBC will also establish construction monitoring programs that include processes to promptly respond to construction complaints.

Net Effect

Traffic impacts associated with construction activities will be temporary and localized. Assuming all the proposed mitigation measures are implemented, no significant net effect is anticipated during the construction of the pipeline.

3.2.5 Construction Waste

Existing Condition

Not applicable

Potential Effect during Construction and Operation

Waste produced during the construction period may include non-hazardous wastes (packaging, spent lubricating cartridges, coffee cups) and hazardous wastes (*e.g.*, pneumatic oils from hydraulic systems, gasoline and other lubricants/oils). The operation of the pipeline will not impact waste.

Proposed Mitigation

All construction waste should be collected and disposed of in accordance with local applicable regulations in a licensed waste facility. Waste management work practices will be identified with the contractor to ensure proper management and clean-up of waste generated during construction activities. Hazardous wastes must be transported by licensed hazardous waste haulers to registered hazardous waste disposal sites. Any temporary storage of wastes on-site should include the use of secured containers in designated areas away from residential and environmentally-sensitive areas. On-site construction staff should be encouraged to eat in designated areas that have containers for the disposal of waste created from food and beverage consumption. Post construction clean-up

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and restoration plans should include waste collection and disposal as appropriate.

Net Effect

No significant net effect is anticipated assuming the proposed mitigation measures are implemented.

3.2.6 Land Use

Existing Condition

Land use along the pipeline routes consists primarily of residential, commercial and industrial lands. There are some sensitive land uses that are within 500 m of the preferred routes. These are outlined below. More information on existing and planned land use is provided in **Section 2: Socio-Economic Environment Baseline Description.**

Fraser IP

Adjacent land uses include both residential and industrial land uses, a golf course, and several park and trail features. The majority of the pipeline section travels south of a Canadian Pacific railway ROW. There are no hospitals, schools or other institutional uses within the Fraser IP Study Area.

Parks located within the Fraser IP Study Area include:

- Gladstone Riverside Park (2500 East Kent Street South, adjacent to the pipeline ROW along the western portion of the route); and
- Riverfront Park (2750 East Kent Street South, adjacent to the pipeline ROW in the eastern portion of the route).

The Fraser River Trail is a multi-use pathway traveling parallel on the south side of the pipeline section through entire length of the Study Area.

There are no local police, fire, or EMS facilities located within the Fraser IP Study Area.

Coquitlam IP

The Coquitlam IP section of pipeline traverses through a wide range of land uses. These include residential, commercial, industrial, and parks and greenspace areas. There are several schools on the Study Area that are identified below.

Coquitlam Schools

- Ranch Park Elementary (2701 Spuraway Avenue, approximately 360 m from the eastern end of the pipeline);
- Dr. Charles Best Secondary (2525 Como Lake Avenue approximately 50 m north of the eastern end of the pipeline);

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- Hillcrest Middle School (2161 Regan Avenue, approximately 50 m south of the pipeline);
- Parkland Elementary (1563 Regan Avenue, approximately 65 m south of the pipeline);
- Queen of All Saints Elementary (1405 Como Lake Avenue, adjacent to the north of the pipeline);
- Porter Street Elementary (728 Porter Street, approximately 140 m south of the pipeline);
- Banting Middle School (820 Banting Street, approximately 100 m north of the pipeline); and
- Miller Park Community School (800 Egmont Avenue, approximately 250 m north of the pipeline).

Burnaby Schools

- Lyndhurst Elementary (Lyndhurst Street, approximately 390 m south of the pipeline);
- Stoney Creek Elementary (2740 Beaverbrook Crescent, approximately 380 m south of the pipeline);
- Forest Grove Elementary (8525 Forest Grove Drive, approximately 40 m north of the pipeline;
- Montecito Elementary (2176 Duthie Avenue, approximately 350 m north of the pipeline);
- Sperling Elementary (2200 Sperling Avenue, approximately 250 m north of the pipeline);
- Parkcrest Elementary (6055 Halifax Street, approximately 390 m north of the pipeline);
- Brentwood Park Elementary (1455 Delta Avenue, approximately 240 m north of the pipeline);
- Holy Cross Elementary (1450 Delta Avenue, approximately 240 m north of the pipeline); and
- Kitchener Elementary (1351 Gilmore Avenue, approximately 240 m north of the pipeline).

Vancouver Schools

- Begbie Elementary (1430 Lillooet St, approximately 200 m north of the pipeline);
- Grandview Elementary (2055 Woodland Drive, approximately 240 m southwest of pipeline);
- Chief Maquinna Elementary (2684 E 2nd Avenue, approximately 325 m south of the alignment);
- Queen Victoria Annex (1850 E 3rd Avenue, approximately 250 m south of the pipeline);
- Chief Maquinna Annex (2882 E 4th Avenue, approximately 100 m south of the pipeline); and

- Lord Nelson Elementary (2235 Kitchener Street, approximately 30 m north of the pipeline).

Parks and recreation areas located within the Coquitlam IP Study Area include:

- Mundy Park (641 Hillcrest Street, adjacent to south side of pipeline for 1 km west of Mariner Way);
- Como Lake Park (686 Gatensbury Street, approximately 200 km south of eastern portion of pipeline);
- Burnaby Mountain Golf Course (7600 Halifax Street, Adjacent to north side of pipeline in Burnaby);
- Camrose Park (2766 Phillips Avenue, approximately 250 m south of the pipeline in Burnaby);
- Sunrise Park (Rupert Street, approximately 200 m south of pipeline in Vancouver);
- Rupert Park Baseball Diamond (Rupert Street and First Avenue East, adjacent to pipeline in Vancouver);
- Clinton Park (First Avenue East and Slocan Street, adjacent to pipeline in Vancouver);
- McSpadden Park (Victoria Drive, approximately 300 m south of pipeline in Vancouver);
- Garden Park (Templeton Drive, approximately 100 m south of pipeline in Vancouver);
- Grandview Park (Commercial Drive, approximately 400 m north of pipeline in Vancouver); and
- Alice Townley Park (Woodland Drive, adjacent to western end of pipeline in Vancouver).

The following trails intersect or run in close proximity to the pipeline (these include bicycle routes in the City of Vancouver):

- Mundy Park Trails (mixed-use trail system through Mundy park, adjacent to eastern end of pipeline);
- Sunrise Bicycle Route (shared local route along Slocan Street, intersecting pipeline in Vancouver);
- Lakewood Bicycle Route (shared local route along Lakewood Drive, intersecting pipeline in Vancouver); and
- Mosaic Bicycle Route (shared local route along Woodland Drive, intersecting pipeline in Vancouver).

There are no local police or EMS facilities located within the Coquitlam IP Study Area but there are two fire hall facilities:

- Mariner Fire Hall, Coquitlam Fire Department (775 Mariner Way, approximately 35 m east of the eastern end of the pipeline); and

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- Fire Hall No. 9, Vancouver Fire Department (1805 Victoria Drive, approximately 150 m south of the western portion of the pipeline).

The Coquitlam IP pipeline does not propose to cross any rail lines; however, there are two rail lines in the Study Area. The SkyTrain travels between Commercial Drive and Clark Drive, approximately 400 m south of the pipeline, and again along Lougheed Hwy between Phillips Avenue and Gilmore Avenue, ranging from 80-400 m south of pipeline. The Holdom SkyTrain Station is located at Holdom Avenue and Lougheed Highway, approximately 100 m south of the Burnaby portion of the Coquitlam IP pipeline.

Cape Horn to Coquitlam TP Loop

Adjacent land uses consist of some residential, large extents of parkland and the Fraser Gateway industrial area. Schools include:

- RC Macdonald Elementary School (2550 Leduc Avenue, approximately 400 west of the pipeline);
- Ranch Park Elementary (2701 Spuraway Avenue, approximately 300 m northeast of the northern end of the pipeline); and
- Dr. Charles Best Secondary (2525 Como Lake Avenue, approximately 400 m northwest of the northern end of the pipeline).

Mundy Park is located adjacent to the northwest portion of the pipeline ROW. Mundy Park is a 178 hectare urban forest that provides a number of recreational amenities to both locals and tourists.

There is no local police or EMS facility in the Cape Horn to Coquitlam Study Area. The Mariner Fire Hall is located at 775 Mariner Way, approximately 35 m west of the northern end of the pipeline.

The pipeline does propose to intersect with a Canadian Pacific railway line at the Lougheed Highway.

Nichol to Port Mann TP Loop

Adjacent land use is primarily residential, but also includes some commercial, industrial, and several institutional land uses. The study area also includes parks and green spaces that are both adjacent to and within the pipeline section ROW. There are two hospitals within the southern portion of Study Area: Surrey Memorial Hospital, and Jim Pattison Outpatient Care and Surgery Centre. Schools include:

Public Schools (from north to south)

- Forsyth Road Elementary School (139 Avenue and 108 Avenue, approximately 200 m east of pipeline);
- Simon Cunningham Elementary School (140 Street and 93A Avenue, approximately 450 m east of southern end of pipeline);

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- Surrey Connect (K-12) (140 Street and 92 Avenue, approximately 490 m south-east of southern end of pipeline); and
- North Surrey Learning Centre (140 Street and 92 Avenue, approximately 500 m south-east of southern end of pipeline).

Private Schools (from north to south)

- Iqra Islamic School (south of 116A Avenue - approximately 400 m west of the pipeline); and
- Our Lady of Good Counsel (north of 104 Avenue on 140 Avenue, - approximately 200 m west of pipeline).

Other Schools

- Fraser Health Adolescent Psychiatric Unit (13750 96 Avenue, approximately 100 m west of southern end of pipeline.

Parks located within the Nichol to Port Mann TP Loop study area include:

- Invergarry Park (14400 Currie Drive, adjacent to the pipeline ROW in north-east portion of Study Area);
- Hawthorne Park (10503 144 Street, approximately 140 m east of the pipeline);
- Cedar Grove Park (10222 141 Street, approximately 400 m east of the pipeline);
- Forsythe Park (10730 139 Street, approximately 280 m west of the pipeline);
- Victoria Park (14310 King Road, adjacent to the pipeline ROW at northern end of pipeline); and
- Green Timbers Urban Forest Park (14698 96 Avenue, approximately 200 m east of the pipeline).

The following trails intersect or run in close proximity to the pipeline:

- Quibble Creek Greenway - multi use path traveling along hydro corridor from 106 Avenue to 140B Street;
- Off-street bike route travelling south from 94A Avenue along Quibble Creek Greenway;
- Off-street bike route traveling south along Quibble Creek Greenway between 106 Avenue and 104 Avenue;
- Off-street bike route traveling south along Quibble Creek Greenway between 102 Avenue and 100 Avenue;
- Off-street bike route traveling south along Quibble Creek Greenway between 138A Avenue and Fraser Highway;
- Shared-local rode bike route traveling east-west, intersecting TP ROW at 106 Avenue; and
- Shared-local rode bike route traveling east-west, intersecting TP ROW at 94A Avenue.

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There are no local police or fire facilities located within the Nichol to Port Mann Study Area, but there is one EMS facility, the BC Ambulance Services located near Surrey Memorial Hospital, at the corner of 96 Avenue and 137 Street. There are no rail corridors proposed to be crossed in this Study Area.

Nichol to Roebuck TP Loop

Adjacent land use is primarily residential, but also includes small areas of parks and green space, commercial land use, and a variety of institutional land uses. The Surrey Memorial Hospital is located approximately 300 m north of the pipeline at 96 Avenue and 94A Avenue. Schools include:

- Simon Cunningham Elementary School (140 Street and 93A Avenue, approximately 450 m east of eastern end of the pipeline);
- Queen Elizabeth Secondary School (136 Street and 93A Avenue, approximately 350 m north of the pipeline);
- Surrey Connect (K-12) (140 Street and 92 Avenue, approximately 490 m south-east of eastern end of pipeline);
- North Surrey Learning Centre (140 Street and 92 Avenue, approximately 500 m south-east of eastern end of pipeline); and
- Cindrich Elementary School (134 Street and 91 Avenue, approximately 250 m south of the pipeline).

Parks located within the Nichol to Roebuck TP Loop study area include:

- Queen Elizabeth Meadows Park (9374 134 Street, approximately 250 m north of the pipeline);
- Cottontail Tot-Lot (9352 132A Street, approximately 400 m north of the pipeline);
- Queen Mary Park (8972 Queen Mary Boulevard, approximately 300 m south of the pipeline); and
- William Beagle Park (12944 92A Avenue, approximately 260 m north of the pipeline).

The following trails intersect the pipeline section:

- Wildflower Greenway - multi use path traveling along the ROW east of 134 Street;
- Wildflower Greenway entrance trail - multi use path intersecting pipeline east of 132 Street; and
- Quibble Creek Greenway - multi use path traveling north-south through eastern end of the ROW.

There are no local police, fire, or EMS facilities located within the Nichol to Roebuck Study Area. There are also no rail corridors proposed to be crossed in this Study Area.

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Potential Effect during Construction and Operation

The construction of the project has the potential to create dust, noise, and construction related nuisances to residents and users of institutional facilities and open space areas located within, and in close proximity to the proposed Projects. Land uses within 100 m of the planned facilities are considered to be most susceptible to nuisance effects during construction periods. Pedestrian and bicycle paths may require temporary detours. These impacts will be temporary and localized.

Proposed Mitigation

FortisBC will consult with relevant municipalities and agencies to further refine the routes and minimize any potential conflicts with land uses and other infrastructure in the area, including coordination with BC Hydro where the pipeline is proposed within or adjacent to an existing BC Hydro transmission corridor. Consultation will help to prepare construction staging plans to minimize disruption and coordinate construction, where necessary, to maintain compatibility with planned land uses in the study area.

Construction in and around sensitive land uses located directly adjacent to the pipeline routes should also consider the following mitigation measures:

- Undertake construction around schools during the summer holiday period (when students are on holidays) to the extent possible;
- Provide educational information related to construction plans and schedules to local residents, businesses, institutions and others in the Study Area to inform and prepare people of the construction impacts and mitigation plans;
- Work with agencies to manage access to emergency, health and institutional facilities as needed;
- Install fencing around the construction areas with appropriate signage to prevent access to the area by unauthorized individuals; and
- Provide construction site managers to lead pedestrians around work areas where needed.

FortisBC will coordinate construction activities with local municipalities to reduce potential impacts to the environment and surrounding community and avoid the need to relocate the pipeline at a future date to accommodate new land uses.

FortisBC will also work with Canadian Pacific railway to manage the crossing of Canadian Pacific rail lines according to Canadian Pacific standards and requirements. This will include the use of HDD to avoid significant disruption to rail operations.

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Net Effect

Some short-term minor disruption effects to various land uses (*e.g.*, residents, open space users) during the construction period are likely. No long-term significant net effect is anticipated following implementation of the recommended mitigation measures.

3.2.7 Access Modifications and Restrictions

Existing Condition

The pipeline routes are located within road rights-of-way and designated utility corridors.

Potential Effect during Construction and Operation

Access to entrance ways (*i.e.*, driveways), sidewalks, roads and recreation trails will be maintained as best as possible during the construction period. Access may be impacted in areas where open trenching will be used; however, this will be temporary and localized. The pipeline, once constructed, will not restrict access as it will be installed underground.

Proposed Mitigation

Where access may be temporarily limited, construction plans will include measures to provide alternative access and procedures to limit the extent of access disruptions. FortisBC will provide advanced notification to tenants and property owners where access may be limited and provide information for people to make alternative arrangements during access disruptions. FortisBC will work with land owners and municipalities to prepare management plans for access disruptions. Appropriate signage and flag personnel will be used should detours be necessary.

Net Effect

No significant net effect is anticipated if the proposed mitigation measures are implemented.

3.2.8 Landscape and Aesthetics

Existing Condition

The pipeline routes are located within road rights-of-way and designated utility corridors. Along the road rights-of-way there are landscape features, signage, lighting, bus stops and street-scaping elements on the sidewalks. On the traffic lanes there are painted traffic lines indicating lanes, direction, bicycle lanes and bus/transit routes. The condition of the road rights-of-way and the features within them vary across the pipeline routes. Within the utility corridors landscaping and aesthetics are limited as these corridors are maintained regularly for safety and maintenance activities related to the existing utilities in the corridors. Additionally, many of the BC Hydro transmission corridors, which are shared with FortisBC, also contain high use pathways and trails which will be impacted by construction.

Potential Effect during Construction and Operation

Construction activities may be a visual nuisance to the local residents, park users, and businesses along the routes. There may also be disturbances to existing landscape and aesthetic features during the construction period. However, these nuisances will be short term during the construction period.

During operations, the pipelines will be underground and will not be visible.

Proposed Mitigation

During constructions some fencing may be used as appropriate mitigation for reducing the visual impact of construction. Upon completion of the construction activities the disturbed areas will be restored to their original condition. FortisBC and the contractors will work with the local municipalities to manage the restoration of any disturbed road rights-of-way, parks, trails and green spaces to meet the construction restoration requirements established in each municipality. FortisBC will also work with BC Hydro to manage the restoration of the utility corridors.

Net Effect

No significant net effect is anticipated following implementation of recommended mitigation measures.

3.2.9 Other Infrastructure

Existing Condition

There are several linear infrastructure corridors and other facilities located within the Study Area including:

- Major highways (Fraser Highway, Trans-Canada Highway, Lougheed Highway);
- Oil and gas pipeline rights-of-way (Kinder-Morgan intersects Nichol to Port Mann TP Loop);
- Smaller local distribution natural gas pipelines (various diameters);
- Rail lines (Canadian Pacific and Translink (Skytrain lines));
- Utility corridors (including 500 kilovolt [kV], 230 kV, and 69 kV transmission lines);
- Underground municipal infrastructure including for example water mains and pipelines; and
- Substations and transformer stations (BC Hydro Whalley Substation located 40 m west of Nichol to Port Mann TP Loop).

Potential Effect during Construction and Operation

There is potential for the pipeline routes to interfere with existing infrastructure corridors and infrastructure during construction. During operations effects are not expected.

Proposed Mitigation

Access to existing linear infrastructure corridors should be maintained throughout the construction period and FortisBC and the contractors should avoid disruption to linear infrastructure wherever possible. Prior to ground disturbance, the first step in construction should involve right-of-way survey and utility locates in order to plan construction around these features. The right-of-way boundaries are surveyed and clearly marked with stakes, flagging or fencing. Other buried infrastructure/pipelines in close proximity to the new pipeline must be exposed prior to installing a pipeline in their vicinity to ensure the safety and protection of the existing infrastructure. Consultation with the appropriate agency responsible for the infrastructure will be conducted in advance of construction. These areas will be restored after the pipeline has been installed. Major highways, roads, and rail lines will be crossed through the use of trenchless technologies (*e.g.*, HDD). Substations and other energy-related facilities will be avoided during construction, where possible. Should access to infrastructure corridors be required, FortisBC will contact the appropriate owners to request access for construction in these areas.

Net Effect

No significant net effect is anticipated following implementation of the recommended mitigation measures.

3.2.10 Population/Residents

Existing Condition

The pipeline routes go through four municipalities: Vancouver, Coquitlam, Burnaby, and Surrey. All of these municipalities are expected to continue to grow in population with continued growth in residential development. The pipeline routes pass through low, medium and high density residential areas that vary in population. More details on population for each of the pipeline routes are provided in **Section 2: Socio-Economic Environment Baseline Description**.

Potential Effect during Construction and Operation

The construction of the project has the potential to impact residents in Metro Vancouver as previously described under the Land Use Section of this report. Although construction will cause nuisances such as noise, vibration, and aesthetics, once constructed, the project will benefit residents throughout Metro Vancouver by securing safe and reliable access to natural gas. It is not anticipated that the proposed projects will directly impact population; however, access to natural gas will support the projected growth planned for Metro Vancouver.

Proposed Mitigation

Proposed mitigation measures are not required.

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Net Effect

The project will result in a net positive to residents in Metro Vancouver and secure continued safe and reliable access to natural gas to meet future population growth.

3.2.11 Economic Activities & Employment

Existing Condition

There are approximately 12 different business, commercial, and industrial areas along the LMSU pipelines. These include large malls, small retail clusters, service stations, and commercial strips. The areas include the following:

- At Commercial Drive and 1st Avenue East the Coquitlam IP pipeline crosses the Commercial Drive BIA. This is a commercial and retail area in the City of Vancouver running perpendicular to the pipeline along Commercial Drive and includes dozens of businesses.
- At Nanaimo Street and 1st Avenue East the Coquitlam IP pipeline crosses a small section of retail and gas station commercial businesses located in the City of Vancouver.
- At Renfrew Street and 1st Avenue East the Coquitlam IP pipeline crosses a commercial area that includes a community shopping centre zoned for comprehensive development and some retail and gas station/commercial. The commercial shopping mall access is along 1st Avenue East.
- At Rupert Street and 1st Avenue East the Coquitlam IP pipeline crosses a small area of commercial use including restaurants and gas stations.
- Between the Trans-Canada Highway in Vancouver and Ingleton Avenue in Burnaby the pipeline crosses a commercial/industrial and comprehensive development area that includes offices, plumbing businesses, and car lots. Boundary Boulevard is a major commercial street with numerous car lots, and auto dealers.
- Approximately 75 m south of the intersection of Brentlawn Drive and Willingdon Avenue along the Coquitlam IP pipeline in Burnaby is the Brentwood Town Centre Mall. This is a large mall with surrounding apartments, Skytrain station, offices, commercial and retail.
- Between Lake City Way and Gagliardi Way in Burnaby the Coquitlam IP pipeline passes along the northern edge of a business centre district (part of the Lake City OCP area). The area includes oil and gas, and other industrial facilities along the base of Burnaby Mountain near the terminus of the Trans Mountain pipeline.
- At the intersection of Clarke Road and Como Lake Road along the Coquitlam IP pipeline in Coquitlam there is an area of commercial uses. This area includes retail and service commercial all zoned Transit Village Commercial and in close proximity to the currently under construction Evergreen Skytrain line.
- Between Linton Street and Montrose Street along Como Lake Road there is a commercial area zoned General Commercial by the City of Coquitlam.

- Between Highway 7 and Rogers Avenue along the Cape Horn to Coquitlam pipeline there is an area of industry and service commercial including warehouses, and other industrial facilities.
- Near the intersection of 104th Street and 140th in Surrey the Nichol to Port Mann pipeline crosses an area of commercial zoned Downtown Commercial Zone. The area includes some offices and retail locations. This area is part of the Downtown Surrey BIA.
- Between the Fraser Highway and the end of the Nichol to Port Mann pipeline there is an area of offices and hospital related commercial/comprehensive development, all within the Downtown Surrey BIA. This includes several medical offices and commercial retail related businesses.

Potential Effect during Construction and Operation

The construction of the project has the potential to impact employment and contribute to the local economy in Metro Vancouver. Table 10 provides an overview of potential construction procurement dollars associated with the project.

Table 10: Overview of Potential Construction Procurement Dollars

ALL AREAS - SUMMARY

Cost	Lower Mainland	All BC (except Lower Mainland)	Canada (excl. BC)	Ex Canada	Sub-Total
[redacted]					

[redacted]

1. *Breakdown is based on cost estimate, dated September 2014 for the LMSU projects.*
2. *The sub totals are extracted from the baseline estimate and the range of the estimate is - 20% + 30%*
3. *The subtotals are generated as detailed below:*
    1. *Materials cost is split 5%/95%. The 5% is the cost associated with freight/taxes etc. when the materials enter Canada*
    2. *Construction cost is split 70%/30%. 70% cost is direct labour cost for local project works and 30% is cost of equipment rentals and direct costs for contractors from Alberta. Also includes contingency*
    3. *Owners cost is direct cost to local area of project.*

WBS 1000 - Roebuck to Nichol - SUMMARY

Cost	Lower Mainland	All BC (except Lower Mainland)	Canada (excl. BC)	Ex Canada	Sub-Total
[redacted]					

WBS 2000 - Nichol to Port Mann - SUMMARY

Cost	Lower Mainland	All BC (except Lower	Canada (excl. BC)	Ex Canada	Sub-Total

		Mainland)			
[redacted]					

WBS 3000 - Cape Horn to Coquitlam - SUMMARY

Cost	Lower Mainland	All BC (except Lower Mainland)	Canada (excl. BC)	Ex Canada	Sub-Total
[redacted]					

WBS 4000 - Coquitlam IP - SUMMARY

Cost	Lower Mainland	All BC (except Lower Mainland)	Canada (excl. BC)	Ex Canada	Sub-Total
Materials		$1,722,000		$32,713,000	**$34,435,000**
Construction	$107,404,000		$46,030,000		**$153,434,000**
Owner	$13,412,000				**$13,412,000**
Sub-Totals	**$120,816,000**	**$1,722,000**	**$46,030,000**	**$32,713,000**	**$201,282,000**

WBS 5000 - Fraser IP - SUMMARY

Cost	Lower Mainland	All BC (except Lower Mainland)	Canada (excl. BC)	Ex Canada	Sub-Total
Materials		$97,000		$1,847,000	**$1,944,000**
Construction	$7,978,000		$3,419,000		**$11,397,000**
Owner	$1,515,000				**$1,515,000**
Sub-Totals	**$9,493,000**	**$97,000**	**$3,419,000**	**$1,847,000**	**$14,855,000**

The project may generate new jobs during the construction period as well as create economic "spin-offs" in Metro Vancouver such as increased demand for local hospitality services such as hotels and restaurants for employees working on the construction sites.

Pipeline construction activities, particularly for the Coquitlam IP project sections, have the potential to disrupt businesses located in proximity to the project. And while the concerns of businesses in the Study Area need to be confirmed by FortisBC, anticipated key concerns of businesses include, noise, dust, access restrictions, and loss of parking. Regarding construction noise, while noise impacts will be temporary and localized, it could disrupt business operators and

customers. Outdoor based businesses (*e.g.*, outdoor patio restaurants) are particularly sensitive to noise and dust effects. For locations where trenchless technology (HDD) will be used, the construction noise impacts are localized to the start and end points where the drilling rigs are located. Between the start and end points, where the line is underground, there will be little to no noise impacts. The locations of the HDD start/end points should be sensitive to business locations and their sensitivities.

Pipeline construction activities could result in temporary access restrictions to businesses and reduce available parking (on-street). Increased road congestions due to lane closures/increased construction traffic could influence peoples decisions to travel to the area, particularly if car based.

Proposed Mitigation

As noted in the Noise Section 3.2.1, to mitigate potential noise effects, all construction activities will be carried out in compliance with municipal noise by-laws. No construction activities will occur on Statutory Holidays, Sundays and at night as stipulated in respective noise by-laws without applicable by-law exemptions. General noise control measures as previously outlined under the noise section of this report will be implemented.

FortisBC will endeavour to limit access restrictions to businesses as much as possible, even if for short durations. As per the mitigation recommendation noted under Access Modifications and Restrictions Section 3.2.7, where access may be temporarily limited, construction plans will include measures to provide alternative access and procedures to limit the extent of access disruptions. FortisBC will provide advanced notification to businesses where access may be limited and provide information to operators to make alternative arrangements during access disruptions. FortisBC will work with the BIAs and municipalities to prepare management plans for access disruptions. Appropriate notifications and signage will be provided. If viable, alternative parking areas will be identified for local businesses. FortisBC will work with the local BIAs to identify the needs for these.

Net Effect

The project has the potential to result in a net positive impact to residents and businesses through the creation of additional employment and economic "spin offs" for local business owners. Improving the long-term natural gas supply to the area also has positive economic benefits. Some short-term disruption effects are possible but these are expected to be temporary and generally minor should the recommended mitigation measures be implemented. No long term negative effects will result.

3.2.12 Tourism and Recreation

Existing Condition

The main tourism and recreation facilities in the study areas include parks, green spaces, golf courses and trails. The following are located in the study areas:

Fraser IP

- Gladstone Riverside Park (2500 East Kent Street South, adjacent to the pipeline ROW along the western portion of the route);
- Riverfront Park (2750 East Kent Street South, adjacent to the pipeline ROW in the eastern portion of the route); and
- The Fraser River Trail is a multi-use pathway traveling parallel on the south side of the pipeline section through entire length of the Study Area.

Coquitlam IP

- Mundy Park (641 Hillcrest Street, adjacent to south side of pipeline for 1 km west of Mariner Way);
- Como Lake Park (686 Gatensbury Street, approximately 200 km south of eastern portion of pipeline);
- Burnaby Mountain Golf Course (7600 Halifax Street, Adjacent to north side of pipeline in Burnaby);
- Camrose Park (2766 Phillips Avenue, approximately 250 m south of the pipeline in Burnaby);
- Sunrise Park (Rupert Street, approximately 200 m south of pipeline in Vancouver);
- Rupert Park Baseball Diamond (Rupert Street and First Avenue East, adjacent to pipeline in Vancouver);
- Clinton Park (First Avenue East and Slocan Street, adjacent to pipeline in Vancouver);
- McSpadden Park (Victoria Drive, approximately 300 m south of pipeline in Vancouver);
- Garden Park (Templeton Drive, approximately 100 m south of pipeline in Vancouver);
- Grandview Park (Commercial Drive, approximately 400 m north of pipeline in Vancouver);
- Alice Townley Park (Woodland Drive, adjacent to western end of pipeline in Vancouver); and
- Mundy Park Trails (mixed-use trail system through Mundy park, adjacent to eastern end of pipeline).

Cape Horn to Coquitlam

Mundy Park is located adjacent to the northwest portion of the pipeline ROW. Mundy Park is a 178 hectare urban forest that provides a number of recreational amenities to both locals and tourists.

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Nichol to Port Mann TP Loop

- Invergarry Park (14400 Currie Drive, adjacent to the pipeline ROW in north-east portion of study area);
- Hawthorne Park (10503 144 Street, approximately 140 m east of the pipeline);
- Cedar Grove Park (10222 141 Street, approximately 400 m east of the pipeline);
- Forsythe Park (10730 139 Street, approximately 280 m west of the pipeline);
- Victoria Park (14310 King Road, adjacent to the pipeline ROW at northern end of pipeline);
- Green Timbers Urban Forest Park (14698 96 Avenue, approximately 200 m east of the pipeline); and
- Quibble Creek Greenway - multi use path traveling along hydro corridor from 106 Avenue to 140b Street.

Nichol to Roebuck TP Loop

- Queen Elizabeth Meadows Park (9374 134 Street, approximately 250 m north of the pipeline);
- Cottontail Tot-Lot (9352 132A Street, approximately 400 m north of the pipeline);
- Queen Mary Park (8972 Queen Mary Boulevard, approximately 300 m south of the pipeline);
- William Beagle Park (12944 92A Avenue, approximately 260 m north of the pipeline);
- Wildflower Greenway - multi use path traveling through the utility corridor ROW east of 134 Street;
- Wildflower Greenway entrance trail - multi use path intersecting pipeline east of 132 street; and
- Quibble Creek Greenway - multi use path traveling north-south through eastern end of the utility corridor ROW.

Potential Effect during Construction and Operation

The project has the potential to restrict access to recreational facilities located along the proposed routes including parks, golf courses and trails during the construction period. No impacts to these facilities are expected during operation as the pipeline is underground.

Proposed Mitigation

Access to the recreational facilities, including trails, will be maintained to the extent possible during construction. In the event that full access cannot be provided, alternative routes and appropriate detour signage will be installed in all locations where construction impedes the use of recreational trails. FortisBC will work with the local municipalities and land owners to provide proper notification to

residents and visitors of construction schedules and detours that may impact access to recreation facilities.

Net Effect

Some minor short term disruption effects are likely to users of the recreation spaces in proximity to the pipeline projects during construction. No long-term effects will result.

3.2.13 First Nation and Métis Communities

The LMSU pipelines do not cross any First Nation Reserves; however, are within 1 km of Coquitlam 2 reserve which belongs to Kwikwetlem First Nation, and 1.4 km from Coquitlam 1 also belonging to Kwikwetlem First Nation. Both of these reserves are east of Cape Horn to Coquitlam.

The LMSU proposed pipelines intersect the statement-of-intent boundaries for the following First Nations:

1. Tsleil-Waututh Nation (Burrard Band)
2. Squamish Nation
3. Musqueam
4. Katzie
5. Hul'qumi'num Tearty Group (Core and Marine)
6. Sto Lo

Further information regarding First Nation interests in the project areas will be collected during the First Nations engagement process.

3.2.14 Planning Policies

Existing Condition

Provincial, regional and municipal planning policies guide development in the Study Areas, including development of natural gas pipelines. The municipalities within which the projects occur have Official Plans and Zoning By-laws that must be adhered to by the proposed project. Provincial policies that apply include the BC Hydro Rights of Way Guidelines for the segments of pipeline proposed within BC Hydro utility corridors.

Potential Effect during Construction and Operation

Within the study areas, pipeline construction is required to conform to the policies of the various municipalities in which it is proposed to be located including Official Plans and Zoning By-laws. The project is also required to conform to provincial policy, specifically the BC Hydro Rights of Way Guidelines. No changes in planning policies are anticipated to be required as a result of the pipeline construction or operation.

Proposed Mitigation

FortisBC will comply with the requirements of the Official Plan policy and Zoning By-laws of the municipalities within which the project is being proposed as well as conformance with provincial plans that apply. FortisBC will work with municipal staff and BC Hydro staff to prepare construction and operation plans that meet the requirements of applicable planning policies.

Net Effect

No significant net effect is anticipated following implementation of the recommended mitigation measures.

4.0 CUMULATIVE EFFECTS

Cumulative effects assessment recognizes that while a particular project may not have a significant impact on the natural or social environment on its own, multiple projects of a similar nature that occur in the same area and over a similar period of time may cause more significant impacts. An example of a social impact from a cumulative effects perspective is the construction of multiple utility facilities (*i.e.*, telephone lines, natural gas pipeline, hydro transmission lines) and regular maintenance in the same road right-of-way within a short timeframe (*i.e.*, within a year). While the potential noise, dust, traffic disruption and other construction impacts may be acceptable from a social standpoint for a single project, cumulatively they may be unacceptable and could potentially impact business operations and/or reduce the enjoyment of personal property should the effects not be managed appropriately. In an effort to reduce the potential for cumulative effects, FortisBC will coordinate their construction schedule with local municipalities, where possible.

For the purposes of the assessment, cumulative effects are defined as:

- the combination and interaction of effects of the same project;
- the combination and interaction of the effects of this project with other projects; and
- the combined effects over time in the same space.

For pipeline projects, the potential for cumulative effects with other projects is greatest during the construction period. The study area for each of the LMSU pipeline projects is primarily urban in nature. There is the potential for various types of future projects to occur in the study area for each of the Projects including land development, upgrades to City infrastructure such as roads, and other utility projects. In its consultations with the study area municipalities, FortisBC will confirm the potential for other projects to be developed at the same time proposed for the LMSU pipeline projects. Should such other projects be identified, FortisBC will consider them in the planning and design of the system upgrades.

One other major project that Dillon did identify is the Kinder Morgan – Trans Mountain Expansion Project. The project includes 994 km of new 914.4 mm (outside diameter) pipeline (twinning) to be completed within the existing right-of-way corridor where practical. This project will transport oil from Alberta to the Vancouver harbour for international export. The new pipeline will carry 890,000 bbl/d of crude oil, refined and semi-refined products. Also included are 12 new pump stations and expansion of existing pump stations, additional storage capacity at existing storage terminals at various locations including Burnaby, BC and the expansion of Westridge Marine Terminal in Burnaby. The proposed

alignment of the Trans-Mountain pipeline crosses two sections of the FortisBC Lower Mainland pipeline project including:

- Coquitlam IP Project - between Lake City Way and Underhill Avenue along Broadway in Burnaby; and
- Nichol to Port Mann Project – within 50 m west of the intersection of 116A Ave and King Road in Surrey (near the Nichol to Port Mann end at the South Fraser Perimeter Road).

Subject to receipt of necessary approvals including the CPCN, Trans Mountain plans to begin construction in late 2015 and be completed by late 2017. Within this construction schedule there is the potential for the FortisBC pipeline project and the Kinder Morgan pipeline project to have overlapping project schedules, which has the potential to result in cumulative construction effects on the local community. Land use in the vicinity of these overlapping areas is primarily residential and industrial. These features could be affected by combined construction disturbance effects such as air, dust, noise and traffic related disruptions.

It is important to note, that given the number of high profile pipeline project proposed in BC at the time of this assessment, there is an underlying "anti-pipeline" sentiment that is prevalent within the general public. Confirmation of this sentiment and development of community education and outreach programs is expected to occur during the community consultation events.

FortisBC will work with the local municipality to determine if an overlap of construction activities for the two projects is likely, how the effects could be managed.

5.0 CONSTRUCTION AND MONITORING RECOMMENDATIONS

It is Dillon's recommendation that FortisBC employ the services of an Environmental Inspector (for the duration of this project) to be present during the construction of the pipeline. The Environmental Inspector will provide inspection of contractor environmental mitigation measures and respond to other environmental issues that may develop during pipeline construction. The Environmental Inspector should be familiar with pipeline construction techniques and applicable guidelines and standards.

The primary objective of environmental inspection is to determine the effectiveness of mitigation measures, inspect the construction site and to determine compliance with pertinent environmental legislation, regulations industry standards, and project permit conditions, including any notification requirements or conditions set by the regulator. Standard conditions of approval set by the regulator for FortisBC may include requirements to:

- Provide notifications of any material changes in construction or restoration procedures;
- Notify commencement and completion of construction and facility testing;
- Prepare file post-construction interim and final monitoring reports; and
- Apply a landowner complaint tracking system (which would be the responsibility of FortisBC lands staff.

The primary objective of environmental monitoring during construction is to oversee the natural and social environments to determine any adverse effects and to verify that the construction site is returned to pre-construction conditions as soon as possible. The purpose of post-construction monitoring is to ascertain the success of the restoration effort and mitigation measures. The knowledge gained from inspection and monitoring can be used in future projects to avoid or minimize similar problems that may arise. Monitoring reports also allow for the collection of quantitative data for the assessment of impacts, and to recommend mitigation measures for the future.

5.1 Pre-Construction

A number of activities should be undertaken prior to construction including:

- Acquisition of permits and approvals listed in Section 1.4 of this report;
- Environmental training for the contractor. This usually occurs with the construction manager and project foremen. The purpose of the training is to educate the construction crew on the location of sensitive environmental and socio-economic features and associated

mitigation measures. Other areas of concern along the rights-of-way are also to be reviewed in the field at this time; and

- A pictorial record of conditions is compiled to compare restoration efforts with pre-construction conditions.

5.2 During Construction

5.2.1 Environmental Inspector

The Environmental Inspector's responsibilities will be to monitor the construction with respect to the mitigation and monitoring recommendations outlined in this report, and that construction activities are carried out in compliance with permit conditions.

5.2.2 Spills Contingency Plan

A contingency plan for accidental spills should be developed. At a minimum, there should be spill kits on site and appropriate spills reporting made to provincial authorities as required. It is noted that FortisBC's *Generic Environmental Management Plan – Low to Medium Risk Projects, April 2011 describes prescribed procedures in* Section 6.12. The pipeline contractor will develop their own environmental management plan which will include procedures for spills response.

5.3 Post-Construction

5.3.1 Monitoring Reports

In order to assess the effectiveness of restoration programs within the rights-of-way used for pipeline construction and in keeping with the intent of local guidelines, environmental monitoring reports will be prepared, including Interim Monitoring Reports and a Final Monitoring Report.

5.3.1.1 Interim Monitoring Report

The following provides an outline of an Interim Monitoring Report:

- Describe the predicted impacts (including cumulative impacts) and mitigation measures;
- Compare predicted impacts with those that actually occurred, explaining the reasons for any deviations;
- Outline any changes in the proposed construction, monitoring or restoration procedures that took place during the project, and the reason for the changes;
- Discuss the effectiveness of the measures applied and indicate opportunities for improvement in future pipeline projects;
- Provide a log of complaints during construction and the actions taken in response; and
- Detail any instances where provisions of a local by-law have not been complied with and the reasons for such non-compliance.

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5.3.1.2 Final Monitoring Report

The following provides an outline of a Final Monitoring Report:

- Describe the condition of the rehabilitated right-of-way and actions taken subsequent to the interim report;
- Compare predicted and actual impacts (including cumulative impacts, mitigation measures, and explain any deviations which occurred;
- Report the results of any monitoring programs and analyses such as soil and water sampling, and make recommendations as appropriate;
- Discuss the effectiveness of the mitigation measures as well as the monitoring programs and indicate opportunities for improvement in future pipeline projects;
- Provide a breakdown of environmental costs incurred for the project. In particular, items of cost associated with specific measures related to pre-construction, construction or restoration should be described;
- Provide a log of complaints received during construction and the actions taken in response (responsibility of Lands Personnel; and
- Include instances where the provision of any local by-law has not been complied with and the reasons for such non-compliance.

The Final Monitoring Report should also address any potential cumulative effects that may arise for pipelines such as reduced soil productivity, land use restrictions due to increased easement widths or additional above ground facilities and/or the repeated construction through sensitive areas.

6.0 SUMMARY AND CONCLUSION

This assessment of socio-economic effects of the LMSU projects proposed by FortisBC confirms that with the implementation of the proposed mitigation measures, monitoring and reporting plans, the projects is expected to have no negative, long-term effects on the socio-economic conditions in the Study Area. However, at selected locations (primarily associated with the Coquitlam IP Section) the project will result in temporary disturbance to vehicular traffic and will temporarily eliminate areas of residential and commercial street parking. Temporary disturbances will be mitigated by development and implementation of a Traffic Management Plan. Assessed environmental effects are expected to be temporary and managed through implementation of appropriate mitigation measures.

This Study considered the existing and planned socio-economic environment and how the construction and operation activities related to the proposed LMSU Projects would interact and affect those conditions. The resulting recommendations for mitigation efforts, monitoring and reporting are based on industry best practices and applicable requirements of local regulations.

FortisBC will continue to work with the local stakeholders, agencies and the public to effectively understand and address the needs of the community and coordinate the construction and operation plans.

Appendix C

PUBLIC CONSULTATION

Appendix C-1

COMMUNICATIONS AND CONSULTATION PLAN

FortisBC Energy Inc.

Lower Mainland Natural Gas Pipeline Upgrades

Communication and Consultation Plan

March 4, 2014

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1. OVERVIEW

FEI has completed the initial stage of developing a consolidated infrastructure sustainment program that will address a number of identified integrity and security of supply issues. The results of this study will be used to initiate a series of inter-related projects that resolve the following issues:

- approaching end of service life for the Coquitlam Intermediate Pressure pipeline, which is 54 years old;
- seismic resistance deficiency on the Fraser to Marine & Elliott Intermediate Pressure pipeline;
- specific security of supply vulnerabilities and operational flexibility limitations where disruption of a single pipeline will result in loss of service to large numbers of customers; and,
- pipeline stress as a result of soil movement.

The Lower Mainland Infrastructure Projects includes replacement or looping of six significant pipeline sections to proactively resolve integrity specific, operational flexibility and security of supply issues. This requires installing up to 34 kilometres of pipe ranging in size from 610 mm to 1067 mm and operating at pressures between 1200 kPa and 4000 kPa. These include:

- Coquitlam IP: Replacing 20 kilometres of 508 mm pipeline with 762 mm pipeline in Coquitlam, Burnaby and Vancouver between Coquitlam Station and 2nd & Woodland Station together with above ground valve stations (Coquitlam IP) to address the projected end of service life of the existing pipeline and to provide security of supply that will enable replacement of the Fraser Station to Marine & Elliott Station pipeline (see below);
- Fraser IP: Replacing 700 metres of 762 mm pipeline in Vancouver with a new pipeline of similar size between Fraser Station and Marine & Elliott Station (Fraser IP) to support improving seismic resistance to current standards;
- Nichol-Port Mann: Installing approximately 5000 metres of 914 mm pipeline in Surrey between Nichol Station and the Port Mann crossing (Nichol – Port Mann) parallel to and in the same Right of Way as the existing 610 mm pipeline to enable In-line Inspections of the existing Fraser River marine crossing and to meet forecasted long term growth in core demand, as well as provide adequate security of supply to the Coquitlam to 2nd & Woodland pipeline;
- Cape Horn-Coquitlam: Installing approximately 4600 metres of 914 mm pipeline in Coquitlam between Cape Horn Station and Coquitlam Station (Cape Horn – Coquitlam) to provide adequate security of supply to the Coquitlam to 2nd & Woodland pipeline;
- Nichol-Roebuck: Installing 1700 metres of 1067 mm pipeline in Surrey between Nichol Station and Roebuck Station (Nichol – Roebuck) to provide adequate security of supply

to customers in Surrey, Delta, Richmond and Vancouver currently supplied through a single 610 mm pipeline; and,

The completion of these projects ensures the continued safe and reliable supply of natural gas to FEI customers in the Lower Mainland area.

FEI expects to submit an Application for Approval of Certificates of Public Convenience and Necessity (CPCNs) to the British Columbia Utilities Commission (BCUC) for the upgrades in Q3, 2014. Approval for the project is expected in Q1, 2015 with project construction beginning in 2016 or 2017.

2. PUBLIC ENVIRONMENT

Given FEI's overall reputation and track record as a safe reliable supplier of natural gas, these upgrades represent an opportunity to reinforce the fact that FEI is British Columbia's leading energy company, which operates to the highest standards including good work practices, environmental management, stakeholder relations and First Nations relationships. To date, the feedback received on the planned upgrades has largely been positive.

Key benefits of the upgrades include:

- Ensuring security of supply for customers
- Community benefits - legacies:
    - Community gardens
    - Parks and playground equipment
    - Green space
- Using local contractors
- Increasing the use of local services, such as restaurants and hotels
- Improving cost effectiveness for customers due to enhanced system reinforcement

While the benefits are clear, these upgrades are being planned at a time when public interest in energy issues and pipelines is fairly high. Additionally, the public expectation for meaningful consultation and engagement is growing. At the same time, given the nature of the upgrades, there will be a host of community and regulatory issues as well as potentially First Nations issues that could arise.

Among the issues identified to date:

- Community specific:
    - Traffic disruption
    - Noise and dust impacts associated with construction

- Economic impact on businesses who may be affected as a result of construction
- Quality of site restoration and remediation
- Visual impairment of above ground facilities
- Customer rate impact
- Right of way access
- Water crossing impact

- Permitting:
  - Role of BCUC and Oil & Gas Commission (OGC)
  - Municipal permitting for use of public roads
  - Coordination of Cities of Vancouver, Burnaby and Coquitlam to all agree on an alignment for the Coquitlam IP pipeline
  - Obtaining approval from BC Hydro for use of joint BC Hydro/FEI right of ways
  - Obtaining approval from Government agencies, such as Ministry of Environment, Department of Fisheries and Oceans, Transport Canada and the Agricultural Land Commission
- First Nations
  - First Nations referrals, if required
  - TBD
- Province-wide issues:
  - Debate and public perception around pipelines, such as Northern Gateway and Kinder Morgan, two proposed exporting pipeline projects
  - LNG debate
  - Natural gas vs. municipal carbon reduction targets
  - Municipal election year

Identified public issues will be updated throughout the communication/engagement process.

3. AUDIENCES

- Municipal governments
  - City of Vancouver
    - Mayor and Council
    - City Manager
    - Municipal staff

- City of Burnaby
  - Mayor and Council
  - City Manager
  - Municipal staff
- City of Coquitlam
  - Mayor and Council
  - City Manager
  - Municipal staff
- City of Port Coquitlam
  - Mayor and Council
  - City Manager
  - Municipal staff
- City of Surrey
  - Mayor and Council
  - City Manager
  - Municipal staff

- Community associations and organizations
  - Boards of Trade/Chambers of Commerce
  - Business Improvement Associations
  - Neighbourhood Groups
  - Community Associations
  - Consumer/Ratepayer-based organizations
  - TBD
- FEI customers and public services impacted by construction
  - Residential (per OGC requirements, see Appendix I)
  - Commercial (per OGC requirements, see Appendix I)
  - Public services TBD
- Regulators
  - BCUC
  - OGC
  - BC Hydro

- BC Ministry of Environment
- Agricultural Land Commission
- Federal Department of Fisheries & Oceans
- Transport Canada

- Metro Vancouver
- First Nations
  - Kwikwetlem First Nation
  - Tsawassen First Nation
  - Semiahmoo First Nation
  - Musqueam First Nation
  - People of the River Referrals Office
- ENGOs and special interest groups
  - Recreational users of specific parks (TBD)
  - Additional special interest groups TBD
- Provincial government
  - BC Ministry of Energy & Mines
  - BC Ministry of Natural Gas Development
  - BC Government MLAs
    - Suzanne Anton, Liberal MLA Vancouver-Fraserview, Minister of Justice and Attorney General
    - Linda Reimer, Liberal MLA, Port-Moody Coquitlam
    - Doug Horne, Liberal MLA, Coquitlam-Burke Mountain
    - Richard Lee, Liberal MLA, Burnaby North
- Opposition MLAs
    - Bruce Ralston, NDP MLA, Surrey Whalley
    - Selina Robinson, NDP MLA, Coquitlam-Maillardville
    - Jane Shin, NDP MLA, Burnaby-Lougheed
    - Shane Simpson, NDP MLA, Vancouver Hastings
    - Jenny Kwan, NDP MLA, Vancouver Mount Pleasant
    - Mike Farnworth, NDP MLA, Port Coquitlam
    - John Horgan, NDP MLA, Energy Critic

        - Andrew Weaver, Green Party MLA
- Federal government MPs
    - Nina Grewal, Conservative MP, Fleetwood-Port Kells
- Opposition MPs
    - Jasbir Sandhu, NDP MP, Surrey North
    - Kennedy Stewart, NDP MP, Burnaby-Douglas
    - Libby Davies, NDP MP, Vancouver East
    - Finn Donnelly, NDP MP, New Westminster-Coquitlam

4. BUSINESS OBJECTIVES

This plan is intended to help meet the following business objectives:

- Complete upgrades on time and on budget
- Maintain corporate reputation
- Negotiate agreements with landowners (including land purchases), municipalities, local agencies and Governments as required
- Meeting all regulatory consultation requirements

5. COMMUNICATIONS OBJECTIVES

This plan aims to meet the following communications objectives:

- Creating awareness of the upgrades, specifically within communities directly impacted by construction
- Ensuring balanced and objective information is provided to all stakeholders regarding the upgrades.
- Providing opportunity for public feedback and managing expectations regarding the feedback
- Seeking to - where possible - address stakeholder concerns, and providing explanations when unable to do so
- Supporting company values of safety, environmental commitment, customer value and community in all communications, as appropriate
- Nurturing and developing project champions within stakeholder groups
- Reinforcing FEI's position as a leading energy provider
- Ensuring FEI's communication and consultation requirements are met.

6. STRATEGIC POSITIONING

These upgrades, though linked, should not necessarily be branded as one project as it carries the potential of making the overall initiative a target for those with concerns about energy issues and/or groups opposed to pipelines. Positioning the upgrades as operational infrastructure improvements within the Lower Mainland is likely to carry less reputational risk than if upgrades were branded under a single umbrella.

7. STRATEGIC CONSIDERATIONS

A strategic decision needs to be made regarding stakeholder engagement, specifically whether engagement will aim to provide information and a rationale for the upgrades, or whether engagement will allow the public to provide input into the upgrades and how that input will be considered by FEI.

8. GUIDING PRINCIPLES & STRATEGIC APPROACH

As these upgrades intersect various municipal boundaries, traversing through scores of neighbourhoods, communities and public spaces such as schools, community centres and hospitals, the associated issues will vary as will the level of public interest and engagement. As a result, a 'one size fits all' approach is not appropriate or recommended for an initiative of this scope.

Rather, the recommended approach should be:

- **Tailored** – to meet the specific needs of each community
- **Cascading** – dependent on communities, audiences and specific issues
- **Integrated and interdependent** – recognizing that all communications activities are integrated and not performed in isolation
- **Transparent** – stakeholders will need to know why routing decisions were made, which alternatives were considered
- **Inclusive** – due to the financial impact on ratepayers, a broad spectrum of stakeholders will need to be consulted

Overall, the strategy is designed to be adaptive, flexible and dynamic to ensure that it meets the needs of the various audiences directly and indirectly impacted by the upgrades.

9. TACTICS

In line with the guiding principles of the plan and the recommended approach, the following tactics can be tailored to the unique response from the communities impacted by the upgrades.

	Low	Medium	High
Consultation & engagement*	• Information letters and newsletters • Mail drop to residents within a specific radius (e.g. 1.5km) • Phone calls and emails to key stakeholders • Project information line • Develop and implement stakeholder/issues management tracking system	• Polling • Direct outreach to private landowners • Private meetings with key stakeholders • Community signage • Letters and/or other communications to stakeholders pursuant to OGC requirements	• Focus groups • Stakeholder & community meetings • Open houses • Community Workshops/Roundtables • Community Offices • Mall displays • Telephone town hall • Mobile community office following construction route
Government relations: municipal, provincial, federal	• Information letters	• Face-to-face meetings	• Advocacy request • Third party validation
Regulatory			• Fulfill all regulatory requirements at the municipal, provincial and federal level
Digital	• Website updates	• Social media engagement • Dedicated project website • Dedicated Twitter handle	• Dark site (crisis communications)

	Low	Medium	High
Earned media	• Reactive media relations in response to queries stemming from special interest groups, customer advocacy groups, customer rate impacts (full Q&A document to be developed)	• Correcting errors and misinformation	• Proactive media relations, interviews, op-eds, letters to the editor • Key messages targeted to specific communities • Site visits for select media
Paid media	• Notification of information sessions, such as open houses	• Public notification, such as construction updates, scope of project, traffic impacts • Targeted reach via community/ethnic newspapers	• Awareness ad campaign • Broad reach via radio, TV and daily newspapers
Employee communications		• Posting construction updates on intranet platform	
First Nations engagement As the upgrades do not impact Aboriginal or Crown lands, notifications and consultation pursuant to the OGC are not required. However, consistent with FEI's commitment, the company will inform various Bands and Nations impacted by the upgrades.	• Letters and phone calls	• Face-to-face meetings	• Community roundtable

	Low	Medium	High
Community investments FEI will need to determine the level and extent of its community investment to ensure they are consistent with FEI principles, with a view to maximizing benefits, but without increasing the public profile of the upgrades	• TBD in consultation with municipalities and the public and FEI principles	• TBD in consultation with municipalities and the public and FEI principles	• TBD in consultation with municipalities and the public and FEI principles
Crisis communications			• As per FEI crisis protocols

*Consultation/engagement activities need to take into consideration the various language requirements of community groups along the pipeline route. These could include, but are not limited to, the following:

- Chinese Canadians
- Korean Canadians
- Indo Canadians

10. COLLATERAL

The plan requires a bank of collateral to assist in creating awareness of the upgrades and providing objective information. The following is a wish list of materials and, in line with the tailored and cascading approach, many pieces of collateral will be developed as and when they are required.

- Stakeholder- and customer-facing collateral
  - Information letters
  - Fact sheet (existing)
  - Backgrounder
  - Newsletter
  - 4-page customer pamphlet, including FAQs
  - Infographic
  - Images, e.g. cross-section of land/pipe
  - Videos
  - Open house storyboards (as required)
  - Maps outlining the pipeline route
  - Stakeholder/issues tracking system
  - Population data, historic and future
  - Dedicated project website
- Media materials
  - Media Q&A
  - Letters to the editor (as required – issue-specific)
  - Op-eds (as required – issue-specific)
  - Maps outlining the pipeline route
- Employee materials
  - Website content
  - Employee talking points summary document
  - Presentations

11. KEY MESSAGES

- FEI is upgrading its Lower Mainland pipeline system to ensure our customers continue to have reliable access to clean natural gas.
    - FEI conducted the initial stage of a consolidated infrastructure sustainment program in 2013 and identified a number of integrity and security of supply issues.
    - Issues include end of life service, with the Coquitlam Intermediate Pressure pipeline reaching 54 years in service; seismic resistance deficiency on the Fraser to Marine & Elliot Intermediate Pressure pipeline; and general pipeline stress as a result of soil movement.
- This $200-million plus upgrade will replace 32km of existing pipeline which is over 50 years old with larger, newer pipe to meet the future needs of our customers in Surrey, Coquitlam, Burnaby and Vancouver. The upgrades will:
    - Replace 20 kilometres of 508 mm diameter IP pipeline with a 762 mm diameter pipeline between Coquitlam and Vancouver (called the “Metro IP pipeline”) which is over 50 years old and now approaching end of service life in order to provide adequate security of supply to customers in Coquitlam, Burnaby and Vancouver.
    - Replace 700 metres of 762 mm diameter IP pipeline with a pipe of the same size in Vancouver between Fraser Station and Marine & Elliott Station (called the “Fraser IP pipeline”) to improve seismic resistance to current standards.
    - Install approximately 5,000 metres of 914 mm diameter pipeline in Surrey between Nichol Station and the Port Mann crossing of the Fraser River (called the “Nichol – Port Mann pipeline”) in order to enable in-line inspections of the existing Fraser River marine crossing and to meet forecasted long term growth in core demand as well as to provide adequate security of supply to Coquitlam.
    - Install approximately 1,700 metres of 1,067 mm diameter pipeline in Surrey between Nichol Station and Roebuck Station (called the “Nichol – Roebuck pipeline”) to provide adequate security of supply to customers in Surrey, Richmond and Vancouver.
    - Install approximately 4,600 metres of 914 mm diameter pipeline in Coquitlam between Cape Horn Station and Coquitlam Station (called the “Cape Horn – Coquitlam pipeline”) to provide adequate security of supply to the Metro IP pipeline.
- FEI will consult/engage with stakeholders to ensure the public understands the reasons for the upgrades, the alternatives that were considered and what mitigation measures are planned to deal with construction-related issues. Additionally, stakeholder engagement aims to create awareness around the community benefits of the upgrades, including local economic benefits as well as legacy projects.

- Construction jobs TBD
- Using local services such as restaurants, hotels and material suppliers
- Potential upgrades to public space such as community gardens, green space and parks and playground equipment

- FEI is committed to meeting or exceeding rigorous safety standards and trains its employees to work to the highest safety standards possible.
  - FEI has emergency plans in place and conducts regular emergency exercises, often including outside emergency response personnel from the City of Burnaby, as follows:
    - Mayor and Council
    - City Manager
    - Municipal staff
  - Police and fire departments.

FEI is regulated by the Oil & Gas Commission and must meet stringent safety standards when constructing and operating pipelines.

12. PROJECT TIMELINE

- The tentative schedule for filing an application for the required CPCN follows:
  - Coquitlam IP Q4, 2014
  - Fraser IP Q4, 2014
  - Nichol – Port Mann Q4, 2014
  - Cape Horn – Coquitlam Q4, 2014
  - Nichol – Roebuck Q4, 2014
- The current scheduled dates for each project follows:
  - Metro IP 2016
  - Nichol – Port Mann 2016
  - Cape Horn – Coquitlam 2016
  - Nichol – Roebuck 2016
  - Fraser IP 2017

All projects are scheduled to be completed and in service by 2018.

13. CRITICAL PATH

Activity	Responsibility	Timing	Status
Communications and stakeholder plan			
Finalize plan	Gord Schoberg	March 6, 2014	Complete
Present and seek approval of plan from executive *PowerPoint slide deck to be developed for presentation to FEI Executive team	Gord Schoberg	March 6, 2014	Complete
Consultation & Engagement			
Develop/refine stakeholder lists by community	Gord Schoberg	September 2013	Complete
Determine consultation timelines	Gord Schoberg	September 2013	Complete
Develop and implement tracking system for stakeholder outreach including timelines, issues classification, stakeholder type and proposed mitigation strategies	Gord Schoberg	September 2013	Complete
Identify local authorities that need to be notified, e.g. BC Hydro, Metro Vancouver	Gord Schoberg	September 2013	Complete
Identify impacted landowners, renters, lessees and holders of other legitimate interests to comply with OGC notification requirements	Chris Coady	September 2013	Complete
Identify collateral (existing and to be developed), such as fact sheets, backgrounders, newsletters, FAQs, storyboards, media Q&A, infographic, videos	Grace Pickell	April 2014	Complete
Overlay community demographics over map of pipeline route	Gord Schoberg	May 2014	In progress (Socio-Economic Study)
Government relations			
Identify applicable municipal, provincial and federal government elected and staff officials that need to be notified	Gord Schoberg	September 2013	Complete
Regulatory			

Activity	Responsibility	Timing	Status
Municipal operating agreements	Gord Schoberg	September 2013	Complete
Statutory right of way agreements	Chris Coady	September 2013	Complete
Road permits or licenses	Chris Coady	September 2013	Complete
Agreements with local authorities, such as the Real Property Operating Agreement with BC Hydro	Chris Coady	September 2013	Complete
Permits authorizing third party use of FEI right of way	Chris Coady	September 2013	Complete
Review statutory right of way agreements to ensure rights to install additional pipe	Chris Coady	September 2013	Complete
Other permits or documentation relevant to the Project	Chris Coady	September 2013	Complete
Obtain clarity from OGC regarding consultation & engagement requirements	Stacie Susheski	June 2014	In progress
Develop consultation / engagement line list and First Nations engagement log in compliance with OGC and BCUC	Gord Schoberg	September 2013	Complete
Develop line list of directly affected properties	Chris Coady	September 2013	Complete
Digital			
Ongoing social media monitoring	Grace Pickell	TBD	In progress
Determine digital needs and level of engagement	Grace Pickell	TBD	In progress
Determine resource needs	Grace Pickell	TBD	In progress
Earned media			
Ongoing media monitoring	Grace Pickell	TBD	In progress
Determine spokesperson(s)	Grace Pickell	TBD	In progress
Refine key messages	Grace Pickell	May 2014	In progress
Develop supporting materials, including letters to the editor and op-eds	Grace Pickell	TBD	In progress
Paid media			
Determine need for and scope of any paid media	Grace Pickell	TBD	In progress
Determine materials, which could include: website updates, employee talking points, presentations and	Grace Pickell	TBD	In progress

Activity	Responsibility	Timing	Status
key messages			
Identify affected First Nations and determine level of engagement	Bruce Falstead	November 2013	Complete
Identify potential community investments along pipeline route	Gord Schoberg	June 2014, then refined over life of project	In progress

APPENDIX 1

1. REGULATORY REQUIREMENTS

The following are the regulatory consultation/notification requirements that FEI must meet:

1.1 *OIL & GAS COMMISSION (OGC)*

Where applicable, notification of a project must be provided to the following groups located within 1500 metres of a FEI facility or 200 metres [quote section of Regulations] from the centre of the FEI pipeline statutory right of way or, in cases where no statutory right of way exists, then 200 metres from the pipeline [*quote section of regulations*]:

- Landowners
- Residents/renters
- First Nations
- Municipal Council
- Government of Canada
- Local Authorities
- Provincial Ministries responsible for the Transportation Act and local municipal councils
- Rights holders

These groups must be provided with a description of each phase of a project which includes its potential impacts (traffic disruption, noise, dust, etc), mitigation measures planned, schedule of the project, a map of the location and notice that they can respond to FEI or the Oil & Gas Commission, and contact information to help them do so.

FEI will track consultation scope, concerns received and status consistent with OGC requirements:

Company Name:
Company File Number:
Application Type
Activity Type
Recipient Type
Recipient Name
Recipient Address
Engagement Type
Construction Plan Map No.
Deemed Received Date

Method of Service
Estimated Distance to Recipient
Summary of Engagement
Outstanding Concerns
Recipient Contact Information
Written Submission
Was a written submission received? (Y/N)

1.2 *BRITISH COLUMBIA UTILITIES COMMISSION (BCUC)*

Public Consultation documentation required by the British Columbia Utilities Commission for a Certificate of Public Convenience and Necessity (CPCN) submission is as follows:

- Overview of the project setting and the parties that will be impacted
- Description of the information and consultation programs undertaken with stakeholders and the public
- Description of any issues or concerns raised during consultation, and an explanation of measures taken to address the concerns and an overview of sufficiency of public consultation process to date
- Community, social and environmental
- Outstanding issues or concerns
- Documentation and evidence supporting consultation efforts

1.3 *LOCAL GOVERNMENT ENGAGEMENT*

1.3.1 City of Surrey

- Meet with City staff (Director of Engineering) and obtain a permit to construct and operate pipe in public roads and on City owned right of way.

1.3.2 City of Port Coquitlam

- Meet with City staff regarding impact on traffic and public roads.

1.3.3 City of Coquitlam

- Meet with City staff (Director of Engineering) and obtain a permit to construct and operate pipe in public roads.

1.3.4 City of Burnaby

- Meet with City staff (Director of Engineering) and obtain a permit to construct and operate pipe in public roads.

1.3.5 City of Vancouver

- Meet with City staff (Director of Engineering) and obtain a permit to construct and operate pipe in public roads.

Appendix C-2

SUMMARY OF PUBLIC CONSULTATION ACTIVITIES

Lower Mainland Natural Gas - Pipeline Upgrades Organization Contact Log

Interested Parties	Stakeholder type (agency, community, First Nations, municipal government, provincial government, federal government, media)	Type of Contact	Location	Date	Who was involved	Key Contact	Discussion	Issues raised	Issue type	Resolution/Action
Organizations:										
BC Hydro	agency	meeting		3-Dec-13	Melanie, John, Peter, Chris and Gord. From BCH: Gary Holisko and 9 others	Gary Holisko (Mgr, Property Rights Services) or Kim Proudlove (Property Rep)	Main issues will concern working together to establish an alignment for the new pipe as well as technical conditions relative to induction	Joint use of right of way: BCH may also have plans to construct in the right of way; new regulations concerning induction	powerline induction; joint use of right of way	ongoing
BC Hydro (Metro North Project)	agency	meeting		9-Jan-14	Melanie, Peter, Gord, Judy Dobrowolski, Antigonie	Judy Dobrowolski	We shared our respective plans for pipeline / powerline upgrades in Coq/Bby/Van	None, however we agreed we would coordinate work together where possible, and keep each other apprised of project planning progress	project coordination	Meeting was held on January 9th
Kinder Morgan Canada (Trans Mountain)	agency	e-mail		17-Dec-13	Michael Davies, Gord Schoberg, Lizette Parsons-Bell	Patrick Hanrahan	KMC pipeline routing relative to FEI Project		project coordination	
Kinder Morgan Canada (Trans Mountain)	agency	meeting	Joey's Restaurant, Lougheed Hwy, Coquitlam	5-May-14	Stephanie Snider, Lexa Hobenshield and Gord Schoberg	Stephanie Snider and Lexa Hobenshield	Stephanie and Lexa are interested in knowing when our Public Information Sessions will be held; they suggested I speak to the Transportation Committee of VBoT; they suggested I obtain a bird/tree study being prepared for City of Vancouver	Potential cumulative impacts of constructing projects within the same year	project coordination	Ongoing communication required
Kinder Morgan Canada (Trans Mountain)	agency	meeting	FortisBC Surrey office	June 19,2014	Lexa Hobenshield, Patrick Hanrahan, Melanie Kilpatrick, John Quinn, Gord Schoberg		Reviewed Trans Mountain proposed alignment; talked about construction timelines; the need to collaborate together given our similar construction timelines	cumulative impacts of both our projects being constructed potentially during the same construction window	cumulative impacts of construction on neighbourhood disruption	regular meetings to update each other on schedule and issues
Kinder Morgan Canada (Trans Mountain)	agency	meeting	Surrey restaurant	27-Jun-14	Greg Toth, Senior Director Trans Mountain Expansion Project, and Gord Schoberg	Greg Toth	municipal road crossing requirements.	Process for working with municipalities	municipal road crossings	none. Will continue to dialogue
Fraser Health Authority	agency	meeting		Feb to June	Jim Riches (FHA), Gord Schoberg, Chris Coady	Jim Riches (now retired)	FHA parking lot extending over FEI pipeline at Surrey Memorial Hospital	Significant cost by FHA to excavate, inspect and test FEI existing pipeline prior to parking	right of way use for parking lot	FHA is postponing parking lot construction in the hope that FEI new pipeline construction will reduce cost to FHA
Fraser Health Authority	agency	meeting			Jim Riches, Gord Schoberg	Jim Riches (now retired)	Updated Jim about LMIP Project and schedule to apply for regulatory approval and construct new pipe	None, Jim appreciated the update, and will remain in a holding pattern regarding parking lot construction	right of way use for parking lot	None needed at this time.
TransLink	agency	meeting	TransLink office, 400-287 Nelson Court, New Westminster	9-Oct-14	Lea Van Dam, Jeffrey Busby, Ian Clements from TransLink, and John Quinn, Gord Schoberg, our pipeline engineer and traffic consultant	Lea Van Dam	John presented the LMSU project and the key discussion point was the proposed gas line crossing at Clark Rd in Burnaby	No issues, but would need a TransLink permit if we intend using TransLink owned property adjacent to the road on Clark.	none	none needed.
Metro Vancouver	agency	meeting		11-Feb-14	Gord Schoberg, Melanie Kilpatrick, John Quinn, Ken Ng, Cal Merry, Ron Nishimura, Dan	Cal Merry, and also Thomas Wu and Ron Nishimura	1. Dan will be the key contact for Worley Parsons re engineering 2. Cal suggested we have a contract which spells out the contacting and operating requirements when working near their facilities, and suggested FEI may need to pay for MV field inspections	Need to identify points of intersection between FEI project and MV facilities, then develop a contract	engineer pipeline crossings	Worley Parsons will work with MV to identify points of intersection with MV facilities

Interested Parties	Stakeholder type (agency, community, First Nations, municipal government, provincial government, federal government, media)	Type of Contact	Location	Date	Who was involved	Key Contact	Discussion	Issues raised	Issue type	Resolution/Action
Surrey Environmental Partners	community									
Bolivar Heights Community Assoc	community					Harold Barbour				Emailed info pkg Dec 19/13; requested response via email Feb 12/14
Downtown Surrey Business Improvement Assoc	community	meeting		6-Jan-14	Elizabeth Model, Gord Schboerg	Elizabeth Model	Asked what impacts (positive and negative) project would have on community. Will ask her Board if they want me to present to them.	none		Done. Meeting was held on January 6th
Downtown Surrey Business Improvement Assoc	community	presentation to Board		4-Feb-14	DSBIA Board		Gord presented project to 12 board members and they asked general questions about pipeline safety and business impact	none	pipeline safety; business impact	none
Whalley Community Assoc	community					Bonnie Burnside				Emailed info pkg Dec 19/13; requested response via email Feb 12/14; She was present at the Downtown Surrey BIA meeting.
Whalley Residents & Merchants Assoc	community					Gerry Morden				Meeting was scheduled for January 6; NO SHOW; Left message January 9 to reschedule; left message January 15; left message February 11
Whalley Community Advisory Association	community					Dave Amero				Spoke Dec 16; he will call back; phoned Jan 24 no answer; phoned Feb 11 no answer.
Green Timbers Heritage Society	community	e-mail		8-Jan-14	Gord Schoberg to Ellen Edwards	Ellen Edwards, President	Ellen inquired about the route of the pipeline near Green Timbers Park. I advised her the route would NOT go through the park.	none	pipeline routing	none
Green Timbers Heritage Society	community	meeting		28-Jan-14	Ellen Edwards, Jim Foulkes, Board member, Gord Schoberg	Jim Foulkes, Board Member	Wants updates of project development (Ellen prefers e-mail, Jim prefers phone)		pipeline routing	
Surrey Board of Trade	community	Luncheon sponsorship	Eaglequest Golf Course Banquet Room, 152nd St, Surrey	7-Mar-14	Gord Schoberg, Melanie Kilpatrick and John Quinn presenting	Anita Huberman	Fortis sponsored the SBOT "Pipeline Industry Series Part 4" to present the Project	Most questions were Fortis related however ancillary to the project, such as NGT, local contracting opportunities, RNG	none	Done. Presentation to 80-100 members was held on March 7th
Tri Cities Chamber of Commerce	community	meeting		20-Feb-14	Gord Schoberg, Joan Isac and Michael Hind	Michael Hind	Good general discussion, and Michael suggested we meet with the Mayor of Port Coquitlam, and he asked about business and contracting opportunities, as well as how we intend communicating with businesses with respect to access during construction	none	business impact	set up meeting with Mayor Greg Moore

Interested Parties	Stakeholder type (agency, community, First Nations, municipal government, provincial government, federal government, media)	Type of Contact	Location	Date	Who was involved	Key Contact	Discussion	Issues raised	Issue type	Resolution/Action
Burquitlam Community Association	community	meeting		9-Jan-14	Gord Schoberg, Joan Isac, and 11 Board members	Don Violette, President	After presenting project update there were several general questions about pipeline integrity, our planning, regulatory approval, effect on rates etc. subsequent to the meeting Cynthia MacKay e-mailed and asked to post our material on their website, to which I agreed.	No issues about direct impact on their community, but lots of general questions.	pipeline safety; construction practices; neighbourhood disruption; business impacts	They suggested I develop a distribution e-mail list to keep everyone updated with respect to planning progress Emailed info pkg Dec 19/13 to Graham Hill
Ranch Park Community Association	community									
Oakdale Neighbourhood Association	community	meeting		20-Feb-14	Gord Schoberg, Joan Isac, Ben Craig and four other members of the Board	Ben Craig	Good general discussion and questions raised about why the City would not be conducting open houses to invite public comment; pipeline safety and pipeline spec details and who will pay for pipeline and how much will add to customer bills	See discussion notes	pipeline safety; public consultation; pipeline specifications; cost	Emailed info pkg Dec 19/13; Spoke on Feb 12 - working on getting information out to his board members; will call back to set up a meeting with either himself or with other members - sent info pkg again.
South East Coquitlam Ratepayers Association	community									
Mundy Park Community Association	community					Harry Warren				Not too concerned; glad to hear we're updating our systems; will call back if there are any concerns; Emailed info pkg Feb 13.
Austin Heights Business Improvement Association	community	e-mail		16-Dec-13	Erin Davidson, Gord Schoberg	Erin Davidson	Erin requested information about the project and will let us know if their group wishes to discuss it further. Erin was send our info package and then advised the group is not concerned since it doesn't impact them.	none		Spoke on Dec 16/13;She is not too concerned with the proposed pipeline upgrade and doesn't feel it will impact her community. Gord sent her information pkg.
North East Burnaby Community Association	community					Karen Agabob				Not too concerned, will not impact us directly; info pkg was sent via email Jan 27, will get back to us if there are concerns.
Burnaby North Community Association	community					Olaf de Shield				Emailed info pkg Jan 14/14; requested response via email Feb 12/14
Burnaby Board of Trade	community	meeting		4-Feb-14	Gord Schoberg, Joan Isac and Paul Holden	Paul Holden	Gord presented the project specifics and mentioned that FEI would be meeting individually with Burnaby business owners and would consider a presentation to the BBoT at a luncheon. Paul appreciated the update.	none	public communications; signage during construction; business impacts	Done. Meeting was held on February 4th.

Interested Parties	Stakeholder type (agency, community, First Nations, municipal government, provincial government, federal government, media)	Type of Contact	Location	Date	Who was involved	Key Contact	Discussion	Issues raised	Issue type	Resolution/Action
Burnaby Board of Trade	community	meeting	Burnaby Board of Trade office, Kingsway, Burnaby	15-May-14	Gord Schoberg, Joan Isac, Paul Holden and 10 business people who registered for the workshop		Gord presented the details of the LMSU with a focus on impacts and opportunities with the Burnaby business community.	Does Fortis have a plan to hire local contractors? Has Fortis engaged the Kwikwitlem First Nation? Questions about the nature of construction (trees impacted, width of trench, abandoning pipe, gas disruption during construction)	job opportunities	Fortis needs to build a skills matrix to catalogue interest in contracting / providing services
North Road Business Improvement Ass'n	community	meeting	9912 Lougheed Hwy, Burnaby	5-Mar-14	Carolyn Orazietti, Gord Schoberg and Joan Isac	Carolyn Orazietti, ED	Carolyn provided guidance in how to work with the Korean Business Community, many of which are members of her BIA, and she suggested we write an article in her quarterly publication "North Road Burnaby BIA" Newsletter.	none, but Carolyn invited Fortis to introduce the project in her April / May edition of the BIA newsletter. Carolyn also suggested we meet with Benjamin Nelson, Shape Properties concerning the Lougheed Mall redevelopment [redacted] She also suggested we may wish to use a Korean UBC intern student by contacting [redacted] at [redacted]	communications	Meeting was held on March 5th.
Burnaby Heights Merchants Association	community	meeting	4419 E Hastings St	4-Apr-14	Isabel Kolic, Joan Isac and Gord Schoberg	Isabel Kolic	Isabel has no problem with the FEI pipeline project since it will not directly impact Hastings St merchants. I told her the only impact would be traffic detours for commercial traffic and also residential traffic. There could be a net benefit to the area with regard to restaurants / hotels etc.	none		Meeting was held April 4th
Brentwood Town Centre Mall	community					Emma Fyfe				Phoned Dec 16/13 left vm; phoned Jan 27 left vm; phoned Feb 11 emailed info pkg.
Lougheed Town Centre Mall	community					Doug Snow				Not too concerned, will not impact us directly; info pkg was sent via email Jan 27, will get back to us if there are concerns.

Interested Parties	Stakeholder type (agency, community, First Nations, municipal government, provincial government, federal government, media)	Type of Contact	Location	Date	Who was involved	Key Contact	Discussion	Issues raised	Issue type	Resolution/Action
Commercial Drive Business Improvement Assoc	community	meeting		6-Feb-14	Gord Schoberg, Amy Hennessey, Jane McFadden	Jane McFadden, ED	1. Jane will invite BIA to our open house 2. Wants to know how our meeting with GWRA and Jac King goes 3. Public thought recent open houses were a sham, and workshops would be better venue to engage public - possibly in April 4. Business wont attend open houses 5. Public will want to know how long construction will take 6. consider using a travelling communications van for public to engage with 7. Don't dig up road near June 1, Italian Days 8. FEI should consider helping sponsor Italian Days and use as opportunity to communicate with public 8. BIA workshops: coordinate with Jane around other topics 9. Send Jane soft copy of collateral information 10. Consider using PlaceSpeak or other electronic bulletin boards to communicate 11. Business community needs fire extinguishers 12. BIA has 600 members w/ 400 ground level retail covering 26 blocks 13. FEI should consider sponsoring a Crime Prevention workshop		meaningful consultation with public and business; address language barriers; sponsor community events; online communication	1. Let Jane know how the meeting goes with Jac King 2. Consider sponsoring Italian Days 3. Begin planning workshops for BIA and general public through Jane 4. Send Jane our collateral material 5. Consider sponsoring other events in neighbourhood, such as Crime Prevention workshops
Commercial Drive Business Improvement Assoc	community	meeting	Commercial Drive BIA		Nick Pogor and Gord Schoberg	Nick Pogor	Nick replaced Jane as ED effective May 1, 2014 and I will send Nick our fact sheet and map and arrange a meeting to discuss how to approach planning our Community Meetings			
Hastings North Business Improvement Assoc	community	meeting		7-Jan-14	Patricia Barnes, Gord Schboerg, Clair MacGougan (Hastings Sunrise Community Policing [redacted]	Patricia Barnes, ED	Construction will not impact BIA, however Patricia suggested we contact Grandview Woodland Area Council, Frog Hollow and School PAC's	none	public consultation	Done. Meeting was held on January 7th.
Hastings Sunrise Community Policing	community	meeting		7-Jan-14	Clair MacGougan, Executive Director, and Gord Schoberg	Clair MacGougan	Discussed project along with Patricia Barnes, and he has no particular concerns	none	public consultation	none

Interested Parties	Stakeholder type (agency, community, First Nations, municipal government, provincial government, federal government, media)	Type of Contact	Location	Date	Who was involved	Key Contact	Discussion	Issues raised	Issue type	Resolution/Action
Hastings Crossing Business Improvement Ass'n	community	meeting		26-Feb-14	Gord Schoberg, Wes Regan	Wesley Regan, ED	No direct impact on BIA members, however suggested we connect with Embers regarding local employment on the project. He asked whether we have labour procurement targets, and mentioned that local developers had worked cooperatively with them in this regard. They work with UDI and several First Nations organizations regarding job opportunities.	Consider how to include local job opportunities in the project	job opportunities	consider how to include local job opportunities in project Meeting was held on Feb 26th
Grandview Woodland Area Council (GWAC)	community	e-mail (February 12, 2014) and telephone conversation (February 13, 2014)			Gord Schoberg and Jak King	Jak King, President; Brittannia Community Centre, [redacted]	1. e-mail: Jak is not in favor of increasing pipelines in BC and he sees no value in meeting. 2. telephone call: I explained the nature of the pipeline upgrade project and the reason we need to increase the size of the metro IP pipeline. Jak agreed to receive more information, but declined a meeting. I left the offer of meeting open.	Jak is not in favor of increasing pipelines in BC and does not want to meet.	no pipelines	Gord will send him the project map along with the fact sheet. Emailed info pkg Jan 14/14; requested response via email Feb 12/14; response received.
Vancouver Board of Trade	community					Rob MacKay-Dunn	Meet with Transportation Committee			
Frog Hollow Neighbourhood House (FHNH)	community	meeting	Frog Hollow, [redacted]	7-Apr-14	Gary Dobbin and Gord Schoberg	Gary Dobbin: [redacted]	Gary suggested connecting with Diane in his office to discuss possible neighbourhood legacies Fortis may consider leaving after construction; big issues will be trees and traffic which should be handled in Community Information Sessions. Gary understands why Fortis needs to do the work, however the neighbourhood will want to engage in a meaningful way, which means having input to key decision points like route selection.	Community legacies need to be determined and presented at Public Information Sessions and Community meetings. Big issues will be traffic and trees. Neighbourhood wants meaningful input.	Community legacies. Trees and traffic	Develop community legacy list and invite public input. Meeting was held April 7th
	community	meeting	Frog Hollow, [redacted]	11-Jun-14	Gary Dobbin and Diane; Gord Schoberg	Gary Dobbin: [redacted]	Gord had meeting at FHNH with Gary Dobbin and Diane. 1. LMSU legacies: FHNH provides social services to community. I mentioned our 4 pillar filter for investments. They will respond with possible legacy ideas by end of June. 2. FHNH have good community networks that can help us connect with the neighbourhood particularly in non-English speaking households.	3. FHNH expressed concern that we ensure continual pedestrian walkways are maintained through construction zones during construction.	Community legacies. Trees and traffic	
Governments:										
Local Governments:										

Interested Parties	Stakeholder type (agency, community, First Nations, municipal government, provincial government, federal government, media)	Type of Contact	Location	Date	Who was involved	Key Contact	Discussion	Issues raised	Issue type	Resolution/Action
City of Port Coquitlam	municipal government	meeting	City Hall, 2580 Shaughnessy St, Port Coquitlam	21-Mar-14	Gord Schoberg, John Leeburn (CAO), Greg Moore (Mayor)	John Leeburn	General introduction to the pipeline upgrades, however the project will not touch Port Coquitlam. The mayor suggested we try to coordinate construction with other utilities, and mentioned Metro Vancouver, if possible.	Construction coordination with other utilities.	construction coordination with other utilities.	The Mayor suggested we meet with Maria Greggs, Metro Vancouver Outreach Coordinator to share approaches to public engagement
City of Coquitlam	municipal government	meeting		1-Feb-13	Joan Isac, Gord Schoberg & Coquitlam staff	Dana Soong, Manager Utility Program, Infrastructure Mgmt. Division (or Eugene Motha, Eng. Tech.)			engineering	
City of Coquitlam	municipal government	Council meeting		25-Nov-13	Carol Greaves, Gord Schoberg, Coquitlam Municipal Council		5 minute presentation and 30 minutes of questions from Councilors	local contracting opportunities; impact on customer rates; challenges disrupting traffic on Como Lake Rd; license fees; taxes; expropriation potential	traffic disruption; taxes; local contracting opportunities; costs	work with staff to identify alignment for new pipe and permit conditions
City of Coquitlam	municipal government	phone call		27-Nov-13	Dana Soong		update on project planning and requested current fact sheet and map	Dana will be project key contact for now, but may change	engineering	none
City of Coquitlam	municipal government	meeting		28-Jan-14	Dana Soong, Mark Zabornial, Mgr, Design & Cst; Gord Schoberg, Melanie, Ken and John; and 10 Worley staff		1. Dana will brief Tracy Kyle, who is handling Trans Mtn and BCH files. 2. How much trench will be open at any one time? 3. Expressed surprise we didn't know about the project two years ago and installed sleeve under new Hwy 1. 4. We want AIP from City re route alignment, subject to detailed construction details 5. Dana wants full lane asphalt repair 6. Is there a risk the Manitoba incident could happen in Coquitlam? 7. One week approval turnaround and Dana will vet through Council		engineering	none
City of Coquitlam	municipal government	meeting	City of Coquitlam office	16-Jun-14	City of Coquitlam Engineering, Traffic and Parks staff; Fortis project team	Eugene Motha	City of Coquitlam's engineering comments after reviewing Fortis preferring routing	1. Work hours; construction speed; 2. transportation impacts involving garbage pick up, bus routes, emergency vehicles, school dro off traffic, resident access to properties 3. if we damage water / sewer need to replace from main to property line 4. future pathway improvement on right of way	1. traffic 2. utility coordination 3. legacy project	regarding legacy project, Gord to discuss further details with Eugene Motha
City of Burnaby	municipal government					Leif Bjorseth, Asst Director Engineering, Development Services (or Leon Gous or Barry Davis)			engineering	Done. Meeting was held on January 27th

Interested Parties	Stakeholder type (agency, community, First Nations, municipal government, provincial government, federal government, media)	Type of Contact	Location	Date	Who was involved	Key Contact	Discussion	Issues raised	Issue type	Resolution/Action
City of Burnaby	municipal government	meeting		27-Jan-14	Lief Bjorseth	Lief	1. Bby has noise bylaw for night construction, however has relaxed it in certain situations like Evergreen. 2. Bby wants imported trench material. 3. Bby wants 2m cover over pipe 4. Bby council wants to know "what's in it for us?" and advised Gord to contact Lou Peltier Director of Planning. 5.. Lief understands CPCN can override municipal authority. 6. Lief will be key contact. 7. We want to work toward AIP with Bby re routing then detailed engineering later.		engineering	Gord has set up a meeting with Lou Peltier for February 5 to discuss approach to the Mayor on Feb 11.
City of Burnaby	municipal government	meeting		5-Feb-14	Gord Schoberg, Lou Pelletier (Director Planning and Building) Edward Kozak (Assistant Director, Current Planning)	Lou	1. Communications with Engineering, Planning and Council are VERY important 2. BCHydro doesn't do it right, so they hope we will 3. Asked whether we intend cooperating with Engineering, or whether we just intend invoking BCUC authority to override municipal construction requirements 4. Meeting with the mayor: he is a pragmatic person very much interested in how the public will accept the project. we will need to indicate what steps we intend taking to communicate and include the public. 5. Keep Lou informed about the Mayor's response.	1. Advise Lou how the Mayor responds. 2. Keep Lou involved as we develop and execute our public engagement strategy	communications	Nothing for now.
City of Burnaby	municipal government	meeting	Hart House, Burnaby	1-May-14	Leon Gous, Director Engineer, Engineering Department, Chad Turpin, Deputy City Manager, Joan Isac, FEI Community Relations and Gord Schoberg	none	Chad suggested we meet with the mayor concerning the reasons for needing to pursue the Metro IP replacement on current schedule and also to discuss a possible bike path legacy project	no concerns raised about the project	legacy project	Gord and Joan to meet with the mayor in May 2014

Interested Parties	Stakeholder type (agency, community, First Nations, municipal government, provincial government, federal government, media)	Type of Contact	Location	Date	Who was involved	Key Contact	Discussion	Issues raised	Issue type	Resolution/Action
City of Burnaby	municipal government	meeting		11-Feb-14	Gord Schoberg, Joan Isac, Mayor Derek Corrigan		1. Mayor believes that our project may be linked to the KMC pipeline during NEB hearings in 2013 and receive unintended collateral damage as a result. As an example, the Chinese community has expressed emotional opposition to the KMC pipeline, and by inference suggested that we may have difficulty differentiating our natural gas pipeline project from the KMC project. Otherwise, he understands and accepts the need to upgrade a pipeline reaching its end of life, and serving domestic customers. He believes the prime use of natural gas should be heating, and supports amending provincial legislation to require multi unit developments install natural gas rather than electric.	1. Communicate our intentions to the mayor	pubic acceptance	none at this time
City of Burnaby	municipal government	meeting	Burnaby City Hall	6-May-14	Lief Bjorseth, Gord Schoberg, John Quinn, Melanie Kilpatrick		Results of review of pipeline routing application; briefing of recent meetings with Mayor, Chad Turpin and Leon Gous; suggestion of legacy of bike path	Reviewed details of pipeline routing review and general engineering issues; Lief was pleased with our meetings with senior staffers and the mayor and encouraged us to pursue bike path legacy project	legacy project	Meet with the mayor to discuss legacy project further and explain why we need to pursue the project now and cannot wait for a couple of years as the mayor had suggested.
City of Burnaby	municipal government	meeting	Burnaby City Hall	20-May-14	Mayor Corrigan, Joan Isac, Gord Schoberg		Gord explained to the mayor that the project planning and public engagement needed to proceed notwithstanding the mayor's prior comments that it should be delayed so not to be confused with KMC's Trans Mountain Expansion project. Gord also mentioned the progress made with Lief in Burnaby's Engineering group with respect to pipeline routing;. Gord also mentioned an interest to provide a modest legacy in the community after construction.	None	legacy project	nothing needed
City of Burnaby	Municipal govt and residents	Meeting	Executive Inn, Burnaby	October 29, 2014	Leif Bjorseth sat in as an observer as Gord Schoberg, John Quinn, and a representative from Great Northern Engineering Consultants (which prepared traffic study) met with members of the Highlawn residents group	Leif Bjorseth, Asst Director Engineering, Development Services	The meeting was a roundtable discussion. Mr. Bjorseth observed as the project team reviewed Fortis's routing analysis and assessment process and results for the section of the Coquitlam IP gas line replacement in the Brentwood Shopping Centre area.			

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City of Burnaby	Municipal government	Phone call		October 30, 2014	Leif Bjorseth , Gord Schoberg	Leif	Leif preparing briefing notes for members of Council who will hear from the Highlawn residents delegation on November 3, 2014.			Gord forwarded map and other information to Leif to draw on for his report to Council.
City of Burnaby	Municipal government	Phone call		November 14, 2014	Leif Bjorseth, Joan Isaac, Viviana Zanocco	Leif	Leif preparing report for Council regarding City's role when it comes to regulated utilities. Requested FEI prepare a briefing note, expanded version of what we had already provided, for circulation to Council members.			
City of Burnaby	Municipal government	Meeting	City Hall	November 24, 2014	For FEI: Gord Schoberg, John Quinn, Melanie Kilpatrick. For City: Burnaby Council members, Leif Bjorseth, Leon Gous and six other members of City staff.	Leif	Discussion centred on route selection process and criteria for the area near the Brentwood Town Centre. FEI asked to return to update Council at a later date.			Will continue to work with staff, and update Council as requested.
City of Burnaby	municipal government	Meeting	City Hall	27-Nov-14	For FEI: Gord Schoberg, John Quinn, Melanie Kilpatrick. For City: Leif Bjorseth, Leon Gous	Leif	Leon encourged Fortis to consider routing the gas line along Lougheed Highway possibly as far as between Bainbridge and Boundary Road, and that the City would take responsibility for public inquiries regarding traffic congestion.			Follow up discussion with Mayor and Council scheduled for December 8th
City of Vancouver	municipal government					Al Luongo, Manager Utilities Mgmt. Branch, or Rodel Arroyo; Lee Robson advises (see Jan 8, 2014 e-mail from Melanie) that Brian Charleston, who is the Utilities Coordination Engineer for the City of Vancouver gets provided with information regarding our upcoming proposed work in the muni on an annual basis (I believe Nik Ong met with one of Brian's colleagues earlier this year).			engineering	

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City of Vancouver	municipal government	meeting		29-Jan-14	Fortis: Gord, John, Ken and Worley Parsons team	Al Luongo	1. 2nd & Woodland will have increased noise bca of pressure reducing equipment 2. we will need to open up 2 lanes of traffic 3. Q: how we leave cst area at end of day? 4. hours of work 5. Parks control ALL trees 6. Trenchless: Hwy 1, Renfrew, Nanaimo, Commercial 7. Coordinate w/other City infrastructure cst and BCH 8. John Q to present to joint utility meeting 9. Cst timeframe: Metro IP 2016 and Marine/Elliott 2017		engineering	none
City of Vancouver	municipal government	meeting	City of Vancouver Engineering office, Broadway	14-May-14	Fortis: Amy, Leslie, John, Melanie, Gord. Vancouver: Al Luongo, Taryn Scolland, Rodel		Fortis explained why First Ave was chosen; construction productivity and how construction would proceed; discussion about how to assess traffic modeling; discussion about route selection and to be specific about tree impacts.	Trees and traffic	traffic disruption and tree impacts	Gord to set up meeting with Al Luongo and City Manager including Parks prior to public info session
City of Vancouver	municipal government	meeting	City of Vancouver office of the City Manager, City Hall	4-Jun-14	Fortis: Gord Schoberg, Amy Hennessy, Melanie Kilpatrick, Leslie Kristoff; City of Vancouver: Al Luongo, Taryn Scollard, Peter Judd		General project update: Peter Judd to update Penny Ballam, City Manager and the Mayor	none	none	none
City of Vancouver Parks Board	municipal government	telephone		23-May-14	Bill Steven City of Vancouver and Gord Schoberg	Bill Steven	CoV Parks wants to meet when the FEI arborist report is complete in order to discuss project impact on trees. They will ask us about route selection and prepare senior managers / elected officials when calls from the public begin.	Trees and routing	Trees and routing	meeting will be arranged before Public Info Session in Vancouver on June 24, 2014
City of Vancouver Parks Board	municipal government	meeting	Parks Board office, City of Vancouver	17-Sep-14	Bill Manning, Director, Parks and Gord Schoberg	Bill Manning	Committing to setting up a meeting that would include Leslie Kristoff from Fortis and possibly our arborist.	Trees	Trees	As of November 10, 2014, still no meeting scheduled.
Joint meeting: Cities of Vancouver, Burnaby and Coquitlam	municipal government	meeting		4-Sep-13	Fortis: Mark Fabbro, Dana Johnston, John Quinn, Melanie Kirkpatrick, Gord Schoberg: Vancouver: Al Luongo: Burnaby: Leif Bjorseth: Coquitlam: Dana Soong, Eugene			Is FEI going to abandon the Metro IP pipeline? If so, what will you do with it. Are you willing to pay for dedicated municipal resource to process application?	engineering	Further work will be required to determine answers to some of the issues raised.
City of Surrey	municipal government	meeting		31-May-13	Gord Schoberg, Chris Coady and Surrey staff: Sam Lau, Jim Riches, Vince LaLonde	Ken Zondervan (Design & Construction Div Mgr) or Sam Lau (Land Dev. Mgr, Eng Department)	General intro to pipeline projects in Surrey	None, however Fraser Health will postpone construction of parking lot across FEI r/w until new pipe alignment is known	engineering	ongoing

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City of Surrey	municipal government	meeting		27-Jan-14	Gord Schoberg and 12 Fortis/Worley staff; Ken Zondervan, Scott Neuman and 4 other Surrey staff	Scott Neuman [redacted]	Surrey wants our environmental report re water crossings. Scott is replacing Ken as key contact. City will take 2-4 weeks to review our drawings. Update Transportation / Environment Committees as needed. We want to work towards an AIP with Surrey for routing, then handle details later.	Trench across roads vs trenchless: City wants trenchless across 108, 104, 96th, Fraser Hwy and King George.	engineering	Detailed issues will be resolved during detailed engineering, later this year.
City of Surrey Environmental Sustainability Advisory Committee (ESAC)	municipal government	meeting		11-Dec-13	Gord Schoberg, Councilor Hayne, Owen Croy (Mgr of Parks) and 9 others		I reviewed project and hi-lighted the Surrey projects. General questions involved pipeline safety and wildlife protection	1. question about seismic capability of pipelines (new and existing) 2. City owned property is park, and City will be very concerned about effects of project on wildlife. 3. if existing pipeline is ruptured during cst what will be effect on powerline / neighbours	pipeline safety; wildlife impacts	Committee wants update once staff has a chance to assess project impacts and once FEI completes baseline environmental study
City of Surrey Transportation Infrastructure Comm	municipal government	meeting		2-Dec-13	Gord Schoberg, Councilors Gill (Chair) Rasode and Steele, Vince Lalonde and 5 other staff		I reviewed project and hi-lighted the Surrey projects. General questions involved public safety	none	public safety	none
City of Surrey Transportation Infrastructure Comm	municipal government	meeting	Brown's Social House, No 10 Hwy in Surrey	7-May-14	Linda Hepner, Bruce Hayne (Surrey Councilors) and Gord Schoberg		General responses by City Engineering staff on this project and efforts by FEI to work with them	none	municipal permitting	n/a
City of Surrey Transportation Infrastructure Comm	municipal government	meeting	Brown's Social House, No 10 Hwy in Surrey	9-Jul-14	Barb Steele (Surrey Councilor) and Gord Schoberg		Outlined status of LMSU project and issues being discussed with Surrey Engineering	none	municipal permitting	n/a
City of Surrey Transportation Infrastructure Comm	municipal government	meeting	Surrey City Hall	12-May-14	Amy, Gord, Melanie, John, Les Corradine, Leslie, Scott Neuman, Ted Uhrich, and four City staff from Environment, Engineering and Parks	Ted Uhrich. [redacted]	Reviewed issues raised by Surrey concerning project including routing, and focused discussion on routing between Nichol and Roebuck and also from Nichol north to 96th Ave; also discussion about green way / bike paths along right of way and negotiating new operating agreement	Constricted construction area around Surrey Memorial hospital	construction alignment; legacies	Gord to meet with Parks about green way / bike pathways; Gord to meet with Scott about beginning to negotiate a new operating agreement; John to address engineering issues raised.
Provincial MLAs and Federal MPs										
NDP MLA's	provincial government	meeting	Fairmont Vancouver Hotel	6-Jun-14						
Sue Hammel, MLA Surrey-Green Timbers	provincial government	meting		27-Aug-13	Gord Schoberg, Vanessa Connolly, Sue Hammel, MLA, Yamilka Arteaga, CA	Sue Hammell	LMIP, in particular the Surrey looping projects with focus on Surrey Memorial Hospital area	Sue mentioned there may be people with environmental sensitivities that she would advise if she becomes aware of concerns	environment	Nothing needed
Selina Robinson, MLA Coquitlam-Maillardville	provincial government	meeting		29-Aug-13	Joan Isac, Vanessa Connolly, Selina Robinson	Selina Robinson	LMIP, Selina understands the need for the project	none	none	None
Vicki Huntington, MLA Delta South	provincial government	meeting		5-Sep-13	Vanessa Connolly, Amy Hennessey, Edmund Leung, Vicki Huntington	Vicki Huntington	Burns Bog pipeline reinforcement	none	none	none
MLA: Linda Reimer, BC Liberal	provincial government			25-Nov-13	Vanessa Connolly, Gord Schoberg	Linda Reimer	No issues, but invited Linda to advise us if she hears of challenges in the community	none	none	none

Interested Parties	Stakeholder type (agency, community, First Nations, municipal government, provincial government, federal government, media)	Type of Contact	Location	Date	Who was involved	Key Contact	Discussion	Issues raised	Issue type	Resolution/Action
MLA: Jane Shin, NDP	provincial government	meeting		7-Feb-14	Gord Schoberg, Vanessa Connolly, Jane Shin	Jane Shin	1. Jane is aligned with the North Road BIA, largely a Korean group and wants to introduce us to them. President is close to Derek Corrigan. 2. Jane has contact with several anti-KMC groups and will pull together a workshop for us in April/May 3. Jane wants to advocate on behalf of G4, a group of inventors in Bby involved with biomass (FEI has been in contact with them re RNG) 4. Jane is a collaborator, and asked what questions our opponents would have with our project. She is skeptical about FEI's ability to objectively present the project, because we have a vested interest in promoting the project. She also suggested the public has lost confidence in the BCUC, so wonders who can provide the "truth" about the project.		public consultation	1. Advise how the meeting went with Mayor Corrigan. 2. Arrange meeting through Jane with the North Road BIA 3. Begin working with Jane to develop workshop with anti-KMC groups. 4. Follow up on what FEI is doing with G4 Meeting was held on Feb 7th
MLA: Jane Shin, NDP	provincial government	e-mail		21-Feb-14	Jane Shin to Gord Schoberg, Carolyn Orazietti, Park@shapepm.com and nelson@shapeproperties.com		Jane sent note to Katrina Kang requesting her to give us complete contact list of Korean media outlets		communications	
MLA: Jane Shin, NDP	provincial government	e-mail		21-Feb-14	Jane Shin to Krystal Smith with cc to Gord Schoberg and Vanessa Connolly		Jane asked Krystal to make sure Gord and Vanessa are available for the meeting with the Consulate, where North Rd BIA, Lougheed Mall and Shapes will be present		communications	
MLA: Jane Shin, NDP	provincial government	meeting	Hanok Korean Restaurant, 9928 Lougheed Hwy	7-Mar-14	Jane Shin, Vanessa Connolly, Gord Schoberg, Carolyn Orazetti (North Rd BIA) and 10 leaders in Korean business community		Gord Schoberg presented project through UBC Coop student interpreter. The only issue raised was with respect to business access, since most Korean businesses on North Road are retail, and whether Fortis would compensate for business loss.	Would Fortis be prepared to compensate for business loss?	compensation	TBD
MLA: Jane Shin, NDP	provincial government	meeting	Jane's office in Burnaby	4-Apr-14	Gord Schoberg, Jane Shin		Update on our meeting with the Korean community leaders	none		none
MLA: Richard Lee, BC Liberal		meeting		29-Nov-13	Gord Schoberg, Vanessa Connolly, Richard Lee	Richard Lee	No issues	none	none	none

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MLA: Richard Lee, BC Liberal		Meeting	Richard's office	October 31, 2014	Gord Schoberg, John Quinn, and a representative from Great Northern Engineering attended at the MLA's request. Also in attendance were representatives from the Highlawn Drive residents group.	Richard Lee	The MLA told residents, who had requested the meeting, he could not get involved in the process. He suggested they approach City Council, which they were scheduled to do the following Monday evening. The MLA noted that Fortis was available for continued dialogue and suggested to Highlawn residents that they pursue this option.	None.		none. Will continue to dialogue
MLA: Shane Simpson, NDP	provincial government	meeting	Shane's office at 2365 E. Hastings St	14-Mar-14	Shane Simpson, Amy Hennessy, Gord Schoberg	Shane Simpson	FEI needs to distinguish itself from KMC and other pipeline projects and encourage Mayors Corrigan and Robertson to help; meet with Mike McGee, Mayor Robertson's Chief of Staff; don't do open houses, the community thinks they are a sham, but develop situations where we create conversations; community minded people want collective conversations; two influential people are Jak King, Grandview-Woodlands Area Council and Garry Dobbin, Frog Hollow. Give current and complete information to the public	Need to distinguish ourselves from KMC; Need to get assistance from Mayors Corrigan and Robertson; Don't try open houses, the community thinks they are merely a "sell job and corporate marketing"; develop collective discussions	community engagement	Intend following up with Mayor Corrigan and having a meeting with Mike McGee and consider how best to engage the Grandview-Woodlands neighbourhood
MLA: Jenny Kwan, NDP	provincial government	meeting	Jenny's office at First Ave and Commercial	20-May-14	Jenny Kwan, Vanessa Connolly, Gord Schoberg	Jenny Kwan	Gord introduced the project and Jenny mentioned several local organizations that could be contacted with respect to Community Meetings and also legacy ideas	none	legacy project	Jenny will provide names of organizations that we can contact with respect to legacy ideas and also organize community meetings with.
MLA: Bruce Ralston, MDP	provincial government	meeting		30-Jan-14	Gord Schoberg, Vanessa Connolly and Bruce Ralston	Bruce Ralston	Bruce asked how long before a THIRD pipeline would need to be built. Otherwise, he was appreciative of the update and had no concerns.	none	none	Done. Meeting was held on January 30th
MLA: Suzanne Anton, BC Liberal	provincial government	meeting		24-Jan-14	Gord Schoberg, Vanessa Connolly, Suzanne Anton	Suzanne Anton	Suzanne suggested we meet with the River District group near Fraser River, and also Peeter Wesik, Parklane Ventures / Wesgroup Properties. Suzanne also wants to be invited to an open house. She also wants a one page laminate describing project for her bulletin board.	none	public consultation	Done. Meeting was held on January 24th

Interested Parties	Stakeholder type (agency, community, First Nations, municipal government, provincial government, federal government, media)	Type of Contact	Location	Date	Who was involved	Key Contact	Discussion	Issues raised	Issue type	Resolution/Action
MP is Kennedy Stewart	federal government	meeting		8-Jan-14	Gord Schoberg, Kennedy Stewart, Joan Isac	Kennedy Stewart	Kennedy may support the project depending on Mayor Corrigan's response, and is satisfied the project serves domestic customers, understands its replacing existing pipeline, not concerned we may move fracked gas, and not concerned about incremental rate increase	Issue is Derek Corrigan, and suggested I talk to him and possibly Burnaby Council; talk to a developer that uses or wants to use natural gas.	public acceptance	Keep him informed about Derek's response
MP is Kennedy Stewart	federal government	telephone	n/a	3-Jun-14	Gord Schoberg, Vanessa Connolly, Kennedy Stewart		Kennedy continues to agree with the need for the project and appreciate we are talking to the public early and keeping himself and the mayor briefed on our planning; he suggests meeting with any neighbourhood groups; local media; and suggests an idea around legacies could include traffic calming, where the local neighbourhood needs to pay 50% of the cost.	See discussion	public engagement, legacies	Gord will set up meetings with the two local Burnaby newspapers to brief them on the LMSU projects.
MP is Libby Davies	federal government					Libby Davies				Not interested in meeting; will get info from other colleagues. May22/14- Libby Davies does not believe a meeting is required. This is not a federal issue. Any complaints from the public will be referred to provincial colleague.
MP is Finn Donnelly	federal government	meeting		14-Feb-14	Gord Schoberg, Joan Isac, Finn Donnolly	Fin Donnelly	Finn's questions: What to do with the abandoned pipe? Can City of Coq use for QNET fibre optic? What is residential impact? Is this project related to the Woodfibre export market? Have we consulted with First Nations? Suggested we meet with Port Coq. Gave us names of environmental orgs to contact. Suggested we engage public with workshops, not just open houses. Feels public will be mostly concerned with traffic and noise.	Agrees with the Mayor of Burnaby's comments that we will need to clearly distinguish our project from KMC.	public consultation	Contact environmental groups. Ensure public engagement program is more engaging than just open houses, but includes workshops where the public can provide more valued feedback. Follow up with City of Coq re QNET. Connect with City of Port Coquitlam. Wants to be invited to public engagement events.
MP is Jasbir Sandhu	federal government	meeting		29-Nov-13	Gord Schoberg, Vanessa Connolly, Jasbir Sandhu	Jasbir Sandhu	Environmental issues (MP sponsoring a private members bill dealing with increasing environmental protection for streams)	ensuring Fortis follows all environmental regulations, and we assured him of the requirement to satisfy OGC	environment	Conduct open houses in neighbourhood
MP is Wai Young	federal government	contact on hold				Wai Young				
Regional Agencies:										
TransLink										

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Ministry of Highways	agency	e-mail		20-Nov-13	Kevin House, Land & Property Administrator MTI		MoTI owns property at 2351 United Blvd, Coquitlam	Property at 2351 United Blvd, Coq, is being used as part of the Port Mann Hwy 1 Project, and FBC needs to contact prior to access	engineering	FBC to instruct contractors to contact Jack Keokanock, Utility Coordinator at 604.629.5456 when requiring access to right of way on the property
Media:										
David Jang - Sing Tao Daily Limited		conversation		27-Nov-13	Gord Schoberg, David Jang		General discussion at Burnaby Board of Trade luncheon about FBC pipeline upgrade projects, including Woodfibre	none	general project information	none
Eric Chan - Ming Pao Newspapers (Canada) Ltd.	media	conversation		27-Nov-13	Gord Schoberg, Eric Chan		General discussion at Burnaby Board of Trade luncheon about FBC pipeline upgrade projects, including Woodfibre	none	general project information	none
Kevin Diakiw, Surrey Leader	media	conversation		3-Dec-13	Kevin Daikiw, Gord Schoberg		Wants location details on Pipeline Upgrades, Woodfibre and Tilbury	none	general project information	none
Individuals:										
[redacted]		phone call		8-Nov-13	[redacted] Gord Schoberg		[redacted] associated with Surrey Healthwise at 96th & Fraser Hwy and can provide valuable development guidance for the right of way from Fraser Highway south to Surrey Memorial Hospital	[redacted] has ideas about locating new pipeline on property and wants to be kept advised of ongoing planning progress	notification prior to entering property	[redacted] can be reached at [redacted] By e-mail to John Quinn on Jan 13/14 I asked Worley to contact [redacted]
	landowner	phone call		20-Jan-14	[redacted] John Quinn		John Q asked [redacted] to send development plans and notes and we would pass them along to Worley Parsons		notification prior to entering property	
	landowner	phone call		30-Nov-13	[redacted] Gord Schoberg		[redacted] wants an air photo showing existing pipeline route across property; wants us to call before entering r/w to do studies and construction	New pipeline routing across property and receive notification as a courtesy prior to entering property to access r/w	notification prior to entering property	Contact [redacted] at [redacted] as a courtesy before entering property to access r/w. [redacted] wants to provide comment about pipeline routing across property.
	landowner	e-mail / phone		13-Nov-13	[redacted] Gord Schoberg		[redacted] owns property in Coquitlam near Fraser River which contains FBC right of way	[redacted] has ideas about the location of our proposed pipeline and wants to be kept advised of ongoing planning progress and also wants FBC contractors to contact his office as a courtesy when accessing right of way on his property	notification prior to entering property	Bill can be reached at [redacted] or by e-mail at [redacted]
	landowner	meeting		2-Dec-13	[redacted] Gord Schoberg		Lives near Green Timbers Park and wants to talk about project	none	general project information	none
	landowner	meeting	Executive Inn, Coquitlam (Public Information Session)	3-Jun-14	FortisBC staff and public	[redacted]		Inquired about re-routing our alignment through a nearby park and school in Burnaby	gas line routing	We will inquire with the City of Burnaby Parks Department as well as the Burnaby School Board

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[redacted]	landowner	meeting	Executive Inn, Coquitlam (Public Information Session)	3-Jun-14	FortisBC staff and public	[redacted]		inquired about re-routing our alignment through a nearby park and school in Burnaby	gas line routing	We will inquire with the City of Burnaby Parks Department as well as the Burnaby School Board
	landowner		Confederation Community Center, Burnaby (Public Info Session)	4-Jun-14	FortisBC staff and public			inquired about re-routing our alignment through a nearby park and school in Burnaby	gas line routing	We will inquire with the City of Burnaby Parks Department as well as the Burnaby School Board
Matt Stradiotti, North Arm Transportation Ltd, 2585 Kent Ave S.E, Vancouver	Business	email		4-Jun-14	Matt Stradiotti, Gord Schoberg, John Quinn, Chris Coady, Les Corradine(Worley Parsons)	Matt Stradiotti	Impact to road access to North Arm Transport during construction	Matt would like to confirm that they will have road access during.	access during construction	John is looking into options to facilitate access during construction and alternative alignment options. We will contact business owner to further discuss, as it is in preliminary stages.
Thrifty Foods, Coquitlam	landowner	meeting	Tri-Cities Chamber of Commerce office	26-Jun-14	Joan Isac, Gord Schoberg & Byron Severs		Access to Thrifty Foods during construction	the main parking lot for the store (and other stores) is on the present hydro/gas right of way and it would seem apparent our new gas line will pass through the parking lot. Access is a challenge for Thrifty's, and the only practical access is off across Austin	access during construction	
[redacted]		email		4-Sep-14	[redacted] Gord Schoberg		wants location details, timeline and degree of impact on traffic disruptions and residential property.	See discussion	general project information	Gord sent email responding to questions.

Lower Mainland Natural Gas - Pipeline Ugrades Public Info Sessions Log

Interested Parties	Stakeholder Type	Type of Contact	Municipality	Date	Who was involved	Discussion	Issues rasied	Issue type	Resolution
COQUITLAM INFO SESSION May 27, 2014	Poirier Sports and Leisure Complex, 633 Poirier Place								
Eugene Motha, 500 Mariner Way, Coquitlam, V3K 7B2	City of Coquitlam	attended Info Session	Coquitlam	27-May-14					
Aeron Robinson, 1209 Pinetree Way, Coquitlam, V3B 7Y3	Chamber of Commerce	attended Info Session	Coquitlam	27-May-14					
[redacted]	landowner	attended Info Session	Coquitlam	27-May-14					
	landowner	attended Info Session	Coquitlam	27-May-14					
	landowner	attended Info Session	Coquitlam	27-May-14					
	landowner	attended Info Session	Coquitlam	27-May-14					
Lexa Hobenshield	Kinder Morgan	attended Info Session	Coquitlam	27-May-14					
[redacted]	Individual	attended Info Session	Coquitlam	27-May-14					
	Individual	attended Info Session	Coquitlam	27-May-14					
	Individual	attended Info Session	Coquitlam	27-May-14					
Mike Viney, 500 Mariner Way, Coquitlam, V3B 7Y3	City of Coquitlam	attended Info Session	Coquitlam	27-May-14					
[redacted]	landowner	attended Info Session	Coquitlam	27-May-14					
GENERAL COMMENTS FROM SESSION	Attendence:17 ppl; 12 signed in					City of Coquitlam- wanting to look at alignment between construction windows on Como Lake Rd; Chamber of Commerce-inquiring on impact on businesses in the construction areas;	Public Comments- Traffic concerns such as detailed routing and impacts on residential areas; Cost and if it will impact rates; Safety-is the pipe leaking and why not replacing the Transmission Pipe		
SURREY INFO SESSION, May 29, 2014	City Centre Public Library, 10350 University Drive								
[redacted]	City of Surrey	attended Info Session	Surrey	29-May-14					
	landowner	attended Info Session	Surrey	29-May-14					
	landowner	attended Info Session	Surrey	29-May-14					
	Green Timbers Heritage Society	attended Info Session	Surrey	29-May-14					
	Individual	attended Info Session	Surrey	29-May-14					
	Individual	attended Info Session	Surrey	29-May-14					
	FortisBC	attended Info Session	Surrey	29-May-14					
	Individual	attended Info Session	Surrey	29-May-14					
	Green Timbers Heritage Society	attended Info Session	Surrey	29-May-14					
	Stave Lake Cabin Owners Association	attended Info Session	Surrey	29-May-14					
	landowner	attended Info Session	Surrey	29-May-14					
	individual	attended Info Session	Surrey	29-May-14					
	individual	attended Info session	Surrey	29-May-14					
	individual	attended Info Session	Surrey	29-May-14					

Interested Parties	Stakeholder Type	Type of Contact	Municipality	Date	Who was involved	Discussion	Issues rasied	Issue type	Resolution
[redacted]	Individual	attended info session	Surrey	29-May-14					
GENERAL COMMENTS FROM SESSION	Attendence:16 ppl,15 signed in					Green Timbers Heritage Assoc.- enviromental concerns such as impact on trees in construction area	Public feedback- Location of construction and gas line; where in the right of way will the gas line be.; where is the gas coming from.		
Burnaby - West June 3, 2014	Signature Pipe Walk: 407 Attendance, Deputations								
Johannes Schumann, 4949 Canada Way, Burnaby, V5G 1M2	City of Burnaby	attended Info Session	Burnaby - East	3-Jun-14			Want quaterly or monthly notification or put on an information distribution list.		
Kavi Bal, Burnaby,BC	Kinder Morgan	attended Info Session	Burnaby - East	3-Jun-14					
[redacted]	landowner	attended Info Session	Burnaby - East	3-Jun-14			inquired about re-routing our alignment through a nearby park and school in Burnaby	gas line routing	We will inquire with the City of Burnaby Parks Department as well as the Burnaby School Board
	landowner	attended Info Session	Burnaby - East	3-Jun-14					
	landowner	attended Info Session	Burnaby - East	3-Jun-14					
Jane Jae Kyung Shin, 3-8699 10th Ave, Burnaby, V3N 2S9	Burnaby -Lougheed MLA	attended Info Session	Burnaby - East	3-Jun-14					
[redacted]	FortisBC	attended Info Session	Burnaby - East	3-Jun-14					
	FortisBC	attended Info Session	Burnaby - East	3-Jun-14					
	FortisBC	attended Info Session	Burnaby - East	3-Jun-14					
Dion Deepker, 4949 Canada Way, Burnaby, V5G 1M2	City of Burnaby	attended Info Session	Burnaby - East	3-Jun-14					
[redacted]	individual	attended Info Session	Burnaby - East	3-Jun-14					
	landowner	attended Info Session	Burnaby - East	3-Jun-14					
	individual	attended Info Session	Burnaby - East	3-Jun-14			inquired about re-routing our alignment through a nearby park and school in Burnaby	gas line routing	We will inquire with the City of Burnaby Parks Department as well as the Burnaby School Board
GENERAL COMMENTS FROM SESSION	Attendence:13ppl, 12 signed in					City of Burnaby- suggested getting in touch with a community association to develop an area service plan; Kinder Morgan-coordinating crossings with their existing or new line.	Public feedback- questions from residents of Highlawn Dr & Brentlawn Dr on the project suchs as 1. how long the construction will be in their area 2. amount of dust and debris 3. will it have any impact on their wheelchair bound neighbours 4. impact on access to schools in area 5. have all routing options been considered 6. suggested re-routing through Park and school 7. Resisdents are willing to meet with City of Burnaby and school board.	Other public feedback- Concerns on abandonment of pipes; life expectancy of new pipe and why we are not removing the old pipe. Also traffic mitigation such as overflow on neighbouring streets and the need for flaggers in those areas as well; congestion from construction crew parking and possibility of workers being bused in from another location. Access to commerical properties on North Rd. during construction and the impact to business.	
Burnaby - West June 4, 2014	Confidentiality Checkbox Series, 4969 Attendance								
[redacted]	landowner	attended Info Session	Burnaby - West	4-Jun-14					
	individual	attended Info Session	Burnaby - West	4-Jun-14					
Demian Rueter, 4949 Canada Way, Burnaby, V5G 1M2	City of Burnaby	attended Info Session	Burnaby - West	4-Jun-14					
[redacted]	individual	attended Info Session	Burnaby - West	4-Jun-14					
	landowner	attended Info Session	Burnaby - West	4-Jun-14					

Interested Parties	Stakeholder Type	Type of Contact	Municipality	Date	Who was involved	Discussion	Issues rasied	Issue type	Resolution
[redacted]	landowner	attended Info Session/email	Burnaby - West	4-Jun-14			inquired about re-reouting our alignment through Brentwood Park to avoid construction on Highlawn Drive.	gas line routing	We will inquire with the City of Burnaby Parks Department as well as the Burnaby School Board
	landowner	attended info session	Burnaby - West	4-Jun-14					
	individual	attended info session	Burnaby - West	4-Jun-14					
	landowner	attended info session	Burnaby - West	4-Jun-14					
	landowner	attended info session	Burnaby - West	4-Jun-14					
	landowner	attended info session	Burnaby -West	4-Jun-14					
GENERAL COMMENTS FROM SESSION	Attendence 14 ppl; 11 signed in					Public feedback; Concerns from residents of Highlawn Dr.such as traffic, dust from construction covering their windows and houses, trees in their neighbourhood, disturbing the newly paved road. Questions regarding re-routing along lougheed hwy and why are going down a residential road rather then commerical rds.			
	Trout Lake Community Vancouver Info Session Centre, 1883 Victoria Drive								
[redacted]	landowner	attended info session	Vancouver	24-Jun-14					
	landowner	attended info session	Vancouver	24-Jun-14					
	landowner	attended info session	Vancouver	24-Jun-14					
	landowner	attended info session	Vancouver	24-Jun-14					
	landowner	attended info session	Vancouver	24-Jun-14					
	Frog Hollow	attended info session	Vancouver	24-Jun-14					
	landowner	attended info session	Vancouver	24-Jun-14					
	landowner	attended info session	Vancouver	24-Jun-14					
	landowner	attended info session	Vancouver	24-Jun-14					
	landowner	attended info session	Vancouver	24-Jun-14					
	landowner	attended info session	Vancouver	24-Jun-14					
	landowner	attended info session	Vancouver	24-Jun-14					
	landowner	attended info session	Vancouver	24-Jun-14					
	landowner	attended info session	Vancouver	24-Jun-14					
	landowner	attended info session	Vancouver	24-Jun-14					
	indivdual	attended info session	Vancouver	24-Jun-14					
GENERAL COMMENTS FROM SESSION	16 signed in					Public feedback: Alternative alignments through Burnaby; questions on traffic disruptions on First Ave, advise that we have will have a traffic consultant; Concerns on the potential impact to trees along routes; Concerns around pedestrian walkways being closed during construction.			
Customer Contact Center- Call Log									

Interested Parties	Stakeholder Type	Type of Contact	Municipality	Date	Who was involved	Discussion	Issues rasied	Issue type	Resolution
Caller would not leave name or any info		contacted Customer Call Center		3-Jun-14			Customer did not like that the information session for the Vancouver area was at the Trout Lake Community center from 6-9pm. He advised it was quite a long drive from the West side. He did not think it was a good idea to have it there as it will require driving in the dark and many people would not be attending because they would have to drive in the dark. He did not give me his name, but asked that I pass this information on.		

Appendix C-3

LMIPSU FACT SHEET

Lower Mainland natural gas system upgrades

Fact sheet

FortisBC continuously monitors its infrastructure system to ensure it's operating as efficiently as possible. As part of our regular maintenance, upgrades to our natural gas system a requirement. This ensures the continued safe and reliable delivery of natural gas to our customers.

We're currently planning improvements to five sections of the existing natural gas system that provides service to customers in Surrey, Burnaby, Coquitlam and Vancouver.

These investments will improve the integrity of the system and provide greater operational flexibility so that we can best meet the future needs of our customers.

Coquitlam, Burnaby, Vancouver: Replace approximately 20 kilometres of the Metro Intermediate Pressure (IP) natural gas pipeline that runs between our Coquitlam station and our station at East 2nd Avenue and Woodland Drive in Vancouver. The Metro IP pipeline must be replaced due to integrity concerns.

Coquitlam*: Install approximately 4.6 kilometres of pipeline between our Cape Horn and Coquitlam stations to provide additional backups and supply the Metro IP pipeline.

Vancouver: Replace approximately 700 metres of pipeline between Fraser Station and our underground station at SE Marine Drive and Elliott Street to provide additional seismic resistance.

Surrey*:

Install approximately five kilometres of new natural gas pipeline between our Nichol Station to the south side of the Fraser River to enable in-line inspections and meet forecasted long-term growth in core demand.

Install approximately 1.7 kilometres of natural gas pipeline between Nichol and Roebuck stations to provide additional backups for customers in Surrey, Richmond and Vancouver.

As with any significant improvement to our natural gas infrastructure, we will be submitting the costs of this project to the BC Utilities Commission for review and approval.

At this time, we do not expect these upgrades to significantly impact the delivery rates for our customers.

Next steps

We will soon apply to the BC Utilities Commission and the BC Oil and Gas Commission for approval of these upgrades.

We are also meeting with the residents and stakeholders in the four communities to provide information about these improvements and answer questions.

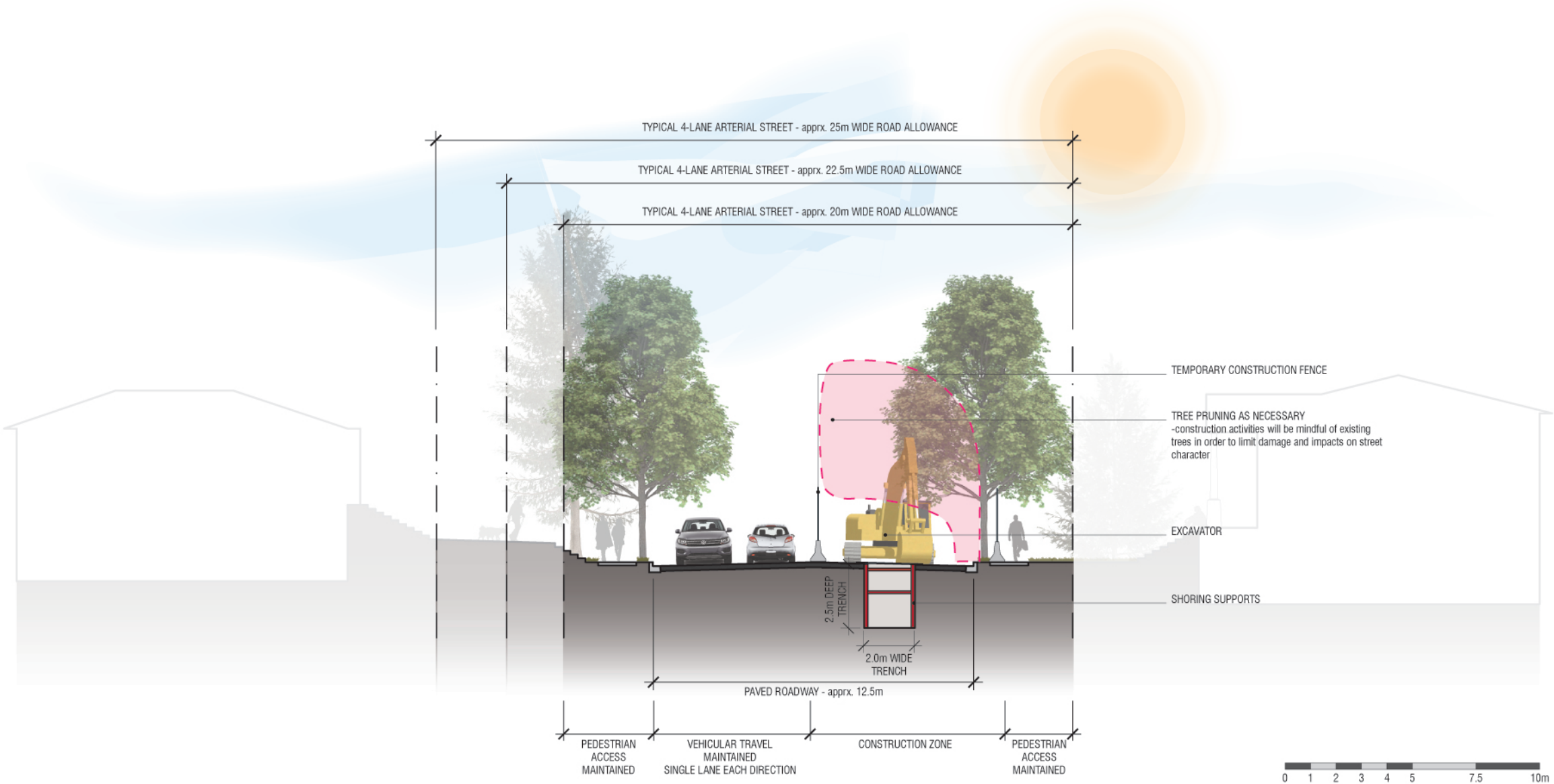
We estimate that construction will begin in early 2017.

For more information, please visit fortisbc.com/inyourcommunity or email us at systemupgrades@fortisbc.com.

*These improvements will be carried out in the same utility corridor as the existing natural gas pipeline.

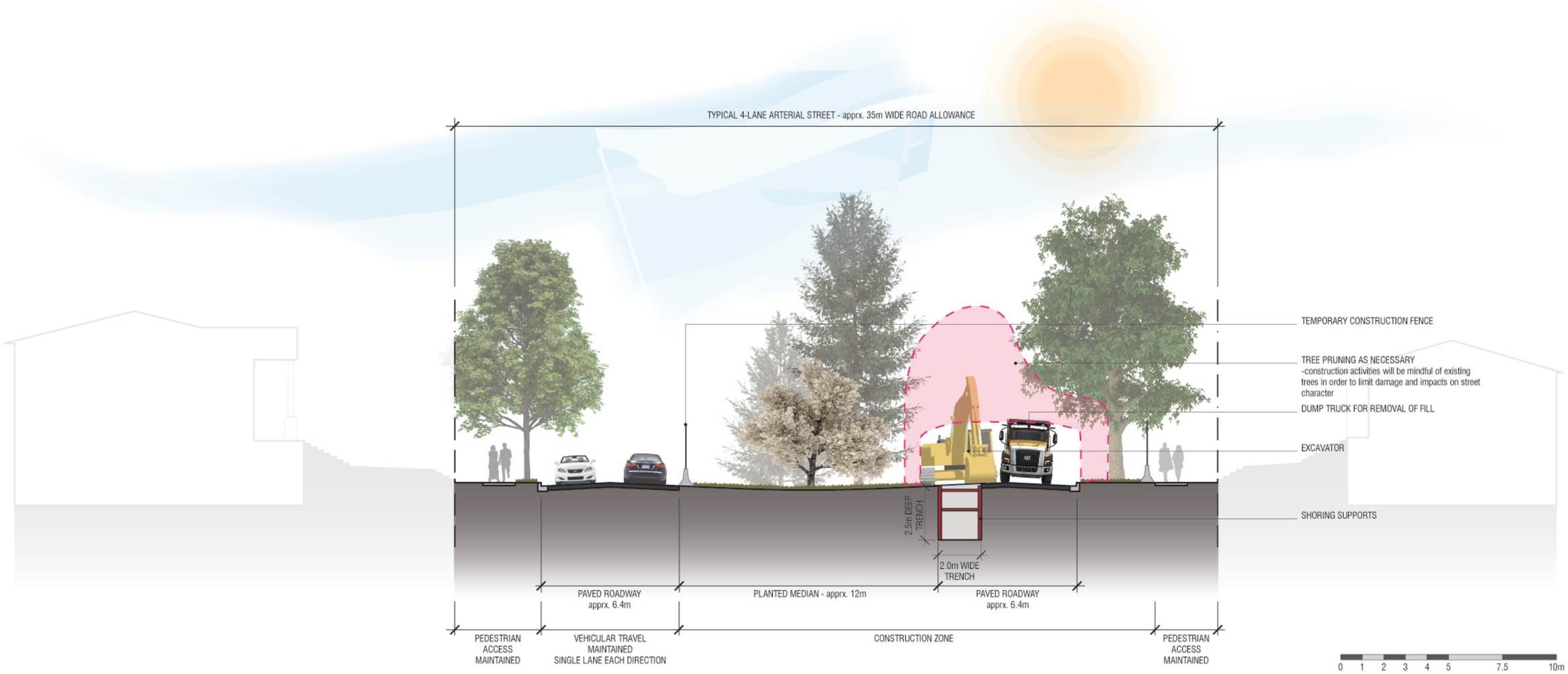
Appendix C-4

STORY BOARDS



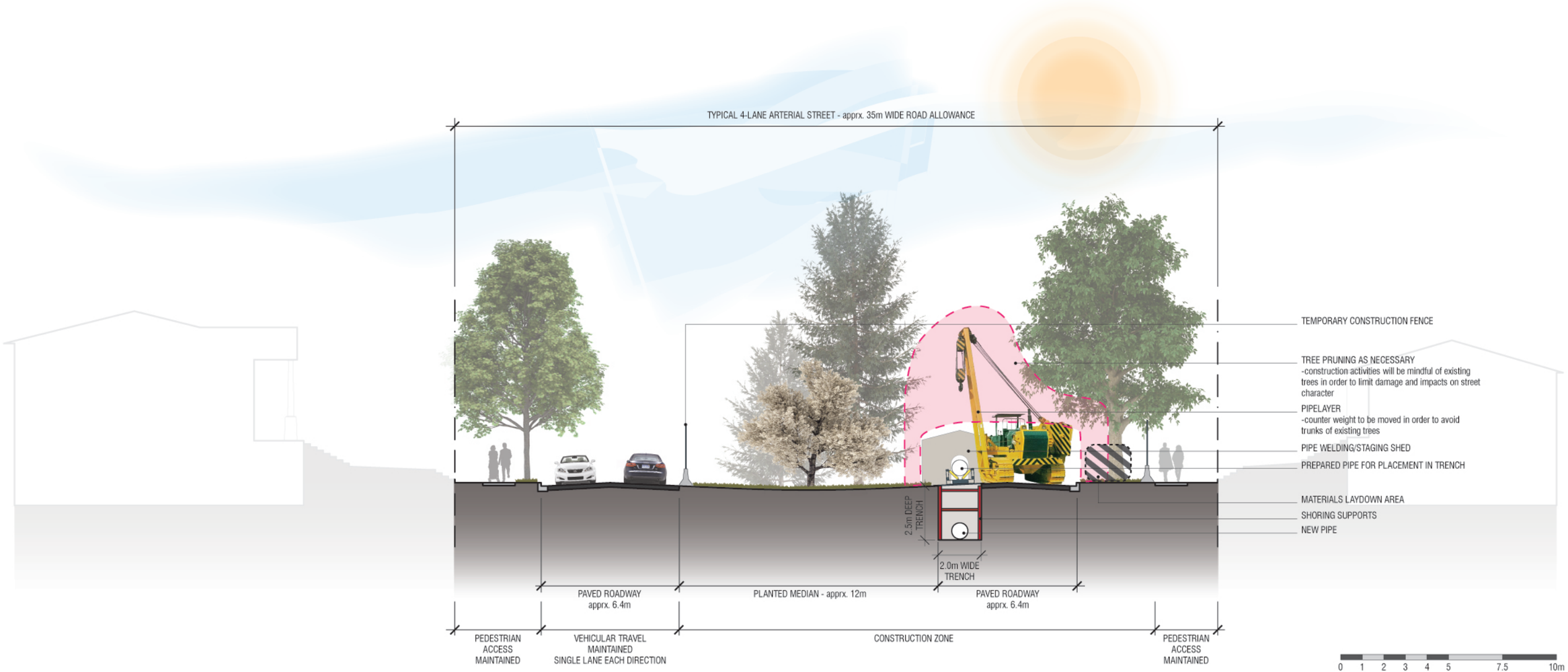
EXCAVATION PHASE

TYPICAL 4-LANE ARTERIAL STREET (NO MEDIAN)



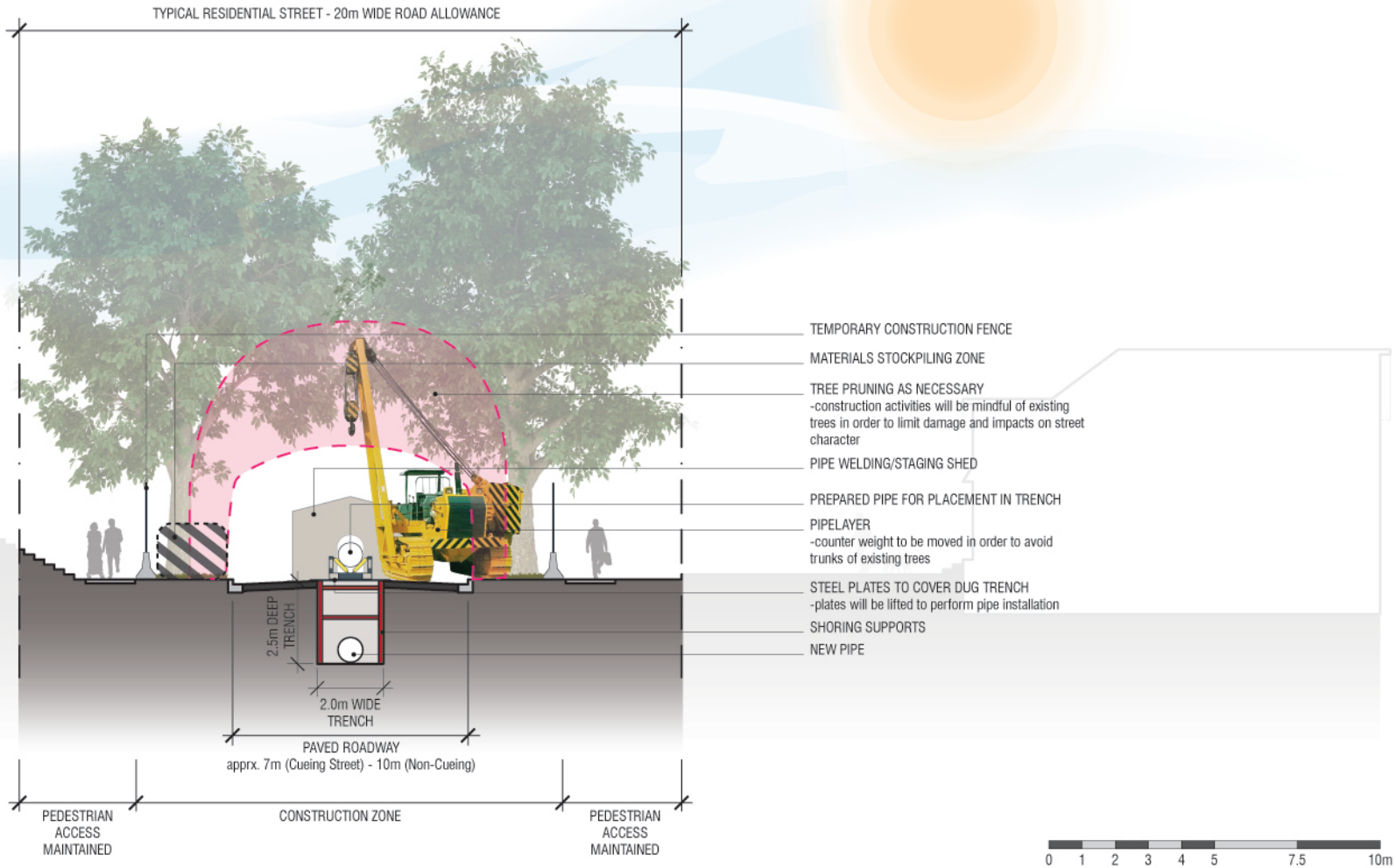
EXCAVATION PHASE

TYPICAL 4-LANE ARTERIAL STREET (WITH PLANTED MEDIAN)



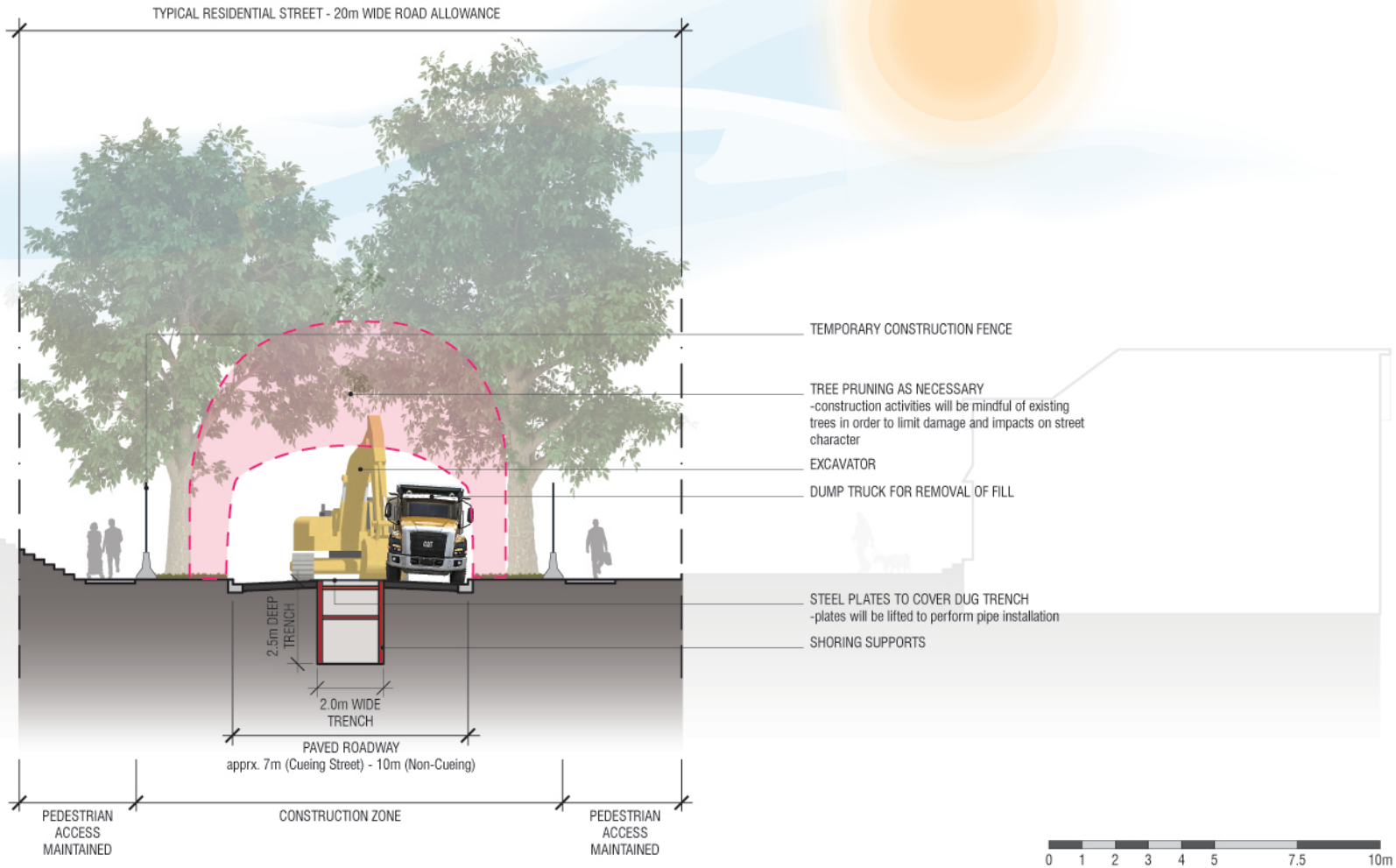
PIPE LAYING PHASE

TYPICAL 4-LANE ARTERIAL STREET (WITH PLANTED MEDIAN)



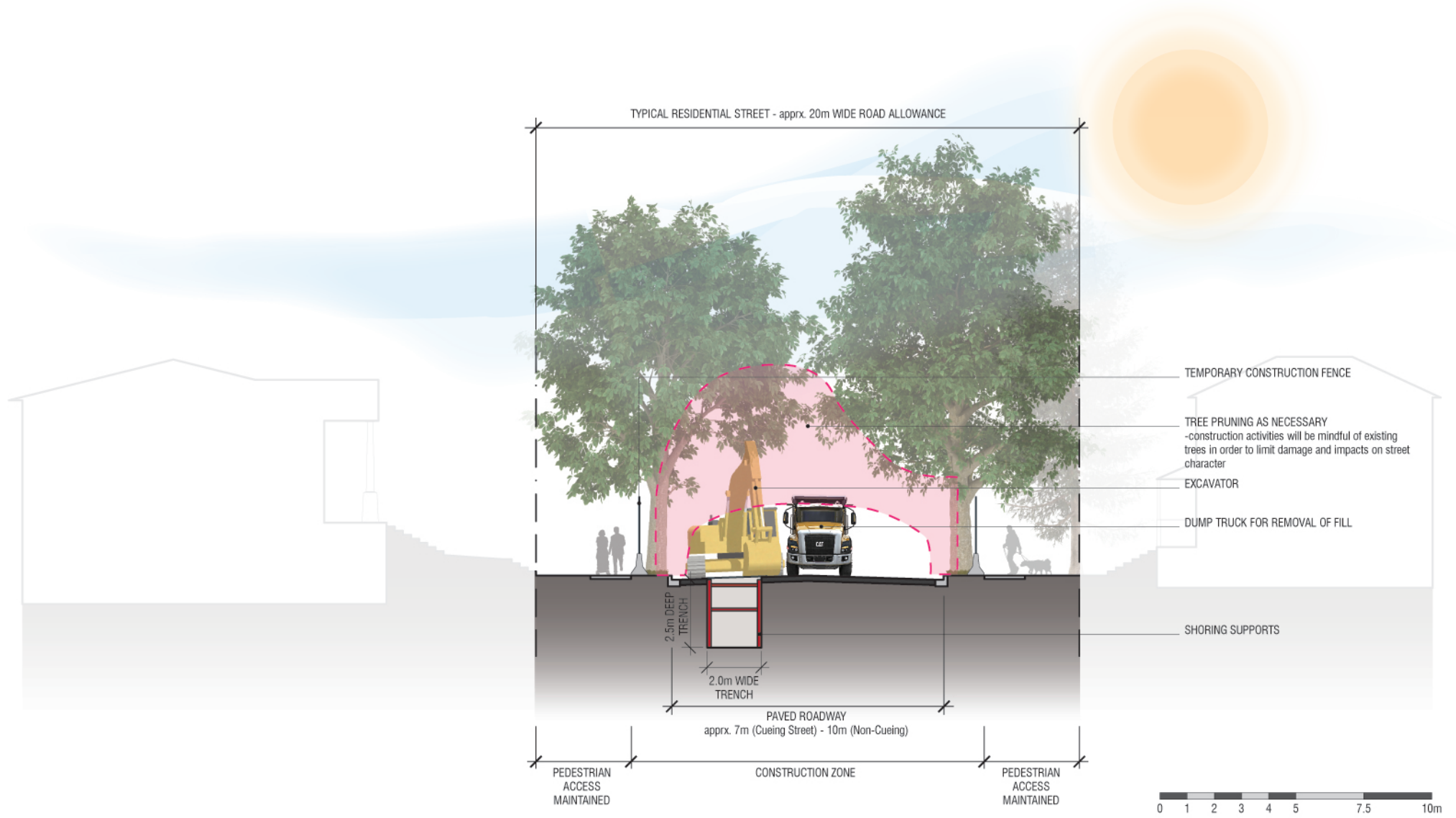
PIPE LAYING PHASE

TYPICAL RESIDENTIAL STREET



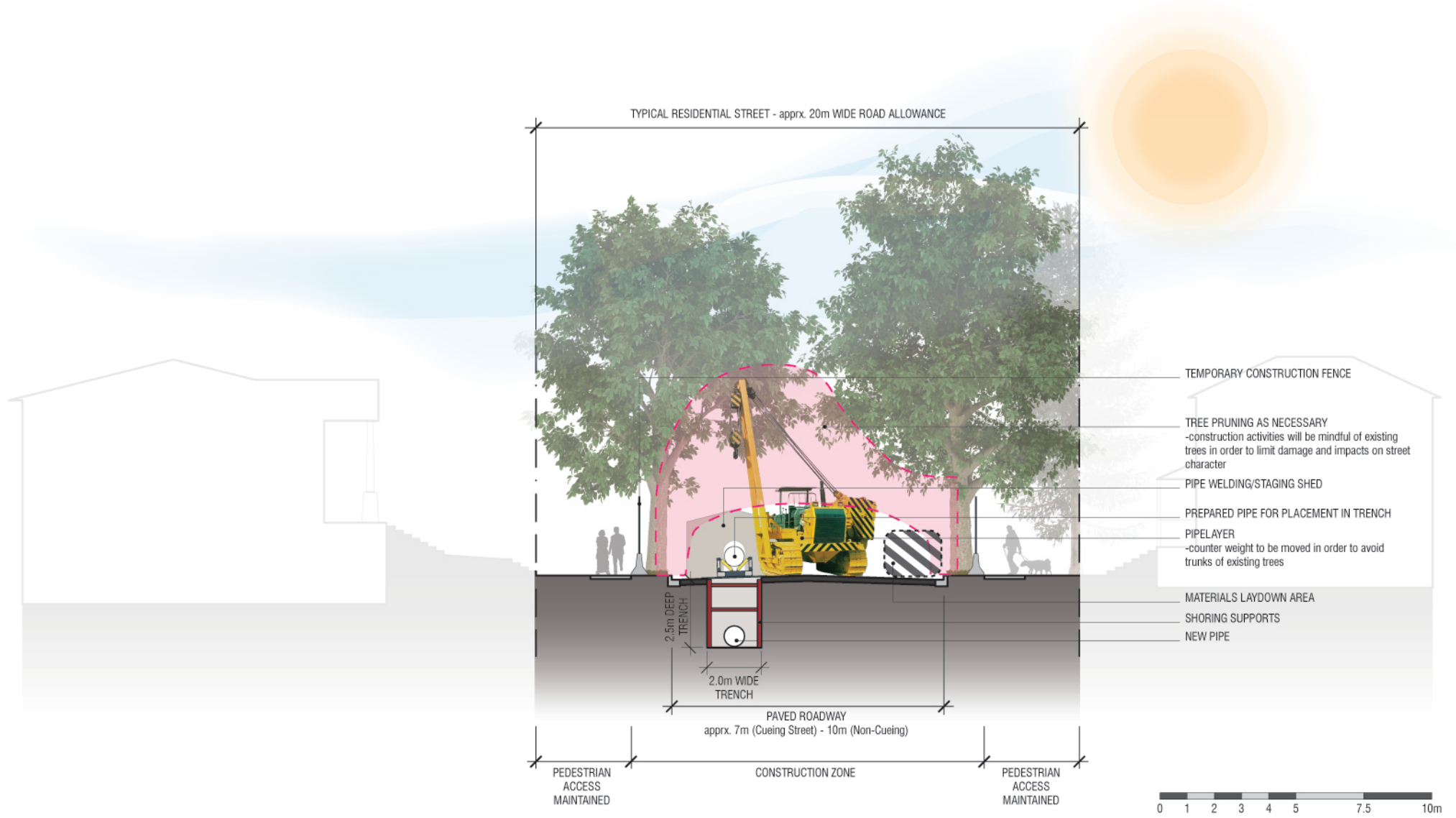
EXCAVATION PHASE

TYPICAL RESIDENTIAL STREET



EXCAVATION PHASE

TYPICAL RESIDENTIAL STREET



PIPE LAYING PHASE

TYPICAL RESIDENTIAL STREET

Appendix C-5

CALL CENTRE SCRIPT

KEY MESSAGES
Issue: Lower Mainland System Upgrades
Date: May 16, 2014

Background

In May and June, FortisBC is holding information sessions regarding proposed natural gas system upgrades in the Lower Mainland. At these sessions, people will have the opportunity to speak with a FortisBC representative and ask questions about our planned system improvements.

The proposed upgrades would be to five sections of our natural gas system that serves customers in the Lower Mainland and on Vancouver Island and would be located in:

Coquitlam, Burnaby, Vancouver:
- Replace approximately 20 kilometres of the Metro Intermediate Pressure (IP) natural gas line that runs between our Coquitlam Station and our station at East 2nd Avenue and Woodland Drive in Vancouver.
- The Metro IP natural gas line is nearing the end of its useful life and must be replaced.

Coquitlam:
- Install approximately 4.6 kilometres of natural gas line between our Cape Horn and Coquitlam stations to provide additional backups and supply the Metro IP gas line.
- The improvements will be carried out in the same utility corridor as the existing natural gas line.

Vancouver:
- Replace approximately 700 metres of natural gas line between Fraser Station and our underground station at SE Marine Drive and Elliott Street to provide additional seismic resistance.

Surrey:
- Install approximately five kilometres of new natural gas line from our Nichol Station to the south side of the Fraser River to enable in-line inspections and meet forecasted long-term growth in core demand.
- Install approximately 1.7 kilometres of natural gas line between our Nichol and Roebuck stations to provide additional backups for customers.
- The improvements will be carried out in the same utility corridor as the existing natural gas line.

Key Messages:

- The planned upgrades will ensure we can continue to meet our customers' needs now and in the future – particularly during times of peak demand or when maintenance work is required.
- We are in the early planning stages for the various upgrades and will submit our application to our regulators – the BC Utilities Commission and the BC Oil and Gas Commission – later this year.
    - During the BC Utilities Commission's review process, you can register to participate at www.bcuc.com.
- If we receive regulatory approval, we expect to start construction in 2017.
- We're holding information sessions in May and June to give the public a chance to learn more about our plans and speak directly with FortisBC representatives:
    - May 27, Coquitlam, Poirier Sports and Leisure Complex, 633 Poirier Street, 6-9 p.m.
    - May 29, Surrey, City Centre Public Library, 10350 University Drive, 5-8 p.m.

    - June 3, Coquitlam, Executive Plaza Hotel, 405 North Road, 6-9 p.m.
    - June 4, Burnaby, Confederation Community Centre, 4585 Albert Street, 6-9 p.m.
    - June 24, Vancouver, Trout Lake Community Centre, 3360 Victoria Drive, 6-9 p.m.
- We are currently finalizing the project costs to properly evaluate the potential impact to the delivery rates for our customers. We will provide more information to the public once available.
- For more information on the Lower Mainland system upgrades, visit fortisbc.com/workinyourcommunity or email systemupgrades@fortisbc.com.

Q&A

Why are you planning this work?

These sections of our Lower Mainland system provide service to customers across the Lower Mainland and Vancouver Island. The upgrades ensure we can continue to meet our customers' needs now and in the future.

What work are you planning?

The planned upgrades are part of our ongoing maintenance program. They include replacing a section of gas line that is nearing the end of its useful life and building additional backups for our customers. We are also upgrading a small section of gas line in south Vancouver to provide additional seismic stability.

When will construction begin?

We are applying to our regulators – the BC Utilities Commission and the BC Oil and Gas Commission – later this year. If approved, we expect to begin construction in early 2017.

Who is paying for these upgrades and how much will they cost?

Each year, we budget for upgrades and maintenance. We expect to invest $200 to $300 million in these upgrades; however the project costs are still being finalized.

As with all infrastructure projects, we pay for the system upgrades and then recover the cost from all customers over the expected life of the gas line. We are currently evaluating the potential impact to delivery rates, which will form part of our regulatory application to the BC Utilities Commission.

Can the public get involved in the regulatory process?

Yes. The public is invited to participate in the regulatory review process. You can send us your comments via email at systemupgrades@fortisbc.com so that we can include them in our regulatory application.

You can also register to participate in the upcoming BC Utilities Commission process at www.bcuc.com.

Appendix C-6

LETTER TO RESIDENTS, MAY 2014

16705 Fraser Highway
Surrey, BC V4N 0E8
fortisbc.com

May 14, 2014

Dear Resident

This letter is to advise you that FortisBC is planning improvements to five sections of its existing natural gas system that provides service to customers in Surrey, Burnaby, Coquitlam and Vancouver.

These upgrades will improve the integrity of the natural gas system and provide greater operational flexibility so that we can best meet the future needs of our customers. As part of the upgrades, we will:

- Replace approximately 20 kilometres of the existing Metro Intermediate Pressure (IP) natural gas line that runs from the corner of Como Lake Road and Mariner Way in Coquitlam to East 2nd Avenue and Woodland Drive in Vancouver. This section of the gas line must be replaced as it is nearing the end of its lifespan;
- Install approximately 4.6 kilometres of natural gas line from the corner of Como Lake Road south to the Fraser River. The work will be completed along the same utility corridor as our existing line. This installation will provide additional backups and supply the Metro IP gas line mentioned above;
- Install approximately 5 kilometres of natural gas line south from the Fraser River crossing to the corner of 94A Avenue and 138th Street (south and east of the Surrey Memorial Hospital) in Surrey. The work will be completed along the same utility corridor as FortisBC's existing line;
- Install approximately 1.7 kilometres of natural gas line from the corner of 94A Ave and 138th Street travelling west across the King George Highway. The work will be completed along the same utility corridor as our existing line. This new natural gas line will provide additional backups for customers in Surrey, Richmond and Vancouver; and
- Replace approximately 700 metres of gas line south from South East Marine Drive & Elliott Street, then east along East Kent Ave North and East Kent Ave South in Vancouver. This replacement will provide additional seismic resistance.

FortisBC plans to submit an application for the upgrades to the BC Utilities Commission and the BC Oil and Gas Commission respectively later this year. During the BC Utilities Commission's application review process, you can register to participate in that process. If the application is approved, FortisBC estimates that the construction will begin in early 2017.

These upgrades are important for you and your community; thus, FortisBC is holding several information sessions to give you a chance to learn more about the planned upgrades and speak directly with FortisBC representatives. The dates and times of the information session are outlined on the back side of this letter.

If you cannot attend an information session in person, we encourage you to participate in the discussion by visiting **fortisbc.com/inyourcommunity** and sending us your questions or concerns by emailing **systemupgrades@fortisbc.com.**

Sincerely,

Gord Schoberg
FortisBC Community Relations

Lower Mainland natural gas system upgrades public information sessions

Coquitlam May 27, 2014 6 p.m. to 9 p.m. Poirier Recreation Centre (633 Poirier St.)	**Surrey** May 29, 2014 5 p.m. to 8 p.m. Surrey Central City Centre Public Library (10350 University Dr.)
Burnaby June 3, 2014 6 p.m. to 9 p.m. Executive Inn (405 North Rd.) June 4, 2014 6 p.m. to 9 p.m. Confederation Centre (4585 Albert St.)	**Vancouver** June 24, 2014 6 p.m. to 9 p.m. Trout Lake Community Centre (3360 Victoria Dr.)

GS:rj

Appendix C-7

PUBLICATION IN NEWSPAPERS

FORTIS BC™

Join us for a public information session

Learn more about planned natural gas system upgrades in your community

We're planning improvements to five sections of the existing natural gas system that serves customers in Surrey, Burnaby, Coquitlam and Vancouver so we can best meet the future needs of these communities.

Upcoming information sessions are being held:

Coquitlam **May 27, 6 p.m. to 9 p.m.** Poirier Sports and Leisure Complex (633 Poirier St.) **June 3, 6 p.m. to 9 p.m.** Executive Plaza Hotel (405 North Rd.)	**Surrey** **May 29, 5 p.m. to 8 p.m.** City Centre Library (10350 University Dr.)
Burnaby **June 4, 6 p.m. to 9 p.m.** Confederation Community Centre (4585 Albert St.)	**Vancouver** **June 24, 6 p.m to 9 p.m.** Trout Lake Community Centre (3360 Victoria Dr.)

For more information, visit **fortisbc.com/inyourcommunity** or email **systemupgrades@fortisbc.com**.

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Appendix C-8

PUBLICATION IN QUICK CONNECT

FORTIS BC™

Quick Connect

Your connection to energy news, offers and tips

Fall 2014

In this issue

- Renewable natural gas 2
- Improving our natural gas system . . .2
- Customer Choice 3
- 2 for 1 home show tickets. 3
- AIR MILES® reward miles offer 3
- Go high efficiency and save 4
- Sign up for *The Conserver* 4
- Go paperless and win! 4

MCC# 900092

Need a natural gas contractor?

The FortisBC Trade Ally Network (formerly called the Contractor Program) launches in September, making it easy to find a licensed natural gas contractor in your community. Not only are contractors in the Trade Ally Network licensed by the BC Safety Authority, but they've also met FortisBC's requirements—making it easier for you to find a reputable business in your neighbourhood. We will have more than 400 contractors from all over B.C. listed in our online directory.*

Trade Ally Network contractors:

- possess a minimum $2 million liability and third-party insurance
- have a business licence for each community they operate in
- have been in business for a minimum of one year
- are encouraged to get permits when installing natural gas appliances
- are informed about our Energy Efficiency and Conservation rebates

Look for the Trade Ally Member logo in your community and be confident knowing you're hiring a professional committed to safety and quality service. Find a Trade Ally Network contractor at **fortisbc.com/findacontractor**.

FORTIS BC™
Trade Ally Member

**Companies that participate in the FortisBC Trade Ally Network are independent gas contractors and are not employed by FortisBC.*

Care for your appliances

Natural gas is used safely and reliably every day in homes across B.C. Regular maintenance and inspection of your natural gas appliances ensures your safety and keeps them operating at their best.

As the heating season approaches, it's a good idea to have a licensed gas contractor inspect and maintain your natural gas equipment. Find one through the FortisBC Trade Ally Network. Our online directory makes it easy to find licensed professionals in communities throughout B.C. For more tips on appliance safety and maintenance, visit **fortisbc.com/appliancesafety**.

New blends of renewable natural gas are here

Pete Schouten, Owner
Fraser Valley Biogas
Abbotsford, B.C.

Starting September 2014, you can sign up for renewable natural gas[1] and choose the blend of conventional and renewable natural gas you purchase from us. There will be five, 10, 25, 50 and 100 per cent blend options—the choice is yours. For a small cost, you can be assured a portion of your natural gas supports the growth of renewable energy in B.C.

Although you pay a little extra for this sustainable source of energy, the funds go directly towards supporting local suppliers so they can produce even more renewable energy.

with OFFSETTERS carbon neutral product

[1]Renewable natural gas is currently available to customers in the Lower Mainland, and Inland (Interior and North) and Columbia (Kootenays) regions. [2]FortisBC's renewable natural gas has been designated as carbon neutral in B.C. by Offsetters. [3]The prize lottery is for residential renewable natural gas subscribers. Terms and conditions apply.

It's naturally better

Renewable natural gas is made right here in B.C. Our suppliers use organic waste from farms and landfills to produce renewable, carbon neutral[2] energy that we deliver along with conventional natural gas through our gas lines to homes and businesses.

Help us stop waste from going to waste. Learn more and sign up at **fortisbc.com/rng**.

Win a gift basket!

Sign up your home and you'll be automatically entered in the new Renewable Natural Gas Prize Lottery.[3] A winner will be drawn every three months for a gift basket worth approximately $200.

Improving our natural gas system

We're planning upgrades to five sections of our natural gas system in the Lower Mainland. The upgrades are necessary to meet the current and future energy needs of our natural gas customers.

The planned work includes:

- replacing a 20 km section of an existing natural gas line nearing the end of its useful life
- adding additional seismic resistance
- installing additional backups to improve the reliability and operational flexibility of the system

We will apply to the British Columbia Utilities Commission (BCUC) for the necessary approval. The potential impact on the delivery rate for our customers can be part of the BCUC review process.

If approved, we expect to start construction in early 2017.

To learn more about the project, visit **fortisbc.com/inyourcommunity** or contact us with your questions at **systemupgrades@fortisbc.com**.

To learn about the BCUC regulatory process, visit **www.bcuc.com**.

Customer Choice: it's your choice

With Customer Choice* you can choose who you buy your natural gas from: FortisBC at a variable rate or an independent gas marketer at fixed rates and terms.

FortisBC's variable rate can go up or down depending on market conditions. FortisBC doesn't mark up the cost of natural gas—you pay what we pay. Independent gas marketers offer fixed rates for terms of one to five years. Locking in a fixed rate can give you the assurance of knowing what you'll be paying down the road.

Before signing a Consumer Agreement with an independent gas marketer, learn more and compare rates at **fortisbc.com/choice**.

CUSTOMER CHOICE

**Customer Choice is not available on Vancouver Island, the Sunshine Coast, Whistler, Revelstoke, Powell River or Fort Nelson.*

Get your 2 for 1 tickets

Vancouver Home + Design Show

Go to **vancouverhomeanddesignshow.com**, select "buy tickets" and enter promotion code: **FORTISBC** to receive two tickets for the price of one regular adult admission, courtesy of FortisBC.

Visit our booth on October 16–19, 2014, at BC Place Stadium, Vancouver. We'll have energy conservation activities, prizes and more. For a full list of where we'll be next, visit **fortisbc.com/events**.

In partnership:

AIR MILES

FORTIS BC™

BC hydro powersmart

RONA HOME & GARDEN RONA

Earn Bonus AIR MILES® reward miles*

Purchase select energy-saving products at RONA until October 12, 2014, and earn Bonus reward miles. Download your coupons at **RONA.ca/energy-savings**, present them in-store with qualifying purchases and start saving energy! See coupons for full offer details.

For full terms and conditions, visit* **RONA.ca/energy-savings. *®™ Trademarks of AIR MILES International Trading B.V. Used under license by LoyaltyOne, Co. and FortisBC.*

Upgrade to energy-efficient natural gas appliances.

Offers*	Rebate	Description
NEW! Home Energy Rebate Offer (with BC Hydro Power Smart)	varies	insulation and draftproofing rebates, plus a $750 Bonus Offer with three eligible upgrades
ENERGY STAR® Water Heater	up to $1,000	purchase a qualifying high-efficiency model
EnerChoice® Fireplace	$300	purchase an EnerChoice model
Energy Saving Kit (with BC Hydro Power Smart)	free for income-qualified customers; apply at **fortisbc.com/esk** or call **1-877-446-8855**	easy-to-install devices to help reduce your home's energy use
New Home (with BC Hydro Power Smart)	varies	for details, visit **fortisbc.com/newhome**

**Conditions apply. FortisBC may modify or cancel programs at any time.*

Learn more and apply for rebates at **fortisbc.com/myfootprint**.

Sign up for *The Conserver*

Our free monthly enewsletter provides the latest information on contests, rebate offers and tips and tools to help you save energy. Sign up at **fortisbc.com/conserver**.

Go paperless and win!

Switch to paperless billing between July 30, 2014 and January 12, 2015, and you'll automatically be entered to win one of six e-readers. Each month, one lucky person's name will be drawn to win an e-reader valued at $199.99.

Read full contest details and get started at **fortisbc.com/paperless** or call **1-888-224-2710**.

Connect with us

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(14-251.1 07/2014)

Appendix C-9

PUBLICATION IN CONSERVER

Joan can find opportunities for energy efficiency almost anywhere. Where did she go this month?

Share Email

The Conserver
Your guide to saving energy

FORTIS BC™

Is it curtains on wasting energy?

With the variety of styles available, they can make your living room prettier. But can they help you save energy? Find out the results of Joan's experiment on thermal curtains in Shopping with Joan.

Is it curtains on wasting energy?

Choose your blend of renewable natural gas

Starting in September, when you sign up for renewable natural gas, you can choose the blend of conventional and renewable natural gas you want. With blends from five to 100 per cent, we've got an option for everyone. And when you sign up you'll be supporting the growth of renewable energy in BC.

Sign up for renewable natural gas

Improving our natural gas system

Ensuring natural gas reaches your home safely and reliably every day is at the core of what we do. So we're planning upgrades to the existing system in the Lower Mainland to help us best meet your future energy needs.

Learn more about the project

A tale of energy-efficiency upgrades

Miss our Renos with Joan series? Read it from the start and find out how Joan turned a drafty fixer into a comfy haven. Whether adding insulation in the attic or a water heater in the basement, Joan tells you how she did it, so you can too!

Get reading

Energy efficiency. Good for smaller footprints.

And saving money on your energy bill. We can help with our rebates, tips and tools.

View all rebates & offers

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Hi, just a reminder that you're receiving this email because you have provided your email address to FortisBC. Don't forget to add no-reply@fortisbc.com to your address book so we'll be sure to land in your inbox!

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www.fortisbc.com
FortisBC
16705 Fraser Hwy
Surrey, British Columbia
V4N 0E8 Canada

About

- Leadership team
- Investor centre
- Regulatory affairs
- Work in your community
- Projects & planning
- Service areas
- Our commitments
- Newsletters
- Events
- About natural gas
- Gas forms and brochures

Work in your community

We constantly monitor our infrastructure to make sure it's operating as efficiently as possible. Part of our regular maintenance includes making upgrades to our natural gas lines to ensure the continued safe and reliable delivery of natural gas to our customers.

Lower Mainland natural gas system upgrades

We're currently planning improvements to five sections of the existing natural gas system that provides service to customers throughout the Lower Mainland and Vancouver Island (view the map). These investments will improve the reliability of the system and provide greater operational flexibility so that we can best meet the future needs of our customers.

Natural gas line upgrade locations

- Coquitlam, Burnaby, Vancouver
- Coquitlam
- Vancouver
- Surrey

As with any significant improvement to our natural gas infrastructure, we will submit the costs of this project to the BC Utilities Commission for review and approval. We are currently evaluating the potential impact to the delivery rates for our customers and will provide more information to the public once available.

Next steps

We will soon apply to the required regulatory agencies for approval of these upgrades. If approved, we anticipate construction will begin in early 2017.

If you have questions or concerns about this project, please email us at systemupgrades@fortisbc.com.

Natural gas main relocation at City Centre Park

In order to accommodate the City of Langford's expansion of the City Centre Park parking lot at 1089 Langford Parkway, FortisBC will relocate a portion of an existing natural gas main from the south side, to the north side of Langford Parkway between the City Centre Park facility and Goudy Turf Field.

» View the map

Natural gas main relocation at City Centre Park

In order to accommodate the City of Langford's expansion of the City Centre Park parking lot at 1089 Langford Parkway, FortisBC will relocate a portion of an existing natural gas main from the south side, to the north side of Langford Parkway between the City Centre Park facility and Goudy Turf Field.

» View the map

This relocation will take place during July and August, 2014.

Limited traffic disruptions along Langford Parkway will take place throughout the duration of this project. We're working closely with the City of Langford to minimize interruptions and communicate upcoming changes.

During this project, natural gas will be vented and may result in a sound similar to a jet engine and a smell like rotten eggs; it may also include the safe burning of natural gas through a flare stack. The venting procedure could take up to three hours.

We do not anticipate any service disruptions to our customers, and we thank you in advance for your patience.

If you have any questions relating to construction or venting operations, please call **250-380-5738**.

Natural gas line twinning in Abbotsford

We will be twinning the Intermediate Pressure natural gas line between Clayburn Road and Hallert Road along Riverside Street in Abbotsford (view the map). Construction is scheduled for July and August 2014. The work may affect traffic so to complete the project safely, flag persons will be on site to direct traffic during construction. If you have any questions relating to this work, please call **604-576-7363**.

Natural gas line seismic upgrades at Elk Falls Provincial Park

FortisBC is conducting seismic upgrades under the pedestrian bridge on Canyon View Trail, within Elk Falls Provincial Park. As a result, the pedestrian bridge will be closed periodically.

You may notice workers removing vegetation and using equipment in the area. This is necessary to safely upgrade the bridge's foundation and improve its seismic stability.

We apologize for any inconvenience and thank you for your patience.
If you have any questions relating to these improvements please call **1-888-224-2710**.

» View the map

Putting your safety first

Natural gas is a safe and reliable energy source and we take safety precautions to ensure continued public safety.

» Natural gas line safety

Lower Mainland pipeline upgrades in your area?

Lower Mainland system upgrades in your area? Take a look at the map to see if we'll be upgrading the natural gas line in your neighbourhood.

» Natural gas system upgrades map

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Appendix C-10

STAKEHOLDER COMMUNICATIONS

Appendix C-10-1

STAKEHOLDER EMAIL INVITATION TO PUBLIC INFO SESSIONS

From: Schoberg, Gord
Sent: May 14, 2014 7:29 PM
Subject: FortisBC Lower Mainland Natural Gas System Upgrades

I am enclosing an invitation to a series of public information sessions being planned for May and June at five locations along the project route. I trust you will be able to join us to get updated on our progress, to provide your thoughts and ask any questions you may have. Some of you offered to post the notice in your office or forward it to interested individuals for which I would be grateful. In an effort to inform the public of these sessions you may see notices in local and provincial newspapers and we are mailing the attached notice to over 11,000 residents along the gas line route.

I hope to see you at these sessions!

Gordon Schoberg
Senior Manager, Government Relations
FortisBC
16705 Fraser Hwy
Surrey, B.C.
Canada, V4N 0E8

604.220.9785 Cel phone
604.592.7534 Office
604.576.7122 Fax

FORTIS BC™

16705 Fraser Highway
Surrey, BC V4N 0E8
fortisbc.com

May 14, 2014

Dear Resident

This letter is to advise you that FortisBC is planning improvements to five sections of its existing natural gas system that provides service to customers in Surrey, Burnaby, Coquitlam and Vancouver.

These upgrades will improve the integrity of the natural gas system and provide greater operational flexibility so that we can best meet the future needs of our customers. As part of the upgrades, we will:

- Replace approximately 20 kilometres of the existing Metro Intermediate Pressure (IP) natural gas line that runs from the corner of Como Lake Road and Mariner Way in Coquitlam to East 2nd Avenue and Woodland Drive in Vancouver. This section of the gas line must be replaced as it is nearing the end of its lifespan;
- Install approximately 4.6 kilometres of natural gas line from the corner of Como Lake Road south to the Fraser River. The work will be completed along the same utility corridor as our existing line. This installation will provide additional backups and supply the Metro IP gas line mentioned above;
- Install approximately 5 kilometres of natural gas line south from the Fraser River crossing to the corner of 94A Avenue and 138th Street (south and east of the Surrey Memorial Hospital) in Surrey. The work will be completed along the same utility corridor as FortisBC's existing line;
- Install approximately 1.7 kilometres of natural gas line from the corner of 94A Ave and 138th Street travelling west across the King George Highway. The work will be completed along the same utility corridor as our existing line. This new natural gas line will provide additional backups for customers in Surrey, Richmond and Vancouver; and
- Replace approximately 700 metres of gas line south from South East Marine Drive & Elliott Street, then east along East Kent Ave North and East Kent Ave South in Vancouver. This replacement will provide additional seismic resistance.

FortisBC plans to submit an application for the upgrades to the BC Utilities Commission and the BC Oil and Gas Commission respectively later this year. During the BC Utilities Commission's application review process, you can register to participate in that process. If the application is approved, FortisBC estimates that the construction will begin in early 2017.

These upgrades are important for you and your community; thus, FortisBC is holding several information sessions to give you a chance to learn more about the planned upgrades and speak directly with FortisBC representatives. The dates and times of the information session are outlined on the back side of this letter.

If you cannot attend an information session in person, we encourage you to participate in the discussion by visiting **fortisbc.com/inyourcommunity** and sending us your questions or concerns by emailing **systemupgrades@fortisbc.com.**

Sincerely,

Gord Schoberg
FortisBC Community Relations

Lower Mainland natural gas system upgrades public information sessions

Coquitlam May 27, 2014 6 p.m. to 9 p.m. Poirier Recreation Centre (633 Poirier St.)	**Surrey** May 29, 2014 5 p.m. to 8 p.m. Surrey Central City Centre Public Library (10350 University Dr.)
Burnaby June 3, 2014 6 p.m. to 9 p.m. Executive Inn (405 North Rd.) June 4, 2014 6 p.m. to 9 p.m. Confederation Centre (4585 Albert St.)	**Vancouver** June 24, 2014 6 p.m. to 9 p.m. Trout Lake Community Centre (3360 Victoria Dr.)

GS:rj

Appendix C-10-2

STAKEHOLDER UPDATE EMAIL JULY 2014

From: Schoberg, Gord
Sent: July 22, 2014 11:31 AM
Subject: FortisBC update: upgrades to natural gas lines in Vancouver, Burnaby, Coquitlam and Surrey

Enclosed is an update on our recent activities as we continue planning for the necessary upgrades to our natural gas lines in Vancouver, Burnaby, Coquitlam and Surrey.

We are on track to apply to the required regulatory agencies later this year. If approved, we anticipate construction will begin in early 2017. For a complete overview of the planned work, visit fortisbc.com/inyourcommunity.

Your input has been valuable throughout this process. I encourage you to continue participating in an ongoing dialogue with us by emailing any comments or questions to systemupgrades@fortisbc.com.

Public Information Sessions

In May and June, we held five public information sessions along the project route to share our plans with local residents, answer questions and gather important feedback.

The most commonly raised question was about how we will manage traffic during construction. We engaged traffic engineers to study traffic patterns along the proposed route and provide us with guidance on mitigating traffic congestion. Their findings will form the basis of our comprehensive traffic management plan. We are committed to communicating early and often with the public to ensure we inform residents and commuters about upcoming work well in advance and allowing people time to plan their activities accordingly.

A small number of residents in one Burnaby neighbourhood suggested we look at an alternative route for part of the project that was outside our initial study area. We are currently studying their suggestion and meeting with additional local stakeholders throughout the summer to evaluate whether the proposed alternative route is a viable option. We expect the results of those discussions early this fall.

Professional Studies

We engaged a certified arborist familiar with doing work in Vancouver to complete a report that outlines how the planned construction work will impact trees in Vancouver. The final report will be useful as we consult with the City of Vancouver Parks and Engineering groups and develop our vegetation management plan. It will also be available publicly as an appendix to our BC Utilities Commission application.

We are also completing a socio-economic report, which indicates impacts – both positive and negative – that the project may have in the communities it passes through. We have developed an internal tracking process to catalogue economic benefits to the local community, to British Columbia and to Canada. This report will also be available publicly after the project is complete.

Community Amenity Projects

We see giving back as an important part of our efforts and are planning some modest community projects to benefit the local communities after the project is complete. We have received useful suggestions from the public, community organizations and municipalities, and will provide a further update as we finalize these plans.

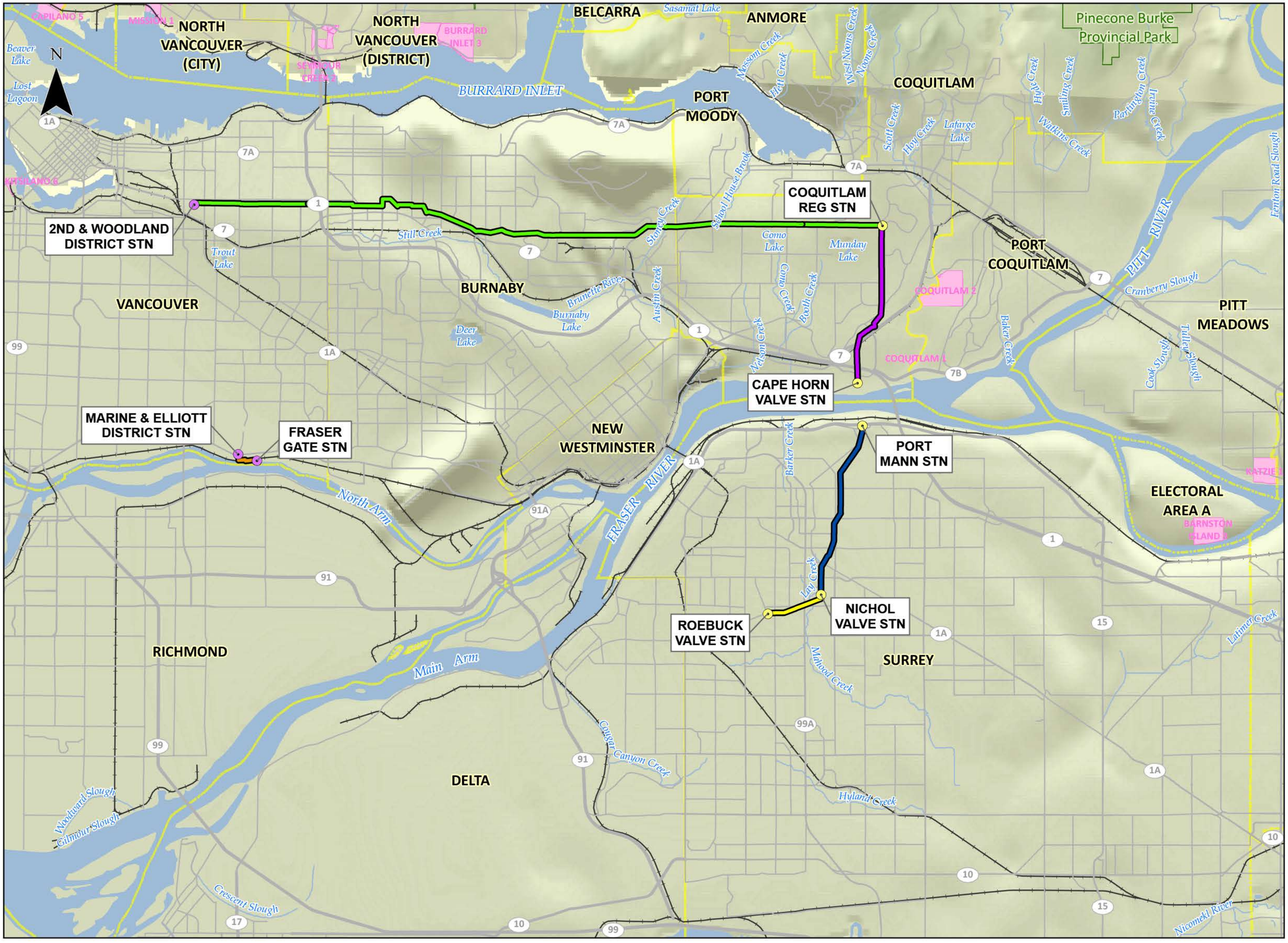
Sincerely,

Gordon Schoberg
Senior Manager, Government Relations
FortisBC
16705 Fraser Hwy
Surrey, B.C.
Canada, V4N 0E8

604.220.9785 Cel phone
604.592.7534 Office
604.576.7122 Fax

Appendix C-11

MAP OF COMMUNITIES



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November 2013

GENERAL STUDY AREA

METRO VANCOUVER

10256

- District Station
- Transfer Station
- Cape Horn - Coquitlam
- Coquitlam IP
- Fraser IP
- Nichol - Port Mann
- Nichol - Roebuck
- Highway
- Road
- Railway
- Watercourse
- Waterbody
- Municipality
- Park/Protected Area
- First Nations Land

SCALE: 1:100,000

0 1 2 3 4 km

(All Locations Approximate)

tera ENVIRONMENTAL CONSULTANTS

UTM Zone 10N

Pipeline Routes & Stations:FortisBC 2013; Roads and Railways: Natural Resources Canada 2012; Hydrography: Natural Resources Canada 2007; Municipal Boundaries and Regional Districts: BC Forests, Lands and Natural Resource Operations 2007; Parks: BC Forests, Lands and Natural Resource Operations 2008; Indian Reserves: Government of Canada 2013; Hillshade: TERA Environmental Consultants 2012.

Although there is no reason to believe that there are any errors associated with the data used to generate this product or in the product itself, users of these data are advised that errors in the data may be present.

Mapped By: DN | Checked By: MH

10256_general_study_area_v2.mxd

Appendix C-12

LETTER TO HIGHLAWN DRIVE RESIDENTS

16705 Fraser Highway
Surrey, B.C. V4N 0E8
Tel: (604) 576-7000
Fax: (604) 576-7220
Toll Free: 1-800-773-7001
www.fortisbc.com

September 18, 2014

«Owner_Name__Address»

Subject: Invitation to a meeting with FortisBC to discuss gas line routing associated with the FortisBC Lower Mainland Natural Gas System Upgrade Projects
Property Address: «Property_Address»

Many residents from Highlawn Drive attended public information sessions sponsored by FortisBC during May and June 2014 and were introduced to several proposed upgrades being considered to the FortisBC gas line system. The preferred alignment of one of these gas lines was shown along Highlawn Drive, and these residents suggested some alternative routings that would not impact Highlawn Drive. FortisBC promised to investigate these suggested routes and communicate further with the Highlawn Drive residents when the analysis was complete. While analyzing these routes this past summer, FortisBC identified and analyzed two additional potential routes for consideration.

We are now ready to invite residents on Highlawn Drive to a meeting to discuss all these routes and confirm a preferred route. Meeting details are:

Date: Tuesday October 7, 2014. Presentation will begin at 7:00pm.

Location: Executive Suites Hotel, 4201 Lougheed Highway, Burnaby: Boardroom A

Parking fees: DO NOT PAY FOR PARKING. Instead check in with the Front Desk, tell them you are with the "FortisBC event" and register your license plate number. Fortis will pay for parking.

Would you please RSVP to Gord Schoberg at either gord.schoberg@fortisbc.com or 604.220.9785.

I hope you can join us,

Yours very truly,

Gord Schoberg

Senior Manager, Community and Aboriginal Relations

FortisBC

Appendix C-13

BURNABY COMMUNITY SESSION PRESENTATION

Lower Mainland System Upgrades

Follow-up Burnaby community session

John Quinn, Project Engineer, FortisBC
Gord Schoberg, Community Relations Manager, FortisBC

October 7, 2014

Welcome

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Agenda

- Overview of planned upgrades
- Selecting route alternatives
- Feedback from spring community consultation sessions
- Evaluating route alternatives through Burnaby
- Next steps: BCUC application
- Questions

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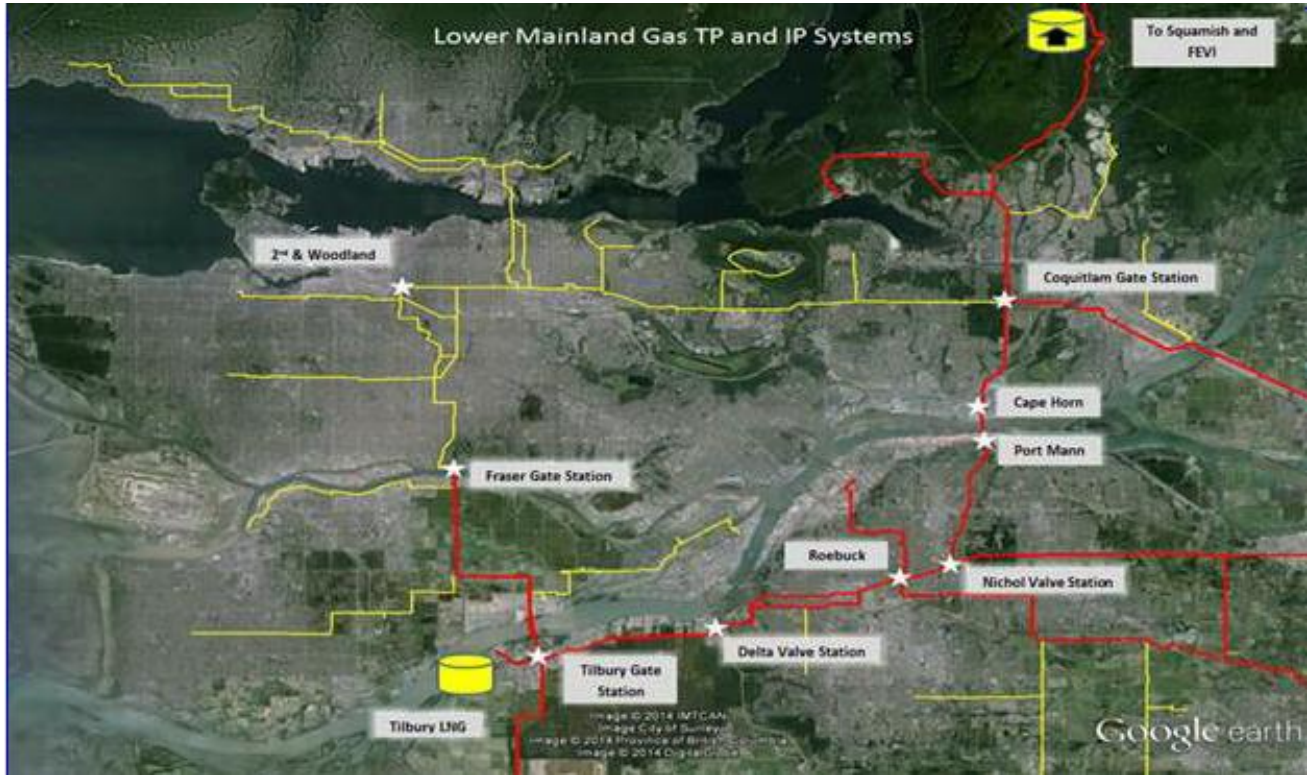
Overview

Aerial View of the Lower Mainland IP and TP Systems



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Project details

- We're currently planning improvements to five sections of the existing Lower Mainland natural gas system.
- The sections being upgraded run through four municipalities – Surrey, Coquitlam, Burnaby and Vancouver.
- The system provides natural gas service to more than 70% of natural gas customers in B.C.
- Before construction begins we must first receive approval from the required regulatory agencies.
- If approved, we anticipate construction of upgraded Coquitlam IP pipeline will begin in early 2018.

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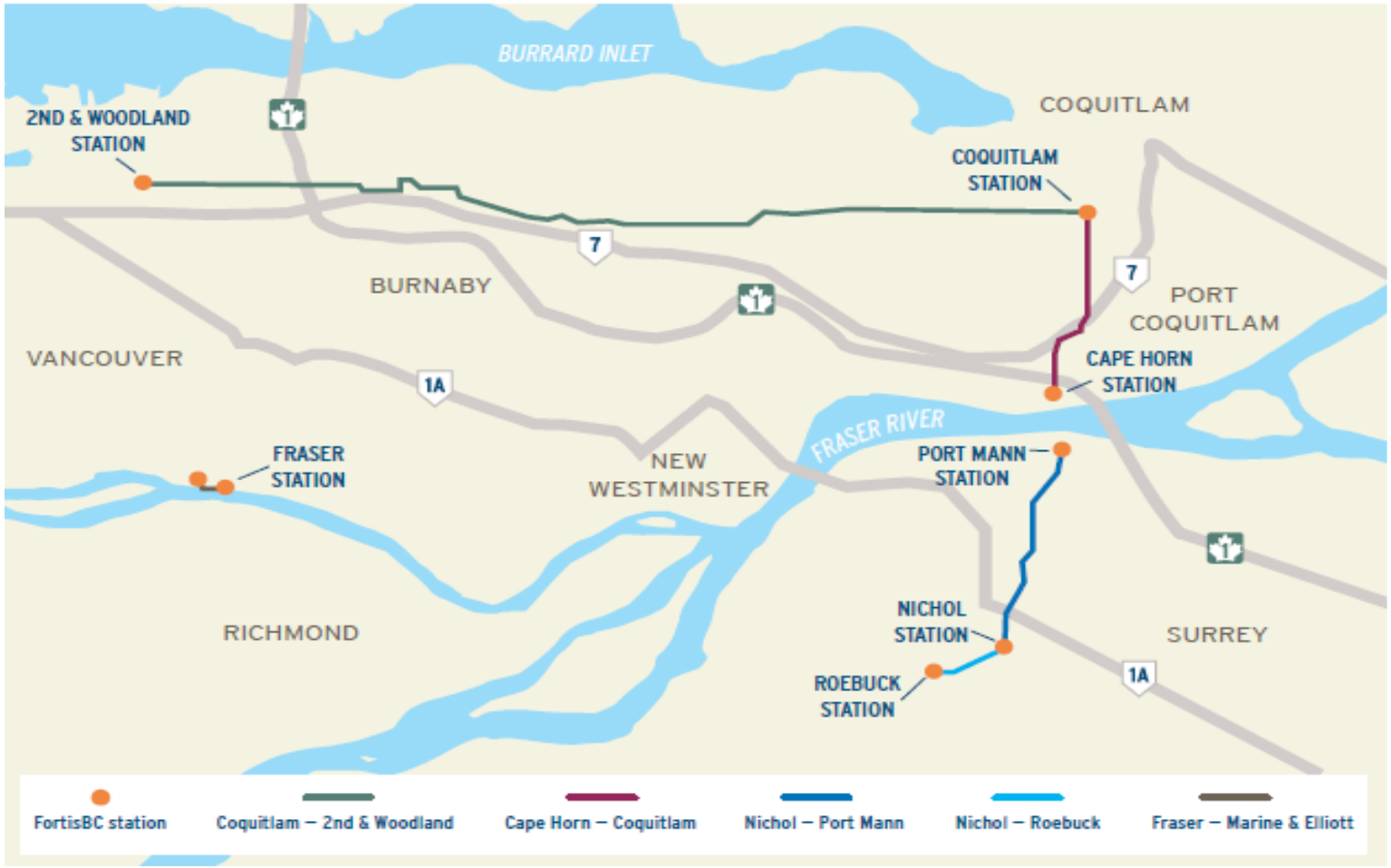
Coquitlam Intermediate Pressure (IP) line



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Commitment to safety

- FortisBC has provided natural gas service to customers for decades and has a strong safety record.
- The Coquitlam IP pipeline is nearing the end of its useful life and must be replaced.
- Upgraded sections of pipeline will provide greater operational flexibility and be constructed to the highest industry best practices
- The BC Oil & Gas Commission regulates construction of natural gas pipeline in B.C.
- Construction crews must follow CSA / WorkSafeBC best practices.

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Selecting possible route alternatives

- **Objective:** select a route alternative that minimizes potential impacts on the community, stakeholders and environment.
- Upgraded pipeline must meet safety requirements.
- Robust evaluation criteria ensures we minimize potential environmental impacts or the use of higher risk techniques and is economical.
- In addition to detailed engineering studies, the feedback we received through our consultation activities also allowed us to fully evaluate all potential routing options.

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Multiple assessed alternatives

- Pipeline routing starts with a wide “corridor of interest”.
- Feasible route alternatives depend on a number of factors and must minimize community and environmental impacts.
- Route assessment corridor for Coquitlam IP was largely based on the existing route alignment:
  - Coquitlam – Como Lake Avenue
  - Burnaby East – Broadway
  - Burnaby West – Springer, Brentlawn, Halifax and 2nd Avenue
  - Vancouver – East 2nd Avenue
- FortisBC assessed a total of 24 different route alternatives, including five in Burnaby West.

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Analysis criteria

- FortisBC established a series of selection criteria to evaluate and select a preferred alternative.
- Assessment process comprised both quantitative and qualitative elements.
- We scored each alternative in the route corridor using the route evaluation criteria:
  - Community and Stakeholder impacts (socio-economic, land use and ownership);
  - Environmental impacts (ecology, cultural, and human); and
  - Technical considerations (engineering, construction, operations, system interface, adjacent utilities, natural hazards, other issues)

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Challenges through Burnaby West

- FortisBC was challenged to find an efficient route through this area.
- A number of alternatives were considered because of:
  - light industrial, commercial and high and low density residential development
  - segmented and interspersed roads with an erratic layout.
- It is not possible to remove the existing pipeline or install another pipeline parallel in some of the same roads due to lack of space caused by the density of adjacent buried utilities.
- Constructing a pipeline underneath Lougheed Hwy would be highly disruptive.

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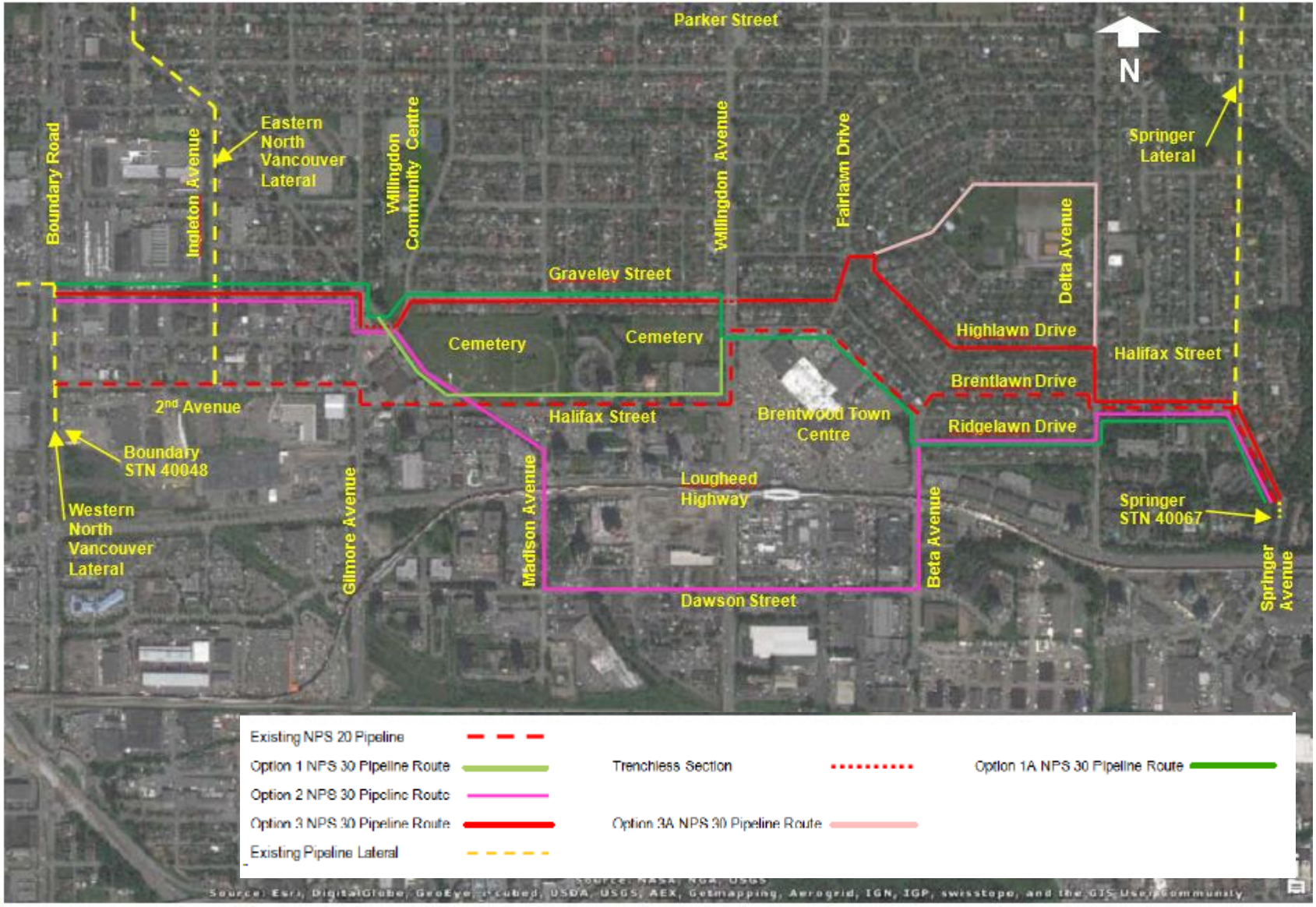
Route alternatives through Burnaby



Feedback from community consultations

- Activities to date included open houses, community meetings and meetings with local officials and municipal staff.
- In Burnaby West, specific feedback included:
  - Safety of upgraded pipeline
  - Environmental considerations / impacts
  - Questions about construction impacts
  - Signage and pipeline markings
  - Property values and neighbourhood enhancements

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Minimizing construction impacts

- We anticipate construction will begin in 2018, if we receive regulatory approval.
- We will minimize impacts from construction and related activities and will maintain access for residents.
  - Local residents will not lose access to their homes or the walkways along the street.
  - We will have to close the road to traffic during construction, but residents will still have access via laneways.
  - Once construction is complete we will replace the black top and return the area to the same condition it was in before work began.
  - Depending on how construction progresses, that could include a full resurface of a street.

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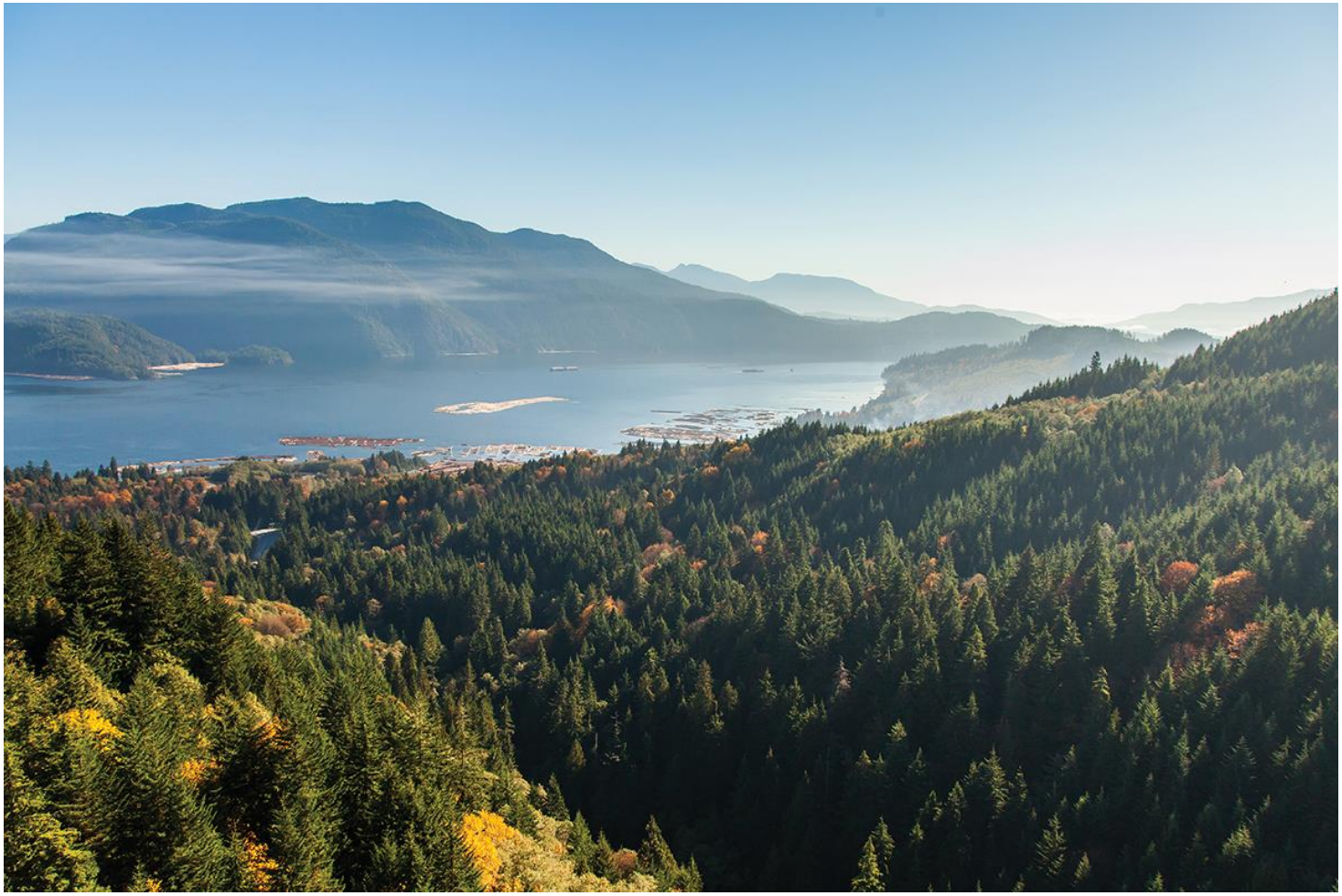
Next steps: continued consultation

- FortisBC will submit its application for the various upgrades to our regulator – the BC Utilities Commission (BCUC) – later this fall.
- Application will include comprehensive overview of our route selection process in all municipalities and feedback from our community consultation activities.
- Anticipated filing date: late October / early November.
- BCUC is open and transparent: the public and stakeholders are encouraged to participate.

FORTIS BC™

Thank you



Appendix C-14

EMAIL CORRESPONDENCE WITH REPRESENTATIVE OF HIGHLAWN DRIVE RESIDENTS

-----Original Message-----
From: Schoberg, Gord
Sent: 23 October 2014 16:25
[redacted]
Subject: RE: Fortis BC proposed pipeline through the Brentwood neighbourhood

[redacted] I can inquire about a small meeting room at the Executive Inn where we met on October 7. Just to confirm attendance, I understand yourself and [redacted] will attend, correct?

I was thinking of having a roundtable discussion and introduce the traffic reports and more detailed information concerning routing selection. I note the more specific items on your list which we will certainly speak to. John would speak to most of the information, but it would be available for you and [redacted] to view and discuss.

The objective of the meeting would be to help you understand the logic behind route evaluation and selection concerning Highlawn Drive and the neighbourhood and respond to the issue and concerns you raise.

As far as an agenda, I anticipate that the main focus of conversation will be the routing selection process that Fortis undertook over the past several months, the criteria used and how the criteria was assessed in order to determine the preferred alignment. One of the key pieces of information will be the traffic studies, which will be brought and reviewed.

Does this sound acceptable to you?

Gord Schoberg

-----Original Message-----
[redacted]
Sent: October 23, 2014 3:58 PM
To: Schoberg, Gord
Subject: RE: Fortis BC proposed pipeline through the Brentwood neighbourhood

Hi Gord,

Thank you for confirming that Oct 29 @ 7 pm will work. We do not have a location, so please suggest a suitable location.

We wanted to suggest an agenda to ensure that we make the best use of everyone's time. We definitely felt that the last meeting that was held was unproductive due to the disconnect between what was presented and the published intention for a consultation.

In addition to the items that we originally listed, here are a few additional items we would like to ensure we are aligned about for the meeting next week:

1. Objective and purpose of the meeting 2. Method of information delivery anticipated (projection, or round
table)
3. What handouts will you provide?
4. More information on what is the signage on the road that depicts the high pressure gas line 5. Timing of application to BCUC 6. Better understanding of interruption during construction

In the end, we would like to come to an agreement that is satisfactory both the residents and Fortis.

Thanks, [redacted]

On Thu, 23 Oct 2014 21:04:26 +0000, Schoberg, Gord wrote:
> [redacted] Yes, Wednesday October 29 at 7pm would work for us. John
> Quinn and I will attend.
>
> We have now received finalized traffic studies which we will bring
> with us along with the other information you requested, such as
> information used to evaluate route options and how we arrived at our
> recommended alignment and the map showing the route options. While
> the front end engineering design (FEED) is complete, site specific
> construction specifications have not been developed. However, we can
> speak to design and construction standards, both Fortis standards and
> regulatory requirements.
>
> While we will bring this information to the meeting and let you see it
> and review it, it is inappropriate for us to provide it to you
> beforehand. It will be available publicly when the application is
> filed with the BC Utilities Commission around mid-November, and I will
> advise you when this happens and, if you wish, will help provide you
> with any and all related studies and information that accompanies the
> filing.
>
> These materials are simply not public until they are filed with the
> Commission. If we provided them to you we would need to also make
> them available to a variety of other landowner groups and interested
> stakeholders which, without considering them in the context of the
> entire application, could lack an understanding of the entire project.
>
> Even though the project application will be filed shortly with the
> Commission, and you and your neighbours may be pouring over the
> details of the reports and information, I am still willing to meet
> with you to continue the dialogue.
>
> I hope you can appreciate this. Please let us know where you would
> like to meet.
>

> Gord Schoberg
> 604.220.9785
>
>
> -----Original Message-----
>[redacted]
> Sent: October 22, 2014 6:15 PM
> To: Schoberg, Gord
> Subject: RE: Fortis BC proposed pipeline through the Brentwood
> neighbourhood
>
> Hi Gord,
>
> Having the meeting is ok but we would like to get the materials ahead
> of time to allow us to digest the information.
>
> Can you provide the requested information this week where available?
>
> As for next week, we would suggest Wed, Oct 29 at 7 or 8 pm.
>
> ---
>
> Thanks, [redacted]
>
> On Mon, 20 Oct 2014 16:40:14 +0000, Schoberg, Gord wrote:
>> Thank you for your email on October 16, 2014. We appreciate you
>> taking the time and effort to participate in our public consultation
>> session about our proposed project, and we value your participation
>> and input.
>>
>> In response to your email, we propose to meet with you during the
>> week of October 28, 2014 to present more detailed information
>> relating to all five of the topics raised in your message. We are
>> still preparing our application to the British Columbia Utilities
>> Commission, and all the materials in support of our application will
>> not be finalized until the application is filed with the British
>> Columbia Utilities Commission. After the application is filed with
>> the British Columbia Utilities Commission, any party participating in
>> that public process will have an opportunity to review the
>> application and all the materials that we file in support of the
>> application and to raise relevant questions about any of the document
>> we file.
>>
>> Please provide two or three alternate times that work for you and let
>> us know if others will also attend.
>>
>> Gord Schoberg
>>

>> -----Original Message-----
>> From: [redacted]
>> Sent: October 16, 2014 7:42 AM
>> To: Schoberg, Gord
>> Cc: [redacted]
>> Subject: Fortis BC proposed pipeline through the Brentwood
>> neighbourhood
>>
>> Dear Mr. Schoberg,
>>
>> I am writing on behalf of a group of concerned Highlawn Drive
>> residents that have met and formed a committee subsequent to the
>> public consultation session hosted by FortisBC on Oct 7.
>>
>> During that session, you outlined the high level evaluation criteria
>> of how your team selected Highlawn Drive as FortisBC's preferred
>> routing for the high pressure gas line from Coquitlam to Vancouver.
>> In addition, you made reference to additional information that
>> although was not presented in the meeting, would be made available.
>>
>> Please consider this a formal request from the residents of Highlawn
>> Drive for that additional information. We would appreciate receiving
>> the following information by Oct 21:
>>
>> 1. Evaluation criteria and decision matrix used in the analysis 2.
>> Ranking, results and commentary for each of the proposed routes 3.
>> Traffic impact study and terms of reference (assumptions and
>> constraints) that was performed for each of the proposed routes and
>> Lougheed Highway 4. Construction specifications for installing the
>> proposed pipeline (depth, width and vertical clearance
>> requirements)
>> 5. Scalable map illustrating the existing route and alternative route
>> options
>>
>> This information is required to help us make more informed decisions
>> about how this proposed pipeline will affect us. The concerned
>> residents of Highlawn would also request that FortisBC defer its
>> November application to the BCUC until such time that it has
>> completed a robust public consultation of affected residents, as we
>> believe this is a requirement of your application.
>>
>> Regards,
>>
>> [redacted]
>>
>>
>>
>> _____

>>
>> This email was sent to you by FortisBC*. The contact information to
>> reach an authorized representative of FortisBC is 16705 Fraser
>> Highway, Surrey, British Columbia, V4N 0E8, Attention:
>> Communications
>> Department. You can
>>
>>
>> unsubscribe<http://www.fortisbc.com/About/Newsletters/Unsubscribe/Pag
>> e s/default.aspx> from receiving further emails from FortisBC or
>> email us at
>> unsubscribe@fortisbc.com<mailto:unsubscribe@fortisbc.com>.
>>
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>> FortisBC Holdings. Inc., FortisBC Energy Inc., FortisBC Energy
>> (Vancouver Island) Inc., FortisBC Energy (Whistler) Inc., FortisBC
>> Inc., FortisBC Alternative Energy Services Inc. and Fortis Generation
>> Inc.
>>
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>> you.
>
>
> _____
>
> This email was sent to you by FortisBC*. The contact information to
> reach an authorized representative of FortisBC is 16705 Fraser
> Highway, Surrey, British Columbia, V4N 0E8, Attention: Communications
> Department. You can
>
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> us at unsubscribe@fortisbc.com<mailto:unsubscribe@fortisbc.com>.
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> recipient, please contact the sender immediately and delete all copies
> of the message including removal from your hard drive. Thank you.

Appendix D

FIRST NATIONS CONSULTATION

Appendix D-1

FIRST NATIONS ENGAGEMENT LOG

First Nations Engagement Log - Lower Mainland IP System Upgrade CPCN Application

Last Updated **December 4 2014**

Date	Community/ies	Communication Type	Meeting Held? Y/N	Date of Meeting	Location	Attendees/ Involved Parties	Topics Discussed	Analysis, comments, concerns, or recommendations from Nation	Commitments to address the Nation's analysis, comments, concerns, or recommendations
October 8 2014	Kwikwetlem	In Person	Yes	October 8 2014	KFN Office, Coquitlam	Paul Le Page (Contractor w/ KFN, B. Falstead & G. Schoberg w/ FEI	Potential contracting opportunities with the KFN	Opportunities include: 1. lease of IR #2 bare land for material/vehicle storage; office 2. deposit residential/ commerical landfill on IR #2 3. Civil Works (partners with Matcon) 4. landscaping (hard and soft)	Ensure opportunities are communicated to Project Team and KFN Enterprises is put on contracting bid list. Band inquired about "set asides" and we told them we don't do this
March 5 2014	Tsawassen First Natlon	Letter			Chief Bryce Williams, 1926 Tsawassen Drive, Delta, V4M 4G2	Chief Bryce William	Introduction to The Project. Outline of the proposed route.	No response received	
March 5 2014	Semiahmoo First Nation	Letter			Chief Willard Cook, 16049 Beach Road, White Rock, V3S9R6	Chief Willard Cook	Introduction to The Project. Outline of the proposed route.	No response received	
March 5 2014	People of the River Referrals Office	Letter			Building #10, 7201 Vedder Road, Chilliwack, V2R 4G5	People of the River Referrals Office	Introduction to The Project. Outline of the proposed route.	No response received	
March 5 2014	Musqueam First Nations	Letter			Leona M. Sparrow, Director, Lands Planning & Resources, 6735 Salish Drive, Vancouver, V6N 4C4	Leona M. Sparrow	Introduction to The Project. Outline of the proposed route.	No response received	
July 15 2014	Tsleil-Waututh Nation	Email/Letter			Erin Hanson, Consultation and Accommodation Coordinator Treaty, Lands, and Resources Department Tsleil-Waututh Nation 3075 Takaya Drive North Vancouver V7H 3A8	Erin Hanson/Amanda King	Introduction to The Project. Outline of the proposed route.	Mailed response from TWN requesting Referral Fee ($250) & inclusion of Consultation Booklet.	Paid referral fee and emailed response to Amanda King (referals analyst w/ TWN) and E.Hanson that we received the letter.
July 15 2014	Squamish Nation	Email/Letter			Lisa Wilcox, Administrator Squamish Nation PO Box 86131, North Vancouver, BC V7L 4J5	Lisa Wilcox	Introduction to The Project. Outline of the proposed route.	Received request for more detailed mapping of the project (July 16th)	Sent detailed maps of the project to Lisa Wilcox on July 16th, 2014
August 20 2014	Tsleil-Waututh Nation	Email/Letter			N/A	Amanda King (referals analyst) and E. Hanson - emailed to S.Singbeil (previously S. Collins)	Requested a meeting to discuss the LMSU project. Also, requested more detailed maps		
August 27 2014	Tsleil-Waututh Nation	Email			N/A	Erin Hanson/Amanda King	emailed shape files to Amanda King in response to August 20, 2014 request	received respons from Amanda King, acknowledging receipt of shape files.	
September 19 2014	Tsleil-Waututh Nation	Email			N/A	Erin Hanson/Amanda King	Amanda King requested which dates would be suitable to meet with FEI to discuss the project		FEI asked if Amanda could provide dates of their availability and we could work around them
October 15 2014	Tsleil-Waututh Nation	Email			N/A	Erin Hanson/Amanda King	Amanda King provided dates to meet with FEI to discuss the project		FEI confirmed that November 5th would work to meet and discuss the project
November 5 2014	Tsleil-Waututh Nation	In Person	Y	November 5 2014	Tsleil-Waututh Nation 3075 Takaya Drive North Vancouver V7H 3A8	Erin Hanson/Amanda King (TWN). Samantha Singbeil, Bruce Falstead, Melanie Kilpatrick (FEI)		TWN discussed TWN's consultation boundaries. There was discussion from FEI over the rationale for the project, the proposed routing, and the potential construction methodologies. TWN asked that FEI send over the archaeology reports and environmental management plans when they are complete. TWN also requested to be kept informed of contracting opportunities related to this project.	FEI will send over the requested documents and keep TWN informed of the contracting opportunities.

Appendix D-2

FIRST NATIONS LETTER, MARCH 2014

FORTIS BC™

16705 Fraser Highway
Surrey, BC V4N 0E8
fortisbc.com

March 5, 2014

Tsawassen First Nation
1926 Tsawassen Drive
Delta, B.C. V4M 4G2

Dear Chief Bryce Williams

RE: LOWER MAINLAND GAS PIPELINE UPGRADES

FortisBC has completed the initial stage of a study that is intended to resolve a number of identified integrity and security of supply issues on its pipeline system in the Lower Mainland. The results of this study will be used to initiate a series of inter-related upgrades that resolve the:

- approaching end of service life for the FortisBC "Metro Intermediate Pressure Pipeline" in Coquitlam, Burnaby and Vancouver;
- necessary upgrades to meet seismic resistance standards on the FortisBC "Fraser to Marine & Elliott Intermediate Pressure Pipeline" in South Vancouver; and,
- security of supply vulnerabilities and operational flexibility limitations on Transmission Pressure pipelines in Coquitlam and Surrey where disruption of a single pipeline will result in loss of service to a large numbers of customers.

The natural gas delivery system that supplies the Lower Mainland of British Columbia area is a complex interconnected network; as such, changes to the system in one area have an impact on the system in another part of the system. These pipeline upgrades address the gas delivery network as a complete system and identifies the dependencies between these pipelines. Upon completion, these pipeline upgrades will result in continued safe, reliable delivery of natural gas to the FortisBC customers in the Lower Mainland area.

Pipeline Upgrade Details

The Lower Mainland pipeline upgrades include replacement or twinning of five significant pipeline sections to proactively resolve integrity, operational flexibility and security of supply issues. This requires installing up to 32 kilometres of pipe ranging in size from 762 mm (30 inch) to 1067 mm (42 inch) and operating at pressures between 1200 kPa and 4000 kPa. These include:

- Replacing approximately 20 kilometres of 508 mm outside diameter, or 20 inch Nominal Pipe Size (NPS 20) pipeline with 762 mm outside diameter (NPS 30) pipeline in Coquitlam, Burnaby and Vancouver between the FortisBC stations called "Coquitlam Station" on Como Lake Road and Mariner Way in Coquitlam and "East 2nd & Woodland Station" in Vancouver to address the projected end of service life of the existing pipeline and to provide security of supply. FortisBC calls this pipeline the "Metro Intermediate Pressure Pipeline";

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Next Steps

The British Columbia Utilities Commission has been advised of FortisBC's intent to proceed with these pipeline upgrades and that the appropriate applications for approval will be filed. The next steps for FortisBC include:

- Communicate with First Nations, the general public, community, business and other organizations, Municipal, Provincial and Federal government elected officials and staff, BC Hydro, Metro Vancouver, other utilities and private landowners along the pipeline routes;
- Confirm routing, engineering, and planning to address associated challenges (including those issues identified by the public and other groups noted above);
- Develop preliminary designs and cost estimates for each pipeline upgrade;
- Draft and file the required applications for financial approval with the British Columbia Utilities Commission (BCUC); and
- Draft and file the required applications with the British Columbia Oil and Gas Commission (OGC).

Tentative Schedule

The final decision to construct will not be made until the appropriate financial and regulatory approvals are in place. FortisBC tentatively intends to file an application with the British Columbia Utilities Commission for a Certificate of Public Convenience and Necessity (CPCN) around October 2014.

I am pleased to be providing you with a high level map showing the general location of these proposed pipeline upgrades route corridors (attached). Once you review the documents you may find that this information will trigger a referral; if that is the case, please let us know so we can set-up a meeting. We look forward, if you so choose, to your feedback in regards to these documents. In addition, if you would just like to be kept informed of the project's progress please let us know.

The Nation's contacts for this project at FortisBC will be myself, along with Bruce Falstead, Manager, Aboriginal Initiatives. You can reach me by telephone (office: 604-220-9785) or through email, gord.schoberg@fortisbc.com, and you can reach Bruce through the same means (office: 604-592-7686 / cell phone: 604-785-8947 or bruce.falstead@fortisbc.com).

Looking forward to working with you.

Respectfully;

Gord Schoberg
Senior Manager, Community and Aboriginal Relations

FORTIS BC™

16705 Fraser Highway
Surrey, BC V4N 0E8
fortisbc.com

March 5, 2014

Leona M. Sparrow
Director, Lands Planning & Resources
Musqueam First Nation
6735 Salish Drive
Vancouver, B.C. V6N 4C4

Dear Ms. Sparrow

RE: LOWER MAINLAND GAS PIPELINE UPGRADES

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Senior Manager, Community and Aboriginal Relations

FORTIS BC™

16705 Fraser Highway
Surrey, BC V4N 0E8
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March 5, 2014

People of the River Referrals Office
Building #10, 7201 Vedder Road
Chilliwack, B.C. V2R 4G5

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Senior Manager, Community and Aboriginal Relations

FORTIS BC™

16705 Fraser Highway
Surrey, BC V4N 0E8
fortisbc.com

March 5, 2014

Semiahmoo First Nation
16049 Beach Road
White Rock, B.C. V3S 9R6

Dear Chief Willard Cook

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- Installing approximately 1,500 metres of 1067 mm outside diameter (NPS 42) pipeline in Surrey between the FortisBC "Nichol Station" located south and east of the Surrey Memorial Hospital and the FortisBC "Roebuck Station" located near 132nd St and 90th Ave in Surrey, which is parallel to and in the same right of way as an existing 610 mm diameter (24 inch) pipeline to provide adequate security of supply to customers in Surrey, Delta, Richmond and Vancouver. FortisBC calls this pipeline the "Nichol to Roebuck" pipeline.

Next Steps

The British Columbia Utilities Commission has been advised of FortisBC's intent to proceed with these pipeline upgrades and that the appropriate applications for approval will be filed. The next steps for FortisBC include:

- Communicate with First Nations, the general public, community, business and other organizations, Municipal, Provincial and Federal government elected officials and staff, BC Hydro, Metro Vancouver, other utilities and private landowners along the pipeline routes;
- Confirm routing, engineering, and planning to address associated challenges (including those issues identified by the public and other groups noted above);
- Develop preliminary designs and cost estimates for each pipeline upgrade;
- Draft and file the required applications for financial approval with the British Columbia Utilities Commission (BCUC); and
- Draft and file the required applications with the British Columbia Oil and Gas Commission (OGC).

Tentative Schedule

The final decision to construct will not be made until the appropriate financial and regulatory approvals are in place. FortisBC tentatively intends to file an application with the British Columbia Utilities Commission for a Certificate of Public Convenience and Necessity (CPCN) around October 2014.

I am pleased to be providing you with a high level map showing the general location of these proposed pipeline upgrades route corridors (attached). Once you review the documents you may find that this information will trigger a referral; if that is the case, please let us know so we can set-up a meeting. We look forward, if you so choose, to your feedback in regards to these documents. In addition, if you would just like to be kept informed of the project's progress please let us know.

The Nation's contacts for this project at FortisBC will be myself, along with Bruce Falstead, Manager, Aboriginal Initiatives. You can reach me by telephone (office: 604-220-9785) or through email, gord.schoberg@fortisbc.com, and you can reach Bruce through the same means (office: 604-592-7686 / cell phone: 604-785-8947 or bruce.falstead@fortisbc.com).

Looking forward to working with you.

Respectfully;

Gord Schoberg
Senior Manager, Community and Aboriginal Relations

Appendix D-3

NEWS RELEASE, JUNE 19, 2014

NEWS RELEASE

For Immediate Release
2014ARR0013-000840
June 19, 2014

Ministry of Aboriginal Relations and Reconciliation
Stó:lō – People of the River Referrals Office

Agreement streamlines consultation in Fraser Valley

CHILLIWACK – A multi-year strategic engagement agreement (SEA) with 14 Stó:lō First Nations will enhance effective consultation and engagement on land and resource management decisions in the Fraser Valley.

The three-year agreement builds on a successful 24-month pilot in which the First Nations and the Province worked together to negotiate and implement a framework agreement to improve relations between the parties. The new agreement will continue to create more effective procedures for administering applications and referrals for the First Nations, government and industry.

The B.C. government is providing a total of $2.1 million over the life of the agreement, which encompasses Stó:lō territory.

The agreement follows the pilot model with a government-to-government forum to oversee implementation. Provincial agencies processing land and resource applications will continue to work closely with the People of the River Referrals Office (PRRO), which acts as a single point of contact to ensure applications are referred to the appropriate signatory First Nation within agreed timelines. The B.C. government, the First Nations and industry benefit from this consultation process.

The provincial government recognizes that the area covered by the SEA hosts a number of major projects, and the agreement includes specific processes on referrals related to major projects.

SEAs with First Nations are intended to encourage a positive and respectful government-to-government relationship; strengthen B.C.'s investment climate and establish mutually agreed-upon procedures for consultation and accommodation. For First Nations who chose to enter the treaty process, SEAs can help to build the mechanisms to support decision-making in a post-treaty environment.

The 14 Stó:lō First Nation members participating in the pilot are Chawathil First Nation, Cheam First Nation, Leq'á:mel First Nation, Scowlitz First Nation, Shxw'ow'hamel First Nation, Skawahlook First Nation, Sumas First Nation and the Ts'elxwéyeqw Tribe, which signed on behalf of the Aitchelitz Band, Shxwhá:y Village, Skowkale First Nation, Soowahlie First Nation, Squiala First Nation, Tzeachten First Nation and Yakweakwisoose First Nation.

The provincial government has reached 31 economic benefit agreements with First Nations since the BC Jobs Plan was launched in 2011, and 13 of the 10 new non-treaty agreements B.C. committed to reaching over the next two years. These agreements support economic opportunities for both First Nations and neighbouring communities.

Quotes:

John Rustad, Minister of Aboriginal Relations and Reconciliation –

"I firmly believe that working in partnership is the best way to ensure meaningful participation in resource management for First Nations. I am delighted to see all the hard work from the pilot project grow into this significant multi-year agreement."

Otis Jasper, Chairperson, Stó:lō First Nations Strategic Engagement Agreement Board –

"Our Stó:lō leadership is firmly supportive of our SEA. This agreement establishes a framework for engaging with the Province on a government-to-government level regarding land and resources uses within our tribal lands. Our lands and resources are vitally important to our culture and economy. Developing a pilot two years ago and now a full-scale SEA speaks to the commitment of our combined leadership as Stó:lō from our multiple tribes to work together with the province on matters that are of great importance to all of our communities."

Quick Facts:

- The $2.1 million funding for the Stó:lō SEA breaks down to $700,000 per year for the signatory First Nations.
- B.C. now has eight fully operating SEAs with First Nations, including the Stó:lō First Nations, Tahltan Nation, Kaska Dena, Taku River Tlingit First Nation, Nanwakolas Council Society, Ktunaxa Nation, Tsilhqot'in Nation and the Secwepemc Reconciliation Agreement. Entering into SEAs with First Nations is one of many tools being used by government. For those First Nations who chose to also enter the treaty process, SEAs can help to build the mechanisms to support decision-making in a post treaty environment.
- SEAs provide an opportunity to take a more active role in the decision-making process and develop a stronger government-to-government relationship with the B.C. government.

Media Contacts:

Robin Platts
Communications Manager
Ministry of Aboriginal Relations and Reconciliation
250 387-1204

Dr David Schaepe
General Manager, People of the River Referral Office
604 819-1467
Dave.schaepe@stolonation.bc.ca

Appendix D-4

TSLEIL-WAUTUTH NATION COMMUNICATIONS

Appendix D-4-1

LETTER TO TSLEIL-WAUTUTH NATION

July 15, 2014

Erin Hanson
Tsleil-Waututh Nation
3075 Takaya Drive
North Vancouver, BC
V7H 3A8

Dear Ms. Hanson,

RE: LOWER MAINLAND NATURAL GAS SYSTEM UPGRADES

FortisBC is currently planning improvements to five sections of the existing natural gas system that provides service to customers throughout the Lower Mainland and Vancouver Island. These upgrades will improve the reliability of the system and provide greater operational flexibility so that we can best meet current and future needs of our customers.

We continuously monitor our infrastructure system to ensure it's operating as efficiently as possible. As part of our regular maintenance, upgrades to our natural gas system are a requirement. This ensures the continued safe and reliable delivery of natural gas to our customers.

The specific portions of the system requiring upgrade are as follows:

• Coquitlam, Burnaby and Vancouver: replace approximately 20 kilometres of the Metro Intermediate Pressure (IP) natural gas line that runs between our Coquitlam Station and our station at East 2nd Avenue and Woodland Drive in Vancouver. The Metro IP gas line is nearing the end of its useful life and must be replaced.

• Coquitlam:* install approximately 4.6 kilometres of gas line between our Cape Horn and Coquitlam stations to provide additional backups and supply the Metro IP gas line.

• Vancouver: replace approximately 700 metres of gas line between Fraser Station and our underground station at SE Marine Drive and Elliott Street to provide additional seismic resistance.

• Surrey:*

- Install approximately five kilometres of new natural gas line between our Nichol Station to the south side of the Fraser River to enable in-line inspections and meet forecasted long-term growth in core demand.

- Install approximately 1.7 kilometres of natural gas line between Nichol and Roebuck stations to provide additional system backups for customers in Surrey, Richmond and Vancouver.
**These improvements will be carried out in the same utility corridor as the existing natural gas line.*

We invest in our system on an annual basis. We are currently evaluating the potential impact to the delivery rates for our customers and will provide more information to the public once available.

Next steps

We will file the necessary application with the required regulatory agencies for approval of these upgrades. We will also meet with First Nations communities, residents and stakeholders in the four communities to provide information about these improvements and answer questions.

We estimate construction will begin in early 2017.

Enclosed is a fact sheet, including a high level map showing the general location of these proposed pipeline upgrades. Please let us know if you have any questions, feedback or would like to set up a meeting to discuss these upgrades in more detail. We look forward to hearing from you.

The Nation's contacts for this project are myself and Bruce Falstead, Manager, Aboriginal Initiatives. You can reach me at 604-220-9785 or email, gord.schoberg@fortisbc.com. Bruce can be reached at 604-592-7686, on his cell at 604-785-8947 or at bruce.falstead@fortisbc.com.

Looking forward to working with you.

Respectfully,

Gord Schoberg
Senior Manager, Community and Aboriginal Relations

Appendix D-4-2

EMAIL TO TSLEIL-WAUTUTH FN JULY 15, 2014

FILED CONFIDENTIALLY

Appendix D-4-3

RESPONSE FROM TSLEIL-WAUTUTH FN JULY 15, 2014

FILED CONFIDENTIALLY

Appendix D-4-4

EMAIL FROM TSLEIL-WAUTUTH FN AUG 20, 2014

FILED CONFIDENTIALLY

Appendix D-4-5

EMAIL TO FROM TSLEIL-WAUTUTH FN AUGUST 27, 2014

FILED CONFIDENTIALLY

Appendix D-4-6

EMAIL TO FROM TSLEIL-WAUTUTH FN CONFIRMING NOV 5 MEETING

FILED CONFIDENTIALLY

Appendix D-5

SQUAMISH NATION COMMUNICATIONS

Appendix D-5-1

LETTER TO SQUAMISH NATION

July 15, 2014

Lisa Wilcox
Squamish Nation
PO Box 86131,
North Vancouver, BC
V7L 4J5

Dear Ms. Wilcox,

RE: LOWER MAINLAND NATURAL GAS SYSTEM UPGRADES

FortisBC is currently planning improvements to five sections of the existing natural gas system that provides service to customers throughout the Lower Mainland and Vancouver Island. These upgrades will improve the reliability of the system and provide greater operational flexibility so that we can best meet current and future needs of our customers.

We continuously monitor our infrastructure system to ensure it's operating as efficiently as possible. As part of our regular maintenance, upgrades to our natural gas system are a requirement. This ensures the continued safe and reliable delivery of natural gas to our customers.

The specific portions of the system requiring upgrade are as follows:

• Coquitlam, Burnaby and Vancouver: replace approximately 20 kilometres of the Metro Intermediate Pressure (IP) natural gas line that runs between our Coquitlam Station and our station at East 2nd Avenue and Woodland Drive in Vancouver. The Metro IP gas line is nearing the end of its useful life and must be replaced.

• Coquitlam:* install approximately 4.6 kilometres of gas line between our Cape Horn and Coquitlam stations to provide additional backups and supply the Metro IP gas line.

• Vancouver: replace approximately 700 metres of gas line between Fraser Station and our underground station at SE Marine Drive and Elliott Street to provide additional seismic resistance.

• Surrey:*

- Install approximately five kilometres of new natural gas line between our Nichol Station to the south side of the Fraser River to enable in-line inspections and meet forecasted long-term growth in core demand.

- Install approximately 1.7 kilometres of natural gas line between Nichol and Roebuck stations to provide additional system backups for customers in Surrey, Richmond and Vancouver.
**These improvements will be carried out in the same utility corridor as the existing natural gas line.*

We invest in our system on an annual basis. We are currently evaluating the potential impact to the delivery rates for our customers and will provide more information to the public once available.

Next steps

We will file the necessary application with the required regulatory agencies for approval of these upgrades. We will also meet with First Nations communities, residents and stakeholders in the four communities to provide information about these improvements and answer questions.

We estimate construction will begin in early 2017.

Enclosed is a fact sheet, including a high level map showing the general location of these proposed pipeline upgrades. Please let us know if you have any questions, feedback or would like to set up a meeting to discuss these upgrades in more detail. We look forward to hearing from you.

The Nation's contacts for this project are myself and Bruce Falstead, Manager, Aboriginal Initiatives. You can reach me at 604-220-9785 or email, gord.schoberg@fortisbc.com. Bruce can be reached at 604-592-7686, on his cell at 604-785-8947 or at bruce.falstead@fortisbc.com.

Looking forward to working with you.

Respectfully,

Gord Schoberg
Senior Manager, Community and Aboriginal Relations

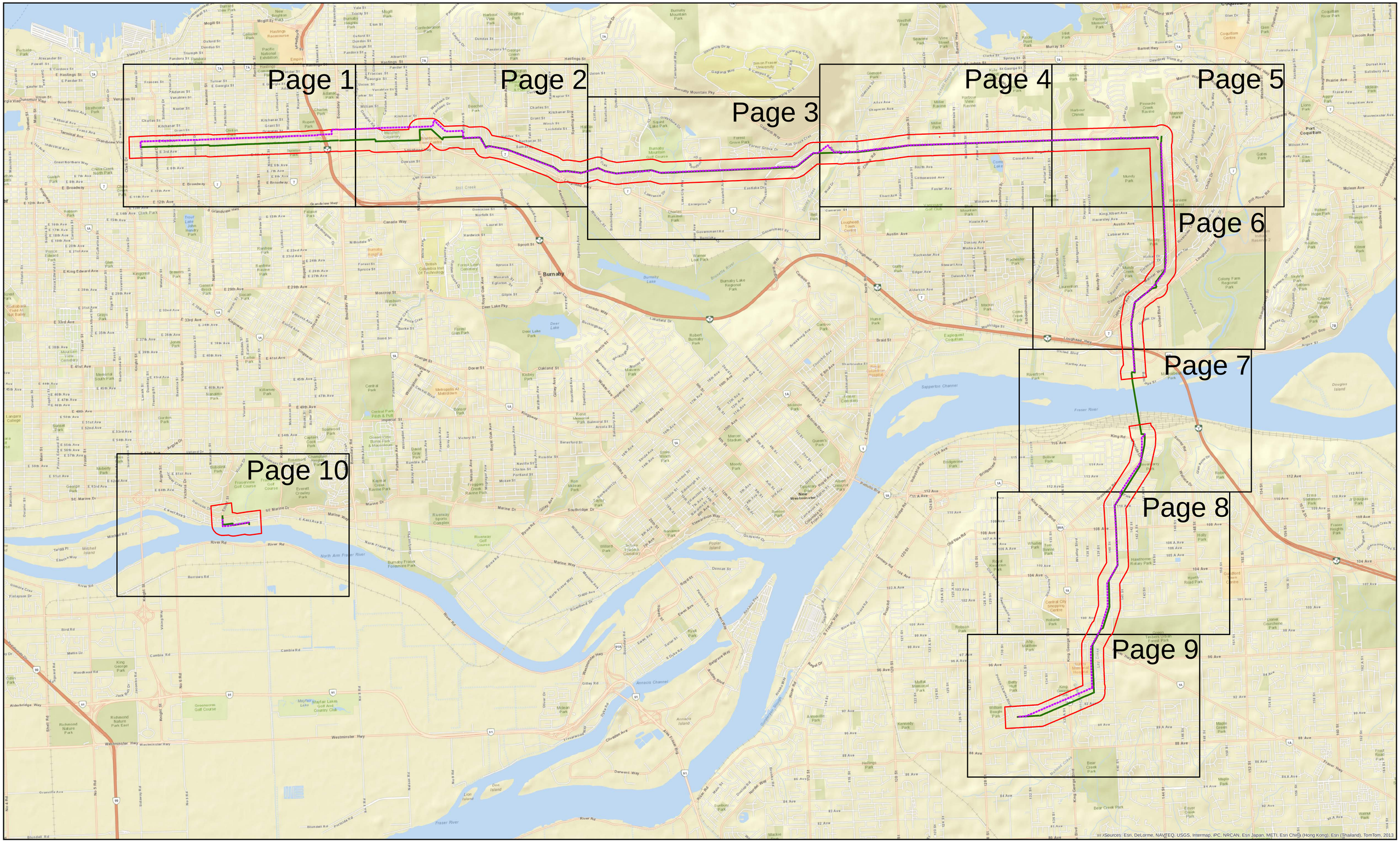
Appendix D-5-2

EMAIL TO FROM SQUAMISH NATION JULY 16, 2014

FILED CONFIDENTIALLY

Appendix D-5-3

DISPLAY MAP OVERVIEW



Proposed Pipeline Alignment
An Overview

N W E S

0 750 1,500 3,000 4,500 6,000 Meters

1 centimeter = 300 meters 1:30,000

Legend
- Proposed Alignment
- Existing Alignment
- 400m Study Corridor

Date: 2014/05/12
Data Source: BC DRA, ESRI Street Map, AMFM Data
Made By: OH
BC Albers NAD 1983
//.../LMSU Address and Alignments/Display Map Overview.mxd

INFORMATION ON THIS MAP FOR REFERENCE ONLY

FORTIS BC™

Appendix E

FINANCIAL SCHEDULES

FILED CONFIDENTIALLY

Appendix E-1

PREFERRED ALTERNATIVES

REFER TO LIVE SPREADSHEET MODELS

FILED CONFIDENTIALLY

(accessible by opening the Attachments Tab in Adobe)

Appendix E-1-1

PREFERRED ALTERNATIVE 6:
COQUITLAM GATE IP PROJECT

REFER TO LIVE SPREADSHEET MODELS

FILED CONFIDENTIALLY

(accessible by opening the Attachments Tab in Adobe)

Appendix E-1-2

PREFERRED ALTERNATIVE FRASER GATE IP PROJECT

REFER TO LIVE SPREADSHEET MODELS

FILED CONFIDENTIALLY

(accessible by opening the Attachments Tab in Adobe)

Appendix E-2

OTHER ALTERNATIVES

FILED CONFIDENTIALLY

Appendix E-2-1

ALTERNATIVE 4:
COQUITLAM GATE IP PROJECT 24 NPS AT 2070 kPa

FILED CONFIDENTIALLY

Appendix E-2-2

ALTERNATIVE 5:
COQUITLAM GATE IP PROJECT 36 NPS AT 1200 kPa

FILED CONFIDENTIALLY

Appendix E-3

PROJECT EXECUTION COSTS

FILED CONFIDENTIALLY

Appendix E-3-1

COQUITLAM GATE IP PROJECT EXECUTION COST

FILED CONFIDENTIALLY

Appendix E-3-2

FRASER GATE IP PROJECT EXECUTION COST

FILED CONFIDENTIALLY

Appendix F

GLOSSARY OF TERMS

GLOSSARY OF TERMS

Acronym or Term	Definition
AFUDC	Acronym for Allowance for Funds Used During Construction, which allows for the cost of borrowing funds until a project is placed into service to be included in rates; the requirement for AFUDC forms a separate line item of the overall project cost.
Annual demand	The cumulative daily demand for natural gas over an entire year.
Anode	In corrosion protection, a formed metal - usually zinc, aluminum, or magnesium - buried near and connected to a structure of lesser galvanic potential such that the metal corrodes in favor of the structure.
Bcf	Billion cubic feet
BCUC	British Columbia Utilities Commission, or Commission - The BCUC is the provincial body regulating utilities in British Columbia.
Block Valve	Main line valve designed to close in or shut down gas flow.
Burner Tip	A generic term that refers to the ultimate point of consumption for natural gas.
Burrard Thermal	Burrard Thermal Generating Station (BC Hydro)
Butt Weld	The joining of two pieces of pipe or other material by full penetration welds.
By-Pass	An auxiliary piping arrangement, generally to carry gas around specific equipment or an integral section of a piping system. A by-pass is usually installed to permit passage through the line while adjustments or repairs are made on the section which is by-passed.
Capital Cost	Expenditures to acquire or improve assets with a service life of greater than one year.
Cathode	Negative electrode in an electrolytic system. See ANODE
Cathodic Protection	A technique to prevent the corrosion of a metal surface by making that surface the cathode of an electrochemical cell.
CIP	Acronym for Capital Infrastructure Plan
CPI	Acronym for Consumer Price Index
CNG	Acronym for Compressed natural gas
Commission	see British Columbia Utilities Commission, BCUC

Acronym or Term	Definition
Compression, Compressor Station	The application of increased pressure a natural gas pipe system to create gas flow. Higher levels of compression can be applied to increase the carrying and storage capacity of the pipe. Increased pressure is applied through a compressor station constructed along the pipeline.
Core, core customers, Core market	Residential, commercial and small industrial customers that have gas delivered to their home or business (bundle sales). FortisBC purchases natural gas and delivers it to the customer in a bundled sales rate. Core Market customer typically use a significant portion of their gas requirements for heating applications, resulting in weather sensitive demand.
CP	Cathodic protection – Generally considered a secondary defense corrosion management tool that relies on the existence of an external pipe coating as the primary defense.
CPCN	Certificate of Public Convenience and Necessity – A certificate obtained from the British Columbia Utilities Commission under Section 45 of the *Utilities Commission Act* for the construction and/or operation of a public utility plant or system, or an extension of either, that is required, or will be required, for public convenience and necessity.
Coquitlam IP or Coquitlam Gate IP	Coquitlam Gate IP (NPS 20 now and proposed NPS 30) Pipeline: Coquitlam Gate Station to 2nd & Woodlands. In some Appendices completed by third parties and in some public information documents completed early in the planning phase, the Coquitlam IP Project was referred to as the Metro IP Project
Corrosion	Destruction of a metal by chemical or electrochemical reaction with its environment.
CSA	Canadian Standards Association
CTS	Coastal Transmission System
Daily demand	The amount of natural gas consumed by the Utilities' customers throughout each day of the year.
Deferred Cost	Cost that incurred but that will be expensed in the future.
Demand forecast	A prediction of the demand for natural gas into the future for a given period and under a specified set of expected future conditions.
Demand side, Demand side programs	Defined as "any utility activity that modifies or influences the way in which customer utilize energy services". From FortisBC perspective, the primary objectives of demand side programs are to increase the overall economic efficiency of the energy services it provides to customers and maintain the competitive position of natural gas relative to other energy sources.

Acronym or Term	Definition
Design day, or design hour demand	The maximum expected amount of gas in any one day or hour required by customers on the utility system. Since core customers' demand is primarily weather dependent, design-day or design-hour demand is forecasted based upon a statistical approach called Extreme Value Analysis, which provides an estimate of the coldest day weather event expected with a 1-in-20-year return period. For transportation customers, the design-day is equivalent to the firm contract demand. (*See also Peak day*)
DCS	Distributed control system
DP	Distribution pressure (700 – 70 kPag)
EPA	Electricity Purchase Agreement
EPC	Engineering, procurement and construction
FEI	FortisBC Energy Inc.
FID	Facility Identification Number – a number assigned by FortisBC, used in various company systems as a unique asset identifier.
FortisBC entities	FortisBC Energy Inc. - FEI FortisBC Energy (Vancouver Island) Inc. - FEVI FortisBC Energy (Whistler) Inc. - FEW FortisBC Energy Utilities – the FEU, comprised of FEI, FEVI and FEW
Fraser IP or Fraser Gate IP	Fraser Gate IP (NPS 30) Pipeline: Fraser Gate Station to 2nd & Woodlands.
Girth Weld	A circumferential weld at a joint connecting two pipes.
GIS	Geographical Information System
GJ – Gigajoule	A measure of energy of natural gas – one billion joules. One joule of energy is equivalent to the heat needed to raise the temperature of one gram (g) of water by one degree Celsius (°C) at a standard pressure (101.325 kPa) and standard temperature (15°C).
GSA	GeoSpatial Analysis – A software application that combines information from various data sources for map-based and/or spreadsheet-based analysis. An important use for the tool at FortisBC is during long-term sustainment planning for the identification and prioritization of main replacements.
GWh	Gigawatt hour - A unit of energy equal to 1 million kilowatt-hours
HDD	Horizontal directional drilling – a trenchless construction method for the installation of underground piping.

Acronym or Term	Definition
Heating degree day	A measure of the coldness of the weather experienced. The number of heating degree days for a given day is calculated based on the extent to which the daily mean temperature falls below a reference temperature, 18 degrees Celsius.
HP	Horsepower
Huntingdon/Sumas	Gas Flow regulating station on either side of the British Columbia/ US border through which much of the regional gas supply is traded.
ILI	In-line inspection – A widely accepted industry practice to monitor pipeline asset health.
IMP	Integrity Management Program
IP	Intermediate pressure (3,100 – 701 kPag)
ITS	Interior Transmission System
kPa	Kilopascal - a metric measurement unit of pressure. Gauge pressure is often given in units with a 'g' appended, e.g. 'kPag'.
LNG	Liquefied Natural Gas - Natural gas stored under high pressure, which turns to liquid form. Approximately 600 times as much natural gas can be stored in its liquid state than in its typical gaseous state; however, specialized storage facilities must be constructed.
Line Pack	The difference in gas volume in a pipeline between maximum pressure and the minimum pressured required for constant supply. A pipeline is said to be "packed" when withdrawal from it is at a minimum and when, therefore, for a constant supply of gas, the discharge pressure is a maximum. A pipeline is "unpacked" when withdrawals are at maximum and pressure is at minimum for a constant supply of gas to the line.
LNG Import Terminals	Terminals that receive liquefied natural gas that is shipped in large tankers from overseas. LNG Import terminals are considered base load supply resources not peaking resources.
LNG Storage Facility	LNG storage tanks and infrastructure located inside the site fence, including liquefaction and send out infrastructure.
Load	The total amount of gas demanded by all customers at a given point in time.
Load duration, load duration curve	A graphical representation of the daily loads over a period of time, typically one year, sorted from highest load to lowest load.
Looping	The twinning of sections of gas transmission pipeline to improve flow characteristics within the service area.

Acronym or Term	Definition
LTRP	Long Term Resource Plan – A plan that identifies resource requirement and acquisition strategies to meet expected natural gas demand and reliability requirements at the lowest reasonable cost to customers over a 20 year planning horizon.
LTSP	Long Term Sustainment Plan - An asset management process/planning approach that assists in creating and supporting long term asset replacement plans and capital expenditures.
MCC	Motor control centre
Metro IP	Metro IP – all IP Pipeline from Coquitlam Gate Station and Fraser Gate Station.
MMscfd	one million standard cubic feet per day
MOP	Maximum operating pressure.
MOT	B.C. Ministry of Transportation and Infrastructure
NGT	Natural gas for transportation
Normal demand, *also called* **annual demand**	When considering historical normal demand, this is the actual demand experience that has been adjusted to account for weather that has been colder/warmer than normal, i.e. the expected demand during a year of normal weather conditions. When considering forecast normal demand, this is the expected demand under normal weather conditions. Normal weather conditions are based on a rolling 10-year average of heating degree days experienced during each of the 10 years.
NPS	Nominal pipe size
NSCI	National Strategy for Critical Infrastructure
OAW	Oxyacetylene welding – Refers to a former technique for welding butt joints of a pipe
OD	Outside diameter
OGC	British Columbia Oil and Gas Commission
On-system Storage	Natural gas storage facilities and services attached to the natural gas transmission or distribution systems owned and operated by FEI or FEVI.
PAS 55	Publicly Available Specification 55 – A standard developed by the British Standards Institute to provide guidance and best practices for asset management in utility, transportation and manufacturing industries.
PE	Polyethelyne – Refers to PE tape which is prone to disbondment or loss of adhesion with pipe, resulting in a void forming between the pipe and tape layers and potentially trapping water, increasing the possibility of corrosion.

Acronym or Term	Definition
Peak day, peak demand, peak day demand	The maximum expected amount of gas in any one day or hour required by customers on the FEI system. Since Core customers' demand is primarily weather dependent, design-day or design-hour demand is forecasted based upon a statistical approach called Extreme Value Analysis, which provides an estimate of the coldest day weather event expected with a 1 in 20 year return period. For transportation customers, the design-day is equivalent to the firm contract demand. (*See also: design day*)
P90, P50, P10 Cost Estimate	The probability, based on a statistical distribution, that actual costs will be at or below a given cost estimate value. For example, a P90 cost estimate of $100,000 has a 90% probability that actual costs will be at or below the stated value of $100,000 for that estimate.
PEC	Pacific Energy Corporation
PJ	Petajoule – equal to 1,000 Terajouldes of 10^6 Gigajoules
Portfolio, resource	Resource portfolio refers to selected supply and / or demand resources that, when grouped together, can meet the future demand and supply needs of a service area.
Portfolio, gas supply	Gas supply portfolio refers to a combination of different upstream gas supply resources that can be purchased or contracted by FEI and/or FEVI to ensure that gas supply and delivery to the FEI and FEVI systems meets customer demand throughout the planning period.
Psig	Pounds per square inch gauge - A measurement of pressure
Purging	The act of replacing the atmosphere within a container by an inert substance in such a manner as to prevent the formation of explosive mixtures.
Re Light	The act of restarting gas service to a customer after a shut in
Resilience	Ability to rebound quickly in case of equipment failure. Robustness and recovery characteristics of utility infrastructure and operations, which avoid or minimize interruptions of service during an extraordinary and hazardous event. A resilient system has the capacity to avoid or minimize interruptions of service during planned activities and/or equipment failure.
ROW	Right-of-way.
RTU	Remote terminal unit
SCADA	System Control and Data Acquisition – The SCADA system provides centralized control of selected remote equipment, while also typically gathering and recording data attributes such as operating pressure and temperature for the purposes of system monitoring and analysis.

Acronym or Term	Definition
Shut in / Shut down	The act of shutting off gas supply to a gas pipeline or customer service line such that there is no gas flow into the line. Shut in /Shut down ensures the gas supply system will be positively isolated from customer service lines when it is re-pressurized. This is a public safety measure to prevent re-pressurization of private systems whose condition will not have been verified until assessed by a qualified person during a relight campaign.
Stations	Coquitlam Gate Station—Coquitlam Cape Horn Station—Cape Horn Delta Valve Station--Delta East 2nd and Woodland District Station—2nd and Woodland Ferguson Station—Ferguson Fraser Gate Station—Fraser Marine and Elliott District Station –marine and Elliott Nichol Valve Station—Nichol Port Mann Station—Port Mann Roebuck Valve Station—Roebuck Tilbury valve Station—Tilbury Tilbury LNG Plant—Tilbury LNG
Tcf	Trillion cubic feet.
TJ	Terajoule - a unit of energy equal to 1,000 gigajoules
TP	Transmission pressure (14,890 – 3,101 kPag)
Tilbury facility / Tilbury LNG Storage Facility	An existing, on-system LNG storage facility located in the Tilbury industrial area in Delta, BC owned and operation by FEI.
UCA or Act	Utilities Commission Act

Appendix G-1

DRAFT PROCEDURAL ORDER

SIXTH FLOOR, 900 HOWE STREET, BOX 250
VANCOUVER, BC V6Z 2N3 CANADA
web site: http://www.bcuc.com

BRITISH COLUMBIA UTILITIES COMMISSION

ORDER NUMBER

TELEPHONE: (604) 660-4700
BC TOLL FREE: 1-800-663-1385
FACSIMILE: (604) 660-1102

DRAFT PROCEDURAL ORDER

IN THE MATTER OF
the Utilities Commission Act, R.S.B.C. 1996, Chapter 473

and

Application by FortisBC Energy Inc.
for a Certificate of Public Convenience and Necessity for the Lower Mainland Intermediate Pressure System Upgrade Projects

BEFORE:

(Date)

WHEREAS:

A. On December 19, 2014, FortisBC Energy Inc. (FEI) applied to the British Columbia Utilities Commission (Commission), pursuant to sections 45 and 46 of the *Utilities Commission Act* (Act), for a Certificate of Public Convenience and Necessity (CPCN) for the Lower Mainland Intermediate Pressure (IP) System Upgrade (LMIPSU) Projects (Application);

B. The Application seeks approval for FEI to construct and operate:

- A new Nominal Pipe Size (NPS) 30 IP pipeline operating at 2010 kPa between Coquitlam Gate Station and East 2nd & Woodland Station to upgrade and replace an existing NPS 20 IP pipeline operating at 1200 kPa (Coquitlam Gate IP Project); and

- A new NPS 30 IP pipeline operating at 1200 kPa between Fraser Gate Station and East Kent & Elliott Street to upgrade and replace an existing NPS 30 IP pipeline (Fraser Gate IP Project), collectively referred to as the Projects;

C. FEI also seeks Commission approval under sections 59-61 of the Act for deferral treatment of:

- Development costs for the two Projects will be recorded in a new deferral account, the LMIPSU Project Development Costs deferral account. This account will attract the weighted average cost of capital until it enters rate base on January 1, 2016 and will be amortized over a three year period commencing January 1, 2016; and

- CPCN Application costs will be recorded in a new deferral account, the LMIPSU Application Costs deferral account. This account will attract the weighted average cost of capital until it enters rate base on January 1, 2016 and will be amortized over a three year period commencing January 1, 2016;

D. FEI estimates the capital cost of the Coquitlam Gate IP Project to be approximately $232.985 million in as-spent dollars, including abandonment and demolition costs, and not including Allowance for Funds Used During Construction (AFUDC);

E. FEI estimates the capital cost of the Fraser Gate IP Project to be approximately $17.231 million in as-spent dollars, not including AFUDC;

F. FEI proposes to start construction of the Coquitlam Gate IP Project in April 2018 and to have the Project in-service by November 2018;

G. FEI proposes to start construction of the Fraser Gate IP Project in July 2018 and to have the Project in-service by November 2018;

H. FEI requests that certain Appendices relating to correspondence between FEI and some First Nations be treated as confidential, and that engineering, risk assessments, and cost estimates for material and construction work for the Projects be treated as confidential due to commercial sensitivity and to maintain public safety;

I. The Commission has determined that a written hearing is necessary for the review of the Application.

NOW THEREFORE the Commission orders as follows:

1. A written hearing process for review of the Application in accordance with the Regulatory Timetable attached as Appendix A to this Order is hereby established.

2. The British Columbia Utilities Commission (Commission) considers FortisBC Energy Inc.'s (FEI) request for confidentiality is reasonably necessary to protect FEI's business interests and to maintain public safety. The Commission will hold detailed information related to correspondence between FEI and some First Nations, engineering, risk assessments, and cost estimates for material and construction work for the Projects confidential. Consumer group Interveners may request access to this information upon executing standard form undertakings of confidentiality. The Commission will consider requests by any other Interveners to access such information and FEI will have an opportunity to comment on any request.

3. FEI will publish, as soon as possible, in display-ad format, the Notice of Application attached as Appendix B to this Order, in the Vancouver Sun or the Province, and such other appropriate local news publications in the Vancouver, Burnaby and Coquitlam service areas that will provide reasonable notice to members of the public who may be affected by the Projects.

4. The Application, together with any supporting materials, will be made available for inspection at FortisBC Energy Inc., 16705 Fraser Highway, Surrey, BC, V4N 0E8, and at the British Columbia Utilities Commission, Sixth Floor, 900 Howe Street, Vancouver, BC, V6Z 2N3 and will also be available on the FortisBC Energy Inc. website at www.fortisbc.com and on the BCUC website at www.bcuc.com.

5. Persons wishing to participate as Interveners or Interested Parties should register with the Commission, in writing or electronic submission, by Monday, January 26, 2015. Interveners should specifically state the nature of their interest in the Application and identify generally the nature of the issues that they may intend to pursue during the proceeding and the nature and extent of their anticipated involvement in the review process.

DATED at the City of Vancouver, In the Province of British Columbia, this day of <month> 2014.

BY ORDER

Attachment

Application by FortisBC Energy Inc.
for a Certificate of Public Convenience and Necessity for the Lower Mainland Intermediate Pressure System Upgrade Projects

REGULATORY TIMETABLE

ACTION	DATE (2015)
Intervener and Interested Party Registration and Confirmation if attending Workshop	Monday January 26
Workshop	Tuesday, February 3
Commission and Intervener Information Request No. 1	Thursday, February 12
FEI Response to Information Requests No. 1	Thursday, March 12
Commission and Intervener Information Request No. 2	Thursday, April 2
FEI Response to Information Requests No. 2	Monday, April 27
FEI Written Final Submission	Thursday, May 21
Intervener Written Final Submissions	Thursday, May 28
FEI Written Reply Submission	Thursday, June 4

SIXTH FLOOR, 900 HOWE STREET, BOX 250
VANCOUVER, B.C. V6Z 2N3 CANADA
web site: http://www.bcuc.com

TELEPHONE: (604) 660-4700
BC TOLL FREE: 1-800-663-1385
FACSIMILE: (604) 660-1102

Application by FortisBC Energy Inc.
for a Certificate of Public Convenience and Necessity for the Lower Mainland Intermediate Pressure System Upgrade Projects

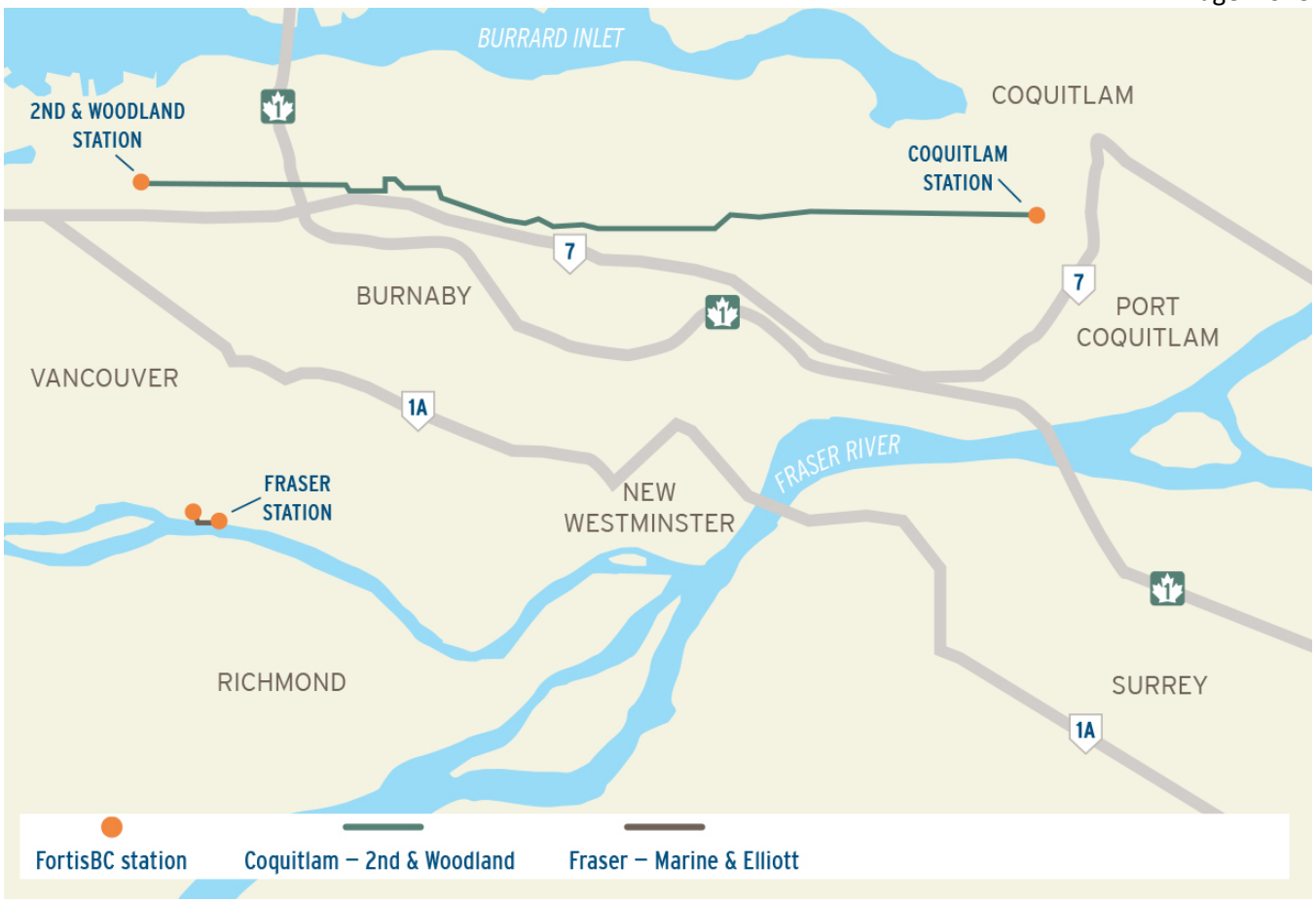
NOTICE OF APPLICATION

THE APPLICATION

On December 19, 2014, FortisBC Energy Inc. (FEI) applied to the British Columbia Utilities Commission (Commission) for a Certificate of Public Convenience and Necessity (Application) for the Lower Mainland Intermediate Pressure (IP) System Upgrade Projects to replace the approximately 20 km existing 1200 kPa Nominal Pipe Size (NPS) 20 IP pipeline between Coquitlam Gate Station in Coquitlam and the East 2nd & Woodland Station in Vancouver with a 2070 kPa NPS 30 pipeline (Coquitlam Gate IP Project), and also to replace a 0.5 km section of the existing 1200 kPa NPS 30 IP pipeline between Fraser Gate Station and East Kent & Elliot Street in Vancouver with a 1200 kPa NPS 30 IP pipeline (Fraser Gate IP Project).

FEI is proposing the Coquitlam Gate IP Project for the purpose of eliminating non-preventable corrosion risks associated with the existing Coquitlam Gate IP pipeline and to address other capacity related constraints. FEI is proposing the Fraser Gate IP Project for the purpose of mitigating seismic vulnerability and associated consequences.

The approximate location of the Coquitlam Gate IP Project and Fraser Gate IP Project pipelines to be replaced are shown on the system location map below.



THE REGULATORY PROCESS

Commission Order G-xx-14 established a Regulatory Timetable for the review of the Application by way of a Written Public Hearing.

The Regulatory Timetable can be reviewed on the Commission's website at www.bcuc.com[link]

INTERVENTION

Persons wishing to actively participate in the proceeding must register as Interveners through the Commission's website at www.bcuc.com by January 26, 2015. In their registration, Interveners must identify the issues that they intend to pursue and indicate the extent of their anticipated involvement in the review process. Interveners will each receive a copy of all non-confidential correspondence and filed documentation, and must provide an email address if available. Parties must explain how their interests or their clients' interests are affected and should be able to reference their interests with respect to the scope in the Application.

Persons not expecting to actively participate, but who have an interest in the proceeding, should register as Interested Parties through the Commission's website or in writing, by January 26, 2015, identifying their interest in the proceeding.

By participating and/or providing comment on the Application, you agree that all submissions will be placed on the public record and posted on the Commission's website.

For more information on ways to get involved in the review, please visit www.bcuc.com and click "How to Get Involved" under "Quick Links" on the home page.

VIEW THE APPLICATION

The Application and supporting documentation are available on the Commission's website on the "Current Applications" page. If you would like to review the material in hard copy, it is available to be viewed at the locations below:

British Columbia Utilities Commission Sixth Floor, 900 Howe Street Vancouver, BC V6Z 2N3 Commission.Secretary@bcuc.com Phone: 604-660-4700 Toll Free: 1-800-663-1385	**FortisBC Energy Inc.** 16705 Fraser Highway Surrey, BC, V4N 0E8 gas.regulatory.affairs@fortisbc.com

FURTHER INFORMATION

For further information, please contact Ms. Erica Hamilton, Commission Secretary, using the contact information above.

Appendix G-2

DRAFT ORDER

SIXTH FLOOR, 900 HOWE STREET, BOX 250
VANCOUVER, BC V6Z 2N3 CANADA
web site: http://www.bcuc.com

BRITISH COLUMBIA UTILITIES COMMISSION

ORDER NUMBER

TELEPHONE: (604) 660-4700
BC TOLL FREE: 1-800-663-1385
FACSIMILE: (604) 660-1102

DRAFT ORDER

IN THE MATTER OF
the Utilities Commission Act, R.S.B.C. 1996, Chapter 473

and

An Application by FortisBC Energy Inc.
For a Certificate of Public Convenience and Necessity for the Lower Mainland Intermediate Pressure System Upgrade Projects

BEFORE:

(Date)

WHEREAS:

A. On December 19, 2014, FortisBC Energy Inc. (FEI) applied to the British Columbia Utilities Commission (Commission), pursuant to sections 45 and 46 of the *Utilities Commission Act* (Act), for a Certificate of Public Convenience and Necessity (CPCN) for the Lower Mainland Intermediate Pressure (IP) System Upgrade (LMIPSU) Projects (Application);

B. The Application seeks approval for FEI to construct and operate:

- A new NPS 30 IP pipeline operating at 2010 kPa between Coquitlam Gate Station and East 2nd & Woodland Station to upgrade and replace an existing NPS 20 IP pipeline operating at 1200 kPa (Coquitlam Gate IP Project); and
- A new NPS 30 IP pipeline operating at 1200 kPa between Fraser Gate Station and East Kent & Elliott Street to upgrade and replace an existing NPS 30 IP pipeline (Fraser Gate IP Project), collectively referred to as the Projects;

C. FEI also seeks Commission approval under sections 59-61 of the Act for deferral treatment of:

- Development costs for the two Projects will be recorded in a new deferral account, the LMIPSU Project Development Costs deferral account. This account will attract the weighted average cost of capital until it enters rate base on January 1, 2016 and will be amortized over a three year period commencing January 1, 2016; and
- CPCN Application costs will be recorded in a new deferral account, the LMIPSU Application Costs deferral account. This account will attract the weighted average cost of capital until it enters rate base on January 1, 2016 and will be amortized over a three year period commencing January 1, 2016;

D. FEI estimates the capital cost of the Coquitlam Gate IP Project to be approximately $232.985 million in as-spent dollars including abandonment and demolition costs, and not including Allowance for Funds Used During Construction (AFUDC);

E. FEI estimates the capital cost of the Fraser Gate IP Project to be approximately $17.231 million in as-spent dollars, not including AFUDC;

F. FEI proposes to start construction of the Coquitlam Gate IP Project in April 2018 and to have the Project in-service by November 2018;

G. FEI proposes to start construction of the Fraser Gate IP Project in July 2018 and to have the Project in-service by November 2018;

H. FEI requests that certain Appendices relating to correspondence between FEI and some First Nations be treated as confidential, and that engineering, risk assessments, and cost estimates for material and construction work for the Projects be treated as confidential due to commercial sensitivity and to maintain public safety;

I. By Order G-XX-14 dated <date>, the Commission granted FEI's request for confidentiality and established a regulatory review process and regulatory timetable;

J. The Commission has considered the evidence and concludes that the Projects are in the public interest, and that a CPCN for the Projects should be granted.

NOW THEREFORE, the Commission orders as follows:

1. Pursuant to sections 45 and 46 of the *Utilities Commission Act* (Act), a Certificate of Public Convenience and Necessity (CPCN) is granted to FortisBC Energy Inc. (FEI) to construct and operate the Lower Mainland IP System Upgrade Projects, as applied for in the Application.

2. Pursuant to sections 59 to 61 of the Act, the deferral treatment and the amortization for the development costs is approved. FEI shall establish the LMIPSU Project Development Costs deferral account to record the project development costs for the two Projects. This account will attract the weighted average cost of

capital until it is included in rate base on January 1, 2016 and the account shall be amortized over a three year period commencing January 1, 2016.

3. Pursuant to sections 59 to 61 of the Act, recording costs of preparing the Application in a deferral account is approved. FEI shall establish the LMIPSU Application Costs deferral account to record the costs of preparing the Application. This account will attract the weighted average cost of capital until it is included in rate base on January 1, 2016 and the account shall be amortized over a three year period commencing January 1, 2016.

4. FEI shall file with the Commission within 30 days of the end of each reporting period Quarterly Progress Reports on the Projects. The Quarterly Progress Reports will address in some detail the risks that the Projects are experiencing, the options available to address the risks, the actions that FEI is taking to deal with the risks and the likely impact on Projects' schedule and cost.

5. FEI shall file with the Commission a Final Report, including a publicly available version, within six months of the end or substantial completion of the Projects, that provides a complete breakdown of the final costs of the Projects, compares these costs to the cost estimates included in Confidential Appendices E-3-1 and E-3-2 of the Application, and provides an explanation and justification of material cost variances.

DATED at the City of Vancouver, In the Province of British Columbia, this XX day of <MONTH>, 2015.

BY ORDER

Appendix G-3

DRAFT UNDERTAKING OF CONFIDENTIALITY

FortisBC Energy Inc. (FEI)
Application for a Certificate of Public Convenience and Necessity (CPCN) for Approval of the Lower Mainland Intermediate Pressure (IP) System Upgrade Projects

UNDERTAKING OF CONFIDENTIALITY

I, _____, am a participant acting for _____ in the matter of the review of the FEI's Application for a CPCN for Approval of the Lower Mainland IP System Upgrade Projects.

In this capacity, I request access to the confidential information. I understand that the execution of this undertaking is a condition of an Order of the British Columbia Utilities Commission (the Commission), and the Commission may enforce this Undertaking pursuant to the provisions of the *ATA.*

I hereby undertake

a) to use the information disclosed under the conditions of the Undertaking exclusively for duties performed in respect of this proceeding;

b) not to divulge information disclosed under the conditions of this Undertaking except to a person granted access to such information or to staff of the Commission;

c) not to reproduce, in any manner, information disclosed under the conditions of this Undertaking except for purposes of the proceeding;

d) to keep confidential and to protect the information disclosed under the conditions of this Undertaking;

e) to return to FEI, under the direction of the Commission, all documents and materials containing information disclosed under the conditions of this Undertaking, including notes and memoranda based on such information, or to destroy such documents and materials and to file with the Commission a certification of destruction at the end of the proceeding or within a reasonable time after the end of my participation in the proceeding; and

f) to report promptly to the Commission any violation of this Undertaking.

Dated at _____ this _____day of _____, 2015.

Signature: _____

Name: _____
(please print)

Address: _____

Telephone: _____

Fax: _____

E-mail: _____