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June 27, 2007

Via Email
Original via mail

Ms. Erica M. Hamilton
Commission Secretary
BC Utilities Commission
Sixth Floor, 900 Howe Street, Box 250
Vancouver, BC V6Z 2N3

Dear Ms. Hamilton:

Re: An Application for a Certificate of Public Convenience and Necessity for the Copper Conductor Replacement Project.

Please find enclosed for filing 20 copies of FortisBC Inc.'s Application for a Certificate of Public Convenience and Necessity for the Copper Conductor Replacement Project pursuant to Sections 45 and 46 of the Utilities Commission Act.

Sincerely,

David Bennett
Vice President, Regulatory Affairs
and General Counsel

FORTISBC

AN APPLICATION FOR A
CERTIFICATE OF PUBLIC CONVENIENCE and NECESSITY

COPPER CONDUCTOR REPLACEMENT (CCR) PROJECT

June 27, 2008

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Executive Summary

The Copper Conductor Replacement (CCR) Project is required to address safety concerns and incidents that are the result of distribution copper conductor failures. The project is necessary to ensure a safe and reliable electrical distribution system that minimizes public and employee safety concerns while protecting plant and equipment.

Electrical distribution systems are usually designed with an economic life of 40 to 50 years, however within the FortisBC service area there are distribution systems with 70 year old poles supporting No. 6, No. 8 and No. 90 MCM (legacy) copper conductors installed in the 1930s that are still in service today. With the historically low customer growth rates in many of these areas and communities, the wholesale replacement of old lines with new ones having lower losses could not be justified on a purely economic basis. Of the various asset classes, conductor is one of the most expensive to replace. The result of not re-conductoring can be a tensile failure during emergency (heavy) loading or during adverse weather conditions. Unfortunately such local failures are not always a motivator to reconductor the whole section of the line due to the economic reasons cited above. Consequently as noted, many lines which were designed and commissioned well over 50 years ago are still in operation today.

Over the past five years, there have been approximately 350 incidents of distribution conductor failure of which approximately 200 or 57 percent involved legacy copper even though the legacy copper comprises only 10 percent of all conductor in service. FortisBC records show that between August 2004 and April 2008 there were 12 incidents where downed copper conductor remained energized on the ground, creating a public and employee electrocution risk and a fire hazard. Although the incidents have been isolated, a study of the situation was deemed necessary to determine the cause of such failures, and to initiate remedial action to prevent as far as practicable, similar incidents in the future. The assessment indicated that the root cause of these failures was primarily metal fatigue of old No. 6, No. 8 and No. 90 MCM copper conductors and conductor failure at tap-off connector points where connectors are directly applied on the main conductor without an accompanying stirrup.

An independent analysis commissioned by FortisBC and conducted by PowerTech Labs Inc., determined that the legacy copper conductors tested showed annealing and mechanical property values below specified requirements and that additional failures can be expected (See Appendix A). The report summary indicated that:

> *"The analysis showed annealing (softening) of the copper conductor leading to ductile overload failure under normal operating stresses. Annealing of the copper conductor is occurring due to elevated service temperatures from high contact resistance within the connections. Over time, the elevated service temperature caused recrystallization and grain growth in the copper microstructure, leading to a reduction in the tensile properties."*

It also states that:

> *"A material properties assessment was preformed on randomly selected samples of various sizes of copper conductor, both solid and stranded, used in the system outside of hardware connections. The conductor sizes tested showed mechanical property values below specified requirements for hard drawn copper wire by ASTM B1 "Standard Specification for Hard-Drawn Copper Wire".*

Other Canadian utilities including BC Hydro, Fortis Alberta and Newfoundland Power have replaced legacy copper conductor distribution lines to accommodate load growth and to improve public and employee safety as well as service reliability.

FortisBC, like other utilities must maintain its equipment and provide a safe environment for employees and the general public. This involves the replacement of deteriorated and unsafe plant even when the economic choice might suggest otherwise. There is no method to maintain bare overhead conductors and consequently they should be replaced if deemed inadequate and vulnerable. Unsafe lines compromise the safety and security of both employees and the general public.

The primary driver for this project is safety; however, the project will also result in other benefits, namely:

- improved reliability;

- reduced electrical loss savings;
- enhanced distribution network capacity;
- reductions in urgent capital repair cost; and
- reduction in future expenditures for the Distribution Rehabilitation and Rebuild programs.

FortisBC evaluated three implementation plans involving 10 year, 13 year and 15 year schedules. The Company proposes the 10 year implementation plan for the following reasons:

- it ensures fastest elimination of the hazardous legacy copper conductors from the 187 sensitive public locations;
- it ensures fastest overall elimination of legacy copper conductor from the system; and
- it has the lowest NPV and the lowest rate impact.

The project is expected to start in the first quarter of 2009 and be completed by the fourth quarter of 2018, with estimated capital expenditures of approximately $102 million, including the cost of removals, over the ten year life of the project. The net present value (NPV) of the Project is estimated at approximately $59 million with an estimated NPV of Customer Rate Impact at 0.15 percent.

1. The Application

FortisBC hereby applies (the Application) to the British Columbia Utilities Commission, (the Commission) pursuant to Section 45 of the Utilities Commission Act, for a Certificate of Public Convenience and Necessity (CPCN) for the Copper Conductor Replacement Project which will be completed over a ten year period. The Company is not seeking a specific level of funding for the ten year period; rather the Company is seeking an approval to undertake in a systematic manner, this initiative which is required to ensure a safe and reliable distribution system. The form of the Order being sought is set out in Section 9 of this Application. The project cost of approximately $102 million over a 10 year period is the Company's best estimate at this time. The estimate for the first two years has a +/- 20 percent level of accuracy, however due to the length of the project and the volatility of cost in the utility industry, the Company cannot determine with certainty the level of accuracy of the estimates for the future years. Although the Company is seeking approval of the Copper Conductor Replacement Project, it is only seeking expenditure approval out to 2010 as set out in the application totaling $11.7 million. The Company will seek further approval for future expenditures beyond 2010 in its future Capital Expenditure Plans.

The project consists of:

- replacement of all No. 8, No. 6 and 90 MCM Copper Distribution Conductors with Aluminum Conductor Steel Reinforced (ACSR) Conductor;
- assessment of poles for age and safety and replacement subject to the assessment result;
- updates to GIS (Geographic Information Systems) Database;
- standardization as per FortisBC existing standards for distribution lines; and
- disposal of the replaced copper conductors through sale.

2. The Applicant

2.1 Name, Address and Nature of Business

FortisBC Inc.
1975 Springfield Road, Suite 100
Kelowna, BC. V1Y 7V7

FortisBC is an investor-owned, integrated utility engaged in the business of generation, transmission, distribution and sale of electricity in the southern interior of British Columbia. The Company serves more than 152,000 customers directly and indirectly, and employs approximately 570 full time and part time people. FortisBC was incorporated in 1897 and is regulated under the Utilities Commission Act of British Columbia.

2.2 Financial and Technical Capacity

FortisBC owns assets of approximately $850 million, including four hydroelectric generating plants with a combined capacity of 223 megawatts and approximately 6,850 circuit kilometres of transmission and distribution power lines for the delivery of electricity to major load centers and customers in its service area.

2.3 Contact Persons

Regulatory/Legal Contact:

Dennis Swanson
Director, Regulatory Affairs
1975 Springfield Road, Suite 100
Kelowna, BC. V1Y 7V7
Phone (250) 717 0890 Fax (866) 605 9431

Technical Contact:

Doug Ruse, P. Eng.
Director, Power Supply
1290, Esplanade
Trail, BC. V1R 4L4
Phone (250) 368 0450 Fax (250) 364 1270

3. Project Need

3.1 Description of the Existing System

FortisBC has approximately 4,900 circuit kilometres of overhead distribution lines in its system, consisting of approximately 9,300 kilometres of conductor. Of this, approximately 660 circuit kilometres, or 13.5 percent, is made up of copper conductors ranging in size from No. 8 to 300 MCM. Approximately 500 circuit kilometres of the copper distribution lines or 960 kilometres of conductor is comprised of No. 8, No. 6 and 90 MCM (legacy) copper which is supported by approximately 8,100 poles.

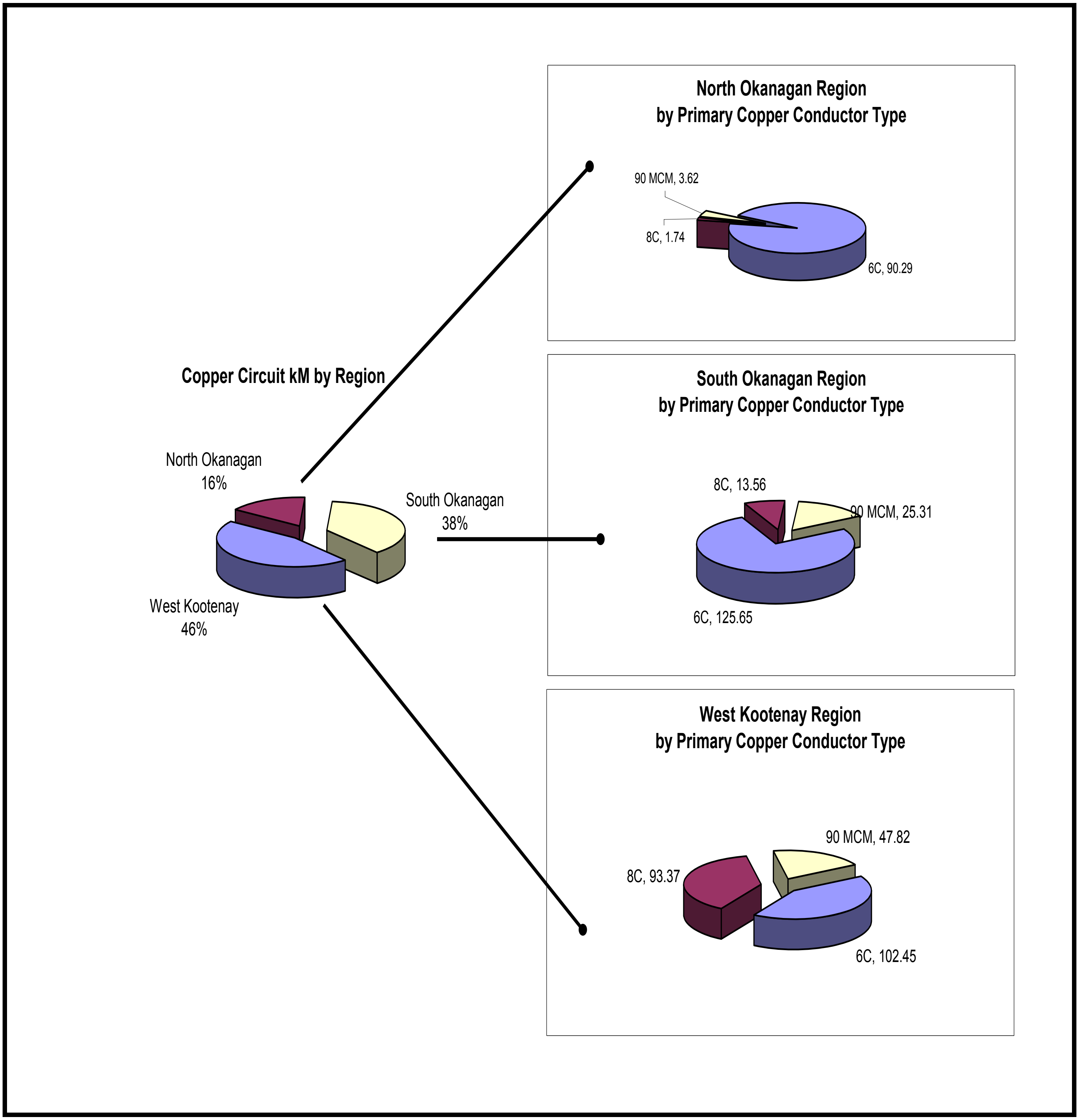
The legacy copper was commonly used for distribution lines 50 years ago due to availability and excellent electrical characteristics. However, the metallurgical characteristics of these legacy conductors have deteriorated over time. Appendix A contains a third party technical investigation report that analyses and describes the condition of the legacy copper conductor in the FortisBC distribution network.

Additionally a majority of the poles currently supporting the legacy copper were also installed at the same time as the conductor. Records show that of the 8,100 poles approximately 4,450 (legacy poles) are in excess of 50 years in age. This is discussed in further detail in section 3.11. The following Table 1 provides a listing of the type, age profile and quantity of the various legacy copper conductors in service at FortisBC as well as the 85 percent amount targeted for replacement though this CPCN Application. Figure 1 on the following page provides a geographical distribution of the various types and quantities of the legacy copper conductor.

Table 1
Legacy Copper Conductor Type, Age Profile

Conductor type	Circuit Length	Conductor Length	Age Profile
	(km)		
No. 90 MCM	77	216	> 65 years
No. 8	109	167	> 50 years
No. 6	318	581	≥ 50 years
Subtotal	**504**	**964**	
85 percent of Subtotal	**428**	**819**	

Figure 1
Legacy Copper Conductor Geographical Distribution Profile



3.2 Copper Conductor Failure

Over the past five years, there have been approximately 350 incidents involving distribution conductor, tie wire or connectors failure, of which approximately 200 incidents involved distribution legacy copper conductor. The Company's records show that within the last four years, twelve incidents involving copper conductor resulted in situations where downed conductors remained energized, creating a public and employee electrocution risk and a fire hazard.

The following Picture 1 provides an example of an incident in FortisBC's service area where a downed copper conductor remained energized on the ground resulting in a grass fire.

Picture 1
Energized Power Line on Ground

Approximately 57 percent of the conductor failure incidents involved legacy copper conductor even though legacy copper only comprises 960 of the 9,300 kilometres or 10 percent of the total conductor in service. The following table shows the failure incidents that occurred in the FortisBC distribution system between January 2003 and August 2007. It shows the number of customers affected and the customer outage hours. In addition to reliability issues some of these incidents also impacted employee and general public safety, as well as customer satisfaction.

Table 2
Copper Conductor Failure (January 2003 - Aug 2007)

Location	No. of Failures	Overhead Conductor Type	Customer	Customer Hours
Castlegar	16	8C	1,511	4,311
	7	90C	37	82
Crawford Bay	4	8C	36	84
Creston	10	6C	248	1,848
	3	8C	138	415
	2	90C	23	6
Grand Forks	8	6C	839	3,040
	5	8C	184	716
	1	90C	10	8
Greenwood	6	90C	337	3,615
Kaslo	1	6C	5	20
	1	90C	1	5
Kelowna	12	6C	179	369
	5	8C	58	72
	12	90C	5,430	16,241
Keremeos	4	6C	177	505
	1	8C	2	5
Oliver	10	6C	128	554
	14	90C	195	638
Penticton	5	6C	510	1,642
	2	90C	5	16
Salmo	6	6C	280	427
	14	8C	1,506	3,750
	11	90C	1,252	2,619
South Slocan	6	8C	75	234
	6	90C	97	232
Trail	9	8C	177	939
	16	90C	2,930	4,812
TOTAL	**197**	**Assorted**	**16,370**	**47,204**

3.3 Copper Conductor Failures in Sensitive Areas

Conductor failure in public areas is of particular concern to FortisBC since the probability of public safety issues increases in areas with a higher volume of public access. The following table shows the incidents that have occurred between August 2004 and April 2008 where conductor failure involving energized lines occurred in areas considered by the Company to be "Sensitive Areas". These areas include school zones, public parks, and high density residential and high density commercial areas.

Table 3

Copper Conductor Failures Sensitive Areas (August 2004—April 2008)

Sl. No.	Location	Conductor Type	Date	Remarks
1	Osoyoos	6C	29/10/2004	Commercial area
2	OK Falls	6C	25/01/2005	Residential area
3	Kelowna	4C	01/07/2005	Residential area
4	OK Falls	6C	25//01/2006	School zone and Public Park
5	Keremeos	4C	17/05/2006	School zone and High Density Commercial
6	Castlegar	8C	02/09/2006	Residential area
7	Fruitvale	8C	06/09/2006	Residential area
8	Castlegar	90C	04/07/2007	School zone
9	Creston	8C	24/08/2007	Public Park and High Density
10	Castlegar	8C	04/03/2008	Residential area
11	Kelowna	3C	19/04/2008	Residential area
12	Castlegar	3C	22/04/2008	Residential area

Note: The failure of the No. 3 and No. 4 Copper Conductors is not attributable to the conductors itself, but to the Hot Tap Connectors, which are directly applied on to the conductor without the use of the Stirrups. Hence, it will be kept outside the scope of this Project.

3.4 Legacy Copper Conductor in Sensitive Areas

As part of FortisBC's review of the risk associated with the legacy copper conductor, an analysis was performed to determine the number of locations where No. 8, No. 6 or No. 90 MCM copper existed in a sensitive area. The table below provides the number of locations where legacy copper conductors are present in a sensitive area. The priority of the locations has been provided in descending order. For example, if an area was both a school and a public park, it would be prioritized as a School Zone below. The table was created from line patrols and maps generated by the Geographic Information Systems.

Table 4
Legacy Copper Conductors in Sensitive Areas (Location Counts)

Sensitive Public Domain Type in FortisBC Inc. Service Area	No. 90 MCM Copper	No. 8 Copper	No. 6 Copper	Total
	Number of Locations			
School Zone	3	5	16	**24**
Public Parks	2	12	16	**30**
High Density Residential Zone	3	25	81	**109**
High Density Commercial Zone	0	4	20	**24**
TOTAL	**8**	**46**	**133**	**187**

3.5 Employee Safety Issues

Upgrades of legacy copper conductor have primarily been undertaken only when the conductor failed. There has been no systematic legacy copper replacement program at FortisBC. Failures were addressed by minimum upgrades which did not resolve the global issue of deterioration of the legacy copper conductor. Past experience and laboratory analysis has shown that deterioration has compromised the integrity of these conductors and they pose a risk not only to the line crews who work on them, but also to the general public.

The Company has recognized the employee safety issues associate with the legacy copper and has established a special Standard Operating Practices (SOP) to minimize safety related incidents while working on copper conductors. The following Picture 2 shows that as a result of the SOP, employees are encouraged to leave old hot tap connectors on the conductor rather than risk the possibility of conductor failure by trying to remove it.

Picture 2
Hot Tap Connector Left on Conductor

To further mitigate the safety issues, the Company initiated a program in 2005 to include infrared scanning as part of its Distribution Condition Assessment Program in an effort to identify failing conductor, however this initiative has not been completely effective in identifying problem areas with copper conductor.

With increased failures in the past five years the Company has determined that a concerted effort to address the issue in a systematic manner must be undertaken.

3.6 Copper Conductor Metallurgical Issues

There are a number of factors that affect the strength and metallurgical properties of copper conductor. These include:

1. Annealing: Annealing is the phenomenon where the conductor softens due to operation at certain temperatures resulting in a reduction of tensile strength. A special problem with legacy copper conductors is the uncertainty of its annealing

properties. While the annealing properties of aluminum are well understood, such properties for copper are very different, much more complex, and were only identified around 1950. Annealing resistant copper conductors were developed and were sold under different trade names after 1950, unfortunately such records cannot be retrieved for the old installed copper lines at FortisBC.

2. The Temperature Factor: An important phenomenon of copper conductors which is not well recognized is that at temperatures above 160 - 175°C copper anneals extremely rapidly. These temperatures may occur during fault conditions. A single exposure to these temperatures may lead to a loss of strength of more than 50 percent. In 50 year old lines, such short term exposures at one time or another during fault conditions is very likely to have occurred.

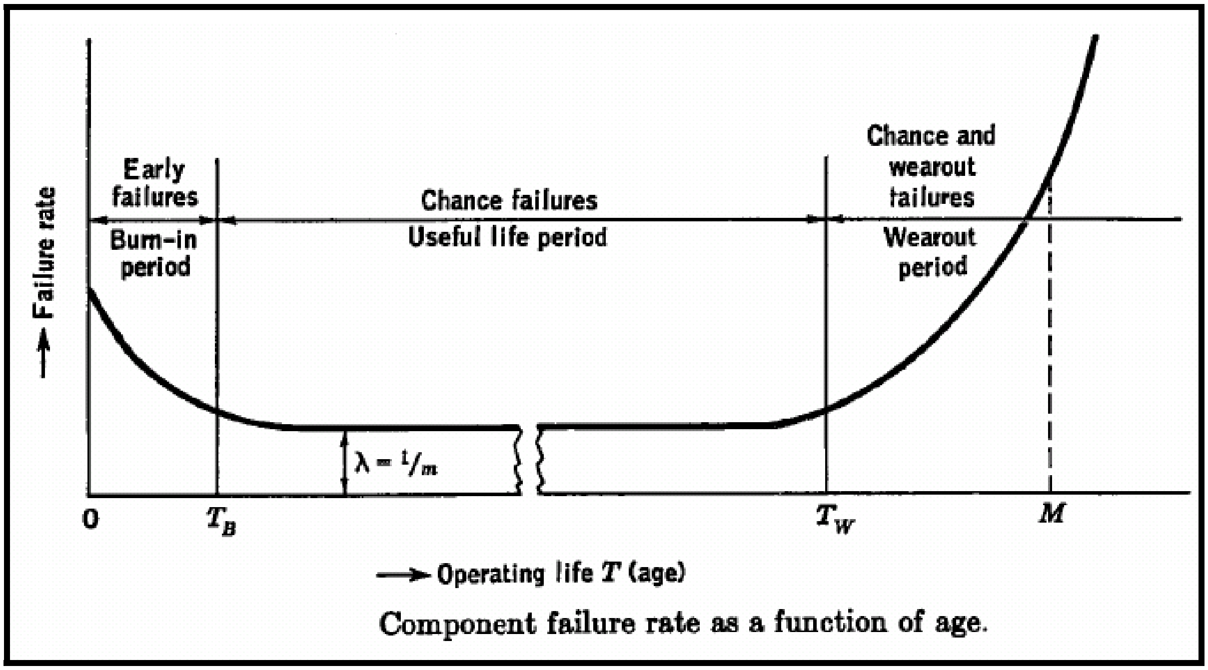
3. Low Cycle Fatigue: Temperature variations and motions caused by wind gust may bend conductors at their support points. At the same time conductor stress also varies as a function of temperature. The combined effect of these factors might explain fatigued strands in old copper conductors. Broken strands reduce breaking strength and increases electrical resistance in the vicinity of the strand breaks thus inducing further fatigue, reducing safety and reliability of the lines.

3.7 Failure Probability of Copper Conductors

The failure of all types of equipment including legacy copper can generally be represented by the classic “bath-tub” curve shown in Figure 2 below. The application of the bath tub Curve is probabilistic. The curve shows the relative likelihood of failure in each year over a period of time.

The graph indicates that the failure rate during the early life period of any element is high which is often caused by flaws in manufacturing, installation or design issues. It stabilizes when corrective measures are taken. The early failures are followed by a long “Useful Life Period”, where the element performs as per design and failures from deterioration are very low. The primary cause of failure during this period is generally sudden stress caused by unpredictable and abnormal events.

Figure 2
Classic Bath-Tub Curve / Failure Rate Curve



The useful life, which is generally considered to be 40 - 50 years for copper conductors, is followed by the "wearout period". At this point the failure rate increases exponentially and is a result of component aging caused by cumulative deterioration over time, service stress and abnormal events.

For bare overhead conductor which has surpassed its "useful life", there is no way to maintain and extend its useful life as is the case of other electrical equipment such as power transformers and breakers. Repair is an option during the useful life period of the conductor when failures occur only due to abnormal stress causing events and when such events are low. After the useful life of the conductor is surpassed, and the failure probability increases exponentially, it generates a "system risk" which cannot be effectively mitigated or accurately predicted to avert a failure or prevent an incident. The prudent option at this stage is the systematic replacement of the aging conductors.

3.8 Protection Issues associated with Detection and Isolation of Downed Distribution Lines

Historical cases of copper failure causing electrical faults have resulted in a number of incidents where the distribution line has remained energized on the ground, creating public, employee and fire safety hazards. Existing protection devices are unable to detect the faults and therefore do not trip or isolate the energized distribution line.

When overhead distribution lines lose support and fall on poorly conductive surfaces, such as asphalt, rock or dry sand, they generate high-impedance faults. These faults are short-circuiting faults with currents lower than what a traditional protective device can detect. Reliable detection of such low fault currents remains challenging. Moreover, the problem of fault detection is compounded in cases where the incident is located far down the distribution line away from the source substation thus adding to the impedance of the circuit, lowering the fault current in the network even further and rendering the protective device less sensitive.

Additionally, a grounded distribution system can be quite unbalanced due to the line-to-ground capacitance per phase not being identical. To avoid false tripping due to cold load pickups and transformer in-rush currents, conventional ground over-current relays are typically set above the maximum foreseeable imbalance. This in turn decreases the relay sensitivity for detecting and isolating low current high-impedance faults. Conversely, reducing the pick up settings can cause reliability problems due to false trips on load imbalance.

Also, fault current magnitudes may change as ground surface moisture escapes from fault generated heat and as ground silicon materials burn transforming into glass. Difference in soil due to changing seasons and distinct geological regions can produce different fault current characteristics. High-impedance faults are common in British Columbia due to its rocky surface content. However, this problem exists for power utilities all over the world. Under these circumstances, it is practically impossible to design a traditional substation-based device that will detect all high-impedance faults or downed-conductor situations.

Since the conventional protective relays cannot detect these energized lines, they remain on the ground and become a public safety concern. This has prompted a significant amount of research in finding a cost-effective substation-based detection device for high-impedance faults. The history of on-going research shows the complexity involved in designing a high-impedance fault detection algorithm that is both fairly dependable and fully secure against false alarms.

Research and development is ongoing, however protection techniques that will automatically detect downed conductors still remain one of the most persistent and difficult challenges facing protection engineers today. At this time, the best defence electrical utilities have is a systematic elimination program for legacy conductors backed up by sound internal safety practices and sustained public education regarding safety in the proximity of downed power lines.

3.9 Laboratory Analysis of Legacy Copper Conductors

An independent analysis commissioned by FortisBC and conducted by the Power Tech Lab Inc., indicated that legacy copper conductors showed annealing and mechanical property values below specified requirements and that additional failures can be expected. The complete report is provided as Appendix A.. The report summary indicated that:

> *"The analysis showed annealing (softening) of the copper conductor leading to ductile overload failure under normal operating stresses. Annealing of the copper conductor is occurring due to elevated service temperatures from high contact resistance within the connections. Over time, the elevated service temperature caused recrystallization and grain growth in the copper microstructure, leading to a reduction in the tensile properties. The increase in contact resistance was from large scale build of corrosion product within the connection. Given the current average service age of 50 years for the conductor and components within the system, similar conditions are likely to exist in the majority of hot tap connections and additional failures will be expected. Additional splice connections relying on contact resistance were examined and also showed a reduction in hardness as well as increasing grain size. A material properties*

assessment was preformed on randomly selected samples of various sizes of copper conductor, both solid and stranded, used in the system outside of hardware connections. The conductor sizes tested showed mechanical property values below specified requirements for hard drawn copper wire by ASTM B1 "Standard Specification for Hard-Drawn Copper Wire". The lower values may be attributable to softening of copper over its long service life. Metallographic examination indicated the presence of some recrystallized grains within the hard drawn microstructure. The lower values may also be attributable to historical standards at the time of installation, which may not have had as stringent requirements for tensile properties."

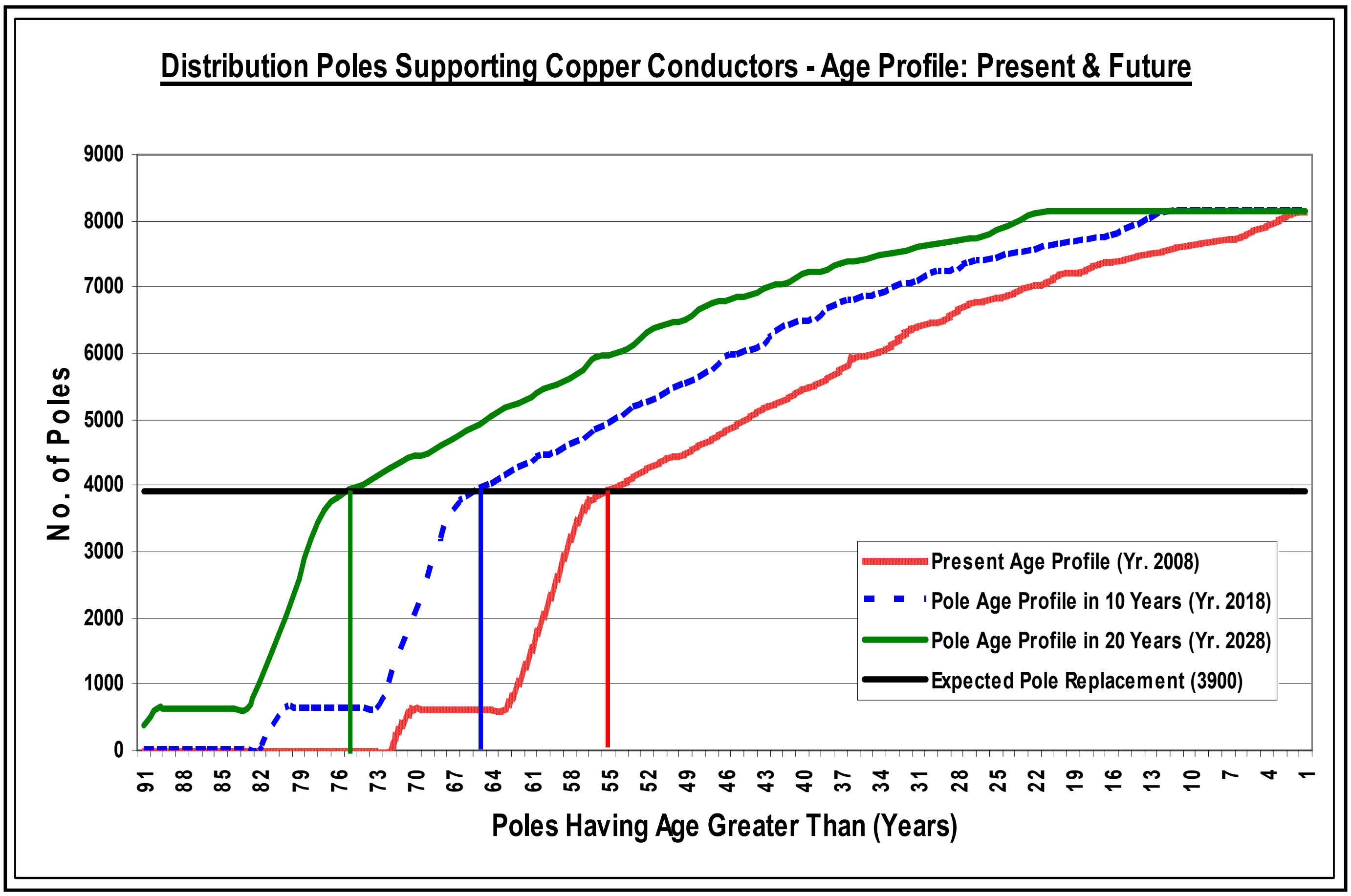
3.10 Copper Conductor Replacement Actions by Other Utilities

Many utilities have upgraded their ageing infrastructures to meet load requirement and to improve system safety and service reliability. BC Hydro completed the replacement of its No. 6 legacy distribution copper conductors in 2004. Fortis Alberta completed the replacement of its legacy copper conductor a number of years ago. Newfoundland Power has also completed the replacement of No. 8 and No. 6 copper conductor. At the 2006 Rural Utility Services – Electrical Engineering Seminar, Robert C. Dew P.E (CEO of PowerTech Engineering) gave a presentation titled "Aging Conductor & Equipment – Analysis and Recommendations" during which he recommended that all small copper lines be replaced within the next ten years or less.

3.11 Legacy Pole Replacement

The structural integrity of wood poles decreases with age due to fungal decay both above and below the ground line. Insects (such as carpenter ants) and woodpeckers can also cause extensive damage to wood poles. As the pole ages and experiences surface rot, its ability to support wind and other mechanical loads deteriorates. For example, one inch of surface rot will decrease the strength of a typical 35 foot class five pole by approximately 50 percent. Surface rot, splits in the pole, and separation of surface growth rings also create safety hazards for employees who have to climb and work on these poles. Like any component of the electrical system, poles have a finite life. FortisBC's experience indicates that the maximum expected service life of its poles is estimated to be between 50 and 70 years. This is based on the fact that it has a very small percentage of poles that have lasted more than 70 years. The Company started its business over one hundred years ago, however it's current pole inventory has very few poles older than 70 years. Figure 3 below provides the age profile of the 8,100 poles that support the legacy conductor. It shows that without the replacement of the legacy poles as part of this project, a significant number will be in excess of 70 years old within ten years.

Figure 3
Age Profile of Distribution Poles carrying Legacy Copper Conductors



In addition to the actual installation of facilities, there are several other factors associated with the cost of replacing existing conductor and poles including the preparation of construction packages, access to the site, set up time at the site, as well as project management. Access and set up includes such items as travel, switching, grounding, material transport, and traffic control. As part of the conductor replacement initiative it would be prudent to replace poles that are 50 years or older at the same time the legacy copper is replaced in order to avoid a duplication of the effort noted above. This is based on the assumption that the 50 year old poles have a high probability of failing the next condition assessment testing process. It is estimated that of a population 4,450 poles that are presently 50 years or older, approximately 3,900 poles will be replaced as part of this Project. It is anticipated that the remainder will be replaced through other projects over the next 10 year period.

3.12 Summary

The need for a copper conductor replacement project is driven by a number of factors, the most important of which is directly related to public and employee safety. The primary concerns related to the existing system are as follows:

- There were approximately 200 failures of legacy copper conductor between January 2003 and August 2007 (see table 2);
- There were 8 failures of legacy copper conductor between August 2004 and April 2008 in sensitive areas. There were also four other failures of copper (see table 3);
- There are currently 187 locations where legacy copper exists in sensitive areas (see table 4);
- FortisBC has previously recognized the safety hazards associated with handling energized legacy copper conductor and implemented a safety practice regulation to reduce but not eliminate the risk to employees (see section 3.5);
- In power distribution systems when overhead conductor loses its support and falls on poorly conductive surfaces, such as asphalt, rock or dry sand, they generate high-impedance faults and sometimes remain energized (see section 3.8); and
- An independent analysis commissioned by FortisBC and conducted by the Power Tech Lab Inc., indicates that legacy copper conductors have deteriorated and further failures can be expected (see section 3.9).

As part of the conductor replacement initiative, the Company plans to replace any poles that are 50 years or older that support the legacy copper in order to avoid a duplication of effort such as the development of construction packages, access and site set-up, and project management. This is based on the assumption that the 50 year old poles have a high probability of failing the next condition assessment testing process.

4. Project Description

The replacement of the legacy copper conductor is being presented as a "Single Option Project". The Project is restricted to a single option since a "Do nothing" or "Run to failure" option cannot be considered as viable options due to the safety implications and consequences that may result for the customers, employees and the public in general.

The Company investigated three implementation plans for the Project. These plans are discussed in further detail in Section 8. An economic comparison of the plans is also presented in Table 9 of this Application.

4.1 General Action Plan

The overall presence of copper conductors in the distribution system was outlined in Table 1 and Figure 1, of Section 3. The Company proposes the following specific replacement plan:

- Replacement of 85 percent of all No. 8, No. 6, and No. 90 MCM legacy copper conductors constituting a net replacement of approximately 820 kilometres of copper conductor and approximately 3,900 distribution poles. The remaining 15 percent of the conductor is anticipated to be replaced by normal system growth requirements which will be covered under regular Distribution Growth / Sustaining Projects identified in the Capital Expenditure Plan (CEP) during the life of the project;
- The cost estimate provided in this Application is the Company's best effort at this time, having an estimate accuracy level of approximately +/- 20 percent for the first two years. However due to the extended length of the project and the volatility of cost in the utility industry, the Company cannot determine with certainty the level of accuracy of the estimates for future years. To address the issue of cost, on a biannual basis as part of its Capital Expenditure Plan Application process, the Company will file a cost estimate for the project for every upcoming two year period until the project is complete;
- A sample of distribution poles recovered during the first few years of the Program will be subjected to destructive testing and analysis to determine any residual life.

The result of this analysis will be used as one of the factors in determining the pole replacement decisions and may influence the current estimated pole replacement quantity in the project;

- Legacy copper in 187 "Sensitive Public areas" (see table 4) will be eliminated in the first three years totalling approximately 117 circuit kilometres;
- Legacy copper conductors will be replaced with ACSR conductor as per FortisBC distribution line practices; and
- Replacement of No. 4, No. 3, No. 2, No. 1/0, No. 2/0, No. 3/0, No. 4/0 and 300 MCM copper conductors are not within the scope of this project since:
    a) the general condition of the these categories of conductors is considered to be fair;
    b) the general age profile is 40 years or less; and
    c) cumulative circuit length in the above 7 categories is 92 kilometres which is expected to be replaced in the next 10 to 15 year under normal Capital Growth and Sustaining programs.

4.2 Implementation Plan 1 – 2018 Completion (Preferred Plan)

4.2.1 General Scope and Engineering Standards

The general scope of the Copper Conductor Replacement Program is as follows:

- replacement of No. 8, No. 6 and 90 MCM copper conductor with ACSR conductor;
- poles to be assessed for age and safety and replaced subject to assessment results;
- all transformers in the work zone to be assessed for capacity and reported for system database updating;
- ensure updates to GIS Database;
- standardization as per FortisBC existing standards; and
- ensure salvage of replaced copper conductors;

4.2.2 Project Plan for the First Three Years (2009-2011)

Table 5 below details the replacement program of distribution legacy copper conductors (No. 8, No. 6 and 90 MCM) during the first 3 years of the program (2009-2011) period. The list represents 187 job locations and assigns priorities to specific hazard categories (please refer Table 4). The implementation plan will be as follows:

1st Year (2009):

- all legacy copper conductors in the vicinity of School Zones to be eliminated;
- No. 8 copper conductors in the vicinity of Parks to be eliminated;
- approximately 22 circuit kilometres of conductor will be replaced;
- 36 locations will be reconductored; and
- approximately 200 poles will be replaced.

2nd Year (2010):

- all remaining No 6 and 90 MCM copper conductors in the vicinity of Parks to be eliminated;
- No. 8 copper in the vicinity of High Density Residential areas to be eliminated;
- approximately 29 circuit kilometres of conductor will be replaced;
- 41 locations will be reconductored; and
- approximately 260 poles will be replaced.

3rd Year (2011):

- all remaining No 6 and 90 MCM copper conductors in the vicinity of High Density Residential and High Density Commercial areas to be eliminated
- approximately 66 circuit kilometres of conductor will be replaced;
- 110 locations will be reconductored; and
- approximately 590 poles will be replaced.

Summary:

During the first three years it is anticipated that the program will achieve the following:

- elimination of 13 circuit kilometres (18 percent) of 90 MCM Copper Conductor;
- elimination of 27 circuit kilometres (23 percent) of No. 8 Copper Conductor;
- elimination of 77 circuit kilometres (26 percent) of No. 6 Copper Conductor;
- elimination cumulatively of 117 circuit kilometres of legacy copper conductors;
- elimination of copper distribution lines from 187 sensitive locations in the service area; and
- elimination of approximately 1,050 legacy poles.

Table 5
Project Plan (2009-2011)

Sl. No.	Project Name	Circuit Length [km]	General Area	Sensitive Zone Type & Number			
				School Zone	Public Parks	High Density Commercial	High Density Residential
Year 1							
NOK - No. 8 Copper							
1	Bell Clarissa	0.2	Kelowna		▲		
2	McBride	0.4	Kelowna		▲		
NOK - No. 6 Copper							
3	KLO Pandosy	0.2	Kelowna	▲			
4	Mallach Rd.	0.1	Kelowna	▲			
5	Mayer Rd.	0.5	Kelowna	▲			
6	Union Rd.	1.2	Kelowna	▲			
7	Valley Rd.	1.0	Kelowna	▲			
8	Gordon Dr.	0.3	Kelowna	▲			
SOK - No. 90 MCM Copper							
9	Ponderosa Ave.	1.6	Kaleden	▲			
10	356th Ave.	0.6	Oliver	▲			
11	Hwy 3A	1.8	Keremeos	▲			
SOK - No. 6 Copper							
12	107th Street	0.4	Oliver	▲			
13	356 Ave.	0.1	Oliver	▲			
14	Sparks Dr.	0.5	Keremeos	▲			
15	10th Ave.	0.9	Keremeos	▲			
16	352nd Ave.	0.5	Oliver	▲			
17	Ponderosa Ave.	0.9	Kaleden	▲			
18	Linden Ave.	0.5	Kaleden	▲			
KOT - No. 8 Copper							
19	Frank Beinder Way	0.4	Castlegar	▲			
20	7th Ave. / 4th St	0.2	Castlegar	▲			
21	Macphee Rd.	1.2	Castlegar		▲		
22	8th Ave.	0.1	Castlegar		▲		
23	1st Ave	0.5	Creston		▲		

Sl. No.	Project Name	Circuit Length [km]	General Area	Sensitive Zone Type & Number			
				School Zone	Public Parks	High Density Commercial	High Density Residential
Year 1							
KOT - No. 8 Copper							
24	8th Street	2.0	Creston	▲			
25	Cedar St	0.4	Creston		▲		
26	Murray St	0.6	Midway		▲		
27	West Lake Rd.	1.0	Christina Lk	▲			
28	Hilliview Rd.	0.5	GrandForks		▲		
29	Koftinkoff	0.2	GrandForks		▲		
30	Carnation Dr	0.6	Trail		▲		
31	Cole St	0.1	Fruitvale	▲			
32	Old Salmo	0.1	Fruitvale		▲		
33	Wilmes Ln.	0.2	Trail		▲		
KOT - No. 6 Copper							
34	Adam Robertson School	1.0	Creston	▲			
35	Canyon Lista Elementary	0.2	Creston	▲			
36	Gretrude Ave.	1.5	Midway	▲			
Subtotal Year 1 - 36 Locations		**22.2**		**24**	**12**	**0**	**0**

Sl. No.	Project Name	Circuit Length [km]	General Area	Sensitive Zone Type & Number			
				School Zone	Public Parks	High Density Commercial	High Density Residential
Year 2							
NOK - No. 90 MCM Copper							
37	Hwy 97 Bulman Rd.	1.2	Kelowna		▲		
NOK - No. 8 Copper							
38	KLO Cedar Ave	0.1	Kelowna				▲
NOK - No. 6 Copper							
39	Finns Rd.	0.3	Kelowna		▲		
40	Eldorado Rd.	0.7	Kelowna		▲		
41	Rutland Rd. N	0.1	Kelowna		▲		
42	Hart Rd.	0.8	Kelowna		▲		
43	Barkley Walker	0.5	Kelowna		▲		
44	Bell Rd.	0.2	Kelowna		▲		
45	Mcintosh Rd.	0.3	Kelowna		▲		
46	Franklyn Rd.	0.4	Kelowna		▲		
47	Swordy Scott	0.7	Kelowna		▲		
48	Ethel-Grenfell Rd.	0.9	Kelowna		▲		
SOK - No. 90 MCM Copper							
49	Lakeshore Dr (16/55)	2.6	Osoyoos		▲		
SOK - No. 6 Copper							
50	Main St/Finch Cres.	0.1	Osooyos		▲		
51	Tuc-el-nuit drive	0.4	Oliver		▲		
52	83rd Street	0.6	Osoyoos		▲		
53	16th Ave./ Lakeshore Dr.	1.1	Osoyoos		▲		
54	378 Avenue	1.3	Oliver		▲		
KOT - No. 8 Copper							
55	18th Street	0.2	Castlegar			▲	
56	Soreson Rd.	0.5	Castlegar				▲
57	4th Avenue	0.7	Castlegar				▲
58	6th Ave./4th St	0.2	Castlegar				▲

Sl. No.	Project Name	Circuit Length [km]	General Area	Sensitive Zone Type & Number			
				School Zone	Public Parks	High Density Commercial	High Density Residential
Year 2							
KOT - No. 8 Copper							
59	Columbia Rd.	0.5	Castlegar				▲
60	Raspberry	0.7	Castlegar				▲
61	Upper Level	1.5	Castlegar				▲
62	12th Ave.	0.2	Creston				▲
63	15th Ave.	0.2	Creston			▲	
64	40th Samuels	2.5	Creston				▲
65	51 & 52nd St	2.0	Creston			▲	
66	Hilton St	0.5	Creston				▲
67	Masuch Rd.	0.2	Creston				▲
68	Andros	0.2	Grandforks				▲
69	College Rd.	1.3	Grandforks				▲
70	Danville Hw	0.5	Grandforks				▲
71	Aspen St	0.6	Trail				▲
72	Dahlia Cr.	0.3	Trail				▲
73	Iris Cr.	0.2	Trail				▲
74	Marinna Cr.	0.6	Trail				▲
75	Regan Cres	0.3	Trail				▲
76	Webster Rd.	1.4	Fruitvale			▲	
KOT - No. 6 Copper							
77	Beam Road	1.3	Creston		▲		
Subtotal Year 2 - 41 locations		**28.4**		**0**	**18**	**4**	**19**

Sl. No.	Project Name	Circuit Length [km]	General Area	Sensitive Zone Type & Number			
				School Zone	Public Parks	High Density Commercial	High Density Residential
Year 3							
NOK - No. 8 Copper							
78	Lakeshore Road	0.2	Kelowna				▲
NOK - No. 6 Copper							
79	Hartman/Craig	1.0	Kelowna				▲
80	Hwy 97 - Mcurdy	0.1	Kelowna			▲	
81	Hwy 97 - Penno Rd.	0.4	Kelowna				▲
82	Asher Road	0.5	Kelowna				▲
83	Cornish Rd.	0.2	Kelowna			▲	
84	Wilkinson Rd.	0.2	Kelowna				▲
85	Fuller Collett Rd.	0.4	Kelowna				▲
86	Hollydell Rd.	0.3	Kelowna				▲
87	Carry Rd.	0.3	Kelowna			▲	
88	Braeloch Rd.	0.2	Kelowna				▲
89	Hobson Rd	1.0	Kelowna				▲
90	Dease Rd.	0.3	Kelowna				▲
91	McCulloch Rd.	0.5	Kelowna			▲	
92	Hwy 97 CNR	0.5	Kelowna			▲	
93	Watson Rd.	0.2	Kelowna				▲
94	Mclure Rd.	0.2	Kelowna				▲
95	KLO Raymer	0.7	Kelowna				▲
96	Mclure Rd.	0.3	Kelowna				▲
97	Montgomery Rd.	0.1	Kelowna				▲
98	Mcdonald	0.1	Kelowna				▲
99	Jade Rd.	0.2	Kelowna				▲
100	Stillingfleet Rd.	0.3	Kelowna				▲
101	Tataryn Rd.	0.3	Kelowna				▲
102	Elwyn Rd.	0.4	Kelowna				▲
103	Graham Rd.	0.5	Kelowna				▲

Sl. No.	Project Name	Circuit Length [km]	General Area	Sensitive Zone Type & Number			
				School Zone	Public Parks	High Density Commercial	High Density Residential
Year 3							
NOK - No. 6 Copper							
104	Moubray Rd.	0.3	Kelowna				▲
105	Dallas Rd.	0.3	Kelowna				▲
106	Yates Rd.	0.4	Kelowna				▲
107	Old Meadows Rd.	0.5	Kelowna				▲
108	Perry Rd.	0.3	Kelowna				▲
109	Gibbs Rd.	0.3	Kelowna				▲
110	Merrifield Rd.	0.2	Kelowna				▲
111	Saddler Rd.	0.2	Kelowna				▲
112	Woods Rd.	0.4	Kelowna				▲
113	Taylor Rd.	0.8	Kelowna				▲
114	Juniper Rd.	0.1	Kelowna				▲
115	Knowles Rd.	0.2	Kelowna				▲
116	Uplands Dr.	0.5	Kelowna				▲
117	Lakeshore Rd.	0.04	Kelowna				▲
118	Braeloch Rd.	0.1	Kelowna				▲
119	Lakeshore Rd.	0.1	Kelowna				▲
120	Sherwood Rd.	0.3	Kelowna				▲
121	Lester Rd.	0.2	Kelowna				▲
122	Henn Rd.	0.3	Kelowna				▲
123	Flemming Rd.	0.3	Kelowna			▲	
124	Fraser Rd.	0.3	Kelowna				▲
125	Ford Rd.	0.3	Kelowna				▲
126	Knorr Rd.	0.3	Kelowna				▲
127	Douglas Rd.	0.3	Kelowna				▲
128	Froeltch	0.5	Kelowna				▲
129	Cambie Rd.	0.1	Kelowna				▲
130	Pemberton Rd.	0.1	Kelowna				▲
131	Holbrook Rd. W.	0.9	Kelowna			▲	
132	Robson Rd. E	0.3	Kelowna				▲

Sl. No.	Project Name	Circuit Length [km]	General Area	Sensitive Zone Type & Number			
				School Zone	Public Parks	High Density Commercial	High Density Residential
Year 3							
NOK - No. 6 Copper							
133	Holbrook Rd. E	0.3	Kelowna				▲
134	Pinegrove Rd.	0.6	Kelowna				▲
135	Ambrosi Rd.	0.4	Kelowna			▲	
136	Vasile Rd.	0.2	Kelowna				▲
137	Dunn St	0.2	Kelowna				▲
138	Cornwall Rd.	0.3	Kelowna				▲
139	Collison Rd.	0.1	Kelowna				▲
SOK - No. 90 MCM Copper							
140	Hwy 97 (322/330)	1.5	Oliver				▲
141	East Lake Shore Dr	1.8	Osoyoos				▲
142	Moorpark Dr.	1.8	Penticton				▲
SOK - No. 8 Copper							
143	89th St/148 Ave.	0.5	Osoyoos				▲
144	22nd Ave.	0.6	Osoyoos				▲
145	Meadowlark Drive	0.7	Osoyoos				▲
SOK - No. 6 Copper							
146	41st Ave.	0.6	Osoyoos				▲
147	81st Street	0.5	Osoyoos				▲
148	89th St (78/77Ave)	0.4	Osoyoos				▲
149	42nd Ave.	0.5	Osoyoos			▲	
150	2nd Ave.	0.4	Osoyoos			▲	
151	85 Street	0.6	Oliver				▲
152	81st Street	0.3	Oliver				▲
153	77th Street	0.1	Oliver				▲
154	109 St/352nd Ave.	0.1	Oliver				▲
155	380th Ave	0.2	Oliver			▲	
156	Seacrest	0.5	Oliver			▲	
157	99th St/Hwy 97	0.3	Oliver			▲	
158	Kaleden	0.8	Kaleden				▲

Sl. No.	Project Name	Circuit Length [km]	General Area	Sensitive Zone Type & Number			
				School Zone	Public Parks	High Density Commercial	High Density Residential
Year 3							
SOK - No. 6 Copper							
159	Eastside Rd.	0.8	OK Falls				▲
160	7th Avenue	0.8	Keremeos				▲
161	Finch Cres.	0.3	Osoyoos				▲
162	26th Ave.	0.3	Osoyoos				▲
163	91 St Along Sawmill	1.9	Oliver			▲	
164	396 Avenue	0.7	Oliver				▲
165	Corey Rd.	1.0	Keremeos				▲
166	107 St (46 to 6 Ave.)	2.3	Osoyoos				▲
167	Hwy 97/25th Ave.	0.9	Osoyoos				▲
168	Oleander Dr.	0.8	Osoyoos				▲
169	Tamarack Dr.	0.6	Osoyoos				▲
170	81st Street	1.6	Oliver			▲	
171	Island Road	1.6	Oliver			▲	
172	384 Avenue	3.4	Oliver			▲	
173	99th St/Hwy 97	0.4	Oliver				▲
174	Willow St	0.5	OK Falls				▲
175	2nd Ave.	0.8	Keremeos				▲
KOT - No. 8 Copper							
176	GN Ave/6th St	0.5	Grandforks				▲
177	Hilliview Rd.	0.4	Grandforks				▲
KOT - No. 6 Copper							
178	4th/Sinclair	0.8	Creston			▲	
179	36th Street	0.5	Creston			▲	
180	Sylvester Rd.	0.3	Creston			▲	
181	25th/Sunset	3.0	Creston				▲

Sl. No.	Project Name	Circuit Length [km]	General Area	Sensitive Zone Type & Number			
				School Zone	Public Parks	High Density Commercial	High Density Residential
Year 3							
KOT - No. 6 Copper							
178	4th/Sinclair	0.8	Creston			▲	
179	36th Street	0.5	Creston			▲	
180	Sylvester Rd.	0.3	Creston			▲	
181	25th/Sunset	3.0	Creston				▲
178	4th/Sinclair	0.8	Creston			▲	
179	36th Street	0.5	Creston			▲	
180	Sylvester Rd.	0.3	Creston			▲	
181	25th/Sunset	3.0	Creston				▲
182	Cedar, Ash	1.0	Creston				▲
183	Kimberley S	0.2	Greenwood				▲
184	Lake Street	0.6	Greenwood				▲
185	Cavell St	2.5	Creston				▲
186	28th/Crestview	4.3	Creston				▲
187	Dimission St	1.2	Greenwood				▲
Subtotal Year 3 - 110 locations		**66.0**		**0**	**0**	**20**	**90**
TOTAL - 187 locations		**116.6**		**24**	**30**	**24**	**109**

4.3 Project Benefits

The primary focus of this project is to address public and employee safety however, the copper replacement project will also provide other benefits including improved reliability, reduced electrical line losses, increased circuit capacity, and reduced capital cost for urgent repairs and distribution rebuild projects.

4.3.1 Improved Safety

Conductor failures in sensitive areas as outlined in Section 3.3 are of concern to FortisBC. The Company's records show that within the last four years, twelve incidents involving copper conductor failure resulted in situations where downed conductors remained energized on the ground for a period of time. This created a public and employee electrocution risk and a fire hazard. The replacement of legacy copper conductor will reduce the number of similar incidents in the future.

4.3.2 Improved Service Reliability

The condition of existing overhead conductors cannot be improved; they can only be repaired when they fail. Whenever an existing legacy deteriorated conductor is replaced, customer reliability is likely to improve.

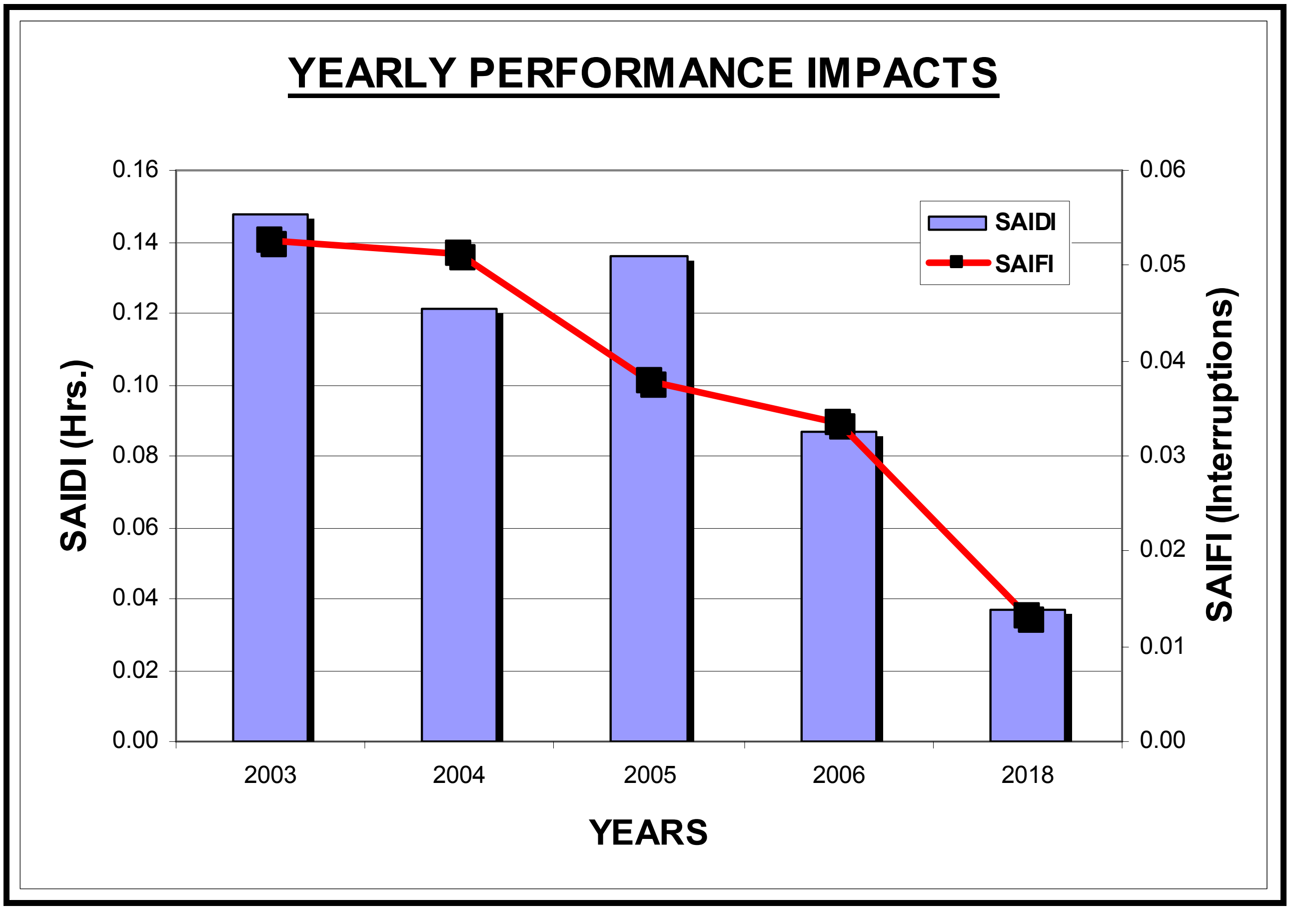
The System Average Interruption Frequency Index ("SAIFI") represents the average number of interruptions and the System Average Interruption Duration Index ("SAIDI") represents the average number of hours of outage experienced by our customers. These indices are also known as Key Performance Indicators ("KPI").

Reliability Impact upon Completion of Project:

Figure 4 below shows the impact on SAIDI & SAIFI during 2003-2006 timeframe due to failure of legacy copper conductors in the distribution network. A majority of the copper conductor failures may be reasonably attributable to the compromised mechanical integrity of the legacy copper distribution lines. Upon re-conductoring, such failures are expected to be reduced.

Figure 4 also shows the expected improvement in SAIDI and SAIFI upon completion of the Project in 2018.

Figure 4
Service Reliability Impact upon Completion

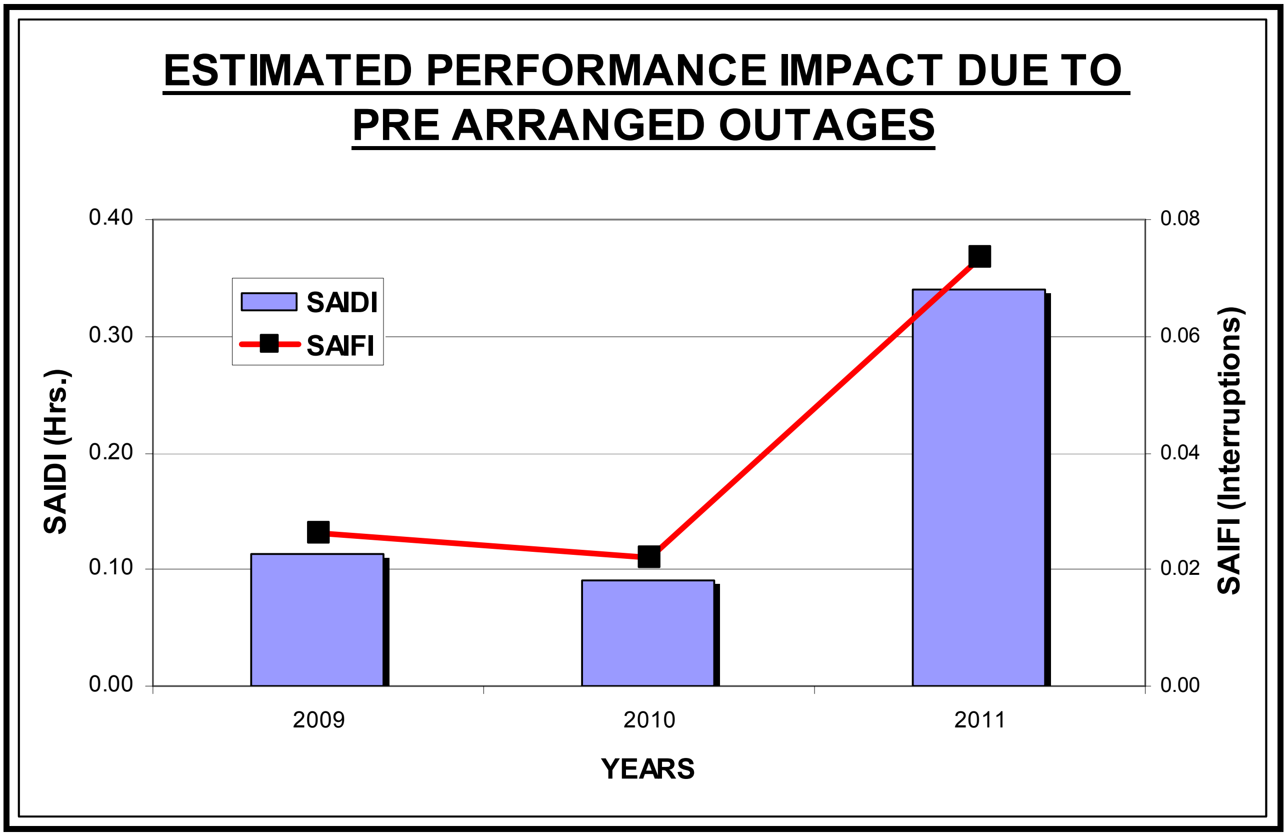


Reliability Impact During the Implementation of the Project

During the project implementation period, (2009-2018) the distribution system reliability will be negatively affected due to the pre-arranged shutdowns that will be necessary for the copper conductor replacements. The impact on SAIDI and SAIFI due to pre-arranged shutdowns is shown in Figure 5.

Figure 5

Impact on SAIDI and SAIFI due to Pre Arranged Outages (2009-2011)



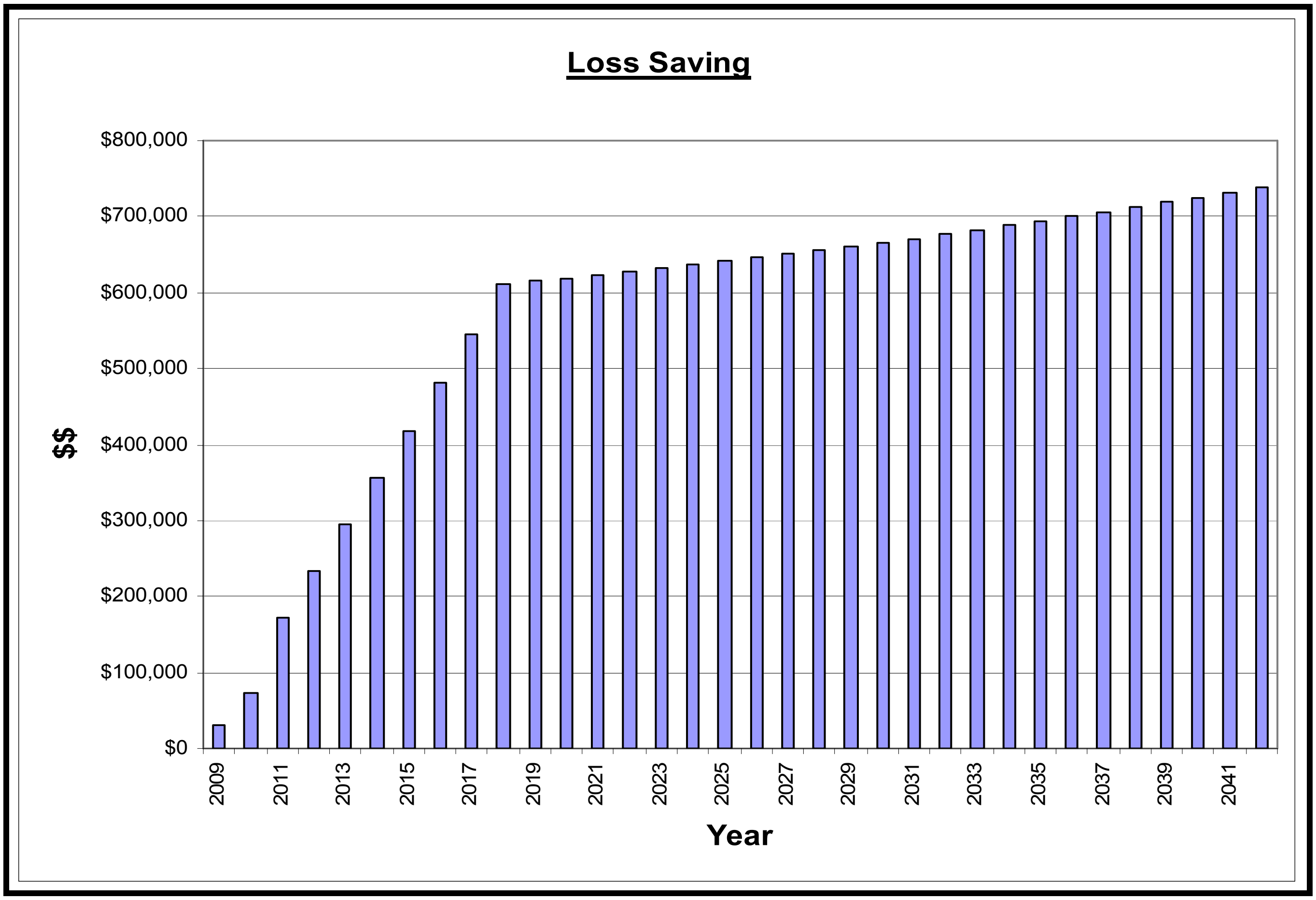
4.3.3 Savings in Electrical Line Losses

Electrical line losses are the result of line resistance and line current. The reduced line resistance associated with the 820 kilometres of new conductor will provide energy savings. This energy saving supports the BC Energy Plan policy action:

> (12) to ensure that British Columbia's transmission technology and infrastructure remains at the leading edge and has the capacity to deliver power efficiently and reliably to meet growing demand.

The reduced line resistance and increased current carrying capacity of new conductor provides energy savings over the projected life of the refurbished lines. The Table below shows the financial impact of electrical loss reduction assuming that the legacy copper conductors in the system will be replaced by ACSR conductors over a 10 year span. The estimated value of the energy saved during the first 15 years is approximately $6.3 Million dollars.

Figure 6
Estimated Loss reductions: Replacing Copper Distribution Conductors with ACSR



4.3.4 Increased Circuit Capacity

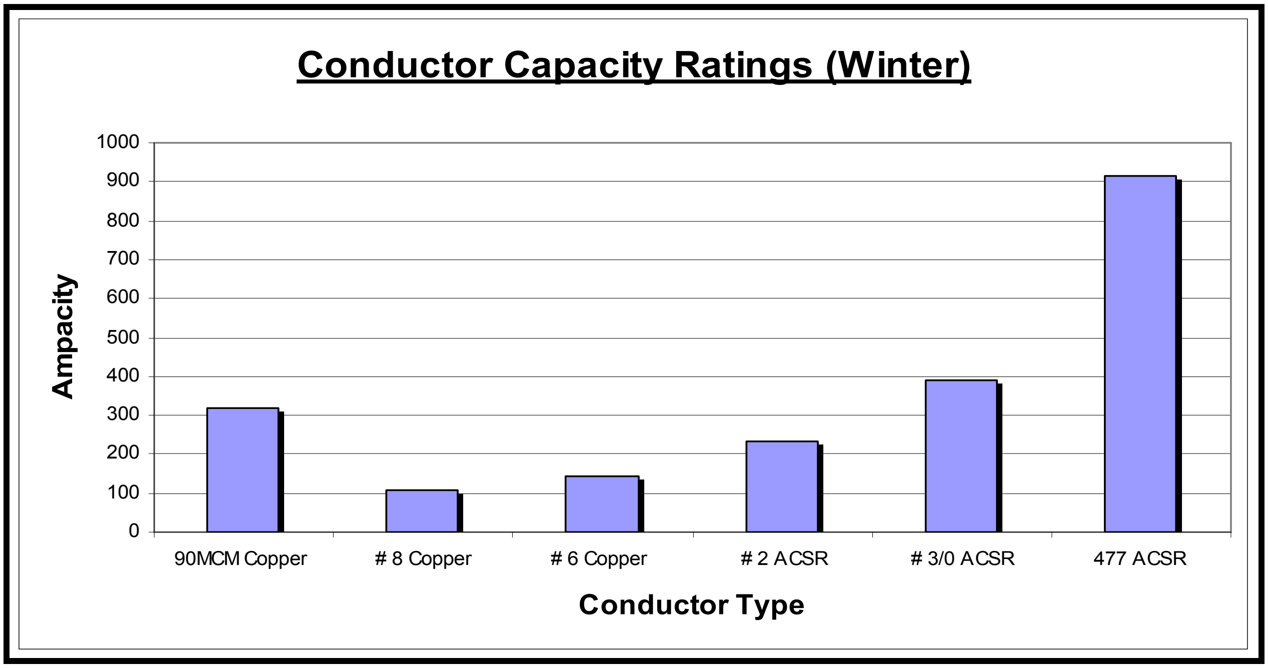
The replacement conductor will have higher capacity / lower resistance than the existing conductor. As a consequence of the higher relative capacity levels it will also have enhanced line end voltage regulation. Figure 7 below depicts Winter Capacity of existing Copper conductors in the system and the corresponding replacement Aluminum (ACSR) conductors.

The upgrades will be as follows:

1. Single and Two Phase No. 8 Copper 13 kV Distribution Lines with No. 2 ACSR;
2. Three Phase No. 8 Copper 13 kV Distribution Lines with No. 3/0 or 477 ACSR;
3. Single and Two Phase No. 6 Copper 13 kV Distribution Lines with No. 2 ACSR;

4. Three Phase No. 6 Copper 13 kV Distribution Lines with No. 3/0 or 477 ACSR;
5. Single and Two Phase 90 MCM Copper 13 kV Distribution Lines with No. 3/0 ACSR; and
6. Three Phase No. 90 MCM Copper 13 kV Distribution Lines with No. 3/0 or 477 ACSR;

Figure 7
Current Ratings of Copper Conductor versus ACSR Conductor



4.3.5 Distribution Urgent Capital Repair Cost Reduction

The replacement of approximately 820 kilometres of legacy conductor and 3,900 poles will reduce unforeseen failures and as a consequence reduce the urgent capital replacement cost. In anticipation of these reductions the “Distribution Urgent Repairs” project has been reduced by approximately $50,000 for 2010.

4.3.6 Distribution Rebuild Capital Cost Reduction

The Copper Conductor Replacement project will require replacement of legacy poles which are of similar vintage as the conductors themselves. The project is expected to replace approximately 3,900 distribution poles and 820 kilometres of legacy copper conductor distribution lines. This will in turn have a positive affect the ongoing Distribution Rebuild Projects. The forecast for the "Distribution Line Rebuilds" project has been reduced by approximately $1.0 million in both 2009 and 2010 to reflect the implementation of the legacy copper conductor project.

4.4 Public Works / Infrastructure

The Project will not impact any known public works or existing infrastructure, other than that owned and operated by FortisBC

5. Environmental and Social Impact

5.1 Environmental Management Plan

The Project is not likely to affect any environmentally sensitive areas since this will be a conductor replacement program and the work will be carried out primarily on existing distribution line corridors. However, individual landowner impacts \ due to shift in pole locations or new anchor positions\ will be mitigated on a case by case basis at the time of execution of the project. Detailed construction and traffic safety plans will be formulated and implemented to manage and monitor risks.

5.2 Health and Safety

The health and safety interests of the public, employees and contractors include community and environmental values, and are well integrated into the planning, tendering and audit protocols for the Project. FortisBC construction safety and risk mitigation standards will be followed during execution phase of the project.

5.3 Public Consultation

Public consultation will be an important aspect in this project. FortisBC regards its responsibility to engage all stakeholders in a meaningful and comprehensive consultation process as a key consideration in the development and execution of the Project to provide electrical service that is safe, reliable, and cost effective.

In order to inform the general public about the Copper Conductor Replacement (CCR) Project and provide a forum for feedback on the Project plan, FortisBC will initiate a bi-annual public consultation program. This public consultation will be a two tier process and will be carried out regionally (east and west Kootenays, south Okanagan and north Okanagan) depending on the job concentration in these regions during the period.

The first tier consultation will be bi-annual and include local government and key stakeholders to discuss the Project and provide preliminary information regarding project need, scope, execution plan and overview of long term power interruption possibilities if any. These meetings will provide an opportunity for feedback and may assist in streamlining the regional job plans.

The second tier of consultation will involve communication with the general public and will also be carried out on an annual basis. Open houses may be held in different regions, depending on the job plan for the period. The purpose of these open houses will be to communicate FortisBC's plans for the Copper Conductor Replacement Project to the general public and obtain feedback on the Project plan. A feedback mechanism for residents with concerns or suggestions will also be in place by the way of exit surveys and identification of key contact personnel from FortisBC with direct access protocol.

Additionally, all major power interruptions in any region as a result of the Project will be publicized in local print and electronic media in advance. The Company will endeavour to ensure minimum power interruption and inconvenience to its customers and the public in general. Project Managers will endeavour to ensure that no single interruption exceeds a continuous six hour period. FortisBC may consider using mobile generators for limited power restoration in cases of interruptions exceeding six hours or for multiple interruptions within a short period of time.

6. Project Cost

The Copper Conductor Replacement Project is intended to be a long term project. As a consequence, the Company has focused on providing a planning level of accuracy estimate (+/- 20 percent) for the first two years (based on an average cost per kilometre) while recognizing that the estimates for the following years will have a lower level of accuracy due to the volatility of cost in the utility industry. The overall estimated ten year cost is provided to give an indication of the magnitude of the project. The estimate provided is for the replacement of No. 6, No. 8 and 90 MCM copper conductors with an appropriate size ACSR conductor installed on wood pole structures. The work is intended to be constructed in snow free conditions. Most of the rebuilds are expected to be done in urban areas with at least some public exposure. Existing circuit alignments are to be reused as far as practical and due to the brittle copper issue, outages have been assumed. Costs include an allocated amount for standby generation for any extended period outage or for critical customers. Due to the circuit configurations and space limitations, the structures will be replaced with single pole structures with a typical ruling span of 70 meters. It is assumed that 85 percent of the old circuits will require pole replacements and full rebuilding including anchoring. For costing purposes it is assumed that 70 percent of structures are tangents and 30 percent are either angles or deadends. The estimate is based on an average cost per kilometre multiplied by the length of the distribution line being replaced. This level of estimating is being provided ahead of any detailed engineering and specific customer requirements due to the significant number of locations that require attention and avoidance of a high pre-approval cost that would be required to refine the estimates.

Table 6
Project Cost 2008/09/10

Sl. No.	SCOPE ITEM	2007/08	2009	2010
1	Labour - Assembly, Framing, Setting, Stringing, etc	0	1,523	2,119
2	Materials	0	1,028	1,430
3	Engineering	0	114	159
4	Other Costs including Traffic Control, Temporary Generation, etc.	0	571	795
5	Project Management	0	114	159
6	Planning and Pre-Engineering	150	0	0
7	Regulatory Cost	150	0	0
8	Annual Public Consultation Cost	0	75	77
9	Capitalized and Direct Overheads (AFUDC = 0)	0	689	897
10	Cost of Removals	0	226	315
11	Contingency	0	457	636
Total Capital Cost (Till 2010)		**300**	**4,798**	**6,585**

The Legacy Copper Conductor Replacement Project cost for the preferred plan of implementation (Plan 1) for a project life of 10 years is summarized in Table 7 below:

Table 7
Summary of Costs

Capital Expenditures	**Yearly Cash Flow During the Project Life ($000s)**										
	2008	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**
Project Cost (Unloaded and Inflation Corrected) without COR	0	3,808	5,297	12,989	8,521	8,691	8,865	9,042	9,223	9,408	9,596
Planning and Pre-Engineering	150	0	0	0	0	0	0	0	0	0	0
Regulatory Cost	150	0	0	0	0	0	0	0	0	0	0
Annual Public Consultation Cost	0	75	77	78	80	81	83	84	86	88	90
Capitalized and Direct Overheads (AFUDC = 0)	0	689	897	2,836	1,054	1,076	1,097	1,119	1,141	1,164	1,188
Credit from Sale of Copper	0	(70)	(93)	(231)	(140)	(142)	(145)	(148)	(151)	(154)	(157)
Cost of Removals	0	226	315	772	506	516	527	537	548	559	570
O & M Cost Savings	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**
Electrical Loss Saving	0	(31)	(72)	(172)	(233)	(294)	(356)	(418)	(482)	(546)	(611)
Project Financial Parameters											
Project Capital Cost	**102.47**										
Net Present Value	**59.19**										
NPV of Rate Impact	**0.15%**										
Max. One Time Rate Impact	**0.67%**										

7. Project Schedule

Investigative and feasibility analysis work on the Project began in March 2007 and was completed during October 2007. The conceptual action plan is complete with detail design to follow subject to Commission's approval of the Project. Upon receipt of Commission approval, the Project will enter the detail design and construction phase during the second quarter of 2009. The Project is slated for completion by the 4th Quarter of 2018.

Further Project milestones are estimated as follows:

- CPCN approval — 4th Quarter 2008
- First Public Consultation prior to Project initiation — 1st Quarter 2009
- Project Initiation — 1st Quarter 2009
- Legacy Copper elimination in sensitive locations — 4th Quarter 2012
- Project Completion — 4th Quarter 2018

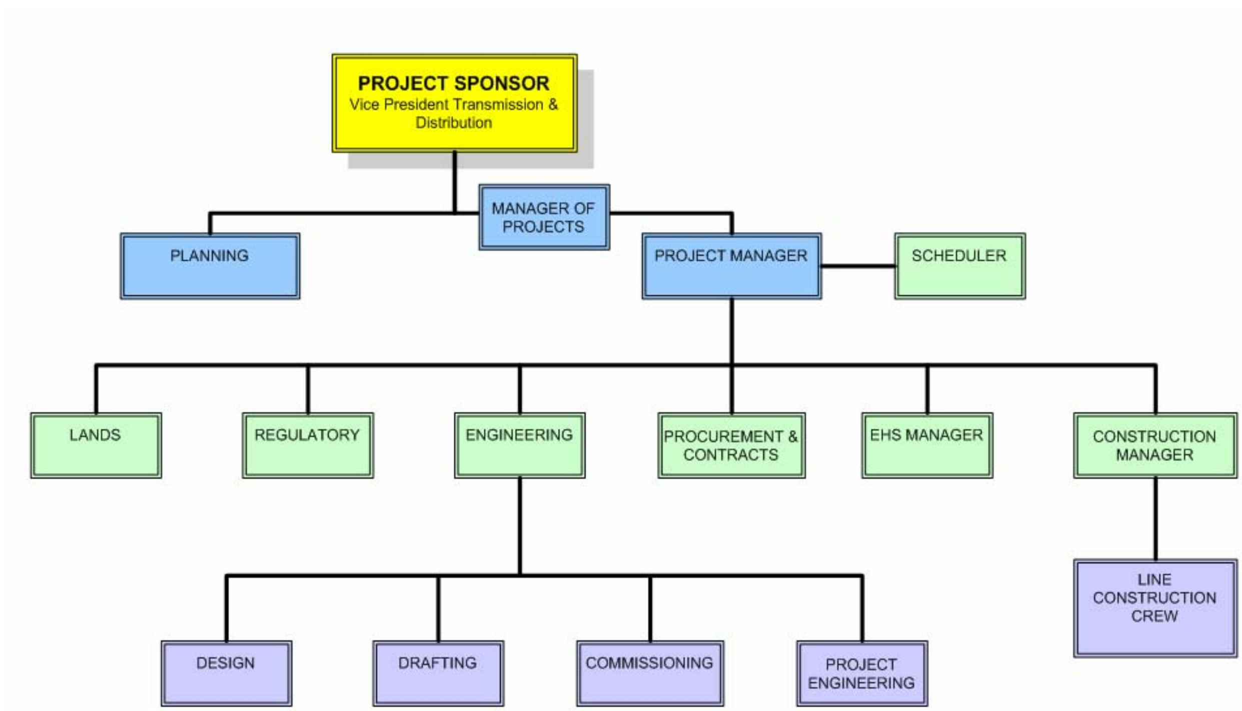
7.1 Project Management

The following principles will underpin the management of the Project:

- Quality, scope and cost control of the Project will be the responsibility of a FortisBC Project Manager;
- Work which impacts utility operations will be done, where possible, by FortisBC internal staff. This includes engineering management and review, construction management, and final commissioning;
- A combination of consultant, contractor and internal resources will be used for all major assessment, design and construction components of the Project;

- Accountability for each Project component (engineering, construction, commissioning, etc.) will reside with FortisBC and will be actively managed by a FortisBC employee or representative; and
- There will be a full time Construction Manager assigned during the construction phases of the Project, with accountability for site health and safety, environmental procedural adherence, quality assurance, employee orientation, and crew scheduling.

The Project Organization Structure



7.2 Other Applications and Approvals

No Federal approvals are anticipated at this point. Provincial approvals that are expected are listed in Table 9 below. However, since this Project will be covered under a long term (10 Year) program, certain issues may arise in the future as a result of detailed engineering (i.e., new Right-of-Way, etc), which will be addressed at those specific stages of the Project.

Table 9

Permits and Approvals Required for the Legacy Copper Conductor Replacement Project

Agency	Department or Branch	Legislative Mandate of Agency	Purpose of Contact or Required Approval	Responsibility
I. PROVINCIAL AGENCIES				
Ministry of Labor and Citizens' Services	Workers' Compensation	Work Safe BC	Notice of Project	FortisBC Inc.
Ministry of Transportation	West Kootenay, east Kootenay, southern Okanagan, central Okanagan and northern Okanagan	Transportation Act	Permit for Access to a Controlled Access Highway	FortisBC Inc.
II. CROWN CORPORATIONS and PRIVATE COMPANIES				
Terasen Gas			Pipeline Crossing Permit – If applicable	FortisBC Inc.
TELUS			Utility Crossing Permit – If applicable	FortisBC Inc.
Private Landowner			Access and Construction Rights – As required	FortisBC Inc.

7.3 Risks to Project Completion

Circumstances that could delay the Project or increase cost include:

- Availability of construction labour;
- Availability of construction material; and
- Abnormal labour and material market fluctuation.

7.4 Contingency Plan for Delay

The contingency plan for project delay may be as follows:

- Enhanced consumer education to ensure safety guidelines in the vicinity of downed electricity conductors; and
- Avoid additional loading of low gauge legacy copper conductors for backup contingency purposes.

8. Analysis of Various Implementation Plans

The replacement of the legacy copper conductor is being presented as a single option Project. The Company did however investigate three implementation plans. All of these plans consider replacement of legacy distribution system No. 8, No. 6, and No. 90 MCM copper conductor, but differ in project duration. These implementation plans are described below and an economic comparison is presented in Table 10 of this Application.

8.1 Implementation Plan 1 – 2018 Completion

- Replacement of 85 percent of No. 8, No. 6 and 90 MCM copper conductors constituting a net replacement of 820 kilometres of copper conductors and approximately 3,900 distribution poles. The remaining 15 percent of the conductors is assumed to be replaced by normal system growth requirements (to be covered under regular Distribution Growth / Sustaining Projects identified in the Capital Expenditure Plan (CEP).
- Legacy Copper Conductors in 187 "Sensitive Public Zones" (please refer to Table 4) will be eliminated in the first three years (2009-2011) totalling 117 circuit kilometres.
- This will result in an average annual removal rate of approximately 39 circuit kilometres for the first 3 years and approximately 44 circuit kilometres for the 4th to 10th year culminating to an overall legacy conductor removal rate of approximately 43 circuit kilometres per year.
- This plan ensures fastest elimination of the hazardous legacy copper conductor from the system.
- This plan will cost approximately $102 million (including cost of removal), having a NPV of $59 million with an NPV of Customer Rate Impact of 0.15 percent.

8.2 Implementation Plan 2 – 2021 Completion

- This implementation Plan anticipates replacement of 85 percent of the legacy copper conductors in the distribution network, namely No. 8, No. 6 and No. 90 MCM Copper totalling 820 kilometres of copper conductors over a period of 13 (2009-2021) years in the general areas of northern Okanagan, southern Okanagan and the Kootenays. The remaining 15 percent of the conductors is assumed to be replaced by normal system growth requirements (to be covered under regular Distribution Growth / Sustaining Projects identified in the Capital Expenditure Plan.
- Legacy Copper Conductors in 187 “Sensitive Public Zones” (please refer to Table 4) will be eliminated in no specific order in the first 3 years (2009-2011) totalling 117 circuit kilometres in the FortisBC service area.
- This will result in an average removal rate of approximately 39 circuit kilometres for the first 3 years and approximately 31 circuit kilometres for the 4th to 13th year culminating to an overall legacy conductor removal rate of approximately 33 circuit kilometres per year.
- This Plan is not preferred, since employees and the general public will be exposed to the hazardous legacy copper conductor for an additional 3 years (2018-2021) relative to Plan 1.
- This Plan will cost approximately $133 million, having a NPV of approximately $66 million with an NPV of Customer Rate Impact of 0.17 percent.
- This plan has a 13 percent higher Rate Impact than plan1 and will take 30 percent more time for completion and thus imposes higher levels of risk for the general public and employees.

8.3 Implementation Plan 3 – 2023 Completion

- This implementation Plan envisages replacement of 85 percent of the legacy copper conductors in the distribution network, namely Copper No. 8, Copper No. 6 and 90 MCM Copper totalling 820 kilometres of copper conductors over a period of 15 (2009-2023) years in the general areas of the northern Okanagan, southern

Okanagan and the Kootenays. The remaining 15 percent of the conductors is assumed to be replaced by normal system growth requirements (to be covered under regular Distribution Growth / Sustaining Projects identified in the Capital Expenditure Plan (CEP).

- This will result in an average removal rate of approximately 29 circuit kilometres over the life of the Project, and is expected at this rate to eliminate legacy Copper Conductors in 187 "Sensitive Public Domain" (please refer to Table 4) in the first 4 to 5 years (2009-2013) totalling 117 circuit kilometres in the FortisBC service area. This is 1 to 2 years longer than Plan 1.
- This Plan has the lowest technical preference since customers will be exposed to the hazardous legacy copper conductor for an additional 5 years (2018-2023), or 50 percent more time relative to Plan 1. Also this Plan falls well short of the replacement Plans of other North American Utilities.
- This Plan will cost approximately $143 million having a NPV of approximately $64 million with an NPV of Customer Rate Impact of 0.16 percent.
- This Plan has a 6 percent higher Rate Impact than Plan 1 and will take 50 percent more time for completion and thus imposes higher levels of risk for the general public and employees.

8.4 Economic Comparison of the Implementation Plans

A revenue requirements analysis was conducted for the three implementation plans using a nominal discount rate of 10 percent. A financial analysis of the three plans is summarized in Table 10 below.

The details are provided in Appendix B (Net Present Value Calculations).

Table 10
Economic Comparison of Alternative Implementation Plans

Item	Plan 1 10 Years	Plan 2 13 Years	Plan 3 15 Years
	$ Million		
Unloaded Capital Cost without Cost of Removals (COR)	86.56	111.31	119.45
Corporate Loadings (No AFUDC)	12.26	16.49	17.68
Loaded Capital Cost without Cost of Removals (COR)	98.82	127.79	137.13
Cost of Removals without adjusting for Copper Salvage	5.08	6.53	7.00
Credit from Sale of Copper	(1.43)	(1.47)	(1.50)
Project Capital Cost including COR and Salvage	**102.47**	**132.85**	**142.63**
Energy Loss Savings During the first 15 years	(6.33)	(5.54)	(4.91)
Net Present Value	**59.19**	**66.40**	**64.07**
NPV of Rate Impact	**0.15%**	**0.17%**	**0.16%**
Max. One Time Rate Impact	**0.67%**	**0.37%**	**0.36%**

8.5 Comparison of the Implementation Plans

Plan 1 is chosen as the “Preferred Plan for Project Implementation” due to the following reasons:

- It ensures fastest elimination of the hazardous legacy copper conductors from the 187 sensitive public areas;
- It ensures fastest overall elimination of legacy copper conductor from the system;
- It is in line with implementation timeline of other North American Utilities; and
- The difference in NPV and Customer Rate Impact is lower than both Plans 2 and 3.

9. Proposed Regulatory Process

The Company proposes that this Application be disposed of by way of a written public hearing in conjunction with its 2009/10 Capital Expenditure Plan Application. The schedule proposed in the 2009/10 Capital Expenditure plan is as follows:

Commission Information Request No. 1 (IR1)	July 17, 2008
FortisBC Response to Commission IR1	August 7, 2008
Workshop	August 12, 2008
Commission IR No. 2 (IR2) and Intervenor IR1	August 15, 2008
FortisBC Response to BCUC IR2 and Intervenor IR1	September 5, 2008
Intervenor Comments	September 17, 2008
FortisBC Reply	September 24, 2008

The form of the Order being sought by FortisBC is attached as Attachment 9.1 Draft Order.

BRITISH COLUMBIA UTILITIES COMMISSION

ORDER NUMBER G-XX-08

IN THE MATTER OF
the Utilities Commission Act, R.S.B.C. 1996, Chapter 473

and

An Application by FortisBC Inc.
for a Certificate of Public Convenience and Necessity
for the Copper Conductor Replacement Project

BEFORE: XXXXXX, Panel Chair and Commissioner
XXXXXX, Commissioner

Month XX, 2008

O R D E R

WHEREAS:

A. On June 27, 2008, FortisBC Inc. ("FortisBC") applied (the “Application”) to the British Columbia Utilities Commission (the “Commission”) for a Certificate of Public Convenience and Necessity (“CPCN”) for the Copper Conductor Replacement Project (the “CCR Project”) as described in this Application; and

B. FortisBC is proposing the CCR Project as the preferred solution to address safety concerns and incidents that are the result of distribution copper conductor failures. The project is necessary to ensure a safe and reliable electrical distribution system.

C. The CCR Project is expected to be completed over a ten year time span with expenditures in 2008 to 2010 totaling $11.7 million. Costs beyond 2010 will be subject to Commission approval with future Capital Expenditure Plan submissions.

D. By Order No. G-xx-08, the Commission established a Written Public hearing process and Regulatory Timetable for the review of the Application; and

E. The XXXX, XXX and XX intervened in the proceeding; and

F. Submissions in the proceeding concluded with XXXX on XXXX xx, 2008; and

G. The Commission Panel has considered the Application and the evidence and submissions in the proceeding and has determined that the CCR Project is in the public interest and that a CPCN be issued to FortisBC for the CCR Project for the reasons set out in the attached Reasons for Decision.

NOW THEREFORE the Commission orders as follows:

1. A Certificate of Public Convenience and Necessity is granted to FortisBC for the CCR Project as described in the Application.

2. FortisBC will file with the Commission quarterly progress reports on the CCR Project schedule and costs, followed by a final report on project completion.

DATED at the City of Vancouver, in the Province of British Columbia, this XX day of July 2008.

BY ORDER

Original signed by:

XXXXXXX
Panel Chair

Attachments

Powertech

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Surrey, British Columbia
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www.powertechlabs.com

POWERTECH LABS, INC.

Project Report

FAILURE INVESTIGATION OF COPPER CONDUCTOR AND MATERIAL PROPERTIES ASSESMENT

Project: 17518-34

January 24, 2008

Prepared for:

Fortis BC
1290 Esplanade
Trail, British Columbia
V1R 4L4

Prepared by: Roger Trip,
Materials Technologist
Energy Systems

Approved by: Joe Wong, P. Eng.
Manager
Energy Systems

PROFESSIONAL ENGINEER J. Y. WONG BRITISH COLUMBIA

TABLE OF CONTENTS

1.0 SUMMARY

Solid copper conductors used in the south central British Columbia region of Fortis BC's electrical distribution system are failing with increasing frequency. The failures are occurring primarily at hot tap and splice type connections. A recently failed conductor within a hot tap connection was subjected to a root cause failure analysis. The analysis showed annealing (softening) of the copper conductor leading to ductile overload failure under normal operating stresses. Annealing of the copper conductor occurred due to elevated service temperatures from high contact resistance within the connection. Over time, the elevated service temperature caused recrystallization and grain growth in the copper microstructure, leading to a reduction in the tensile properties. The increase in contact resistance was from large-scale buildup of corrosion product within the connection. Given the current average service age of 50 years for the conductor and components within the system, similar conditions likely exist in the majority of hot tap connections and additional failures will be expected. Additional splice connections relying on contact resistance were examined and also showed a reduction in hardness as well as increasing grain size. A material properties assessment was performed on randomly selected samples of various sizes of copper conductor, both solid and stranded, used in the system outside of hardware connections. The conductor sizes tested showed mechanical property values below that specified for hard drawn copper wire by ASTM B1 "Standard Specification for Hard-Drawn Copper Wire". The lower values may be attributable to softening of the copper over its long service life. Metallographic examination indicated the presence of some recrystallized grains within the hard drawn microstructure. The lower values may also be attributable to historical standards at the time of installation, which may not have had as stringent requirements for tensile properties.

2.0 FAILURE INVESTIGATION OF COPPER CONDUCTOR IN HOT CLAMP

2.1 INTRODUCTION

Powertech Labs Inc. was contracted to investigate the failure of a copper conductor in a hot tap electrical connection. The conductor failed while in service, resulting in a downed energized line. Solid copper wire is used extensively within the south central British Columbia distribution system of Fortis BC, with various sizes from #3 to #10 AWG (American Wire Gauge size) employed. These copper conductors were predominantly installed in the 1940s to 1960s, giving the conductor and associated hardware an average service life of 50 years A number of incident reports were provided to Powertech Labs Inc. for the investigation, the majority of which dealt with conductor failures at hot tap or splice connections. Failures at these types of connections have been occurring regularly over the last few years, with an increase in frequency noted within the previous year.

A hot tap refers both to the piece of hardware utilized as well as the method of connection. In most instances, a feeder conductor is tapped to provide electrical service to a nearby application. Both the feeder and secondary conductor are mechanically attached to the hot tap hardware in a saddle type compression fitting. The electrical connection occurs between the outer surface of the conductor and the surface of the clamps, with the entire hot tap hardware energized. Dependent on its service configuration, some level of tensile stress will be present on the conductor.

2.2 VISUAL EXAMINATION

Upon receipt, the hot tap containing the failed conductor was photographed for documentation purposes, dissected, and examined with the aid of a low power stereomicroscope. Following are observations noted during the examination:

- The hot tap in which the failure occurred consists of a cast aluminum body which is tin coated to prevent galvanic corrosion between aluminum and copper (Figure 1). The conductor failed in the approximate center of the clamp portion of the hot tap (Figure 2).
- Disassembling of the hot tap revealed a very thick layer of corrosion and contaminant debris. The thick layer of debris was present around the entire circumference of the conductor (Figures 3 and 4). The conductor required substantial force to be removed from the encasing corrosion layer and was bent in the process (Figure 5).
- The fracture surface and outer surface of the conductor were coated in a sooty black dust likely from arcing in the vicinity of the failure (Figures 2 and 5). The conductor was subsequently cleaned with a corrosion inhibited acid solution to facilitate examination.
- The fracture surface of the conductor was fibrous and dimpled in topography, consistent with macro scale features of a ductile overload failure (Figure 6).
- The outer surface of the failed conductor in the portion within the hot tap clamp was pitted heavily from corrosion attack (Figure 7).
- The diameter of the wire just below the fracture surface was measured with a micrometer to be 3.96 mm. The diameter of the wire at the opposite end of the sample was 5.15 mm (#4 AWG size). The measurements show a 41% reduction in the cross sectional area of the conductor at fracture. The large scale elongation and necking down of the diameter is typical of ductile overload in annealed copper.

Figure 1: Hot tap and failed #4 AWG conductor received for examination

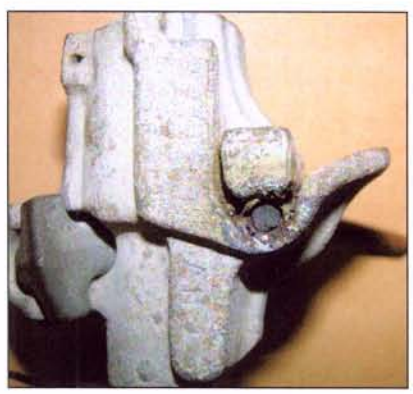


Figure 2: View of fractured conductor in hot tap saddle

Figure 3: Hot tap disassembled for examination

Figure 4: Buildup of contamination on clamping surface of hot tap in contact with copper conductor

Figure 5: Section of failed #4 AWG conductor removed from hot tap

Figure 6: Macro image of fracture surface of copper conductor

Figure 7: Macro image of surface condition of failed copper conductor

2.3 SCANNING ELECTRON MICROSCOPY

The cleaned fracture surface of the failed conductor was sectioned approximately half an inch below the fracture and examined in a Hitachi S-2500 Scanning Electron Microscope. Microscale features of the fracture consisted of rupture dimples formed by microvoid coalescence, characteristic of a ductile overload fracture (Figures 8 and 9).

Figure 8: Low magnification scanning electron micrograph of fracture surface of copper conductor.

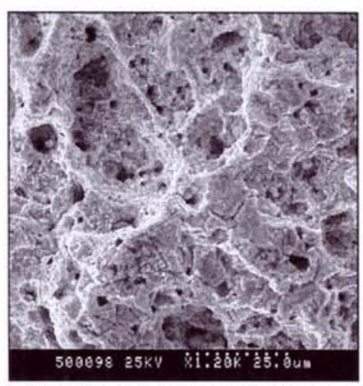


Figure 9: High magnification scanning electron micrograph of fracture surface of copper conductor.

A portion of the adherent contaminant layer was removed from the clamp surface and analyzed by Energy Dispersive X-Ray Spectroscopy (EDS) using Quartz X-One Microanalysis Software. The spectrum obtained from the analysis (Figure 10) showed an elemental composition high in aluminum (Al), copper (Cu), tin (Sn), zinc (Zn) and oxygen (O), indicating the majority of the contaminant is corrosion (oxide) product from the tin coating, the aluminum alloy body of the clamp, and the copper conductor itself. Minor traces of silicon (Si) and chlorine (Cl) are attributable to general environmental contamination.

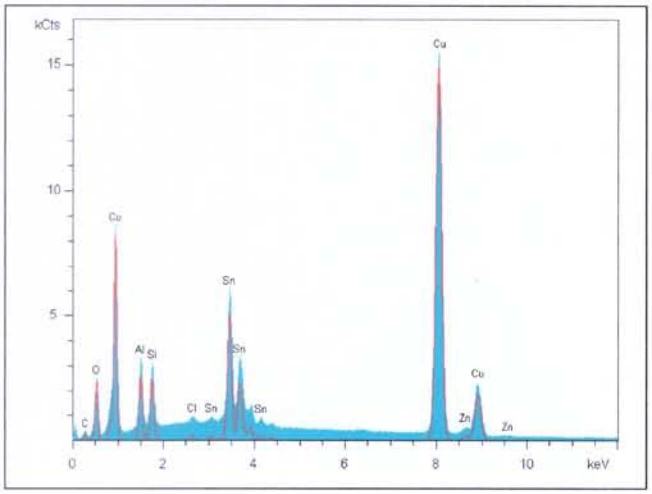


Figure 10: EDS spectrum obtained from the analysis of corrosion product within hot tap connection.

2.4 METALLOGRAPHY

The failed conductor was subjected to a metallographic examination. The fracture surface section previously removed for electron microscopy, as well as the remaining length, were mounted in acrylic, ground and polished to a 0.05 μm finish, and etched to examine their microstrucutral properties. The microstructure of the failed conductor varied considerably along its length. Within 0.5 inches of the fracture (corresponding to the length of conductor within the hot tap), the microstructure of the copper consisted of large equiaxed and twinned grains of copper, characteristic of copper in the annealed condition. Between 0.5 inches to 2.5 inches from the fracture the microstructure consisted of progressively finer equiaxed grains and a mixture of fine equiaxed grains and elongated grains. At 3 inches away from the fracture area the microstructure consists of predominantly elongated grains, characteristic of a hard drawn structure.

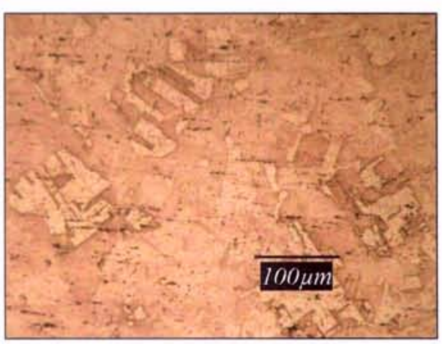


Figure 11: Microstructure 0.025 inches below fracture surface Hardness 57 HV Mag: 200X

Figure 12: Microstructure 0.500 inches away from fracture surface Hardness 60 HV Mag: 200X

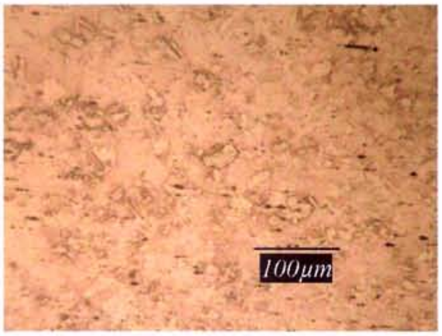


Figure 13: Microstructure 1.00 inches away from fracture surface Hardness 63 HV Mag: 200X

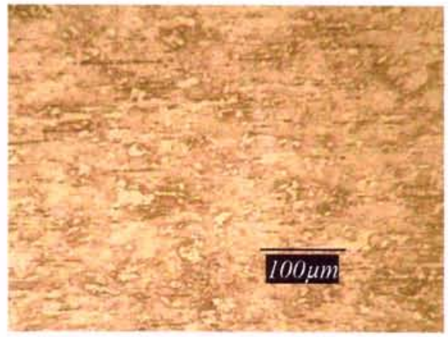


Figure 14: Microstructure 2.00 inches away from fracture surface Hardness 80 HV Mag: 200X

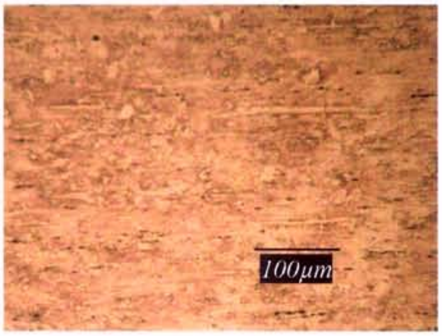


Figure 15: Microstructure 2.50 inches away from fracture surface Hardness 91 HV Mag: 200X

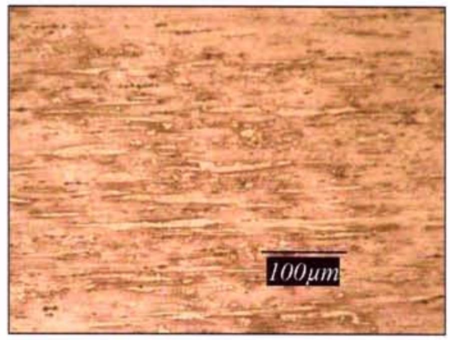


Figure 16: Microstructure 3.00 inches away from fracture surface Hardness 104 HV Mag: 200X

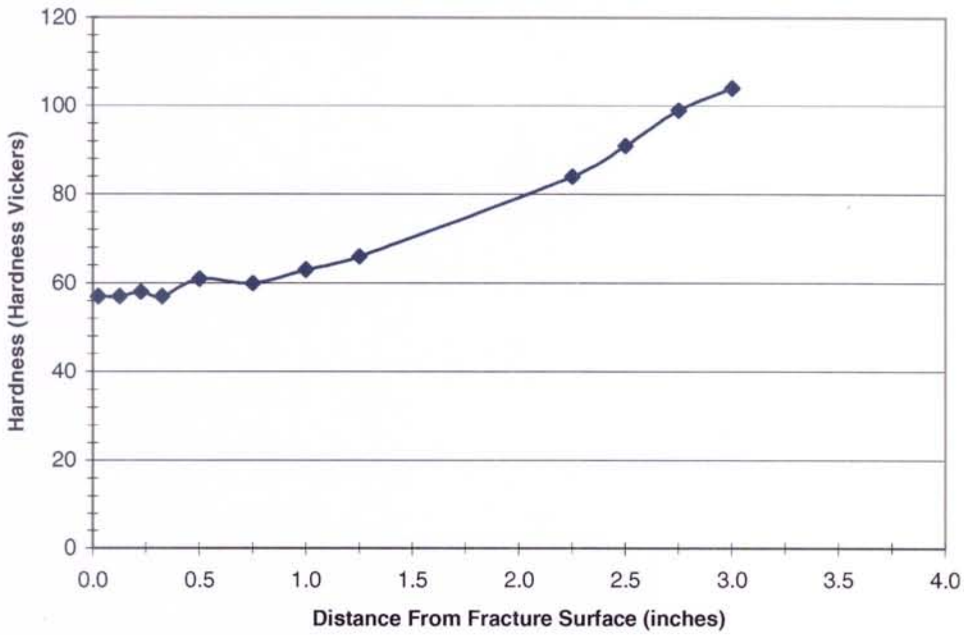
2.5 MICROHARDNESS TESTING

A microhardness survey was performed on the polished metallographic sample in accordance with ASTM E 92 "Test Method for Vickers Hardness of Metallic Materials". Testing was performed on a Tukon-Wilson Microhardness Tester with a load of 200 grams. Microhardness readings were taken linearly along the center of the cross section, from 0.025 inches below the fracture surface to 3.00 inches away.

Table 1: Microhardness Survey, Failed Copper Conductor

Distance From Fracture Surface (inches)	Microhardness Value (Hardness Vickers)
0.025	57
0.125	57
0.225	58
0.325	57
0.500	61
0.750	60
1.000	63
1.250	66
2.250	84
2.500	91
2.750	99
3.000	104

Figure 17: Hardness vs. Distance From Fracture Surface



The hardness values obtained from the survey show that the conductor within the clamping area of the connection had softened considerably, consistent with copper in the annealed condition. Outside of the connection area, the hardness returns to values closer to that expected for the hard drawn condition.

2.6 CONCLUSIONS

The copper conductor failed in the hot tap connection by ductile overload, from normal operating tensile stresses on the wire. Corrosion of the tin coating of the aluminum hot tap hardware likely occurred slowly over its long service life. As the tin oxide formed, the coating deteriorated to the point were contact between the aluminum body and copper conductor occurred, leading to galvanic corrosion of both materials. The buildup of all three corrosion products resulted in increased contact resistance within the hot tap junction. As the contact resistance increased, the service temperature for any given current load also increased. The elevated service temperature, over the long duration of the connections service life, led to the annealing of the copper from its original hard drawn condition. The tensile strength of the copper conductor is significantly decreased in the annealed condition, leading to ductile overload failure at the tensile stress present in its normal configuration. Corrosion attack also reduced the cross sectional area of the conductor and introduced stress concentrators in the form of pits that may also have contributed to the failure. Away from the failure area the hardness value of the conductor and its microstructure indicate it was originally in the hard drawn condition and likely would have been close to its expected strength.

Given the long average service life of the conductors and connection hardware, varying levels of corrosion attack within hot tap connections and splice connections will be present. In these connections the service temperature will be elevated, and similar conductor failures are likely to occur.

3.0 MATERIAL PROPERTIES ASSESMENT OF COPPER CONDUCTOR SAMPLES

3.1 INTRODUCTION

In addition to the repeated failures occurring in hot tap connections, concern was expressed over the condition of other common connections used with the solid copper conductor, as well as the general material properties of copper conductors away from any connections. Random selections of copper conductor (solid and stranded, varying sizes some containing splice connections) were forwarded to Powertech Labs Inc. for examination. Samples were received at staggered dates, and subsequently ascribed identification tags by Powertech Labs. The examination consisted of tensile testing, metallographic examination and hardness testing. Following is a list of sample types received for examination (seen in Figures 18-25).

Table 2: Sample Description and Identification

Sample ID	Sample Description
6a	Large coil (>20') of #6 AWG solid conductor
6b	46" length of #6 AWG solid conductor
6c	18" length of #6 AWG solid conductor
8a	56" length of #8 AWG solid conductor
8b	56" length of #8 AWG solid conductor
3a	50" length of #3 AWG solid conductor containing spring loaded tapered barrel splice connection near one end
3b	50" length of #3 AWG solid conductor
3c	12" length of #3 AWG solid conductor
4a	4 – 24" lengths of #4 AWG solid conductor
4b	30" length of #4 AWG solid conductor containing compression splice in approximate center
90	18" length of 90 MCM – hemp core stranded conductor (6 strands with individual strand diameter equivalent to #8 AWG)
2s	12" length of #2 stranded copper conductor (7 strands with individual strand diameter equivalent to #10 AWG)

Figure 18: Coil of #6 AWG copper conductor received for examination, identified as sample 6A

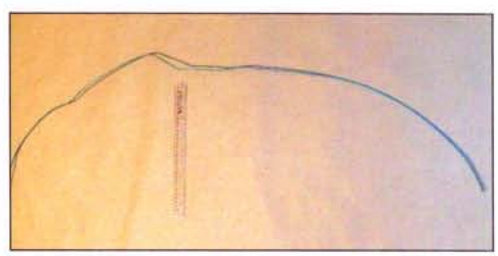


Figure 19: Length of #8 AWG wire received for examination, identified as sample 8A

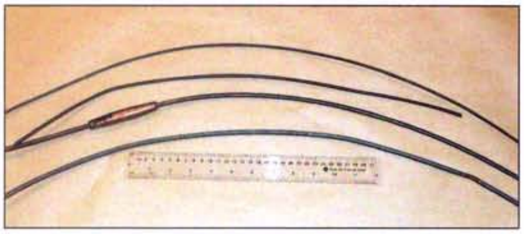


Figure 20: Single pieces of copper conductor samples received for examination. Conductor sizes were #8, #6, #3 containing a spring loaded tapered barrel splice, and #3 (top to bottom). Samples identified as: 8b, 6b, 3a and 3b (top to bottom)

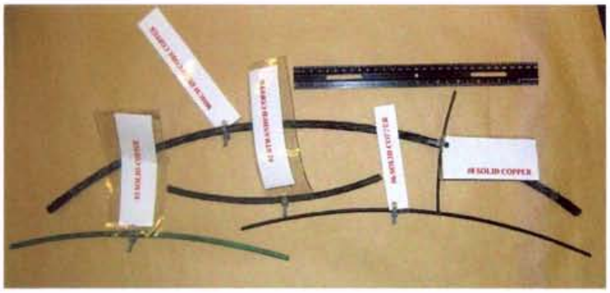


Figure 21: Single pieces of both stranded and solid copper conductor samples with identification. Stranded conductors were a 90 MCM hemp core (6 strands), and a #2 stranded conductor (7 strands), solid conductors were #8, #6 (6c), #3 (3c) and #2

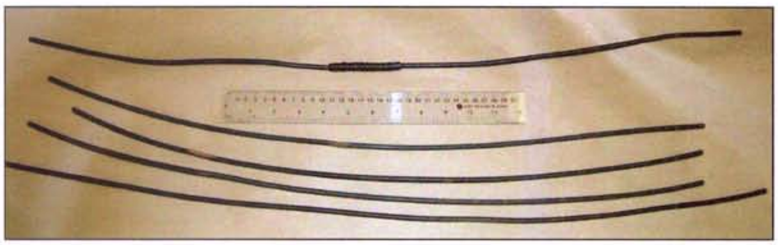


Figure 22: Single pieces of #4 AWG solid copper conductor (grouped as 4a), and #4 solid copper conductor containing a compression splice (4b)

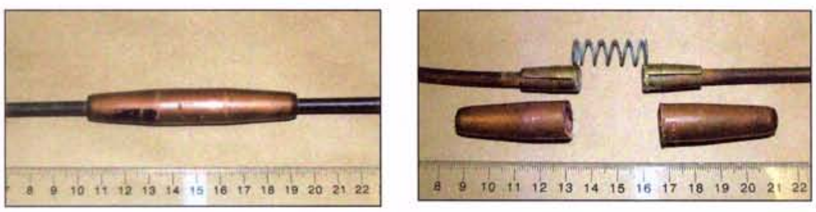


Figure 23: Macro image of spring loaded tapered barrel splice on sample 3b, before and after dissection. Note corrosion product on surface of conductor and on jaw inserts

Figure 24: Macro image of compression splice on sample 4b. Note corrosion product on surface of conductor and splice

3.2 APPLICABLE SPECIFICATIONS

Specifications for copper wire used for electrical purposes are governed by ASTM B1-01 "Standard Specification for Hard-Drawn Copper Wire". Section 5 of the standard details the tensile strength and elongation requirements of the copper wire.

Table 3: Standard Tensile Properties for Hard-Drawn Copper Wire, ASTM B1

Conductor Size	Nominal Diameter (mm)	Nominal Tensile Strength (Mpa)	Nominal Elongation %
#10	2.59	445	1.2
#8	3.26	440	1.3
#6	4.12	430	1.5
#4	5.19	415	1.7
#3	5.83	405	1.8

3.2 TENSILE TESTING

Tensile strength and elongation were determined simultaneously, in accordance with section 6 of ASTM B1. Testing was performed on a Sintech 20 G/T Universal Test Frame with a crosshead extension rate of 5 mm/min. Tensile strength was calculated by dividing the peak load by the cross sectional area of the strand. Elongation was calculated using a gage length of 250 mm. The maximum number of tensile specimens available was tested, based on the length of sample provided. Values for the tensile specimens, which fractured in the jaws of the test machine, were discarded and the values not reported, as dictated by ASTM B1. For the large coil, sample 6a, testing was performed until ten valid tensile test results were obtained, in accordance with a lot average dictated by ASTM B1.

Table 4: Tensile Test Results, Sample 6a

Sample ID	Diameter (mm)	Peak Load (N)	Tensile Strength (Mpa)	% Elongation
6a-1	4.12	5,625	422	2.2
6a-2	4.12	5,617	421	2.4
6a-3	4.13	5,604	420	1.9
6a-4	4.12	5,620	422	1.8
6a-5	4.10	5,579	423	2.1
6a-6	4.11	5,641	427	1.6
6a-7	4.12	5,449	409	2.0
6a-8	4.12	5,559	417	2.0
6a-9	4.11	5,608	425	1.9
6a-10	4.11	5,653	426	1.7
	Averages	**5,596**	**421**	**2.0**

Table 5: Tensile Test Results, Sample 6b and 6c

Sample ID	Diameter (mm)	Peak Load (N)	Tensile Strength (Mpa)	% Elongation
6b-1	4.14	5,662	421	2.1
6c-1	4.13	5,821	436	2.0
6c-2	4.13	5,682	425	2.2
6c-3	4.13	5,788	433	2.0
	Averages	**5,738**	**429**	**2.1**

Table 6: Tensile Test Results, Sample 8a

Sample ID	Diameter (mm)	Peak Load (N)	Tensile Strength (Mpa)	% Elongation
8a-1	3.25	3,219	388	2.2
8a-2	3.24	3,193	387	1.7
8a-3	3.24	3,191	387	2.5
8a-4	3.23	3,258	398	2.6
	Averages	**3,215**	**390**	**2.2**

Table 7: Tensile Test Results, Samples 3a, 3b and 3c

Sample ID	Diameter (mm)	Peak Load (N)	Tensile Strength (Mpa)	% Elongation
3a-1	5.84	10,400	388	2.3
3a-2	5.85	9,425	353	2.2
3b-1	5.85	10,311	388	2.2
3c-1	5.82	10,271	384	2.3
	Averages	**10,102**	**378**	**2.3**

Table 8: Tensile Test Results, Sample 4a

Sample ID	Diameter (mm)	Peak Load (N)	Tensile Strength (Mpa)	% Elongation
4a-1	5.19	8,213	388	3.0
4a-2	5.19	8,511	402	2.2
4a-3	5.16	8,634	413	2.0
4a-4	5.16	8,527	408	2.1
4a-5	5.18	8,509	404	2.1
4a-6	5.18	8,740	415	1.8
	Averages	**8,522**	**405**	**2.2**

Table 9: Tensile Test Results, Sample #2 Stranded Conductor

Sample ID	Diameter (mm)	Peak Load (N)	Tensile Strength (Mpa)	% Elongation
2s-1	2.54	2,128	422	1.9
2s-2	2.54	2,116	419	2.0
2s-3	2.56	2,178	423	2.0
2s-4	2.55	2,110	413	2.1
2s-5	2.56	2,095	407	2.2
2s-6	2.57	2,142	413	2.2
	Averages	**2,131**	**414**	**2.1**

Table 10: Tensile Test Results, 90 MCM Stranded Conductor

Sample ID	Diameter (mm)	Peak Load (N)	Tensile Strength (Mpa)	% Elongation
90-1	3.25	3,060	369	2.6
90-2	3.25	3,087	372	2.4
90-3	3.25	3,008	363	2.6
90-4	3.25	3,052	368	2.6
90-5	3.25	3,074	371	2.4
90-6	3.25	3,112	375	2.2
	Averages	**3,062**	**369**	**2.5**

For all conductor wire sizes tested, the tensile strength was below that of the nominal values required by ASTM B1. Elongation requirements of the samples were exceeded. The elongation requirements of the standard are a minimum requirement, however large positive variances would indicate that the copper has softened, or was not originally in the hard drawn condition. Of the samples the #8 AWG size showed the largest variance in both tensile and elongation properties, with an average tensile strength 12% below that of the nominal requirement.

3.3 METALLOGRAPHY

Metallographic specimens were prepared from samples 6a, 8a, 90, and 2s. Specimens were also prepared from sections of conductor within the splices of samples 3a and 4b, as well as approximately 2" outside the splice area. Sections of the conductor were prepared in the transverse and longitudinal cross section. Micrographs taken of the microstructure of samples 6a, 8a, 2s show elongated grains consistent with hard drawn copper (Figures 25-27). In sample 8a some fine equiaxed grains are seen, indicating some recrystallization and grain growth may be occurring. The microstructure of sample 90 shows elongated grains are not as compacted as the other samples, indicating the conductor may have been in the medium drawn condition, or some grain growth has occurred (Figure 28). Both the microstructures seen in sample 8a and 90 are consistent with the lower tensile strengths seen.

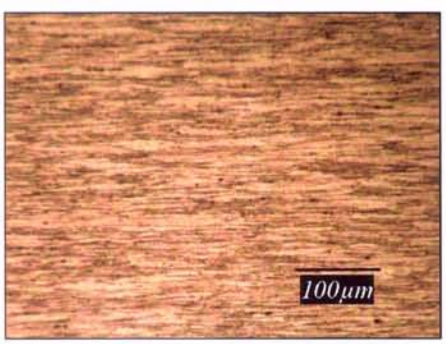


Figure 25: Microstructure seen in sample 6a Magnification: 200X

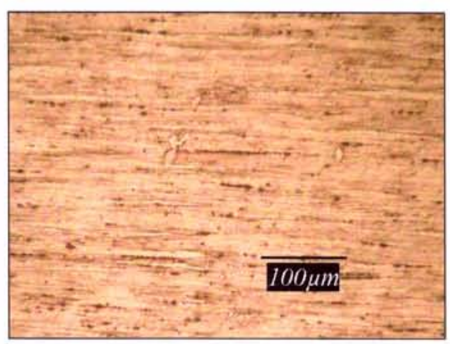


Figure 26: Microstructure seen in sample 8a Magnification: 200X

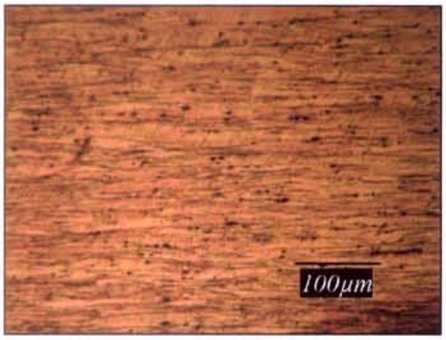


Figure 27: Microstructure seen in sample 2s Magnification: 200X

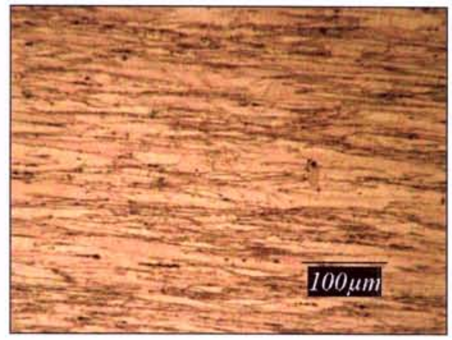


Figure 28: Microstructure seen in sample 90 Magnification: 200X

In samples 3a and 4b, the microstructure of the conductor outside the splice area consisted of elongated grains typical of hard drawn copper, with some recrystallization seen in 3a (Figures 29 and 31). In both samples the area within the splice showed markedly larger grain sizing, indicating some annealing has occurred within the splice connections (Figures 30 and 32).

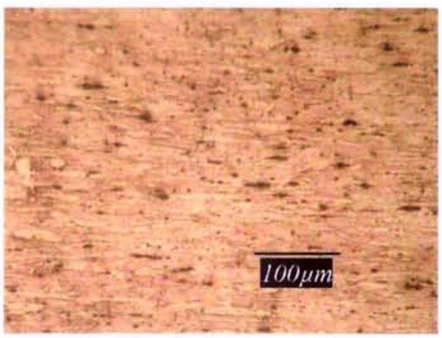


Figure 29: Microstructure seen in sample 3a, outside of splice area Magnification: 200X

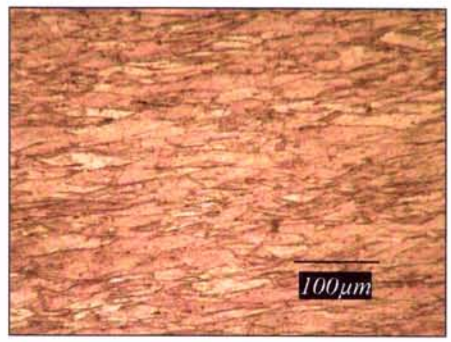


Figure 30: Microstructure seen in sample 3a within splice area Magnification: 200X

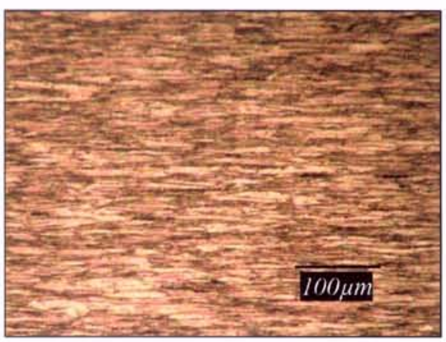


Figure 31: Microstructure seen in sample 4b outside splice area. Magnification: 200X

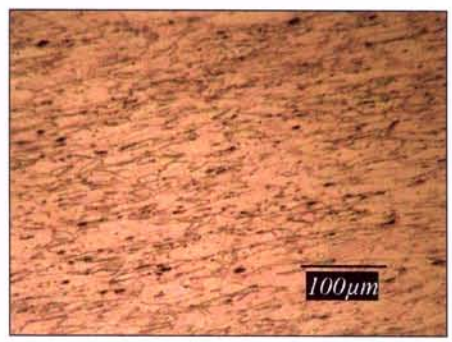


Figure 32: Microstructure seen in sample 4b within splice area. Magnification: 200X

3.4 MICROHARDNESS TESTING

Microhardness testing was performed on the polished metallographic samples in accordance with ASTM E 92, on a Tukon-Wilson Microhardness Tester with a load of 200 grams. Five microhardness readings were taken on each sample and averaged.

Table 11: Microhardness Values, Samples 6a and 8a

Sample ID	**Average Microhardness (Hardness Vickers)**
6a	102
8a	96
3a outside of splice area	100
3a within splice area	90
4b outside of splice area	99
4b within splice area	92
2s	99
90	98

The hardness values of sample 6a and the conductor from sample 3a outside the splice are consistent with the approximate hardness expected of hard drawn copper. The hardness values of samples 8a, 4b outside the splice area, 2s, and 90 are lower, consistent with the lower tensile strengths and microstructures seen. The conductor within the splice area of samples 3a and 4b is significantly lower than that of hard drawn copper, consistent with the larger grain size seen in those samples.

3.5 CONCLUSIONS

The tensile properties of the copper conductors provided for examination are below that of the nominal values dictated by the current standard. Examination of the microstructure and hardness would indicate that the conductors are slightly outside the expected parameters for copper wire in the hard drawn condition. The condition of the conductors may be attributable to one of two principle causes:

- The copper conductors present in the system may be undergoing a slow softening process from the combination of service temperature and their prolonged service life. Given the extended time in service of the conductor, it is possible that recrsytallization and grain growth is occurring in the microstructure, leading to a reduction in the hardness and tensile properties of the conductor.
- At the time of installation it is uncertain what the historical specifications of hard drawn copper wire were. Historical specifications or standards for hard drawn copper may have had lower strength requirements.

The hardness of the conductor within the splices is significantly lower than outside of the splice. The microstructure of the conductor within the splice has a larger grain size, similar to the trend seen in the failed hot tap examined. Both splice types examined rely on contact resistance between the two ends of the conductor and the splice body to transfer the current. Contact resistance within the splices has likely increased over time due to the buildup of corrosion product and external contamination. The increased resistance within the splices has led to elevated service temperatures, which over the long duration of their service life have caused grain growth.

Copper Replacement Project: Plan 1 - 2018 Completion

Line No.		0 Dec-09	1 Dec-10	2 Dec-11	3 Dec-12	4 Dec-13	5 Dec-14	6 Dec-15	11 Dec-20	16 Dec-25	26 Dec-35	46 Dec-55
	Summary											
	Revenue Requirements											
1	Annual Operating Expense	(31)	(72)	(172)	(233)	(294)	(356)	(418)	(619)	(641)	(694)	(937)
2	Depreciation Expense	0	106	242	587	796	1,010	1,227	2,134	2,119	2,084	1,989
3	Carrying Costs	200	616	1,463	2,423	3,128	3,831	4,533	6,718	5,868	4,168	775
4	Income Tax	(129)	(216)	(750)	(380)	(395)	(398)	(389)	172	624	986	811
5	Yearly Revenue Requirement for Project	40	434	783	2,398	3,235	4,087	4,952	8,405	7,969	6,543	2,638
6	Net Present Value of Revenue Requirements at a Discount Rate of 10%	**4,608**										
7	**Rate Impact**											
8	Revenue Requirement Inflation	2.00%	2.00%	2.00%	2.00%	2.00%	2.00%	2.00%	2.00%	2.00%	2.00%	2.00%
9	Cummulative Revenue Requirement Inflation	2.00%	4.04%	6.12%	8.24%	10.41%	12.62%	14.87%	26.82%	40.02%	70.69%	153.63%
10	Forecast Revenue Requirements ($2008)	225,369	229,916	234,908	239,946	246,344	252,061	257,889	288,677	317,459	383,845	563,257
11	Incremental Revenue Requirements	40	394	348	1,615	838	852	865	(54)	(107)	(165)	(214)
12	Rate Impact	0.0%	0.2%	0.1%	**0.67%**	0.3%	0.3%	0.3%	0.0%	0.0%	0.0%	0.0%
13	Cummulative Rate Impact	0.02%	0.19%	0.34%	1.01%	1.36%	1.70%	2.04%	3.34%	3.19%	2.78%	1.93%
14	Discounted Yearly Revenue Requirement for Project at a Discount Rate of 6%	40	372	310	1,356	664	637	610	(28)	(42)	(36)	(15)
15	Discounted Yearly Revenue Requirement for Project at a Discount Rate of 8%	40	365	299	1,282	616	580	545	(23)	(31)	(22)	(6)
16	Discounted Yearly Revenue Requirement for Project at a Discount Rate of 10%	40	359	288	1,213	572	529	488	(19)	(23)	(14)	(3)
17	**NPV of Project / Total Revenue Requirements at at a Discount Rate of 10%**	**0.15%**										
18	**Discounted Cash Flow**											
19	Net Power Purchase Expense	(31)	(72)	(172)	(233)	(294)	(356)	(418)	(619)	(641)	(694)	(937)
20	Income Tax	(129)	(216)	(750)	(380)	(395)	(398)	(389)	172	624	986	811
21	Capital Cost	4,867	6,259	15,876	9,617	9,800	9,986	10,175	(133)	(147)	(179)	(266)
22	Total Revenue Requirement for Project	4,707	5,971	14,953	9,005	9,111	9,232	9,368	(580)	(165)	113	(392)
23	Project Net Present Value at at a Discount Rate of 10%	**59,177**										

Line		0	1	2	3	4	5	6	11	16	26	46
No.		**Dec-09**	**Dec-10**	**Dec-11**	**Dec-12**	**Dec-13**	**Dec-14**	**Dec-15**	**Dec-20**	**Dec-25**	**Dec-35**	**Dec-55**
24	**Regulatory Assumptions**											
25	Equity Component	40.00%	40.00%	40.00%	40.00%	40.00%	40.00%	40.00%	40.00%	40.00%	40.00%	40.00%
26	Debt Component	60.00%	60.00%	60.00%	60.00%	60.00%	60.00%	60.00%	60.00%	60.00%	60.00%	60.00%
27	Equity Return	9.02%	9.02%	9.02%	9.02%	9.02%	9.02%	9.02%	9.02%	9.02%	9.02%	9.02%
28	Debt Return	6.50%	6.50%	6.50%	6.50%	6.50%	6.50%	6.50%	6.50%	6.50%	6.50%	6.50%
29	AFUDC	6.30%	6.40%	6.40%	6.50%	6.50%	6.50%	6.50%	6.50%	6.50%	6.50%	6.50%
30	**Capital Cost**											
31	Project Cost (Unloaded & Inflation Corrected)	3,808	5,297	12,989	8,521	8,691	8,865	9,042	0	0	0	0
32	Planning & Pre-Engineering											
33	Regulatory Cost (Oral Hearing)											
34	Yearly Public Consultation Cost	75	77	78	80	81	83	84	0	0	0	0
35	Yearly Capital Cost Savings	(5)	(11)	(27)	(38)	(48)	(59)	(71)	(133)	(147)	(179)	(266)
36	Capitalized & Direct Overheads	689	897	2,836	1,054	1,076	1,097	1,119	0	0	0	0
37	AFUDC = 0	0	0	0	0	0	0	0	0	0	0	0
38	Total Construction Cost in Year (Less Land Cost)	4,567	6,259	15,876	9,617	9,800	9,986	10,175	(133)	(147)	(179)	(266)
39	Cumulative Construction Cost	4,867	11,126	27,002	36,620	46,419	56,405	66,580	97,967	97,260	95,619	91,180
40	Land	0	0									
42	Total Capital Cost in Year	4,567	6,259	15,876	9,617	9,800	9,986	10,175	(133)	(147)	(179)	(266)
43	Cumulative Capital Cost	4,867	11,126	27,002	36,620	46,419	56,405	66,580	97,967	97,260	95,619	91,180
41	Cost of Removal	156	222	541	367	374	381	389	0	0	0	0
43	Total Construction Cost in Year	4,723	6,481	16,417	9,984	10,174	10,367	10,564	(133)	(147)	(179)	(266)
44	Additions to Plant in Service	4,867	6,259	15,876	9,617	9,800	9,986	10,175	(133)	(147)	(179)	(266)
45	Cummulative Additions to Plant	4,867	11,126	27,002	36,620	46,419	56,405	66,580	97,967	97,260	95,619	91,180
46	CWIP	0	0	0	0	0	0	0	0	0	0	0
47	**Annual Operating Costs / (Savings)**											
48	Energy Loss Savings	(31)	(72)	(172)	(233)	(294)	(356)	(418)	(619)	(641)	(694)	(937)
49	Total Incremental Operating Costs (Savings)	(31)	(72)	(172)	(233)	(294)	(356)	(418)	(619)	(641)	(694)	(937)
50	**Depreciation Expense**											
51	Opening Cash Outlay	0	4,867	11,126	27,002	36,620	46,419	56,405	98,100	97,407	95,798	91,446
52	Additions in Year (Without Land-Since no Depreciation for Land)	4,867	6,259	15,876	9,617	9,800	9,986	10,175	(133)	(147)	(179)	(266)
53	Cumulative Total	4,867	11,126	27,002	36,620	46,419	56,405	66,580	97,967	97,260	95,619	91,180
54	Depreciation Rate - composite average	2.18%	2.18%	2.18%	2.18%	2.18%	2.18%	2.18%	2.18%	2.18%	2.18%	2.18%
55	Depreciation Expense (Without Land)	0	106	242	587	796	1,010	1,227	2,134	2,119	2,084	1,989

Line No.		0 Dec-09	1 Dec-10	2 Dec-11	3 Dec-12	4 Dec-13	5 Dec-14	6 Dec-15	11 Dec-20	16 Dec-25	26 Dec-35	46 Dec-55
56	**Net Book Value**											
57	Gross Property (With land)	4,867	11,126	27,002	36,620	46,419	56,405	66,580	97,967	97,260	95,619	91,180
58	Accumulated Depreciation (net of cost of removal)	156	272	571	350	(72)	(700)	(1,538)	(9,618)	(20,242)	(41,241)	(81,982)
		5,023	11,398	27,573	36,970	46,347	55,705	65,042	88,349	77,019	54,378	9,198
59	Land (included in gross property above)	0	0	0	0	0	0	0	0	0	0	0
60	Net Book Value	5,023	11,398	27,573	36,970	46,347	55,705	65,042	88,349	77,019	54,378	9,198
61	Carrying Costs on Average NBV											
62	Return on Equity	96	296	703	1,164	1,503	1,841	2,178	3,229	2,820	2,003	373
63	Interest Expense	104	320	760	1,259	1,625	1,990	2,355	3,490	3,048	2,165	403
64	Total Carrying Costs	200	616	1,463	2,423	3,128	3,831	4,533	6,718	5,868	4,168	775
65	**Income Tax Expense**											
66	Combined Income Tax Rate	30.00%	29.00%	27.50%	26.00%	26.00%	26.00%	26.00%	26.00%	26.00%	26.00%	26.00%
67												
68	Income Tax on Equity Return											
69	Return on Equity	96	296	703	1,164	1,503	1,841	2,178	3,229	2,820	2,003	373
70	Gross up for revenue (Return / (1- tax rate)	137	417	970	1,573	2,031	2,488	2,944	4,363	3,810	2,706	503
71	Income tax on Equity Return	41	121	267	409	528	647	765	1,134	991	704	131
72	Income Tax on Timing Differences											
73	Depreciation Expense	0	106	242	587	796	1,010	1,227	2,134	2,119	2,084	1,989
74	Capitalized OH - 100% deduction	204	314	1,512	562	574	585	597	0	0	0	0
74	Less: Capital Cost Allowance	193	617	1,410	2,271	2,850	3,397	3,915	4,873	3,164	1,281	54
75	Total Timing Differences	(397)	(825)	(2,681)	(2,246)	(2,627)	(2,973)	(3,285)	(2,739)	(1,045)	803	1,935
76	Gross up for tax (Total Timing Differences/(1-tax rate))	(567)	(1,162)	(3,698)	(3,035)	(3,550)	(4,017)	(4,440)	(3,701)	(1,412)	1,084	2,615
77	Income tax on Timing Differences	(170)	(337)	(1,017)	(789)	(923)	(1,044)	(1,154)	(962)	(367)	282	680
78	Total Income Tax	(129)	(216)	(750)	(380)	(395)	(398)	(389)	172	624	986	811
79	**Capital Cost Allowance**											
80	Opening Balance - UCC (Undepreciated Capital Cost)	0	4,626	10,176	23,671	30,822	37,572	43,957	60,976	39,619	16,103	808
81	Total Plant in Service (includes salvage, excludes capitalized OH and AFUDC)	4,819	6,167	14,905	9,421	9,600	9,782	9,968	(133)	(147)	(179)	(266)
82	Subtotal UCC	4,819	10,793	25,081	33,092	40,422	47,354	53,925	60,843	39,472	15,924	542
83	Capital Cost Allowance Rate	8.00%	8.00%	8.00%	8.00%	8.00%	8.00%	8.00%	8.00%	8.00%	8.00%	8.00%
84	CCA on Opening Balance	0	370	814	1,894	2,466	3,006	3,517	4,878	3,170	1,288	65
85	CCA on Capital Expenditures (1/2 yr rule)	193	247	596	377	384	391	399	(5)	(6)	(7)	(11)
86	Total CCA	193	617	1,410	2,271	2,850	3,397	3,915	4,873	3,164	1,281	54
87	Ending Balance UCC	4,626	10,176	23,671	30,822	37,572	43,957	50,009	55,970	36,309	14,643	488

Copper Replacement Project: Plan 2 - 2021 Completion

Line No.		0 Dec-09	1 Dec-10	2 Dec-11	3 Dec-12	4 Dec-13	5 Dec-14	6 Dec-15	11 Dec-20	16 Dec-25	26 Dec-35	36 Dec-45	46 Dec-55
	Summary												
	Revenue Requirements												
1	Annual Operating Expense	(46)	(93)	(140)	(185)	(232)	(278)	(326)	(572)	(641)	(694)	(769)	(937)
2	Depreciation Expense	0	157	317	487	660	843	1,037	2,195	2,751	2,714	2,669	2,613
3	Carrying Costs	291	841	1,415	1,999	2,594	3,214	3,860	7,549	8,058	5,876	3,697	1,520
4	Income Tax	(263)	(314)	(337)	(334)	(355)	(369)	(376)	(318)	590	1,226	1,292	1,109
5	Yearly Revenue Requirement for Project	(18)	590	1,256	1,967	2,667	3,409	4,195	8,854	10,758	9,122	6,888	4,306
6	Net Present Value of Revenue Requirements at a Discount Rate of 10%	**5,199**											
7	**Rate Impact**												
8	Revenue Requirement Inflation	2.00%	2.00%	2.00%	2.00%	2.00%	2.00%	2.00%	2.00%	2.00%	2.00%	2.00%	2.00%
9	Cummulative Revenue Requirement Inflation	2.00%	4.04%	6.12%	8.24%	10.41%	12.62%	14.87%	26.82%	40.02%	70.69%	108.07%	153.63%
10	Forecast Revenue Requirements ($2008)	225,369	229,858	235,064	240,419	245,914	251,493	257,211	288,036	320,250	386,457	466,861	564,977
11	Incremental Revenue Requirements	(18)	609	665	711	700	742	786	1,037	(108)	(198)	(246)	(266)
12	Rate Impact	-0.01%	0.26%	0.28%	0.30%	0.28%	0.30%	0.31%	0.36%	-0.03%	-0.05%	-0.05%	-0.05%
13	Cummulative Rate Impact	-0.01%	0.26%	0.54%	0.84%	1.12%	1.42%	1.73%	3.46%	4.13%	3.65%	3.12%	2.60%
14	Discounted Yearly Revenue Requirement for Project at a Discount Rate of 6%	(18)	574	592	597	554	555	554	546	(43)	(44)	(30)	(18)
15	Discounted Yearly Revenue Requirement for Project at a Discount Rate of 8%	(18)	564	570	565	514	505	495	445	(32)	(27)	(15)	(8)
16	Discounted Yearly Revenue Requirement for Project at a Discount Rate of 10%	(18)	553	550	534	478	461	444	363	(24)	(17)	(8)	(3)
17	**NPV of Project / Total Revenue Requirements at at a Discount Rate of 10%**	**0.17%**											
18	**Discounted Cash Flow**												
19	Net Power Purchase Expense	(46)	(93)	(140)	(185)	(232)	(278)	(326)	(572)	(641)	(694)	(769)	(937)
20	Income Tax	(263)	(314)	(337)	(334)	(355)	(369)	(376)	(318)	590	1,226	1,292	1,109
21	Capital Cost	7,201	7,380	7,819	7,947	8,420	8,923	9,456	12,628	(156)	(191)	(233)	(283)
22	Total Revenue Requirement for Project	6,891	6,973	7,342	7,428	7,834	8,275	8,754	11,738	(208)	341	290	(111)
23	Project Net Present Value at at a Discount Rate of 10%	**66,378**											

Line No.		0 Dec-09	1 Dec-10	2 Dec-11	3 Dec-12	4 Dec-13	5 Dec-14	6 Dec-15	11 Dec-20	16 Dec-25	26 Dec-35	36 Dec-45	46 Dec-55
24	**Regulatory Assumptions**												
25	Equity Component	40.00%	40.00%	40.00%	40.00%	40.00%	40.00%	40.00%	40.00%	40.00%	40.00%	40.00%	40.00%
26	Debt Component	60.00%	60.00%	60.00%	60.00%	60.00%	60.00%	60.00%	60.00%	60.00%	60.00%	60.00%	60.00%
27	Equity Return	9.02%	9.02%	9.02%	9.02%	9.02%	9.02%	9.02%	9.02%	9.02%	9.02%	9.02%	9.02%
28	Debt Return	6.50%	6.50%	6.50%	6.50%	6.50%	6.50%	6.50%	6.50%	6.50%	6.50%	6.50%	6.50%
29	AFUDC	6.30%	6.40%	6.40%	6.50%	6.50%	6.50%	6.50%	6.50%	6.50%	6.50%	6.50%	6.50%
30	**Capital Cost**												
31	Project Cost (Unloaded & Inflation Corrected)	5,942	6,363	6,750	6,867	7,284	7,727	8,197	11,011	0	0	0	0
32	Planning & Pre-Engineering												
33	Regulatory Cost (Oral Hearing)												
34	Yearly Public Consultation Cost	75	77	78	80	81	83	84	93	0	0	0	0
35	Yearly Capital Cost Savings	(7)	(15)	(22)	(30)	(38)	(46)	(55)	(128)	(156)	(191)	(233)	(283)
36	Capitalized & Direct Overheads	891	955	1,013	1,030	1,093	1,159	1,230	1,652	0	0	0	0
37	AFUDC = 0	0	0	0	0	0	0	0	0	0	0	0	0
38	Total Construction Cost in Year (Less Land Cost)	6,901	7,380	7,819	7,947	8,420	8,923	9,456	12,628	(156)	(191)	(233)	(283)
39	Cumulative Construction Cost	7,201	14,580	22,399	30,346	38,766	47,689	57,145	113,564	126,340	124,592	122,462	119,865
40	Land	0	0										
42	Total Capital Cost in Year	6,901	7,380	7,819	7,947	8,420	8,923	9,456	12,628	(156)	(191)	(233)	(283)
43	Cumulative Capital Cost	7,201	14,580	22,399	30,346	38,766	47,689	57,145	113,564	126,340	124,592	122,462	119,865
41	Cost of Removal	249	272	293	303	325	349	375	531	0	0	0	0
43	Total Construction Cost in Year	7,150	7,652	8,112	8,249	8,746	9,272	9,831	13,159	(156)	(191)	(233)	(283)
44	Additions to Plant in Service	7,201	7,380	7,819	7,947	8,420	8,923	9,456	12,628	(156)	(191)	(233)	(283)
45	Cummulative Additions to Plant	7,201	14,580	22,399	30,346	38,766	47,689	57,145	113,564	126,340	124,592	122,462	119,865
46	CWIP	0	0	0	0	0	0	0	0	0	0	0	0
47	**Annual Operating Costs / (Savings)**												
48	Energy Loss Savings	(46)	(93)	(140)	(185)	(232)	(278)	(326)	(572)	(641)	(694)	(769)	(937)
49	Total Incremental Operating Costs (Savings)	(46)	(93)	(140)	(185)	(232)	(278)	(326)	(572)	(641)	(694)	(769)	(937)
50	**Depreciation Expense**												
51	Opening Cash Outlay	0	7,201	14,580	22,399	30,346	38,766	47,689	100,936	126,496	124,783	122,694	120,149
52	Additions in Year (Without Land-Since no Depreciation for Land)	7,201	7,380	7,819	7,947	8,420	8,923	9,456	12,628	(156)	(191)	(233)	(283)
53	Cumulative Total	7,201	14,580	22,399	30,346	38,766	47,689	57,145	113,564	126,340	124,592	122,462	119,865
54	Depreciation Rate - composite average	2.18%	2.18%	2.18%	2.18%	2.18%	2.18%	2.18%	2.18%	2.18%	2.18%	2.18%	2.18%
55	Depreciation Expense (Without Land)	0	157	317	487	660	843	1,037	2,195	2,751	2,714	2,669	2,613

Line No.		0 Dec-09	1 Dec-10	2 Dec-11	3 Dec-12	4 Dec-13	5 Dec-14	6 Dec-15	11 Dec-20	16 Dec-25	26 Dec-35	36 Dec-45	46 Dec-55
56	**Net Book Value**												
57	Gross Property (With land)	7,201	14,580	22,399	30,346	38,766	47,689	57,145	113,564	126,340	124,592	122,462	119,865
58	Accumulated Depreciation (net of cost of removal)	249	365	341	157	(178)	(672)	(1,334)	(7,538)	(20,465)	(47,779)	(74,676)	(101,067)
		7,450	14,946	22,740	30,502	38,588	47,017	55,811	106,027	105,875	76,814	47,785	18,798
59	Land (included in gross property above)	0	0	0	0	0	0	0	0	0	0	0	0
60	Net Book Value	7,450	14,946	22,740	30,502	38,588	47,017	55,811	106,027	105,875	76,814	47,785	18,798
61	Carrying Costs on Average NBV												
62	Return on Equity	140	404	680	961	1,246	1,544	1,855	3,628	3,872	2,824	1,776	730
63	Interest Expense	151	437	735	1,038	1,347	1,669	2,005	3,921	4,186	3,052	1,920	790
64	Total Carrying Costs	291	841	1,415	1,999	2,594	3,214	3,860	7,549	8,058	5,876	3,697	1,520
65	**Income Tax Expense**												
66	Combined Income Tax Rate	30.00%	29.00%	27.50%	26.00%	26.00%	26.00%	26.00%	26.00%	26.00%	26.00%	26.00%	26.00%
67													
68	Income Tax on Equity Return												
69	Return on Equity	140	404	680	961	1,246	1,544	1,855	3,628	3,872	2,824	1,776	730
70	Gross up for revenue (Return / (1- tax rate)	200	569	938	1,298	1,684	2,087	2,507	4,902	5,233	3,816	2,401	987
71	Income tax on Equity Return	60	165	258	337	438	543	652	1,275	1,361	992	624	257
72	Income Tax on Timing Differences												
73	Depreciation Expense	0	157	317	487	660	843	1,037	2,195	2,751	2,714	2,669	2,613
74	Capitalized OH - 100% deduction	475	509	540	549	583	618	656	881	0	0	0	0
74	Less: Capital Cost Allowance	279	821	1,344	1,848	2,334	2,820	3,308	5,847	4,946	2,049	769	187
75	Total Timing Differences	(754)	(1,174)	(1,567)	(1,910)	(2,257)	(2,595)	(2,926)	(4,532)	(2,194)	665	1,899	2,426
76	Gross up for tax (Total Timing Differences/(1-tax rate))	(1,078)	(1,653)	(2,162)	(2,581)	(3,050)	(3,507)	(3,955)	(6,125)	(2,965)	898	2,567	3,279
77	Income tax on Timing Differences	(323)	(479)	(594)	(671)	(793)	(912)	(1,028)	(1,592)	(771)	234	667	853
78	Total Income Tax	(263)	(314)	(337)	(334)	(355)	(369)	(376)	(318)	590	1,226	1,292	1,109
79	**Capital Cost Allowance**												
80	Opening Balance - UCC (Undepreciated Capital Cost)	0	6,696	13,018	19,245	25,097	30,926	36,760	66,948	61,899	25,710	9,731	2,476
81	Total Plant in Service (includes salvage, excludes capitalized OH and AFUDC)	6,975	7,143	7,572	7,700	8,163	8,654	9,176	12,278	(156)	(191)	(233)	(283)
82	Subtotal UCC	6,975	13,839	20,589	26,945	33,260	39,580	45,935	79,226	61,742	25,519	9,499	2,192
83	Capital Cost Allowance Rate	8.00%	8.00%	8.00%	8.00%	8.00%	8.00%	8.00%	8.00%	8.00%	8.00%	8.00%	8.00%
84	CCA on Opening Balance	0	536	1,041	1,540	2,008	2,474	2,941	5,356	4,952	2,057	779	198
85	CCA on Capital Expenditures (1/2 yr rule)	279	286	303	308	327	346	367	491	(6)	(8)	(9)	(11)
86	Total CCA	279	821	1,344	1,848	2,334	2,820	3,308	5,847	4,946	2,049	769	187
87	Ending Balance UCC	6,696	13,018	19,245	25,097	30,926	36,760	42,627	73,379	56,797	23,470	8,730	2,006

Copper Replacement Project: Plan 3 - 2023 Completion

Line No.		0 Dec-09	1 Dec-10	2 Dec-11	3 Dec-12	4 Dec-13	5 Dec-14	6 Dec-15	11 Dec-20	16 Dec-25	26 Dec-35	36 Dec-45	46 Dec-55
	Summary												
	Revenue Requirements												
1	Annual Operating Expense	(39)	(93)	(140)	(185)	(232)	(278)	(326)	(572)	(641)	(694)	(769)	(937)
2	Depreciation Expense	0	133	268	411	562	723	893	1,908	2,957	2,918	2,871	2,813
3	Carrying Costs	248	711	1,193	1,695	2,218	2,762	3,330	6,569	8,959	6,617	4,278	1,942
4	Income Tax	(221)	(264)	(283)	(289)	(309)	(323)	(330)	(283)	435	1,260	1,392	1,223
5	Yearly Revenue Requirement for Project	(12)	486	1,038	1,631	2,239	2,884	3,567	7,623	11,710	10,101	7,771	5,040
6	Net Present Value of Revenue Requirements at a Discount Rate of 10%	**5,021**											
7	**Rate Impact**												
8	Revenue Requirement Inflation	2.00%	2.00%	2.00%	2.00%	2.00%	2.00%	2.00%	2.00%	2.00%	2.00%	2.00%	2.00%
9	Cummulative Revenue Requirement Inflation	2.00%	4.04%	6.12%	8.24%	10.41%	12.62%	14.87%	26.82%	40.02%	70.69%	108.07%	153.63%
10	Forecast Revenue Requirements ($2008)	225,369	229,865	234,960	240,202	245,578	251,065	256,686	286,938	321,188	387,440	467,757	565,728
11	Incremental Revenue Requirements	(12)	498	552	593	608	645	683	903	(94)	(202)	(259)	(283)
12	Rate Impact	0.0%	0.2%	0.2%	0.2%	0.2%	0.3%	0.3%	0.3%	0.0%	-0.1%	-0.1%	0.0%
13	Cummulative Rate Impact	-0.01%	0.21%	0.45%	0.69%	0.94%	1.20%	1.47%	2.98%	4.37%	3.91%	3.34%	2.80%
14	Discounted Yearly Revenue Requirement for Project at a Discount Rate of 6%	(12)	470	491	498	481	482	482	476	(37)	(44)	(32)	(19)
15	Discounted Yearly Revenue Requirement for Project at a Discount Rate of 8%	(12)	461	473	471	447	439	431	387	(27)	(27)	(16)	(8)
16	Discounted Yearly Revenue Requirement for Project at a Discount Rate of 10%	(12)	453	456	446	415	400	386	316	(20)	(17)	(8)	(4)
17	**NPV of Project / Total Revenue Requirements at at a Discount Rate of 10%**	**0.16%**											
18	**Discounted Cash Flow**												
19	Net Power Purchase Expense	(39)	(93)	(140)	(185)	(232)	(278)	(326)	(572)	(641)	(694)	(769)	(937)
20	Income Tax	(221)	(264)	(283)	(289)	(309)	(323)	(330)	(283)	435	1,260	1,392	1,223
21	Capital Cost	6,104	6,206	6,575	6,966	7,381	7,821	8,288	11,065	(164)	(200)	(243)	(296)
22	Total Revenue Requirement for Project	5,844	5,849	6,152	6,491	6,840	7,219	7,632	10,210	(370)	366	380	(11)
23	Project Net Present Value at at a Discount Rate of 10%	**64,056**											

Line No.		0 Dec-09	1 Dec-10	2 Dec-11	3 Dec-12	4 Dec-13	5 Dec-14	6 Dec-15	11 Dec-20	16 Dec-25	26 Dec-35	36 Dec-45	46 Dec-55
24	**Regulatory Assumptions**												
25	Equity Component	40.00%	40.00%	40.00%	40.00%	40.00%	40.00%	40.00%	40.00%	40.00%	40.00%	40.00%	40.00%
26	Debt Component	60.00%	60.00%	60.00%	60.00%	60.00%	60.00%	60.00%	60.00%	60.00%	60.00%	60.00%	60.00%
27	Equity Return	9.02%	9.02%	9.02%	9.02%	9.02%	9.02%	9.02%	9.02%	9.02%	9.02%	9.02%	9.02%
28	Debt Return	6.50%	6.50%	6.50%	6.50%	6.50%	6.50%	6.50%	6.50%	6.50%	6.50%	6.50%	6.50%
29	AFUDC	6.30%	6.40%	6.40%	6.50%	6.50%	6.50%	6.50%	6.50%	6.50%	6.50%	6.50%	6.50%
30	**Capital Cost**												
31	Project Cost (Unloaded & Inflation Corrected)	4,987	5,341	5,666	6,010	6,375	6,763	7,174	9,637	0	0	0	0
32	Planning & Pre-Engineering												
33	Regulatory Cost (Oral Hearing)												
34	Yearly Public Consultation Cost	75	77	78	80	81	83	84	93	0	0	0	0
35	Yearly Capital Cost Savings	(6)	(12)	(19)	(25)	(32)	(40)	(47)	(111)	(164)	(200)	(243)	(296)
36	Capitalized & Direct Overheads	748	801	850	902	956	1,014	1,076	1,446	0	0	0	0
37	AFUDC = 0	0	0	0	0	0	0	0	0	0	0	0	0
38	Total Construction Cost in Year (Less Land Cost)	5,804	6,206	6,575	6,966	7,381	7,821	8,288	11,065	(164)	(200)	(243)	(296)
39	Cumulative Construction Cost	6,104	12,310	18,885	25,851	33,231	41,052	49,340	98,791	135,792	133,964	131,736	129,020
40	Land	0	0										
42	Total Capital Cost in Year	5,804	6,206	6,575	6,966	7,381	7,821	8,288	11,065	(164)	(200)	(243)	(296)
43	Cumulative Capital Cost	6,104	12,310	18,885	25,851	33,231	41,052	49,340	98,791	135,792	133,964	131,736	129,020
41	Cost of Removal	209	229	246	265	285	306	328	464	0	0	0	0
43	Total Construction Cost in Year	6,013	6,435	6,821	7,231	7,665	8,127	8,616	11,529	(164)	(200)	(243)	(296)
44	Additions to Plant in Service	6,104	6,206	6,575	6,966	7,381	7,821	8,288	11,065	(164)	(200)	(243)	(296)
45	Cummulative Additions to Plant	6,104	12,310	18,885	25,851	33,231	41,052	49,340	98,791	135,792	133,964	131,736	129,020
46	CWIP	0	0	0	0	0	0	0	0	0	0	0	0
47	**Annual Operating Costs / (Savings)**												
48	Energy Loss Savings	(39)	(93)	(140)	(185)	(232)	(278)	(326)	(572)	(641)	(694)	(769)	(937)
49	Total Incremental Operating Costs (Savings)	(39)	(93)	(140)	(185)	(232)	(278)	(326)	(572)	(641)	(694)	(769)	(937)
50	**Depreciation Expense**												
51	Opening Cash Outlay	0	6,104	12,310	18,885	25,851	33,231	41,052	87,726	135,956	134,164	131,979	129,316
52	Additions in Year (Without Land-Since no Depreciation for Land)	6,104	6,206	6,575	6,966	7,381	7,821	8,288	11,065	(164)	(200)	(243)	(296)
53	Cumulative Total	6,104	12,310	18,885	25,851	33,231	41,052	49,340	98,791	135,792	133,964	131,736	129,020
54	Depreciation Rate - composite average	2.18%	2.18%	2.18%	2.18%	2.18%	2.18%	2.18%	2.18%	2.18%	2.18%	2.18%	2.18%
55	Depreciation Expense (Without Land)	0	133	268	411	562	723	893	1,908	2,957	2,918	2,871	2,813

Line No.		0 Dec-09	1 Dec-10	2 Dec-11	3 Dec-12	4 Dec-13	5 Dec-14	6 Dec-15	11 Dec-20	16 Dec-25	26 Dec-35	36 Dec-45	46 Dec-55
56	**Net Book Value**												
57	Gross Property (With land)	6,104	12,310	18,885	25,851	33,231	41,052	49,340	98,791	135,792	133,964	131,736	129,020
58	Accumulated Depreciation (net of cost of removal)	209	305	284	138	(140)	(557)	(1,121)	(6,481)	(18,027)	(47,390)	(76,317)	(104,713)
		6,313	12,615	19,169	25,988	33,091	40,495	48,218	92,310	117,765	86,575	55,419	24,307
59	Land (included in gross property above)	0	0	0	0	0	0	0	0	0	0	0	0
60	Net Book Value	6,313	12,615	19,169	25,988	33,091	40,495	48,218	92,310	117,765	86,575	55,419	24,307
61	Carrying Costs on Average NBV												
62	Return on Equity	119	341	573	815	1,066	1,328	1,600	3,157	4,305	3,180	2,056	933
63	Interest Expense	129	369	620	881	1,152	1,435	1,730	3,412	4,654	3,437	2,222	1,009
64	Total Carrying Costs	248	711	1,193	1,695	2,218	2,762	3,330	6,569	8,959	6,617	4,278	1,942
65	**Income Tax Expense**												
66	Combined Income Tax Rate	30.00%	29.00%	27.50%	26.00%	26.00%	26.00%	26.00%	26.00%	26.00%	26.00%	26.00%	26.00%
67													
68	Income Tax on Equity Return												
69	Return on Equity	119	341	573	815	1,066	1,328	1,600	3,157	4,305	3,180	2,056	933
70	Gross up for revenue (Return / (1- tax rate)	170	481	791	1,101	1,440	1,794	2,163	4,266	5,818	4,297	2,778	1,261
71	Income tax on Equity Return	51	139	217	286	374	466	562	1,109	1,513	1,117	722	328
72	Income Tax on Timing Differences												
73	Depreciation Expense	0	133	268	411	562	723	893	1,908	2,957	2,918	2,871	2,813
74	Capitalized OH - 100% deduction	399	427	453	481	510	541	574	771	0	0	0	0
74	Less: Capital Cost Allowance	237	695	1,134	1,568	1,999	2,428	2,859	5,099	6,024	2,513	965	265
75	Total Timing Differences	(636)	(989)	(1,319)	(1,638)	(1,947)	(2,247)	(2,540)	(3,962)	(3,067)	405	1,905	2,548
76	Gross up for tax (Total Timing Differences/(1-tax rate))	(908)	(1,393)	(1,820)	(2,214)	(2,630)	(3,036)	(3,433)	(5,354)	(4,144)	548	2,575	3,443
77	Income tax on Timing Differences	(272)	(404)	(500)	(576)	(684)	(789)	(893)	(1,392)	(1,077)	142	669	895
78	Total Income Tax	(221)	(264)	(283)	(289)	(309)	(323)	(330)	(283)	435	1,260	1,392	1,223
79	**Capital Cost Allowance**												
80	Opening Balance - UCC (Undepreciated Capital Cost)	0	5,678	10,991	16,225	21,406	26,563	31,720	58,354	75,379	31,511	12,185	3,461
81	Total Plant in Service (includes salvage, excludes capitalized OH and AFUDC)	5,914	6,008	6,368	6,750	7,155	7,585	8,042	10,759	(164)	(200)	(243)	(296)
82	Subtotal UCC	5,914	11,685	17,359	22,974	28,562	34,148	39,762	69,113	75,215	31,311	11,942	3,165
83	Capital Cost Allowance Rate	8.00%	8.00%	8.00%	8.00%	8.00%	8.00%	8.00%	8.00%	8.00%	8.00%	8.00%	8.00%
84	CCA on Opening Balance	0	454	879	1,298	1,713	2,125	2,538	4,668	6,030	2,521	975	277
85	CCA on Capital Expenditures (1/2 yr rule)	237	240	255	270	286	303	322	430	(7)	(8)	(10)	(12)
86	Total CCA	237	695	1,134	1,568	1,999	2,428	2,859	5,099	6,024	2,513	965	265
87	Ending Balance UCC	5,678	10,991	16,225	21,406	26,563	31,720	36,903	64,014	69,191	28,798	10,977	2,900