REPORT

System Impact Assessment Report

CONNECTION ASSESSMENT & APPROVAL PROCESS

Issue 1.0

Final Report

CAA ID 2010-419

Project: Musselwhite Mine Expansion – Esker Substation

Applicant: GoldCorp Canada Ltd.

IESO Market Facilitation Department

January 24, 2011

Document ID	ISO_REP_0673
Document Name	System Impact Assessment Report
Issue	1.0
Reason for Issue	Final
Effective Date	January 24, 2011

System Impact Assessment Report

Musselwhite Mine Expansion – Esker Substation Project

Acknowledgement

The IESO wishes to acknowledge the assistance of Hydro One in completing this assessment.

Disclaimers

IESO

This report has been prepared solely for the purpose of assessing whether the connection applicant's proposed connection with the IESO-controlled grid would have an adverse impact on the reliability of the integrated power system and whether the IESO should issue a notice of conditional approval or disapproval of the proposed connection under Chapter 4, section 6 of the Market Rules.

Conditional approval of the proposed connection is based on information provided to the IESO by the connection applicant and Hydro One at the time the assessment was carried out. The IESO assumes no responsibility for the accuracy or completeness of such information, including the results of studies carried out by Hydro One at the request of the IESO. Furthermore, the conditional approval is subject to further consideration due to changes to this information, or to additional information that may become available after the conditional approval has been granted.

If the connection applicant has engaged a consultant to perform connection assessment studies, the connection applicant acknowledges that the IESO will be relying on such studies in conducting its assessment and that the IESO assumes no responsibility for the accuracy or completeness of such studies including, without limitation, any changes to IESO base case models made by the consultant. The IESO reserves the right to repeat any or all connection studies performed by the consultant if necessary to meet IESO requirements.

Conditional approval of the proposed connection means that there are no significant reliability issues or concerns that would prevent connection of the proposed facility to the IESO-controlled grid. However, the conditional approval does not ensure that a project will meet all connection requirements. In addition, further issues or concerns may be identified by the transmitter(s) during the detailed design phase that may require changes to equipment characteristics and/or configuration to ensure compliance with physical or equipment limitations, or with the Transmission System Code, before connection can be made.

This report has not been prepared for any other purpose and should not be used or relied upon by any person for another purpose. This report has been prepared solely for use by the connection applicant and the IESO in accordance with Chapter 4, section 6 of the Market Rules. The IESO assumes no responsibility to any third party for any use, which it makes of this report. Any liability which the IESO may have to the connection applicant in respect of this report is governed by Chapter 1, section 13 of the Market Rules. In the event that the IESO provides a draft of this report to the connection applicant, the connection applicant must be aware that the IESO may revise drafts of this report at any time in its sole discretion without notice to the connection applicant. Although the IESO will use its best efforts to advise you of any such changes, it is the responsibility of the connection applicant to ensure that the most recent version of this report is being used.

HYDRO ONE
Special Notes and Limitations of Study Results

The results reported in this report are based on the information available to Hydro One, at the time of the study, suitable for a System Impact Assessment of this transmission system reinforcement proposal.

The short circuit and thermal loading levels have been computed based on the information available at the time of the study. These levels may be higher or lower if the connection information changes as a result of, but not limited to, subsequent design modifications or when more accurate test measurement data is available.

This study does not assess the short circuit or thermal loading impact of the proposed facilities on load and generation customers.

In this report, short circuit adequacy is assessed only for Hydro One circuit breakers. The short circuit results are only for the purpose of assessing the capabilities of existing Hydro One circuit breakers and identifying upgrades required to incorporate the proposed facilities. These results should not be used in the design and engineering of any new or existing facilities. The necessary data will be provided by Hydro One and discussed with any connection applicant upon request.

The ampacity ratings of Hydro One facilities are established based on assumptions used in Hydro One for power system planning studies. The actual ampacity ratings during operations may be determined in real-time and are based on actual system conditions, including ambient temperature, wind speed and facility loading, and may be higher or lower than those stated in this study.

The additional facilities or upgrades which are required to incorporate the proposed facilities have been identified to the extent permitted by a System Impact Assessment under the current IESO Connection Assessment and Approval process. Additional facility studies may be necessary to confirm constructability and the time required for construction. Further studies at more advanced stages of the project development may identify additional facilities that need to be provided or that require upgrading.

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Executive Summary

Description

Goldcorp Canada Ltd. is planning to install a new transformer susbstation named Esker within the Musselwhite mine complex, North-East of Pickle Lake, in the Ear Falls area. The new Esker substation will be connected through a 3.2 km, 115 kV line extension, called M1X, at the end of the existing M1M circuit.

The purpose of this SIA is to analyze the impact of the new Esker TS on the reliability of the IESO-controlled grid.

SIA Findings

The assessment concludes that the proposed connection of the Esker substation does not have any material adverse impact on the reliability of the IESO-controlled grid if the IESO requirements for connection are satisfied.

The findings of the SIA are summarized below:

1. The pre-contingency and post-contingency thermal loadings of critical transmission elements in the project's vicinity are within acceptable limits with the Esker substation in service. The power transfer capability of the local grid, before and after the inclusion of the Esker substation, is marginally within acceptable limits as per Ontario Resource and Transmission Assessment Criteria (ORTAC) Section 4.1.

2. With the addition of the Esker substation, given the existing network limitations in the area, monitoring the voltage at the high voltage side of the Musselwhite SS (the point of connection of the Musselwhite mine complex to the IESO-controlled grid) and taking corrective actions at the Musselwhite mine complex is necessary, in order to maintain the Musselwhite SS voltage within the required range, both in pre-contingency (at all times) and within 30 minutes following contingencies on the IESO-controlled grid (i.e. outside the Musselwhite mine complex facilities). The corrective actions need to be achieved by either:

   - utilizing the existing reactive devices, along with post-contingency load reduction at the Musselwhite mine complex (please note that if one of the existing SVCs at the Musselwhite station is unavailable, the combined load at the Musselwhite mine complex cannot exceed 16 MW even in pre-contingency; further load reductions would likely be required following contingencies on the IESO-controlled grid); or

   - installing and operating additional reactive compensation at the Esker substation, thus eliminating the need for post-contingency load reduction at the Musselwhite mine complex.

   From a voltage performance viewpoint, the most severe contingency for the Ear Falls area is the loss of a single Manitou Falls unit which may be the only unit in service at the plant during low water conditions. Post-contingency, before -tap changer action, voltages were found to be within the limits specified in Section 4.3 of the ORTAC. Post-contingency, after tap changer action, voltages were also found to be within the limits specified by Section 4.3 of the ORTAC.

   However, studies show that under the existing network limitations in the area, corrective actions will be required within 30 minutes following a contingency on the IESO-controlled grid involving the loss of the single Manitou Falls unit in service, to bring the voltage at Musselwhite SS above the minimum level required by the ORTAC. Either the Musselwhite mine complex load will have to be reduced post-contingency such that voltages at Musselwhite SS return within the required range, or an additional 10.0 Mvar of reactive compensation is required at the Esker substation.

If additional reactive compensation is installed at the Esker substation, switching studies were performed to determine the maximum amount of reactive compensation that can be switched in or out without exceeding the voltage raise or decline limits specified in Section 4.3.2 of the ORTAC. The results show that blocks no larger than 5.0 Mvar can be switched without exceeding the 4% change limits on the Musselwhite SS 115 kV bus, per the ORTAC. However, analysis of the historic Musselwhite mine load indicates that a block of this size is likely to be switched in or out 4 or more times a day and the associated voltage change would violate the Transmission System Code (TSC) flicker limits (Appendix 2, Ref 5). To satisfy the TSC requirements, the block size must be reduced to 3.33 Mvar. Three switchable blocks of this size are required at Esker and, assuming a similar load profile to what has been historically observed, they are expected to be switched in and out several times during the day.

If additional reactive compensation is installed at the Esker substation, the applicant is recommended to consider installing an SVC (static var compensator – that can be a +/- 5 Mvar SVC in conjunction with a 5 Mvar switched capacitor) instead of discrete capacitors, in order to achieve more operational flexibility.

IESO's Requirements for Connection

Specific Requirements: The following specific requirements are applicable to the applicant for the incorporation of the Esker substation. Specific requirements pertain to the level of reactive compensation needed, operation restrictions, Special Protection Systems, upgrading of equipment and any project specific items not covered in the general requirements:

The applicant shall:

- monitor and maintain the voltages at the Musselwhite SS within 118 kV and 132 kV in pre-contingency conditions at all times.
- within 30 minutes following contingencies on the IESO-controlled grid (i.e. outside the Musselwhite mine complex facilities), take corrective actions to return the Musselwhite SS station voltage within the 113 kV - 132 kV range. The corrective actions must be achieved by either:
    - utilizing the existing reactive devices, along with post-contingency load reduction at the Musselwhite mine complex (please note that if one of the existing SVCs at the Musselwhite station is unavailable, the combined load at the Musselwhite mine complex cannot exceed 16 MW even in pre-contingency; further load reductions would likely be required following contingencies on the IESO-controlled grid); or
    - installing and operating three switchable capacitor banks of 3.33 Mvar at Esker.

If additional reactive compensation is installed at the Esker substation, the applicant is recommended to consider installing an SVC (static var compensator – that can be a +/- 5 Mvar SVC in conjunction with a 5 Mvar switched capacitor) instead of discrete capacitors, in order to achieve more operational flexibility.

General Requirements: The proposed connection must comply with all the applicable requirements from the Transmission System Code (TSC), IESO Market Rules and standards and criteria. The most relevant requirements are summarized below and are presented in more detail in Section 2 of this report

1. All new 115 kV equipment must have a maximum continuous voltage rating and the ability to interrupt fault current at a voltage of at least 132 kV as specified in Appendix 4.1 of the Market rules. Protective relaying must be configured to ensure transmission equipment remains in service for voltages between 94% of minimum continuous and 105% of maximum continuous values as per Market Rules, Appendix 4.1.
2. GoldCorp Canda Ltd. shall ensure that equipment at the new Esker substation is designed to sustain the fault levels in the area. Should future system enhancements result in fault levels exceeding equipment capability, GoldCorp Canada Ltd. is required to replace equipment at its own expense with higher rated equipment designed to sustain the increased fault levels, up to the limit allowed under the Transmission System Code, Appendix 2.
3. GoldCorp Canada Ltd. shall have the capability to maintain the power factor at the defined meter point of the Esker substation within the range of 0.9 lagging to 0.9 leading, as specified in Appendix 4.3 of the Market Rules.
4. If metering is installed at the proposed substation, GoldCorp Canada Ltd. shall ensure that the revenue metering equipment installed for the Esker substation complies with Chapter 6 of the Market Rules.
5. The connection equipment must be designed such that adverse effects due to failure do not propagate in the IESO-controlled grid.
6. The connection equipment must be designed for full operability in all reasonably foreseeable ambient temperature conditions.
7. The Esker substation must satisfy telemetry requirements as per Appendices 4.17 and 4.22 of the Market Rules. The determination of telemetry quantities and telemetry testing will be conducted during the IESO Facility Registration/Market Entry process.
8. Protection systems must satisfy all requirements of the TSC and specific requirements from the transmitter. New protection systems must be coordinated with existing protection systems.
9. Although the SIA has found that a Special Protection Scheme (SPS) is not required for the Esker substation, provisions must be made in the design of the protections and controls at the facility to allow for the installation of SPS equipment and participation, if an SPS will be required in the future.
10. Models and data, including any controls that would be operational, must be provided to the IESO through the IESO Facility Registration/Market Entry process at least seven months before energization to the IESO-controlled grid.
11. During the commissioning period, a set of IESO specified tests must be performed. The commissioning report must be submitted to the IESO within 30 days of the conclusion of commissioning. The registration of the new facilities will need to be completed through the IESO's Market Entry process before any part of the facility can be placed in-service. If the data or assumptions supplied for the registration of the facilities materially differ from those that were used for the assessment, then some of the analysis might need to be repeated.
12. The proposed facility must be compliant with applicable reliability standards set by the North American Electric Reliability Corporation (NERC) and the North East Power Coordinating Council (NPCC) prior to energization to the IESO controlled grid. The applicant may meet

restoration participant criteria as per the NERC standard EOP-005. Further details can be found in section 3 of Market Manual 7.8 (Ontario Power System Restoration Plan).

Notification of Conditional Approval

Connecting the new Esker substation does not result in any significant adverse impacts to the IESO-controlled grid, provided that the requirements listed in this report are met.
It is recommended that a *Notification of Conditional Approval for Connection* be issued to GoldCorp Canada Ltd. subject to the requirements listed in this report being implemented.

– End of Section –

1. Project Description

GoldCorp Canada Ltd. is proposing to modify an existing load supply point by extending the existing applicant owned, circuit M1M, with a 3.2 km section of 115 kV overhead line, M1X, and adding a 2x25/33.5/42 MVA, 121/13.8 kV, Delta/grounded-Wye connected transformer station under the name "Esker" within the Musselwhite mining complex. The two transformers, designated T1 and T2 will each be connected through a high voltage SF6 circuit switcher rated at 138 kV, 1200 A continuous, 40 kA symmetrical short circuit capability. On the low voltage side the transformers will be connected to 13.8 kV buses, designated Bus 1 and Bus 2, each through a vacuum breaker rated at 15 kV, 2000 A continuous, 25 kA short circuit capability. Two feeders, each out of the two 13.8 kV buses, will supply two 13.8/4.16 kV transformers rated at 10 MVA connected to a new 4.16 kV distribution system that will have 4x2MVA emergency generators to be operated in isolation from the grid.

The total combined load at the Musselwhite and Esker substations is 20 MVA (18MW at 0.9 PF lagging).

The planned in-service date is December 2010.

The purpose of this System Impact Assessment is to identify the effect of the new facility on the IESO-controlled grid reliability.

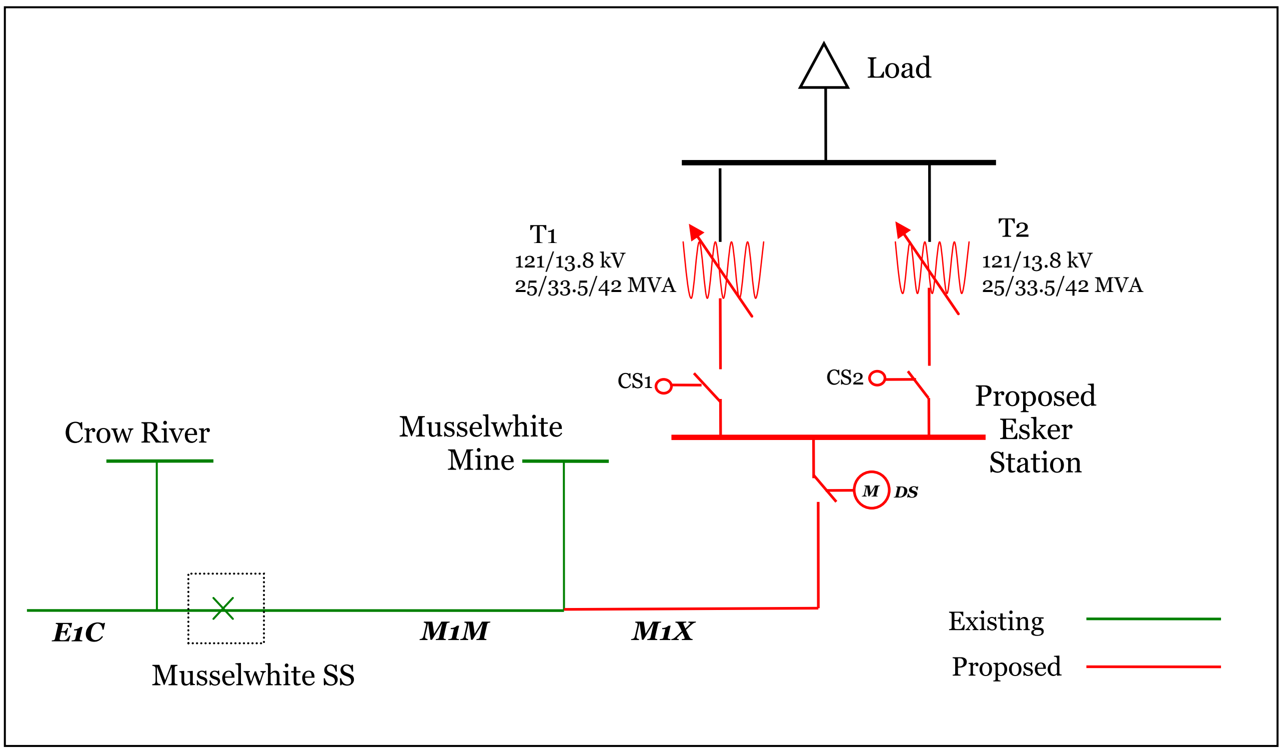

Figure 1: Proposed Esker Substation

– End of Section –

2. IESO General Requirements

GoldCorp Canada Ltd. shall satisfy the requirements and standards specified in the Market Rules, Market Manuals and the Transmission System Code. The following sections highlight some of the general requirements that are applicable to the applicant.

2.1 Voltage Requirements

Appendix 4.1 Reference 2, of the Market Rules states that under normal conditions voltages in northern Ontario are maintained within the range of 113 kV to 132 kV. Thus, the IESO requires that the 115 kV equipment in northern Ontario must have a maximum continuous voltage rating of at least 132 kV.

Fault interrupting devices must be able to interrupt fault current at the maximum continuous voltage. Appendix 2 of the TSC establishes maximum fault levels for the transmission system. For the 115 kV system the maximum 3 phase symmetrical fault level and single line to ground (SLG) symmetrical fault level are both 50 kA. The TSC requires that new equipment be designed to sustain the fault levels in the area where the equipment is installed.

Protective relaying at grid connected facilities must be set to ensure that transmission equipment remains in-service for voltages between 94% of the minimum continuous and 105% of the maximum continuous values in the Market Rules, Appendix 4.1.

GoldCorp Canada Ltd. shall ensure that all 115 kV equipment at Esker TS is capable of continuously operating for a voltage level up to 132 kV. Fault interrupting devices must be able to interrupt fault currents at the maximum continuous voltage of 132 kV. Protective relaying at Esker TS must be set to ensure that transmission equipment remains in service for voltages between 94% of the minimum continuous and 105% of the maximum continuous values.

2.2 Power Factor Requirements

The Market Rules (Appendix 4.3) require that the connection applicant have the capability to maintain a power factor (PF) within the range of 0.9 lagging and 0.9 leading as measured at the defined metering point of the facility.

Goldcorp Canada Ltd. shall have the capability to maintain the power factor at the defined meter point of Esker Substation within the range of 0.9 lagging to 0.9 leading.

2.3 Under Frequency Load Shedding

The GoldCorp Canada Ltd. Musselwhite/Esker mine site has a total peak load at its station that is less than 25 MW. Therefore, it is not required to participate in the under frequency load shedding (UFLS) according to Section 4.5 of the Market Manual Part 7.4.

2.4 Protection Systems Requirements

Protection systems must be designed to satisfy all the requirements of the Transmission System Code as specified in Schedules E, F and G of Appendix 1 and any additional requirements identified by the transmitter. New protection systems must be coordinated with existing protection systems.

GoldCorp Canada Ltd. is required to have adequate provision in the design of protections and controls at the facility to allow for future installation of Special Protection Scheme (SPS) equipment.

GoldCorp Canada Ltd. is required to initiate an assessment of the protection systems proposed for the new facility with the transmitter. The transmitter shall identify any protection relay modifications (e.g. equipment and settings) required to incorporate the Esker substation into the integrated power system. To allow sufficient time to assess the impact on power system reliability, the transmitter must submit any proposed protection relay modifications to the IESO as soon as the protection assessment for the new facility is finished or at least six (6) months before any actual modifications are to be implemented on the existing protection systems.

GoldCorp Canada Ltd.can send documentation for protection modifications triggered by new or modified primary equipment (i.e. new or replacement relays) to connection.assessments@ieso.ca.

The IESO would deem the modifications acceptable if they do not cause any new and/or reduced operating security limits under normal operating conditions. Should the modifications be unacceptable, the IESO would require the connection applicant to investigate other mitigating measures.

For protection modifications that are not associated with new or modified equipment (i.e. protection setting modifications), GoldCorp Canada Ltd. can send the documentation to protection.settings@ieso.ca.

New protection systems at the Esker substation must be designed to satisfy all the requirements of the Transmission System Code and any additional requirements identified by the transmitter. New protection systems must be coordinated with existing protection systems.

GoldCorp Canada Ltd. shall have adequate provision in the design of protections and controls at the facility to allow for future installation of Special Protection Scheme (SPS) equipment.

2.5 Fault Levels

The TSC requires that new equipment be designed to sustain the fault levels in the area where the equipment is installed. If any future system enhancement results in an increased fault level higher than the equipment's capability, the owner is required to replace the equipment at their own expense with higher rated equipment capable of sustaining the increased fault level, up to a maximum fault level as specified in Appendix 2 of the Transmission System Code.

Appendix 2 of the Transmission System Code (TSC), establishes maximum fault levels for the transmission system. For the 115 kV system, the maximum 3 phase and single line to ground symmetrical fault levels are 50 kA.

GoldCorp Canada Ltd. shall ensure that the new equipment at the Esker substation is designed to sustain the fault levels in the area. If any future system enhancement results in an increased fault level higher than the equipment's capability, GoldCorp Canada Ltd. is required to replace the equipment at its own expense with higher rated equipment capable of sustaining the increased fault level, up to maximum fault level specified in Appendix 2 of the Transmission System Code.

2.6 Telemetry Requirements

In accordance with the telemetry requirements for connected wholesale customers and distributors as specified in Appendices 4.17 and 4.22 of the Market Rules, connection applicants must install equipment at their projects with specific performance standards to provide telemetry data to the IESO. The data is to consist of certain equipment status and operating quantities which will be identified during the IESO Market Entry Process.

As part of the IESO Facility Registration/Market Entry process, the applicant must also complete end to end testing of all necessary telemetry points with the IESO to ensure that standards are met and that sign conventions are understood. All found anomalies must be corrected before IESO final approval to connect any phase of the project is granted.

GoldCorp Canada Ltd. is required to install all the equipment needed to provide telemetry data to the IESO on a continuous basis, as required by the Market Rules.

2.7 Revenue Metering Requirements

Connection applicants must ensure that revenue metering installations comply with Chapter 6 of the Market Rules. For more details the applicant is encouraged to seek advice from their Metering Service Provider (MSP) or from the IESO metering group.

GoldCorp Canada Ltd. shall ensure that the revenue metering installations at Esker TS comply with the IESO's requirements specified in Chapter 6 of the Market Rules.

2.8 Facility Registration/Market Entry Requirements

Connection applicants must complete the IESO Facility Registration/Market Entry process in a timely manner before IESO final approval for connection is granted. Models and data, including any controls that would be operational, must be provided to the IESO. This information should be submitted at least seven months before energization to the IESO-controlled grid, to allow the IESO to incorporate this project into IESO work systems and to perform any additional reliability studies.

As part of the IESO Facility Registration/Market Entry process, the connection applicant must provide evidence to the IESO confirming that the equipment installed meets the Market Rules requirements and matches or exceeds the performance predicted in this assessment. This evidence shall be either type tests done in a controlled environment or commissioning tests done on-site. In either case, the testing must be done not only in accordance with widely recognized standards, but also to the satisfaction of the IESO. Until this evidence is provided and found acceptable to the IESO, the Facility Registration/Market Entry process will not be considered complete and the connection applicant must accept any restrictions the IESO may impose upon this project's participation in the IESO-administered markets or connection to the IESO-controlled grid.

During the commissioning period, a set of IESO specified tests must be performed. The report must be supplied to the IESO within 30 days after completion of commissioning tests. Failure to provide evidence may result in disconnection from the IESO-controlled grid.

If the submitted models and data differ materially from the ones used in this assessment, then further analysis of the project will need to be done by the IESO.

GoldCorp Canada Ltd. must complete the IESO Facility Registration/Market Entry process in a timely manner before IESO final approval for connection is granted.

– End of Section –

3. Data Verification

GoldCorp Canada Ltd. has provided the following specifications of the new equipment proposed for installation at the Esker substation:

Tap Line	M1X (Extension of M1M)
Type	Overhead
Voltage	115 kV
Length	3.2 km
Summer Thermal Rating	84 A (Cont. = LTE = 15-minute)
Conductor	336.4kcmil, ACSR
Impedance (p.u. on 118.05 kV)	R = 0.00428ohms, X = 0.010845ohms, B = 0.001556 mhos

Disconnect Switch	
Identifier	DS
Maximum Continuous Rated Voltage	132 kV
Continuous Current Rating	1200 A
Rated Symmetrical Short Circuit Capability	38 kA

Main Buses	
Quantity	1 (Station Bus - T1, T2, 115 kV side)
Voltage	115 kV
Summer Continuous	2000 A
Winter Continuous	2000 A
Conductor	4/0 AWG (ACSR)

Circuit Switchers	
Quantity	2 (SF6: CS1, CS2)
Maximum Continuous Rated Voltage	138 kV
Interrupting Time	100ms (=6cycles)
BIL Voltage	650 kV
Rated Continuous Current	1200 A
Rated Symmetrical Short Circuit Capability	40 kA

Surge Arrestors	
Quantity	2 (Station - SA1, SA2)
Voltage Rating	132 kV, MCOV 106 kV
Type	ZnO

Step-down Transformer	
Quantity	2 x 3-phase (T1, T2)
Thermal ratings	25/33.5/42 MVA (ONAN, ONAF, OFAF)
Rated voltage	121 kV/13.8 kV
Under-load tap changer (ULTC)	±8.8 kV in ±16 steps (on the 115 kV side)
Transformer connections	HV: Delta LV: Wye-n (neutral solidly grounded)
Positive Sequence Impedance	HX: (0.008+j0.08) % on 25 MVA base R: 0.032, X: 0.32 on 100 MVA base

Bus	**Total Fault Current Symmetrical (kA)**		**Total Fault Current Asymmetrical (kA)**	
	3-ph Fault	**L-G**	**3-ph Fault**	**L-G**
Musselwhite 115 kV	0.378	0.273	0.440	0.286

Table 1: Symmetrical and Asymmetrical Faults at Musselwhite TS Station

Hydro One has calculated the maximum three phase and line to ground faults as shown in Table 1 above. The interrupting capability of the proposed 115 kV circuit switchers is 40 kA, which satisfies the Transmission System Code (TSC). If any future system enhancement results in an increased fault level higher than the equipment's capability, GoldCorp Canada Ltd. is required to replace the equipment at their own expense with higher rated equipment capable of sustaining the increased fault level, up to the TSC's maximum fault level (50 kA) for the 115 kV system.

The proposed equipment at Esker TS satisfies the IESO requirements for connection.

– End of Section –

4. Review of Existing System

4.1 Existing System

Generation for the area is injected from the Manitou Falls GS and Ear Falls GS plants into Ear Falls TS. Three 115 kV circuits stem out of Ear Falls TS, i.e. E1C, E2R and E4D. Circuits E2R and E4D connect the Red Lake TS and Dryden TS to Ear Falls TS respectively. The privately owned M1M circuit connects to E1C, at Musselwhite SS, in the vicinity of Crow River TS. The Musselwhite and Esker substations are connected at the end of circuit M1M. Thermal flows on these lines and voltages at all buses encompassed within the mentioned areas have been monitored for the study.

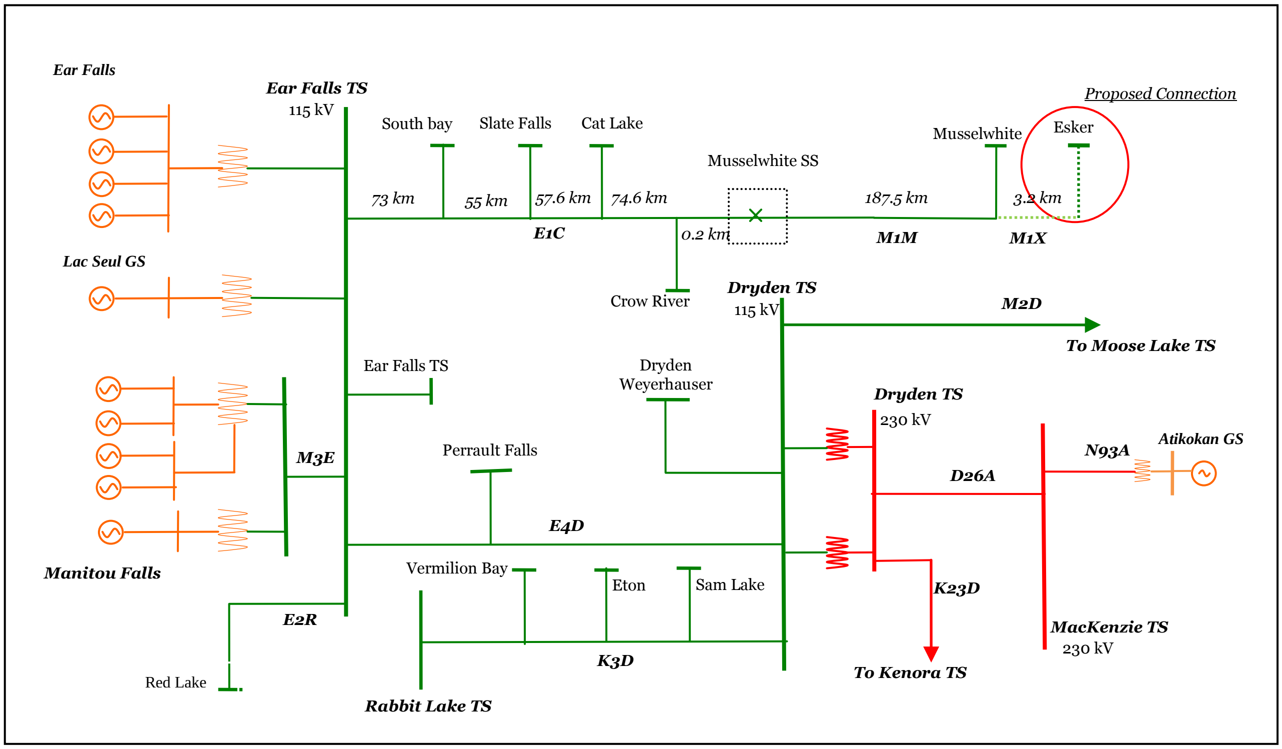

Figure 2: Existing Connection Arrangement

4.2 Historical data

Historical data, consisting of hourly average samples for winter 2009 (November 2009 – April 2010) and summer 2010 (May 2010 – October 2010), were obtained from IESO real-time data for the following quantities:

- 115 kV bus voltage levels at Ear Falls TS, Dryden TS, and Musselwhite mine
- Red Lake Load (MW)
- active (MW) and reactive (Mvar) power flows on E1C and E4D (out of the Ear Falls TS bus)

Graphs for these quantities are shown in Figures 3 to 10. Note that for active/reactive power flows, positive values represent flows out of Ear Falls TS.

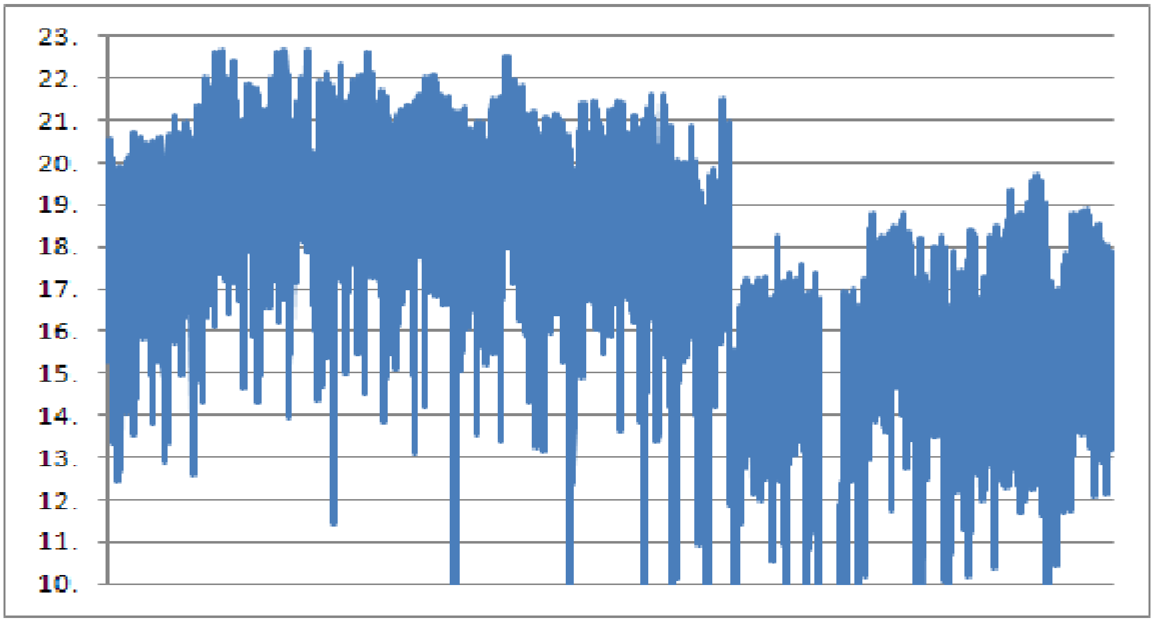

Figure 3: E1C - Active Power Flow (MW)

Average active power flow = 17 MW
For the study, initial active flow out of Ear Falls = 21.5 MW

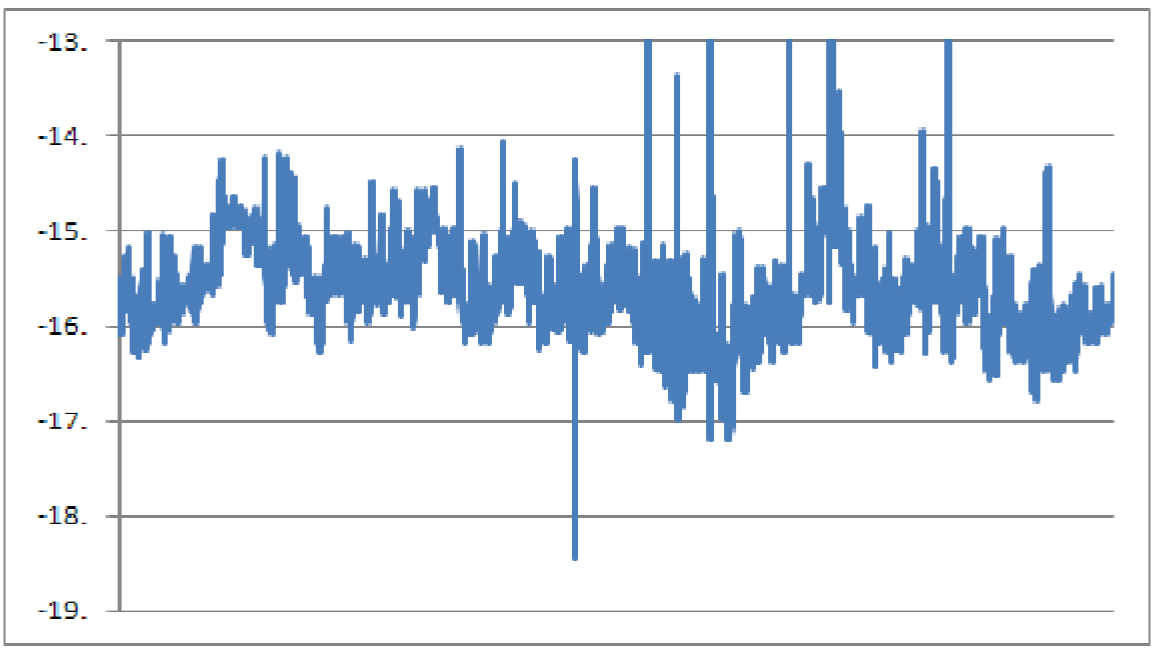

Figure 4: E1C - Reactive Power Flow (Mvar)

Average reactive power flow = -15.5 Mvar.

For the study, initial reactive power flow into Ear Falls = 15.7 Mvar

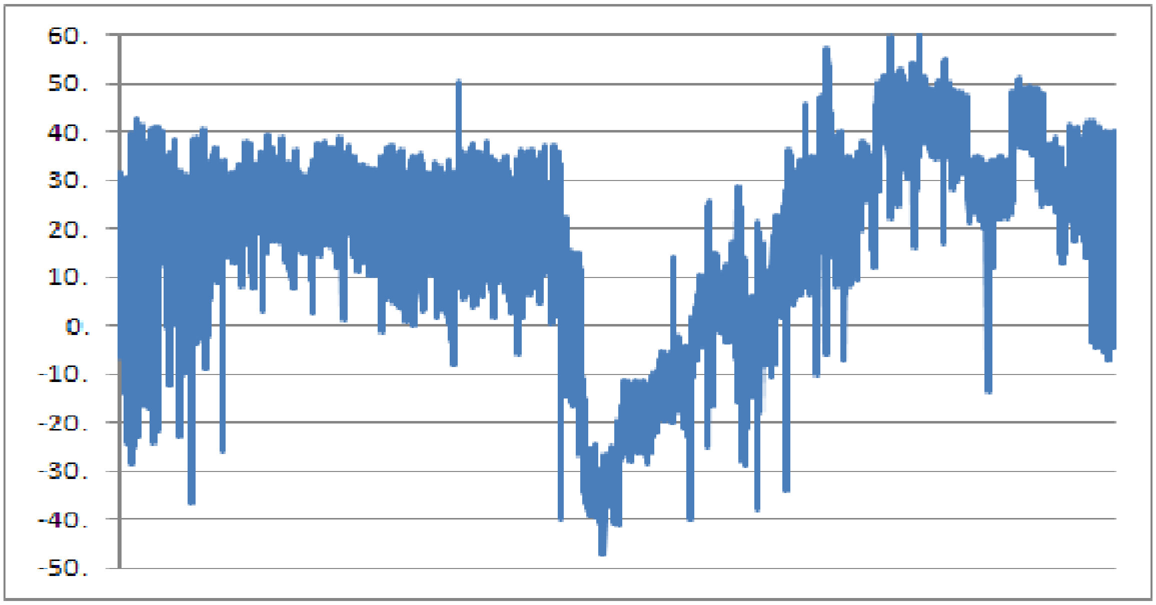

Figure 5: E4D - Active Power Flow (MW)

For the study, initial active flow into Ear Falls = 57 MW

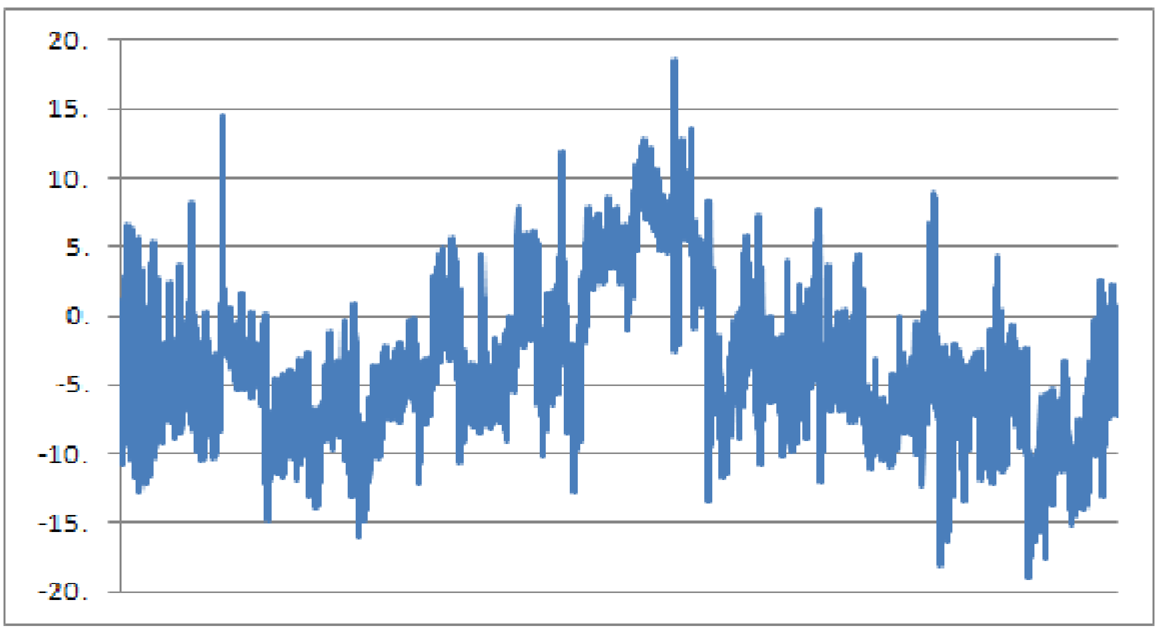

Figure 6: E4D - Reactive Power Flow (Mvar)

For the study, initial reactive flow out of Ear Falls = 23 Mvar

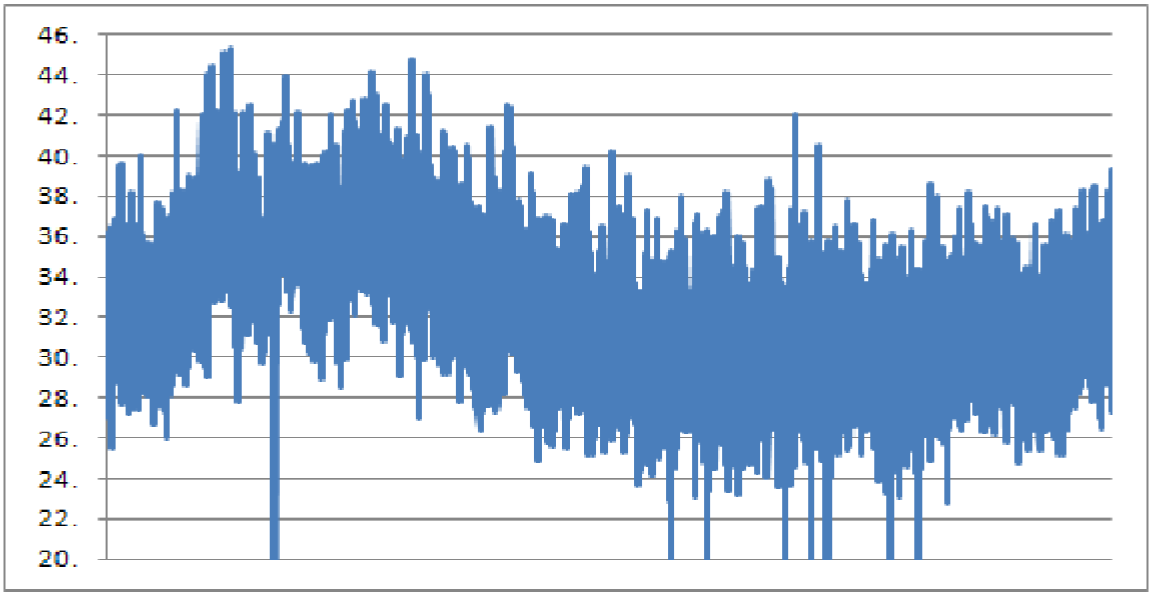

Figure 7: Red Lake Load (MW)

Average load = 32.5 MW. For the study, peak value of load = 45.5 MW

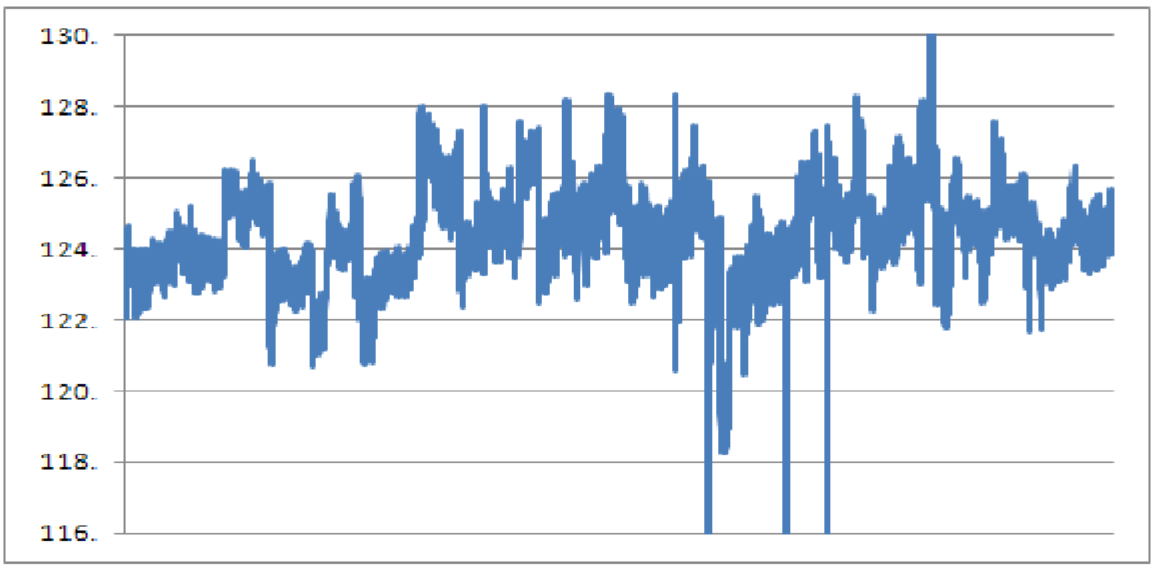

Figure 8: Ear Falls TS Voltage (115kV)

Average voltage is 124 kV. For the study, initial starting voltage is 126.5 kV.

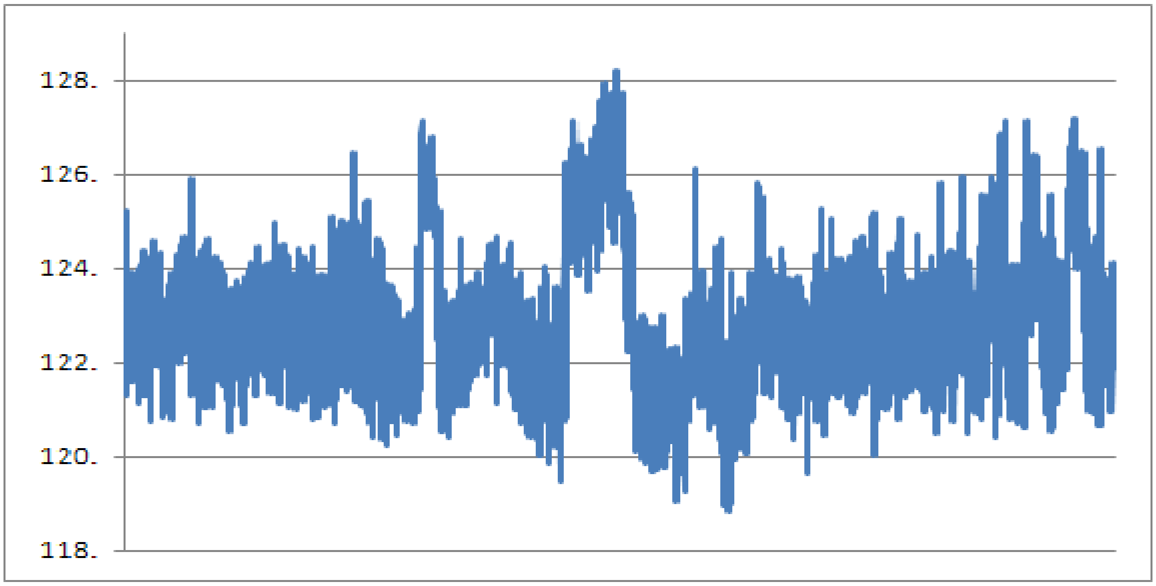

Figure 9: Dryden TS Voltage (115kV)

Average voltage = 123 kV. For the study, initial starting voltage is 125 kV.

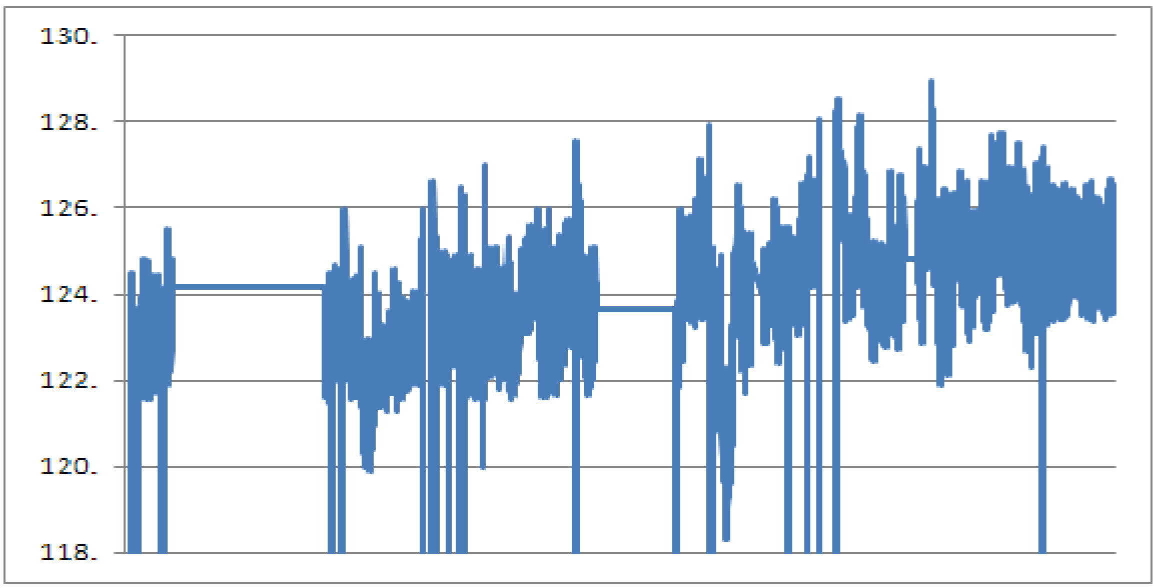

Figure 10: Musselwhite Mine Voltage (115 kV)

Average voltage = 123.5 kV

4.3 Generation Assumptions

Figure 11 below indicates that for the four consecutive summers from 2006 to 2009, the dependable hydro-electric generation into Ear Falls TS for at least 98% of the time was one Manitou Falls unit and one Ear Falls unit, with an output of 18.8 MW (Figure 12). Although the Northwest zone is generally winter peaking, the summer case was studied due to a higher likelihood of lower water conditions that would reduce the hydro-electric generation available in the zone. Also, line ratings are substantially reduced during summer while the load peaks in the Ear Falls area are not significantly lower. Based on historical data, one Manitou Falls unit and one Ear Falls unit were assumed to be in service, corresponding to the 98th percentile dependable water conditions, per section 2.6 of the ORTAC.

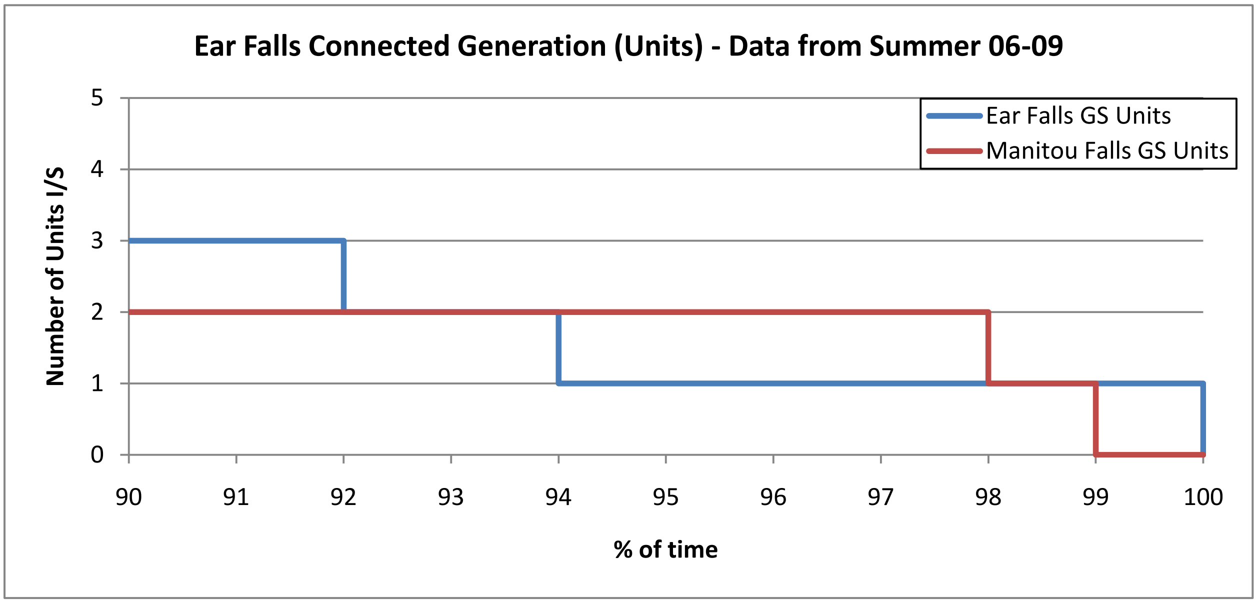

Figure 11: Ear Falls TS connected generation (no. of units)

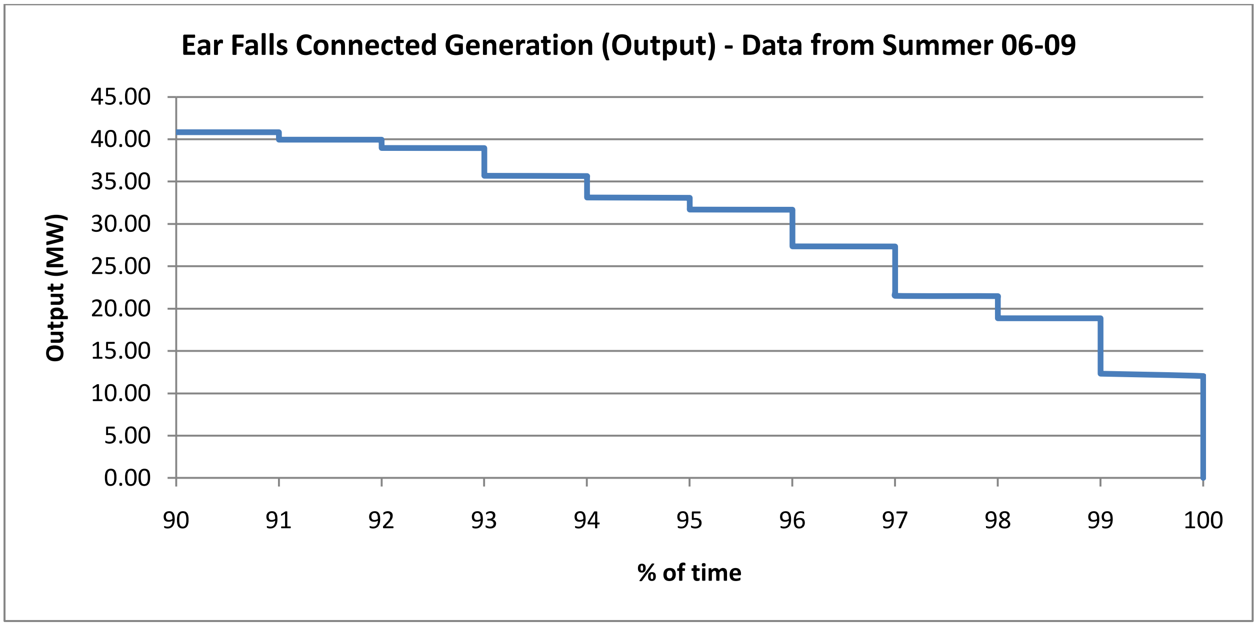

Figure 12: Ear Falls TS connected Generation (Output - MW)

From the above figures 3 - 12, the following can be observed:

Bus	Average Voltage
Ear Falls TS (115kV)	124 kV
Dryden TS (115kV)	123 kV
Musselwhite TS (115kV)	123.5 kV

Table 2: Average voltages at main stations

Quantity	Maximum	Average
Active Flow on E1C out of Ear Falls	22.7 MW	17 MW
Reactive Flow on E1C into Ear Falls	18.4 Mvar	15.5 Mvar
Active Flow on E4D out of Ear Falls	60.2 MW	19.3 MW
Active Flow on E4D into Ear Falls	47.2 MW	19.3 MW
Red Lake Load	45.5 MW	32.5 MW

Table 3: Flows on circuits E1C, E4D and Red Lake load

Quantity	Generation (98% dependable)	No. of Units (98% dependable)
Generation out of Ear Falls	18.5 MW	1 + 1 (8.47 Mvar)

Table 4: Dependable generation output connected at Ear Falls TS

4.4 Load Forecast

The peak load forecast for stations located in the Ear Falls area used in this study were provided by Hydro One (Table 5). They are based on the most recent peak load recorded at each station plus a reasonable margin to account for growth, measurement, and simulation inaccuracies. A 0.90 lagging power factor, as required under section 2.4 of the ORTAC, was assumed for the loads at all stations in the area.

Station	Peak Load (MW)	Station	Peak Load (MW)
Dryden TS	20.7	Sam Lake DS	23.5
Ear Falls DS	5.8	Cat Lake MTS	0.4
Slate Falls DS	0.4	Weyerhauser D	4.3
Vermilion Bay DS	3.8	Agimak DS	4.4
Crow River DS	1.9	Valora DS	0.7
Eton DS	4.2	Red Lake TS	45.5
Perrault Falls DS	0.3	Musselwhite CTS	18.0

Table 5: Loads in Ear Falls area.

4.5 Line ratings

The circuit ratings used in the thermal assessment were provided by Hydro One and are summarized in the following table below:

Circuit	Thermal Rating at 30°C ambient temperature & 4km/hr wind			
	Continuous		LTE	
	Amperes	MVA	Amperes	MVA
E1C	220 A	(47 MVA)	220 A	(47 MVA)
M1M	340 A	(69.5 MVA)	340 A	(69.5 MVA)
E4D	470 A	(96 MVA)	470 A	(96 MVA)
E2R	420 A	(86 MVA)	420 A	(86 MVA)

Table 6: Line Ratings

4.6 Study assumptions

The following new facilities were assumed in service:

Project	Facility Type	CAA ID
Fort Frances Capacitor	Transmission	2005-195
Dryden Capacitor	Transmission	2008-352
Longlac Refurbishment	Transmission	2007-EX360
Greenwich	Generation (Wind)	2008-337

Table 7: New Facilities Added to the Summer 2010 Case

During the analysis the following assumptions were used:

1. Generation at Manitou and Ear Falls = one unit at each plant (controlling terminal voltages at 1.05 p.u).
2. The existing Musselwhite mine SVC is controlling the low voltage bus at 4.16 kV (1.0 p.u).
3. Shunt capacitors at Red Lake (4x5.5Mvar, 1x5 Mvar) in service.
4. Reactors at MacKenzie (40 Mvar) and Fort Frances (36 Mvar) out of service.
5. Atikokan generation was used to supply the assumed load increase.

6. Initial load at Musselwhite and Esker was assumed as 10 MW and 8 MW, respectively. Subsequent studies in this report assumed loads fixed 10 MW at Musselwhite with the remainder of the total load at Esker.

– End of Section –

5. System Impact Studies

5.1 Description

This connection assessment was performed to identify the impact of the proposed Esker substation, on the thermal loading and voltage performance of the IESO-controlled grid.

5.2 Study Criteria

The requirements described below are from the Ontario Resource and Transmission Assessment Criteria (ORTAC) and were adhered to in the study:

- Section 4.2: Pre-contingency voltages for 230 kV buses must be within 220 kV and 250 kV, while for 115 kV buses must be within 113 kV and 132 kV.

- Section 4.3: Post-contingency voltages following a contingency are to be within 207 kV and 250 kV for 230 kV buses and 108 kV and 127 kV for 115 kV buses. In addition, the voltage change from pre-contingency to post-contingency should be less than 10%. A constant MVA load model should be used. If the pre-ULTC voltage change exceeds the prescribed limits a voltage dependent load model can be used.

  Also, after corrective actions are taken, the system must return to within the maximum and minimum continuous voltages identified in Section 4.2 of the ORTAC.

- Section 4.3.2: Capacitive devices should be sized to ensure that voltage declines or rises at delivery point buses on switching operations will not exceed 4% of steady state rms voltage for line switching operations per Chapter 4 of the Market Rules. This 4% is based on load flows before tap changer action using the voltage dependent load model specified in section 2.4 of the ORTAC.

- Section 4.5.1: The maximum acceptable pre-contingency power transfer identified in this study is the lesser of :

  - a pre-contingency power transfer that is 10% lower than the voltage instability point of the pre-contingency P-V curve
  - a pre-contingency power transfer that results in a post-contingency power flow that is 5% lower than the voltage instability point of the post-contingency P-V curve

- Section 4.7.2: All line and equipment loads shall be within their continuous ratings with all elements in service and within their long-term emergency ratings with any one element out of service. Immediately following contingencies, lines may be loaded up to their short-term emergency ratings (STE) where control actions are available to reduce the loading to the long-term emergency ratings (LTE).

The following requirement from the Transmission System Code, Appendix 2, was adhered to:

	Voltage flicker shall be limited as tabulated	
	Magnitude (%)	Limit
Reference 5	0.5	3 per second
	1.0	20 per minute
	2.0	45 per hour
	3.0	4 per day

Table 8: Transmission System Connection Point Performance Standards (Reference 5)

5.3 System Conditions

- The studies were performed assuming extreme weather summer conditions due to the more limited thermal capability of the lines. Although the Northwest zone is generally winter peaking, line ratings are substantially reduced during summer while the peak loads in the area are not significantly different between summer and winter.
- Generation, voltages and loads were set to historical values as described in Section 4.1 of this report.
- A 0.90 lagging power factor, as required under section 2.4 of the ORTAC, was assumed for the loads at all stations in the area from Dryden TS to Musselwhite/Esker area and Red Lake area. Loads, as shown in Section 4.4 of this report, Table 5, were modeled as constant MVA loads. Where permitted by the criteria, a variable load model was utilized.
- All existing transmission system elements were assumed in service.
- Red Lake TS was set to operate close to unity power factor on the HV side of the transformer based on findings from the System Impact Assessment: *" Red Lake TS: Refurbish 115/44 kV TS and Load Increase (CAA 2006-228)"*.

5.4 Thermal Loading Assessment

The purpose of this assessment is to determine the impact of the new Esker substation on the thermal loadings of the lines, namely E1C, E2R, and E4D. The criteria for the assessment are:

a) With all elements in service, equipment loadings shall be within the Continuous ratings.

b) With any one element out of service, equipment loadings shall be within the Long-term Emergency ratings (LTE), per Section 4.7.2 of ORTAC.

The thermal ratings used for the existing transmission elements (conductors) are displayed in Section 4.5, Table 6 of this report. The percentage loading of the equipment is calculated as follows:

$$\%Loading = \frac{\text{(Equipment Loading)}}{\text{Equipment Rating}} \text{ x } 100$$

The loadings and ratings are in amperes for conductors. The results for the thermal loading assessment are presented in Appendix A. The results for the thermal loading assessment presented in Appendix A1 show that the loadings of all sections of the monitored circuits are within acceptable limits with the proposed

Esker substation connected to the M1X circuit. Circuit E4D was the highest loaded section at 66.8% of its continuous rating. Circuit E1C was loaded at 62.5% of its rating. Appendix A2 shows that for the most limiting contingency, loss of one Manitou Falls unit in service, circuit E4D and circuit E1C were loaded at 84.4% and 71.8% of their continuous ratings, respectively. The critical elements are within their continuous ratings following the contingency.

The thermal loading assessment shows that the pre-contingency and post-contingency thermal loadings of the critical elements are within acceptable limits with the Esker substation in service.

5.5 System Voltage Assessment

The purpose of this section of the assessment is to determine the effect of the new Esker substation on the system voltages with all elements in service and following the loss of one Manitou Falls unit in service, which was identified to have the highest impact on the system voltages in the area. The percentage change in voltage is calculated as follows:

$$\%\,Voltage_{Ch} = \frac{Voltage_{Pre-contingency} - Voltage_{Post-contingency}}{Voltage_{Pre-contingency}} \text{ x } 100$$

The results for the system voltage assessments for different scenarios are presented in Appendix B.

5.5.1 Pre-Contingency Voltage Analysis

The results in Appendix B1 show that the pre-contingency voltages at all monitored elements are within the acceptable limits as per section 4.2 of the ORTAC, for the studied case with the proposed Esker substation connected to circuit M1X, with a combined loading of 18.0 MW at the Musselwhite mine complex. Voltage levels with the proposed Esker substation in service were compared with voltages of the current system having the same load of 18.0 MW at Musselwhite only. The lowest voltage level in the Ear Falls area, before adding the Esker substation, was recorded on the high voltage bus of Musselwhite SS at 118.97 kV. After adding the Esker substation, the Musselwhite SS voltage dropped by 1.06%, to 117.7 kV. The connection of this new substation impacts all station voltages on circuit E1C (please refer to Appendix B1). Additional reactive support on the load voltage bus of the Esker substation would improve the overall voltage profile.

5.5.2 Post-Contingency Voltage Analysis

Pre tap changer action

Post contingency simulations immediately following the loss of the only Manitou Falls unit in service were performed with a voltage dependent load model permitted by section 4.3 of the ORTAC. For a combined load of 18 MW at the Musselwhite mine complex, the highest voltage change was 5.3%, on the 115 kV buses at Red Lake TS and Slate Falls DS. The lowest voltage of 112.6 kV was observed on the 115 kV bus of Musselwhite SS. The voltage changes and minimum levels simulated are within section 4.3 of the ORTAC ranges. Detailed results are presented in Appendix B2.

Post tap changer action

Post contingency simulations after tap changer action were performed with a constant load model. For a combined load of 18 MW at the Musselwhite mine complex, the highest voltage change of 7.5% occurred on the 115 kV Slate Falls DS bus. The voltage at the Musselwhite SS 115 kV bus was 110 kV, which is within the limits specified in section 4.3 of the ORTAC. Detailed results are presented in Appendix B2.

However, according to the criteria mentioned in Section 5.2 of this report, after the corrective actions are taken, the system must, within 30 minutes or less, return to within the required range identified in section 4.2 of the ORTAC. Hence, following a contingency on the IESO-controlled grid (i.e. outside the Musselwhite mine complex facilities), GoldCorp Canada Ltd. must take corrective actions to restore the Musselwhite SS voltage within the 113 kV – 132 kV range. This can be achieved by either:

- utilizing the existing reactive devices, along with post-contingency load reduction at the Musselwhite mine complex (please note that if one of the existing SVCs at the Musselwhite station is unavailable, the combined load at the Musselwhite mine complex cannot exceed 16 MW even in pre-contingency; further load reductions would likely be required following the loss of a Manitou Falls unit); or
- installing and operating additional reactive compensation at the Esker substation

Studies were completed to determine the minimum amount of reactive compensation necessary to avoid post-contingency load reductions at the Musselwhite mine complex. The reactive compensation study results are presented in Section 5.6 below.

5.6 Reactive Compensation

The voltages will have to be corrected to within the required range of section 4.2 within 30 minutes of experiencing a contingency. The following studies were completed to determine the minimum amount of reactive compensation required at Esker substation to keep voltages on the IESO-controlled grid, i.e. at Musselwhite SS, within the range specified in section 4.2 of the ORTAC, if load reduction at the Musselwhite mine complex is not desired.
Assuming the inability to reduce load within 30 minutes following a contingency, the studies were performed in pre-contingency conditions in anticipation of the loss of the single Manitou Falls unit in service.

Voltage Stability Analysis

A Power-Voltage (P-V) analysis was performed to identify the maximum power transfers allowed under section 4.5.1 of the ORTAC. The P-V curve (Figure 13) for the main stations connected to E1C following the loss of the single Manitou Falls unit in service is shown below. The Musselwhite SS post-contingency voltage corresponding to 18 MW of combined load at Musselwhite/Esker is below the minimum voltage, per section 4.2 of the ORTAC. Again, assuming there is no ability for load reduction at the Musselwhite mine complex, this indicates the need for additional reactive compensation at the new station. The combined Musselwhite/Esker load could not be operated above a maximum of 16.8 MW without reactive compensation. Detailed results of the study are presented in Appendix B3 and B4.

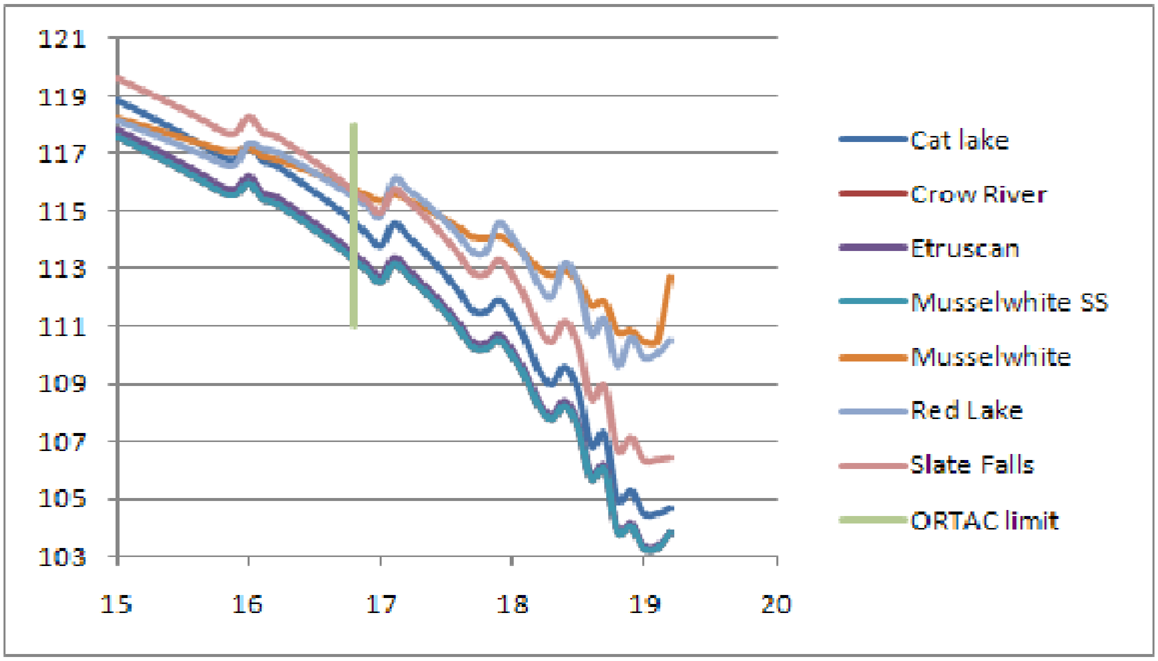

Figure 13: P – V curve following the loss of one Manitou Falls unit in service

Further tests indicate that a minimum of 10 Mvar of additional reactive compensation is required at the Esker station to supply 18 MW of combined load at the Musselwhite/Esker complex such that the minimum voltage criteria is met following the loss of one Manitou Falls unit in service. Figure 14 below shows the results of the P-V analysis with 10 Mvar of additional reactive compensation at Esker. Detailed results are presented in Appendix B3.

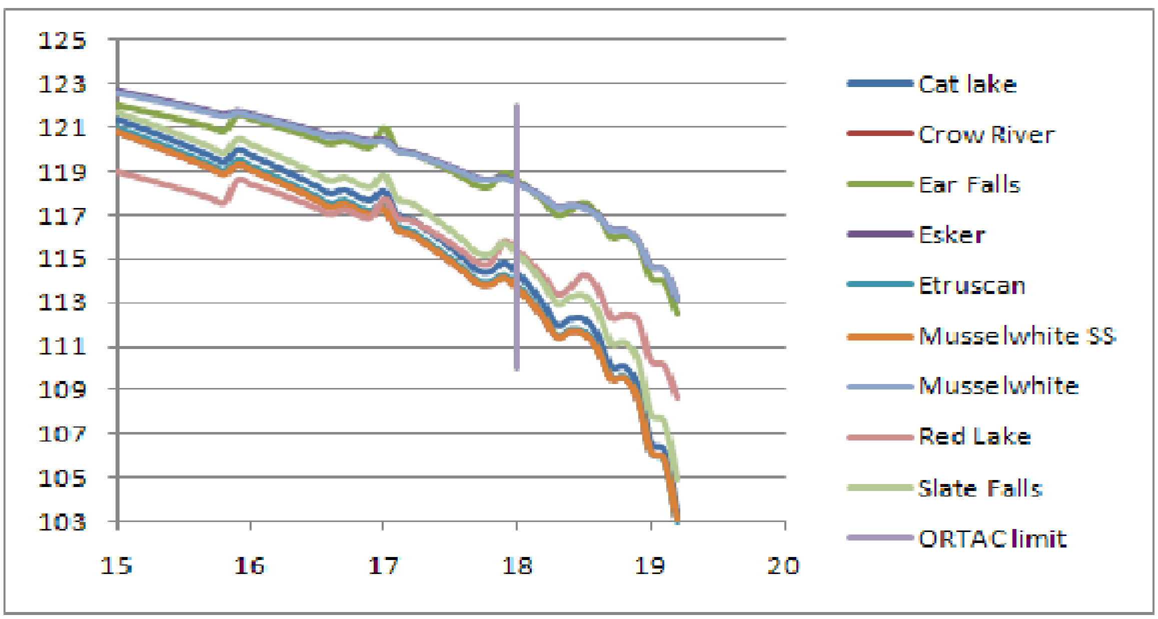

Figure 14: P – V curve following the loss of one Manitou Falls unit in service with 10.0 Mvar additional reactive compensation at the Esker substation

Switching Studies

The voltage stability analysis above indicates that 10 Mvar of additional reactive compensation is required at the Esker substation to supply combined load levels exceeding 16.8 MW. A minimum of 10 Mvar of reactive compensation is required to supply the proposed combined maximum load of 18 MW such that the Musselwhite SS voltage is kept above 113 kV. Switching studies were performed to determine the maximum capacitor bank size that does not result in voltage rises in excess of 4% of steady state rms voltage per section 4.3.2 of the ORTAC. These studies were performed close to the maximum combined load (16.5 MW) that can be supplied without additional compensation assuming that the first block will be brought in service at this load level, in anticipation of further load increase. Appendices B5 and B6 show the detailed results.
The simulations also indicate that if 10 Mvar of reactive compensation is kept on line while the combined load drops below 14 MW, the voltages on the 115 kV circuits might exceed the maximum permissible level of 132 kV. The amount of on-line reactive compensation will have to be reduced during low load periods in order to maintain voltages within the permissible range. Details of this study results are presented in Appendix B7.

<u>10 Mvar Capacitor Bank</u>
An initial study was performed to analyze the effect of switching in one single capacitor bank of 10.0 Mvar size. This resulted in a voltage rise of 5.8% at Musselwhite SS, which exceeds the maximum allowed under section 4.3.2 of the ORTAC. Detailed results are presented in Appendix B5.

<u>5.0 Mvar Capacitor Banks</u>
A second study was conducted to investigate the effects of switching in a capacitor bank of 5.0 Mvar size. This resulted in a voltage change at Musselwhite SS of 3.3% which is within the specified limits of Section 4.3.2 of the ORTAC. Voltage changes on the Musselwhite and proposed Esker stations however, exceeded 4%. Detailed results are presented in Appendix B5.

<u>5.0 Mvar Capacitor Bank switching to support the actual Musselwhite load profile</u>
Based on recent historical data, the daily profile of the Musselwhite mine load varies frequently. Figure 15 shows a typical profile for the Musselwhite load. The load variations require capacitor switching of 4 or more times per day which, under reference 5 of appendix 2 of the TSC, cannot cause more than 3% voltage fluctuations. The 5.0 Mvar bank switching results is more than 3% voltage fluctuations, indicating that a lower capacitor bank size is likely to be required.

<u>3.33 Mvar Capacitor Bank</u>
A third study was conducted to investigate the effects of switching in a capacitor bank of 3.33 Mvar size. This is expected to result in voltage changes of less than 3% at Musselwhite SS when the combined Musselwhite/Esker load is around 16.5 MW. Detailed results are presented in Appendix B6. Switching out studies, when the combined load is around 14 MW, were also performed which resulted in voltage changes of less than 3 % at Musselwhite SS. Detailed results are presented in Appendix B8.

The following analysis was performed with the assumption that reactive compensation, in lieu of load reductions, will be switched in service in a pre-contingency situation, in anticipation of the loss of one Manitou Falls unit in service. In order to estimate the number of capacitor switchings per day, tests, based on the historical load profile of Musselwhite mine, were performed to identify the combined load levels that would trigger the need for capacitor blocks switching operations. For this analysis, the capacitors are assumed switched in at 16.5 MW, just before voltages may violate limits section 4.2 of the ORTAC. After load has reached peak value with all three capacitor blocks I/S, load reductions will cause system voltages to violate section 4.2 of the ORTAC specified limit of 132 kV when capacitor banks are in service at the

Esker load side. The maximum available loads with three, two, or one capacitor blocks in service, that would not cause system voltages to violate section 4.2 of the ORTAC, were determined at the Musselwhite/Esker mine site. Table 9 below shows the likely load levels with associated number of capacitor blocks in service such that system voltages do not exceed 132 kV.

Combined Load at Musselwhite/Esker (MW)	No. of capacitor blocks I/S
14.0 < Load < 18.0	3
12.5 < Load < 14.0	2
10.5 < Load < 12.5	1
Load < 10.5	0

Table 9: Likely load levels with associated number of capacitor banks switched in service when load is reduced from peak (18 MW) with 3 x 3.33 Mvar blocks I/S

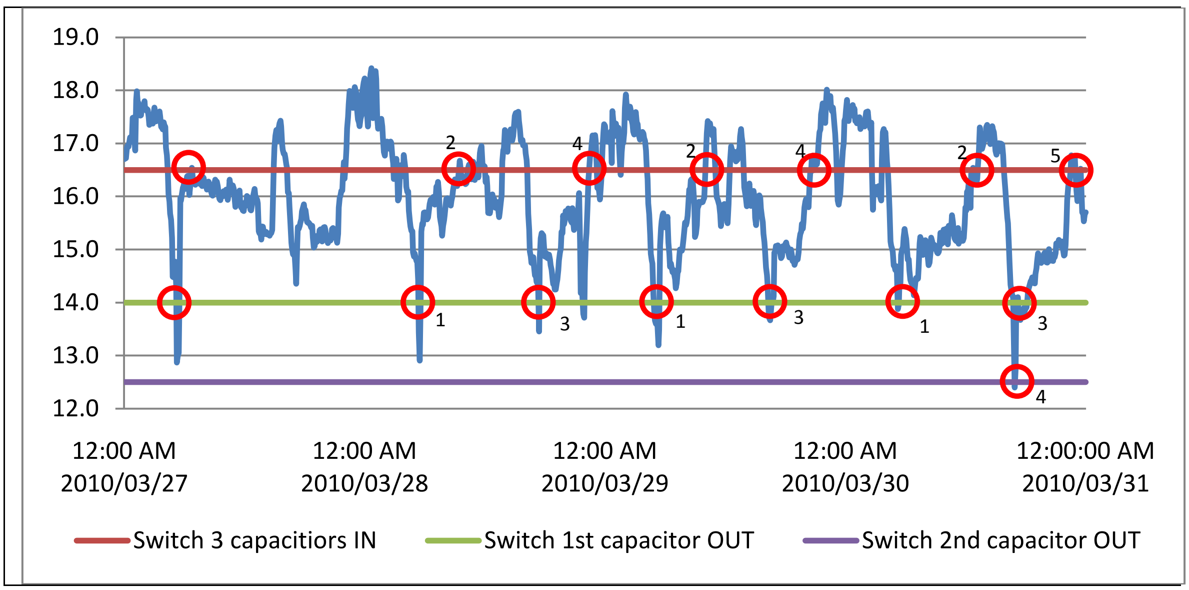

Figure 15: Load profile for Musselwhite Mine (March 27 – 30, 2010)

In Figure 15 above:

- The red line depicts the load level of 16.5 MW. For any load above 16.5 MW, up to 10 Mvar reactive compensation is required to maintain voltages on circuit E1C above section 4.2 of the ORTAC minimum voltage of 113 kV.
- The green line depicts the load level of 14 MW. For loads below 14 MW and with 3 x 3.33 Mvar blocks I/S, station voltages on circuit E1C will exceed levels above section 4.2 of the ORTAC maximum limit of 132 kV.
- The purple line depicts the load level of 12.5 MW. For loads below 12.5 MW and with 2 x 3.33 Mvar blocks I/S, station voltages on circuit E1C will violate section 4.2 of the ORTAC maximum limit of 132 kV.

Based on the analysis shown above, circles assume moments when capacitor blocks may be switched in and out. On average, more than 3 switching operations/day are required to maintain voltages within section 4.2 of the ORTAC range. Therefore the TSC voltage flicker requirement applies.

In conclusion, if additional reactive compensation is required at the Esker substation due to the inability to reduce sufficient load during a contingency situation, to bring Musselwhite SS voltages back to within the pre-contingency range, the studies indicate that 10.0 Mvar of additional reactive compensation is required to support combined Musselwhite/Esker load up to 18 MW. The largest capacitor bank size that can be switched without violating the criteria is 3.33 Mvar. The block size is limited by the maximum flicker levels per reference 5 of appendix 2 of the TSC.

The load profile of the Musselwhite mine complex shows that switching of capacitor banks in and out will be frequent during an average daily cycle. In order to reduce the number of times capacitors are switched in and out and associated voltage fluctuations during normal operations, it is recommended that GoldCorp Canada Ltd. considers installing Static Var Compensation (SVC) at Esker. A +/- 5 Mvar SVC in conjunction with a 5 Mvar capacitor bank is expected to be acceptable.

– End of Section –

Appendix A: Thermal Loading Assessment Results

Appendix A1: Thermal Assessment with Musselwhite (18.0 MW) vs. Musselwhite/Esker (18.0 MW)

Circuit	From	To	18 MW at Musselwhite		10 MW at Musselwhite + 8 MW at Esker	
			Current (A)	% Loading (%)	Current (A)	% Loading (%)
E4D	DRYDEN_TS	SCOUT_LAKE	315.04	67.03	314.08	66.83
E4D	SCOUT_LAKE	EAR_FALLS_TS	309.23	65.79	308.45	65.63
E2R	EAR_FALLS_TS	PACKWASH_J	214.32	51.01	214.95	51.16
E2R	PACKWASH_J	RED_LAKE_TS	214.01	50.94	214.68	51.10
E1C	EAR_FALLS_TS	SOUTH BAY	145.09	63.12	143.63	62.49
E1C	SOUTH BAY	SLATE_FALLS	136.32	59.30	135.20	58.82
E1C	SLATE_FALLS	CAT LAKE	128.69	55.99	127.83	55.61
E1C	CROW_RIVER	MUSSELWHITE SS	105.77	31.12	105.44	31.02
M1M	MUSSELWHITE SS	MUSSLEWHITE	105.75	35.18	105.42	35.07
M1X	MUSSELWHITE	ESKER	-	-	43.82	52.17

Appendix A2: Thermal Assessment for loss of one Manitou Falls unit in service with Musselwhite/Esker load at 18.0 MW

Circuit	From	To	Pre-contingency		Post-Contingency	
			Current (A)	% Loading (%)	Current (A)	% Loading (%)
E4D	DRYDEN_TS	SCOUT_LAKE	314.08	66.83	396.64	84.39
E4D	SCOUT_LAKE	EAR_FALLS_TS	308.45	65.63	394.73	83.98
E2R	EAR_FALLS_TS	PACKWASH_J	214.95	51.16	231.46	55.09
E2R	PACKWASH_J	RED_LAKE_TS	214.68	51.10	231.40	55.08
E1C	EAR_FALLS_TS	SOUTH BAY	143.63	62.49	165.05	71.81
E1C	SOUTH BAY	SLATE_FALLS	135.20	58.82	157.50	68.52
E1C	SLATE_FALLS	CAT LAKE	127.83	55.61	150.30	65.39
E1C	CROW_RIVER	MUSSELWHITE SS	105.44	31.02	127.40	37.48
M1M	MUSSELWHITE SS	MUSSLEWHITE	105.42	35.07	127.38	42.37
M1X	MUSSELWHITE	ESKER	43.82	52.17	45.17	53.77

Appendix A3: Thermal Assessment for loss of one Manitou Falls unit in service with Musselwhite/Esker load at 16.8 MW

Circuit	From	To	Pre-contingency		Post-Contingency	
			Current (A)	% Loading (%)	Current (A)	% Loading (%)
E4D	DRYDEN_TS	SCOUT_LAKE	303.37	64.55	378.41	80.51
E4D	SCOUT_LAKE	EAR_FALLS_TS	297.41	63.28	376.11	80.02
E2R	EAR_FALLS_TS	PACKWASH_J	213.85	50.90	228.51	54.39
E2R	PACKWASH_J	RED_LAKE_TS	213.51	50.82	228.49	54.39
E1C	EAR_FALLS_TS	SOUTH BAY	134.68	58.59	152.05	66.15
E1C	SOUTH BAY	SLATE_FALLS	125.58	54.63	143.56	62.46
E1C	SLATE_FALLS	CAT LAKE	117.88	51.28	135.91	59.13
E1C	CROW_RIVER	MUSSELWHITE SS	95.22	28.01	112.40	33.07
M1M	MUSSELWHITE SS	MUSSLEWHITE	95.20	31.67	112.38	37.38
M1X	MUSSELWHITE	ESKER	36.74	43.74	37.65	44.82

Appendix A4: Thermal Assessment for loss of one Manitou Falls unit in service with Musselwhite/Esker load at 18.0 MW and 10.0 Mvar reactive compensation at Esker load side

Circuit	From	To	Pre-contingency		Post-Contingency	
			Current (A)	% Loading (%)	Current (A)	% Loading (%)
E4D	DRYDEN_TS	SCOUT_LAKE	314.08	66.83	395.91	84.24
E4D	SCOUT_LAKE	EAR_FALLS_TS	308.45	65.63	393.55	83.73
E2R	EAR_FALLS_TS	PACKWASH_J	214.95	51.16	228.95	54.50
E2R	PACKWASH_J	RED_LAKE_TS	214.68	51.10	228.85	54.47
E1C	EAR_FALLS_TS	SOUTH BAY	143.63	62.49	168.45	73.28
E1C	SOUTH BAY	SLATE_FALLS	135.20	58.82	160.06	69.63
E1C	SLATE_FALLS	CAT LAKE	127.83	55.61	152.32	66.27
E1C	CROW_RIVER	MUSSELWHITE SS	105.44	31.02	128.32	37.75
M1M	MUSSELWHITE SS	MUSSLEWHITE	105.42	35.07	128.30	42.68
M1X	MUSSELWHITE	ESKER	43.82	52.17	48.41	57.63

Appendix B: System Voltage Assessment Results

Appendix B1: Voltage Assessment with Musselwhite (18.0 MW) vs. Musselwhite/Esker (18.0 MW)

Bus name	18 MW at Musselwhite Mine		10 MW at Musselwhite + 8 MW at Esker +0.0 Mvar		10 MW at Musselwhite+ 8 MW at Esker +3.5 Mvar	
	Voltage (p.u.)	Voltage (kV)	Voltage (kV)	% change	Voltage (kV)	% change
MANITOU FALLS	1.0764	127.07	126.69	0.30	127.06	0.00
EAR FALLS TS	1.0700	126.31	125.93	0.30	126.31	0.00
RED_LAKE_TS	1.0468	123.57	123.12	0.37	123.57	0.00
SLATE_FALLS	1.0402	122.80	122.00	0.65	122.78	0.02
CAT_LAKE_CTS	1.0268	121.22	120.21	0.83	121.18	0.03
ETRUSCAN_JNC	1.0116	119.41	118.20	1.01	119.37	0.04
CROW_RIVER	1.0078	118.97	117.72	1.06	118.92	0.04
MUSSLEWHITE	1.0073	118.92	117.27	1.39	118.82	0.08
MUSSELWHITE SS	1.0078	118.97	117.72	1.06	118.92	0.04
ESKER HV	-	-	117.17	-	118.78	-
DRYDEN_115	1.0677	126.05	125.96	0.07	126.05	-0.01
DRYDEN_ 220	1.1121	244.65	244.54	0.05	244.67	-0.01
FT_FRANCES 220	1.1059	243.30	243.27	0.01	243.31	0.00

Appendix B2: Voltage Assessment for loss of one Manitou Falls unit in service with Musselwhite/Esker load at 18.0 MW

Bus name	Pre-Contingency (constant MVA load)		Post-Contingency					
			Pre-ULTC (variable load)			Post-ULTC (constant MVA load)		
	Voltage (p.u.)	Voltage (kV)	Voltage (p.u.)	Voltage (kV)	% change	Voltage (p.u.)	Voltage (kV)	% change
MANITOU FALLS	1.0731	126.69	-	-	0.00	-	-	0.00
EAR FALLS TS	1.0668	125.93	1.0111	119.36	5.21	0.9946	117.41	6.77
RED_LAKE_TS	1.0429	123.12	0.9873	116.55	5.33	0.9665	114.09	7.33
SLATE_FALLS	1.0334	122.00	0.9784	115.50	5.33	0.9557	112.82	7.52
CAT_LAKE_CTS	1.0183	120.21	0.9670	114.15	5.04	0.9436	111.39	7.34
ETRUSCAN_JNC	1.0013	118.20	0.9561	112.86	4.52	0.9337	110.23	6.75
CROW_RIVER	0.9972	117.72	0.9536	112.57	4.37	0.9316	109.98	6.57
MUSSLEWHITE	0.9934	117.27	0.9750	115.10	1.85	0.9646	113.87	2.90
MUSSELWHITE SS	0.9972	117.72	0.9536	112.58	4.37	0.9317	109.98	6.57
ESKER HV	0.9926	117.17	0.9742	115.01	1.85	0.9638	113.77	2.90
DRYDEN_115	1.0670	125.96	1.0523	124.23	1.37	1.0534	124.36	1.27
DRYDEN_230	1.1115	244.54	1.1002	242.05	1.02	1.0894	239.68	1.99
FT_FRANCES 230 kV	1.1058	243.27	1.1027	242.59	0.28	1.1000	242.00	0.52

Appendix B3: Voltage Assessment for loss of one Manitou Falls unit in service with Musselwhite/Esker load at 18.0 MW and with/without 10.0 Mvar reactive compensation at Esker load side

Bus name	Pre-Contingency (constant MVA load)		Post-Contingency					
			Post-ULTC (0.0 Mvar)			Post-ULTC (10.0 Mvar)		
	Voltage (p.u.)	Voltage (kV)	Voltage (p.u.)	Voltage (kV)	% change	Voltage (p.u.)	Voltage (kV)	% change
MANITOU FALLS	1.0731	126.69	-	-	-	-	-	-
EAR FALLS TS	1.0668	125.93	0.9946	117.41	6.77	1.0048	118.62	5.80
RED_LAKE_TS	1.0429	123.12	0.9665	114.09	7.33	0.9775	115.39	6.28
SLATE_FALLS	1.0334	122.00	0.9557	112.82	7.52	0.9762	115.24	5.54
CAT_LAKE_CTS	1.0183	120.21	0.9436	111.39	7.34	0.9689	114.38	4.85
ETRUSCAN_JNC	1.0013	118.20	0.9337	110.23	6.75	0.9638	113.78	3.74
CROW_RIVER	0.9972	117.72	0.9316	109.98	6.57	0.9628	113.66	3.45
MUSSLEWHITE	0.9934	117.27	0.9646	113.87	2.90	1.0034	118.45	-1.01
MUSSELWHITE SS	0.9972	117.72	0.9317	109.98	6.57	0.9628	113.66	3.45
ESKER HV	0.9926	117.17	0.9638	113.77	2.90	1.0037	118.49	-1.13
DRYDEN 115kV	1.0670	125.96	1.0534	124.36	1.27	1.0560	124.66	1.03
DRYDEN 230kV	1.1115	244.54	1.0894	239.68	1.99	1.0913	240.09	1.82
FT_FRANCES 230kV	1.1058	243.27	1.1000	242.00	0.52	1.1006	242.12	0.47

Appendix B4: Loss of one Manitou Falls unit in service with Musselwhite/Esker = 16.8 MW

Bus name	Pre-Contingency (constant MVA load)		Post-Contingency					
			Pre-ULTC (variable load)			Post-ULTC (constant MVA load)		
	Voltage (p.u.)	Voltage (kV)	Voltage (p.u.)	Voltage (kV)	% change	Voltage (p.u.)	Voltage (kV)	% change
MANITOU FALLS	1.0788	127.35	-	-	-	-	-	-
EAR FALLS TS	1.0724	126.60	1.0217	120.61	4.73	1.0066	118.83	6.14
RED_LAKE_TS	1.0497	123.91	0.9989	117.92	4.84	0.9780	115.46	6.83
SLATE_FALLS	1.0471	123.61	0.9988	117.91	4.61	0.9804	115.73	6.38
CAT_LAKE_CTS	1.0341	122.07	0.9895	116.81	4.31	0.9711	114.64	6.09
ETRUSCAN_JNC	1.0181	120.19	0.9792	115.60	3.82	0.9619	113.56	5.52
CROW_RIVER	1.0141	119.71	0.9767	115.30	3.69	0.9597	113.30	5.36
MUSSLEWHITE	1.0040	118.53	0.9884	116.68	1.56	0.9805	115.75	2.35
MUSSELWHITE SS	1.0141	119.71	0.9767	115.30	3.69	0.9598	113.30	5.35
ESKER HV	1.0034	118.45	0.9877	116.60	1.56	0.9798	115.67	2.35
DRYDEN_115kV	1.0688	126.18	1.0554	124.58	1.26	1.0572	124.81	1.09
DRYDEN_230kV	1.1130	244.87	1.1026	242.57	0.94	1.0924	240.33	1.85
Ft. FRANCES 230 kV	1.1062	243.36	1.1034	242.74	0.26	1.1008	242.18	0.49

Appendix B5: Switching Studies for proposed 10 Mvar and 5 Mvar capacitor banks at Esker station load side with Musselwhite/Esker = 16.5 MW

Bus name	Pre-Switching		Post-Switching			
			10.0 Mvar		5.0 Mvar	
	Voltage (p.u.)	Voltage (kV)	Voltage (kV	% change	Voltage (kV	% change
MANITOU FALLS	1.0797	127.45	128.34	-0.70	128.08	-0.49
EAR FALLS TS	1.0733	126.70	127.62	-0.72	127.35	-0.51
RED_LAKE_TS	1.0507	124.04	124.96	-0.74	124.69	-0.52
SLATE_FALLS	1.0498	123.93	126.39	-1.98	125.59	-1.33
CAT_LAKE_CTS	1.0373	122.45	126.57	-3.36	124.96	-2.05
ETRUSCAN_JNC	1.0216	120.60	127.03	-5.32	124.24	-3.02
CROW_RIVER	1.0176	120.13	127.13	-5.83	124.05	-3.26
MUSSLEWHITE	1.0064	118.80	134.06	-12.84	126.61	-6.57
MUSSELWHITE SS	1.0176	120.13	127.14	-5.83	124.05	-3.26
ESKER HV	1.0058	118.73	134.12	-12.96	126.60	-6.63
ESKER LV	0.9750	13.80	15.84	-17.79	14.83	-10.29
DRYDEN_115	1.0691	126.21	126.27	-0.05	126.30	-0.07
DRYDEN_ 220	1.1133	244.92	244.89	0.01	245.00	-0.03
FT_FRANCES 220.00	1.1063	243.38	243.36	0.01	243.40	-0.01

Appendix B6: Switching Studies for proposed 3.33 Mvar, 2.5 Mvar capacitor banks at Esker station load side with Musselwhite/Esker = 16.5 MW

Bus name	Pre-Switching		Post-Switching			
			3.33 Mvar		2.5 Mvar	
	Voltage (p.u.)	Voltage (kV)	Voltage (kV	% change	Voltage (kV	% change
MANITOU FALLS	1.0797	127.45	127.90	-0.35	127.80	-0.27
EAR FALLS TS	1.0733	126.70	127.16	-0.36	127.06	-0.28
RED_LAKE_TS	1.0507	124.04	124.50	-0.37	124.40	-0.29
SLATE_FALLS	1.0498	123.93	125.11	-0.95	124.84	-0.73
CAT_LAKE_CTS	1.0373	122.45	124.20	-1.43	123.79	-1.09
ETRUSCAN_JNC	1.0216	120.60	123.10	-2.07	122.50	-1.57
CROW_RIVER	1.0176	120.13	122.81	-2.23	122.16	-1.69
MUSSLEWHITE	1.0064	118.80	124.02	-4.39	122.71	-3.29
MUSSELWHITE SS	1.0176	120.13	122.81	-2.23	122.16	-1.69
ESKER HV	1.0058	118.73	123.99	-4.43	122.67	-3.32
ESKER LV	0.9750	13.80	14.49	-7.72	14.32	-6.44
DRYDEN_115	1.0691	126.21	126.28	-0.06	126.27	-0.04
DRYDEN_220	1.1133	244.92	244.99	-0.03	244.98	-0.02
FT_FRANCES 220.00	1.1063	243.38	243.40	-0.01	243.40	-0.01

Appendix B7: Pre-contingency system voltages with Musselwhite/Esker load < 14 MW, 3x3.33 Mvar capacitor banks I/S

Bus name	Musselwhite/Esker load and 3x3.33 Mvar I/S							
	13.9 MW		13.8 MW		13.7 MW		13.6 MW	
	Voltage (p.u.)	Voltage (kV)	Voltage (p.u)	Voltage (kV)	Voltage (p.u)	Voltage (kV)	Voltage (p.u)	Voltage (kV)
MANITOU FALLS	1.0957	129.35	1.0958	129.36	1.0925	128.97	1.0961	129.39
EAR FALLS TS	1.0894	128.60	1.0895	128.61	1.0862	128.23	1.0898	128.65
RED_LAKE_TS	1.0682	126.10	1.0680	126.07	1.0629	125.47	1.0671	125.97
SLATE_FALLS	1.1070	130.68	1.1085	130.86	1.1052	130.47	1.1118	131.25
CAT_LAKE_CTS	1.1121	131.28	1.1142	131.53	1.1110	131.15	1.1189	132.09
ETRUSCAN_JNC	1.1138	131.49	1.1165	131.80	1.1135	131.45	1.1227	132.54
CROW_RIVER	1.1136	131.46	1.1163	131.78	1.1134	131.44	1.1229	132.56
MUSSLEWHITE	1.1280	133.16	1.1315	133.57	1.1291	133.29	1.1410	134.69
MUSSELWHITE SS	1.1136	131.46	1.1164	131.79	1.1134	131.44	1.1229	132.56
ESKER HV	1.1284	133.21	1.1319	133.62	1.1295	133.34	1.1414	134.74
ESKER LV	1.0113	13.96	1.0145	14.00	1.0125	13.97	1.0232	14.12
DRYDEN_115	1.0654	125.77	1.0654	125.77	1.0646	125.68	1.0655	125.78
DRYDEN_220	1.1217	246.76	1.1217	246.76	1.1211	246.64	1.1218	246.79
FT_FRANCES 220.00	1.1080	243.77	1.1080	243.76	1.1079	243.73	1.1081	243.77

Appendix B8: Switching OUT 1st 3.33 Mvar capacitor bank with Musselwhite/Esker load = 14MW

Bus name	Pre-Switching		Post-Switching (pre-ULTC)		Post-Switching (post-ULTC)	
	3 x 3.33 Mvar		2 x 3.33 Mvar		2 x 3.33 Mvar	
	Voltage (p.u.)	Voltage (kV)	Voltage (kV)	% change	Voltage (kV)	% change
MANITOU FALLS	1.0917	128.88	128.29	0.46	127.40	1.15
EAR FALLS TS	1.0854	128.14	127.52	0.48	126.65	1.16
RED_LAKE_TS	1.0635	125.55	124.94	0.49	123.78	1.41
SLATE_FALLS	1.0998	129.83	128.27	1.20	126.10	2.87
CAT_LAKE_CTS	1.1034	130.26	128.11	1.65	125.42	3.72
ETRUSCAN_JNC	1.1038	130.30	127.43	2.20	124.26	4.64
CROW_RIVER	1.1032	130.23	127.19	2.33	123.92	4.85
MUSSLEWHITE	1.1151	131.64	126.41	3.97	122.66	6.82
MUSSELWHITE SS	1.1032	130.23	127.20	2.33	123.92	4.85
ESKER HV	1.1155	131.68	126.42	4.00	122.67	6.84
ESKER LV	0.9995	13.79	13.17	4.52	13.71	0.63
DRYDEN_115	1.0644	125.65	125.53	0.10	125.30	0.28
DRYDEN_220	1.1209	246.60	246.46	0.06	246.12	0.20
FT_FRANCES 220.00	1.1078	243.72	243.67	0.02	243.57	0.06

Appendix B9: Pre-contingency system voltages with Musselwhite/Esker load < 12.5 MW, 2x3.33 Mvar capacitor banks I/S

Bus name	Musselwhite/Esker load and 2x3.33 Mvar I/S							
	12.4 MW		12.3 MW		12.1 MW		12.0 MW	
	Voltage (p.u.)	Voltage (kV)	Voltage (p.u)	Voltage (kV)	Voltage (p.u)	Voltage (kV)	Voltage (p.u)	Voltage (kV)
MANITOU FALLS	1.0977	129.58	1.0986	129.69	1.0952	129.29	1.0979	129.61
EAR FALLS TS	1.0914	128.84	1.0923	128.95	1.0889	128.55	1.0916	128.87
RED_LAKE_TS	1.0706	126.38	1.0717	126.51	1.0661	125.85	1.0692	126.22
SLATE_FALLS	1.1111	131.16	1.1127	131.36	1.1107	131.11	1.1156	131.69
CAT_LAKE_CTS	1.1156	131.69	1.1175	131.92	1.1160	131.75	1.1219	132.44
ETRUSCAN_JNC	1.1158	131.72	1.1179	131.97	1.1171	131.88	1.1240	132.68
CROW_RIVER	1.1151	131.63	1.1172	131.89	1.1166	131.81	1.1236	132.64
MUSSLEWHITE	1.1189	132.09	1.1211	132.34	1.1216	132.40	1.1302	133.43
MUSSELWHITE SS	1.1151	131.63	1.1172	131.89	1.1166	131.81	1.1236	132.65
ESKER HV	1.1191	132.10	1.1212	132.35	1.1217	132.42	1.1304	133.44
ESKER LV	1.0096	13.93	1.0000	13.80	1.0007	13.81	1.0085	13.92
DRYDEN_115	1.0662	125.86	1.0665	125.90	1.0657	125.80	1.0663	125.88
DRYDEN_220	1.1224	246.93	1.1226	246.97	1.1220	246.84	1.1225	246.95
FT_FRANCES 220.00	1.1082	243.81	1.1083	243.82	1.1081	243.78	1.1083	243.82

Appendix B10: Switching OUT 2nd 3.33 Mvar capacitor bank with Musselwhite/Esker load = 12.5MW

Bus name	Pre-Switching		Post-Switching (pre-ULTC)		Post-Switching (post-ULTC)	
	2 x 3.33 Mvar		1 x 3.33 Mvar		1 x 3.33 Mvar	
	Voltage (p.u.)	Voltage (kV)	Voltage (kV)	% change	Voltage (kV)	% change
MANITOU FALLS	1.0948	129.24	128.54	0.54	127.57	1.29
EAR FALLS TS	1.0885	128.49	127.78	0.56	126.82	1.30
RED_LAKE_TS	1.0671	125.97	125.26	0.57	124.00	1.57
SLATE_FALLS	1.1057	130.53	128.73	1.38	126.72	2.92
CAT_LAKE_CTS	1.1092	130.94	128.50	1.86	126.08	3.71
ETRUSCAN_JNC	1.1083	130.84	127.66	2.43	124.87	4.57
CROW_RIVER	1.1074	130.72	127.38	2.56	124.50	4.76
MUSSLEWHITE	1.1095	130.97	125.46	4.21	122.30	6.62
MUSSELWHITE SS	1.1074	130.73	127.38	2.56	124.50	4.76
ESKER HV	1.1096	130.99	125.44	4.24	122.28	6.65
ESKER LV	1.0010	13.81	13.16	4.75	13.77	0.33
DRYDEN_115	1.0655	125.78	125.63	0.12	125.38	0.32
DRYDEN_220	1.1218	246.81	246.61	0.08	246.27	0.22
FT_FRANCES 220.00	1.1081	243.77	243.70	0.03	243.61	0.07

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