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# REPORT

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## System Impact Assessment Report

### CONNECTION ASSESSMENT & APPROVAL PROCESS

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**Project:** *Third Line T.S. 115 kV Refurbishment*

**Applicant:** Great Lakes Power Limited – Transmission  
Division

*CAA ID 2009-355*

Final Report

Market Facilitation Department

July 16th, 2009

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# **System Impact Assessment Report**

Third Line TS 115 kV Refurbishment

## **Acknowledgement**

The IESO wishes to acknowledge the assistance of Great Lakes Power Limited 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 approval or disapproval of the proposed connection under Chapter 4, section 6 of the Market Rules.

Approval of the proposed connection is based on information provided to the IESO by the connection applicant and the transmitter(s) 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 the transmitter(s) at the request of the IESO. Furthermore, the connection approval is subject to further consideration due to changes to this information, or to additional information that may become available after the approval has been granted. 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, connection 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, you must be aware that the IESO may revise drafts of this report at any time in its sole discretion without notice to you. 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 it is using the most recent version of this report.

### **Transmitter(s)**

The results given in this System Impact Assessment report are based on the information available at the time of the study, suitable for a preliminary 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.

The short circuit results are only for the purpose of assessing the capabilities of existing 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 the transmitter(s) and discussed with any connection proponent upon request.

The ampacity ratings of transmission facilities are established based on assumptions used by the transmitter (s) for power system planning studies. The actual ampacity ratings during operations may be determined in realtime 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 preliminary 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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# System Impact Assessment Report

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## Summary

Great Lakes Power Limited (GLPL) is proposing a refurbishment and configuration change of the existing 115kV switchyard located at Third Line TS. This project is classified as a development project for providing enhanced system efficiency and maintaining an acceptable level of customer reliability.

## Conclusions

This System Impact Assessment has examined the impact of the proposed Third Line TS 115 kV Refurbishment, on the reliability of the IESO-Controlled grid. The studies concluded that:

1. The proposed project will not have a materially adverse impact on the reliability of the IESO-controlled grid.
2. The proposed project will improve 115 kV transmission elements connectivity and the reliability of power supply at Third Line TS under various breaker failure scenarios.
3. All the pre-contingency voltages, post-contingency voltages and voltage declines meet the requirements described in the “Ontario Resource and Transmission Assessment Criteria (ORTAC)” document.
4. No thermal overloading concerns were identified for the monitored transmission circuits in the studied scenarios. All pre and post-contingency power flows on the monitored circuits were observed to be within the applicable ratings of the circuits.
5. The IESO recognizes that Great Lakes Power Limited - Transmission Division plans to install 40 kA rated circuit breakers which do not meet maximum symmetrical values of 50kA for 115kV equipment specified in the Transmission System Code requirements. While 40 kA breakers are sufficient in meeting the present fault current levels, should future power system changes result in fault currents greater than 40 kA, Great Lakes Power Limited - Transmission Division will be required to change these circuit breakers at their expense.
6. The proposed station configuration change meets the IESO guidelines for general requirements for station layout described in the “Ontario Resource and Transmission Assessment Criteria (ORTAC)” document.

## Notification of Approval for Connection Proposal

It is recommended that Notification of Conditional Approval for connection be issued to Great Lakes Power Limited – Transmission Division, subject to IESO’s Requirements for Connection listed below, and any further requirements that may be identified by GLPL in the Customer Impact Assessment.

## **IESO's Requirements for Third Line T.S. 115 kV Refurbishment Connection**

The IESO requirements for the connection of the proposed Third Line TS 115 kV Refurbishment are as follows:

- Great Lakes Power Limited – Transmission Division must ensure that the conductors used for the Main and Breaker Buses for Third Line 115 kV TS meet thermal capabilities for pre-contingency and post-contingency power flows at Third Line TS.
- Great Lakes Power Limited – Transmission Division is required to update all inputs and outputs to all of the effected Special Protection Schemes listed in section 2.4 of this report and update Facility Description Documents (FDDs) for each SPS. The updated FDDs should be sent to the IESO sufficiently (preferably 6 months) in advance of the modified SPS being deployed, in order to allow for NPCC classification.
- Great Lakes Power Limited – Transmission Division is required to update the existing UFLS facilities at Third Line TS.
- Great Lakes Power Limited – Transmission Division is required to install all the equipment needed to continuously monitor the information that is required by the IESO. The IESO will finalize items to be monitored during the IESO Facility Registration Process.
- Great Lakes Power Limited – Transmission Division must design protection systems to meet all the requirements of the Transmission System Code (TSC). They must be fully duplicated and supplied from separate batteries, and coordinated with the existing schemes.
- Great Lakes Power Limited – Transmission Division is required to initiate an assessment of the modified protection systems. Great Lakes Power Limited – Transmission Division shall identify any relay protection modifications (equipment and settings) required to incorporate the new facility. The IESO will evaluate the impact on system reliability due to any relay protection modifications and in this regard changes to functionality, timing, or reach. The IESO will not assess aspects of protection systems which are solely the accountability of Great Lakes Power Limited – Transmission Division (e.g. coordination of relay protections).
- To allow sufficient time to assess the impact on system reliability, Great Lakes Power Limited – Transmission Division must submit to the IESO any proposed relay protection changes as soon as the protection assessment for the new facility is finished but at least six (6) months before any actual changes are to be implemented on the existing protection systems.
- 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 Great Lakes Power Limited – Transmission Division to investigate other mitigating measures.

# 1. Project Description

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Great Lakes Power Limited (GLPL) is proposing a refurbishment and configuration change of the existing 115kV switchyard located at Third Line TS.

The GLPL owned portion of the IESO-controlled grid is bounded by the 230 kV L23 bus, 115 kV DL1 and KL4 buses at Wawa TS and 230 kV A and K buses at Mississagi TS. Third Line TS is connected to the Hydro One system through 230 kV circuits P21G and P22G to Mississagi TS and K24G and W23K to Wawa TS, to the Northern GLP system through 115 kV circuit No. 3 Sault and to Patrick St. / Steelton TS through 115 kV Algoma circuits No.1, No.2 and No.3.

Third Line TS 230/115 kV T1 and T2 autotransformer ULTCs and the Third Line capacitors are used to regulate the voltages in Sault Ste. Marie area. Third Line TS voltage regulation is essential as most of the customer station transformers in Sault Ste. Marie do not have ULTCs to regulate low voltages.

The GLP Area is susceptible to a variety of operational problems, including pre-contingency voltage instability and post-contingency voltage decline. As a result a number of special protection schemes used to trip breakers at Third Line TS are used to facilitate operation of the area. The armed schemes at Third Line TS include Under-Voltage Partial L/R Scheme, Under-Voltage Total L/R Scheme, GLP Instantaneous L/R Scheme, Northwestern System L/R Scheme, Under Frequency Partial Load Shedding, Under Frequency Total Load Shedding and Steelton TS Algoma Lines L/R Scheme.

The proposed Third Line TS refurbishment will address the following issues regarding the existing 115kV switchyard at Third Line TS:

- Address the end of life (EOL) station equipment (breakers and disconnect switches)
- Remove operating constraints and the risk of single contingencies removing the entire station from service (bus configuration and ratings)
- Improve the customer reliability through the reconfiguration of the 115 kV supply circuits
- Provide a configuration that can cost effectively accommodate future expansion of the station

In addition to the above issues, the configuration change will ensure that the IESO requirements for station layout as documented in the IESO document entitled “Ontario Resource and Transmission Assessment Criteria (ORTAC)” are met.

The proposed project will replace the existing fifteen (15) breaker 115 kV switchyard configuration with a new seventeen (17) breaker switchyard configuration, which will be constructed with the main buses in a north/south arrangement just west of the existing switchyard on GLPs’ existing Third Line TS property. In addition to the new breakers, six (6) new Motor Operated Air Break (MOAB) 115 kV line disconnect switches including manual interlocked ground switches, and two (2) new MOAB 115 kV transformer disconnect switches on Third Line 230/115 kV transformers T1 and T2 will be added as part of the project. These disconnect switches will allow restoration of the buses if a transformer or line is out of service for a planned or forced outage. The existing No.3 Sault, No.2 Algoma and No.3 Algoma MOAB’s

with manual ground switches will be part of the final configuration. The project will also upgrade local 115 kV protections.

A one line diagram of the existing Third Line TS is shown in Figure 1 while an overview of the existing 115 kV switchyard configuration and the proposed 115 kV switchyard configuration is provided in Figure(s) 2 and 3 respectively.

The project has an initial in-service date of September 2010 and a permanent in-service date of December 2010.

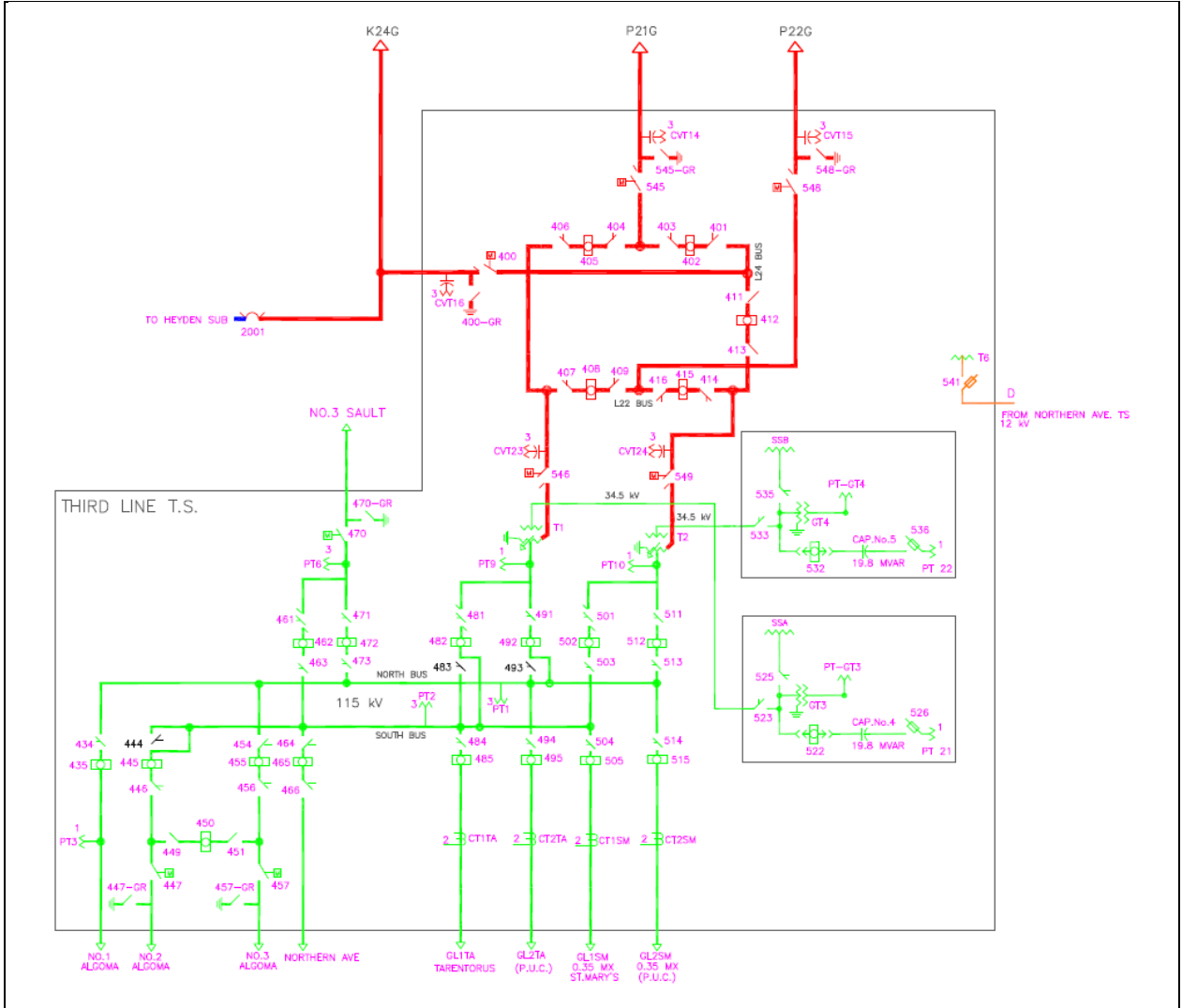


Figure 1 - Third Line TS One Line Diagram

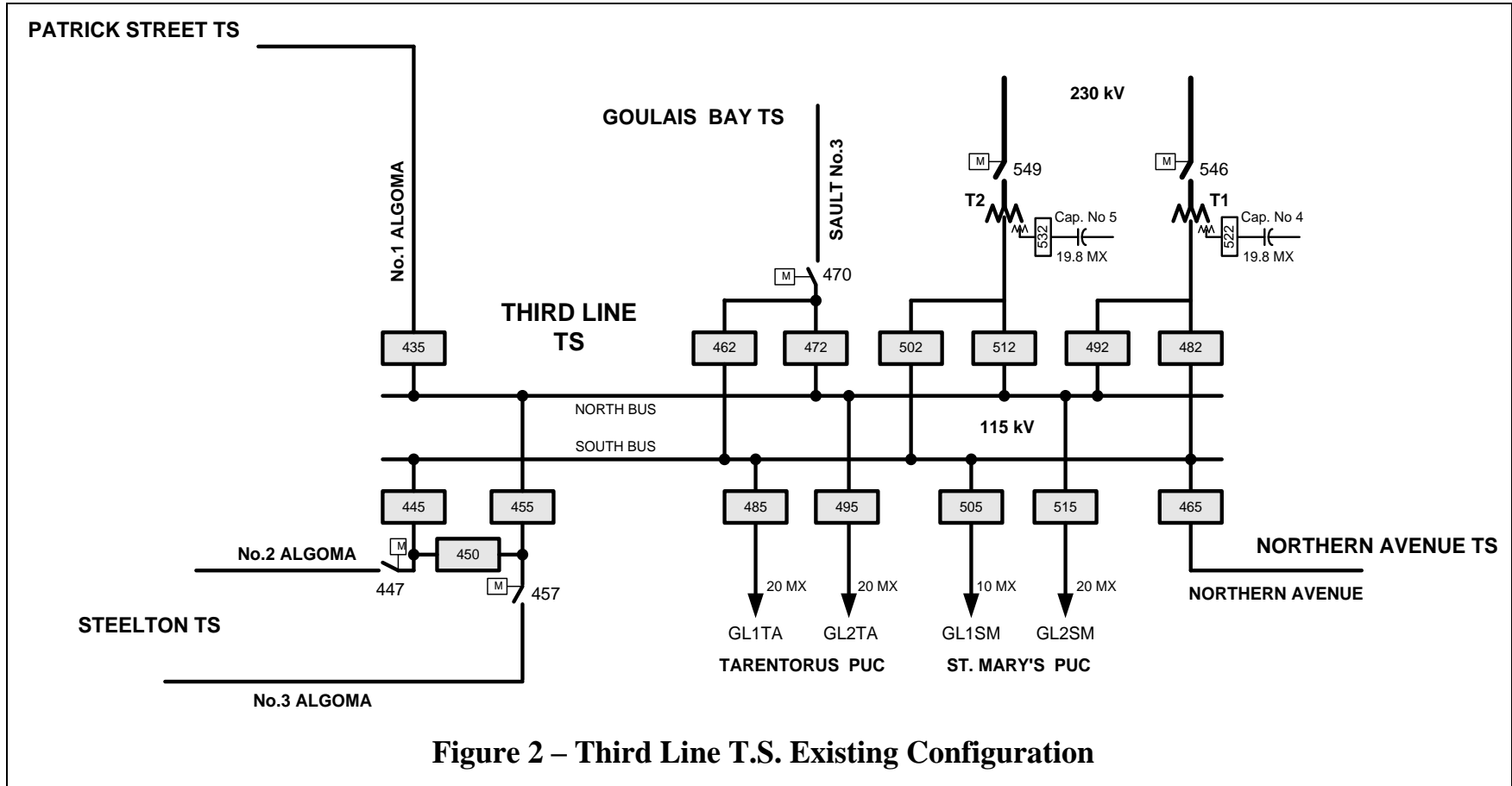


Figure 2 – Third Line T.S. Existing Configuration

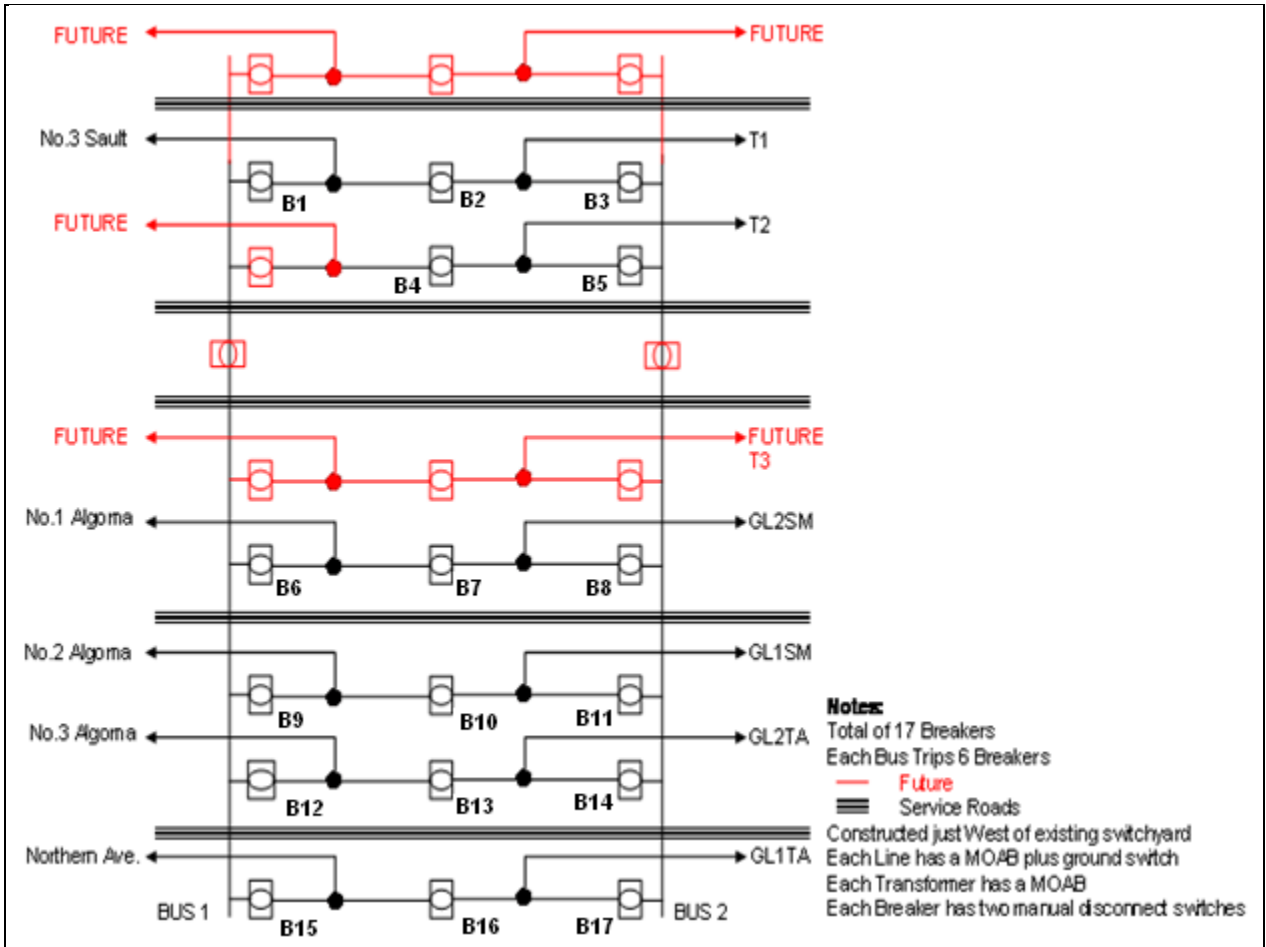


Figure 3 - Third Line TS 115 kV Proposed Configuration

**Note:** Breaker names have not been specified by GLPL, but have been labeled in Figure 3 to make referencing easier in latter sections of this report.

## 2. Review of Connection Proposal

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### 2.1 Configuration

The proposed configuration change will replace the existing 15 breaker system with a 17 breaker, one and a half breaker, system. The new configuration will ensure that each 115 kV transmission element at Third Line TS will terminate on dedicated positions on a three breaker diameter. This layout allows for the isolation of a faulted element without removing other elements from service, thus improving the reliability of operation. Also, in the event of a breaker failure, no more than one of the Algoma circuits or one of Third Line Transformers T1/T2 will be removed from service (in addition to the faulted element).

The proposed configuration change will meet all other IESO guidelines for station layout as outlined in Appendix B of “Ontario Resource and Transmission Assessment Criteria (ORTAC)”. Specifically, 6 high voltage breakers are tripped for a fault to either of the 2 buses, satisfying the IESO requirement. The proposed connection will allow for convenient future expansions of Third Line TS while still meeting IESO station layout guidelines.

### 2.2 Equipment

#### 2.2.1 Circuit Breakers

The applicant has provided the following equipment specifications for the 17 proposed breakers:

Number	17
Rated Voltage	145 kV
Interrupting Media	SF6
Interrupting Time	<50 ms
Continuous Current Rating	2000 A
Short Circuit Rating	40 kA

#### 2.2.2 Switches

The applicant has provided the following equipment specifications for all proposed switches:

Equipment	Number	Type	Rated Voltage (kV)	Cont. Current Rating (A)
Breaker Disconnect Switch	34	Manual	145	2000
Line Disconnect Switch	6	Motor Operated Air Break	145	2000
Transformer Disconnect Switch	2	Motor Operated Air Break	145	2000
Ground Disconnect Switch	6	Manual	145	N/A

Note: The applicant has indicated that the 6 manual ground disconnect switches will be interlocked with the 6 MOAB line disconnect switches.

The 6 line disconnect switches and 2 transformer switches will allow restoration of the buses if a transformer or a 115 kV line is out of service for a planned or forced outage.

### 2.2.3 Buses

The applicant has provided the following equipment specifications for the main and breaker buses:

Operating Temperature	90 °C
Conductor Size	N/A
Conductor Type	N/A

Bus conductor information has not been finalized by the applicant at the time of writing this report.

## 2.3 Protection Systems

The applicant has indicated the replacement of the following 115 kV protections with new relaying:

Equipment	New Relaying
No.3 Sault	A & B Impedance Protections plus addition of A & B Transfer Trip and Permissive Trip signals to/from MacKay TS
Northern Ave.	A & B Impedance Protections
No.1 Algoma	A & B Line Differential Protections with Impedance Back-up
No.2 Algoma	A & B Line Differential Protections with Impedance Back-up
No.3 Algoma	A & B Line Differential Protections with Impedance Back-up
GL1TA	A & B Impedance Protections
GL2TA	A & B Impedance Protections
GL1SM	A & B Impedance Protections
GL2SM	A & B Impedance Protections
Bus 1	A & B Differential Protections
Bus 2	A & B Differential Protections
T1M Bus	A & B Differential Protections
T2M Bus	A & B Differential Protections
Breakers	Breaker Failure Protections (17)

Protections information has not been finalized by the applicant at the time of writing this report.

## 2.4 Special Protection Systems (SPS)

The following SPS schemes will require modification to their inputs and/or outputs:

- Under-Voltage Partial L/R scheme
- Under-Voltage Total L/R scheme
- GLP Instantaneous L/R scheme
- Northwestern System L/R scheme
- Steelton TS Algoma Lines L/R Scheme

Under current operation, Under Voltage Partial L/R, GLP Instantaneous L/R and Northwestern System L/R are armed to trip current Third Line TS breakers 435, 445, 455, 485, 495, 505 and/or 515. The outputs of all 3 schemes would need to be modified, in order to correctly trip the appropriate breakers in the new switchyard. In addition, the input to GLP Instantaneous L/R will need modification for the detection of the loss of both Third Line transformers T1/T2.

Under Voltage Total L/R is armed to trip current Third Line TS breakers 435, 445, 455, 465, 485, 495, 505 and 515. The outputs of this scheme need modification in order to correctly trip the appropriate breakers in the new switchyard.

The inputs to Steelton TS L/R need modification in order to detect line end open (LEO) conditions at Third Line TS for the 115kV Algoma circuits. This L/R is used to trip load at Patrick St. and Clergue TS to prevent thermal overloading of the Algoma circuits.

Great Lakes Power Limited – Transmission Division is required to update all inputs and outputs to all of the effected Special Protection Schemes listed in this section of the report and update Facility Description Documents (FDDs) for each SPS. The updated FDDs should be sent to the IESO sufficiently (preferably 6 months) in advance of the modified SPS being deployed, in order to allow for NPCC classification.

## 2.5 Under Frequency Load Shedding

The GLP system has been designated as a Local Area and has been requested by the IESO to meet the requirements as outlined in the IESO Market Manual 7: System Operations Part 7.4: IESO-Controlled Grid Operating Policies section 4.5. As such, an under frequency load shedding (UFLS) facility is installed at Third Line TS. Currently, breakers 485, 495, 505 and 515 are armed for Partial UFLS and breakers 435, 445, 455, 465, 485, 495, 505 and 515 are armed for Total UFLS. The outputs for Under Frequency Partial Load Shedding and Under Frequency Partial Total Load Shedding will require modification in order to correctly trip the appropriate breakers in the new switchyard.

Great Lakes Power Limited – Transmission Division is required to update the existing UFLS facilities at Third Line TS.

## 2.6 On-line Monitoring

The Market Rules (Chapter 4 section 7.4) require that each transmitter shall provide the IESO on a continual basis with on-line monitored quantities as specified in Appendix 4.16. GLPL shall install all the necessary monitoring equipment.

The IESO requires that the following quantities at the proposed 115 kV Third Line TS switchyard be provided to the IESO on a continual basis via approved communication protocols:

1. The voltage on both 115 kV buses
2. The frequency on both 115 kV buses
3. The status of all 17 proposed new circuit breakers
4. The status of all 6 proposed new line disconnect switches
5. The status of both proposed new transformer disconnect switches
6. MW and MVAR line flows of all circuits terminating at Third Line TS

Great Lakes Power Limited – Transmission Division is required to install all the equipment needed to continuously monitor the information that is required by the IESO. The IESO will finalize items to be monitored during the IESO Facility Registration Process.
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– End of Section –

### 3. Data Verification

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As previously mentioned in section 2.1 of this report, the proposed connection arrangement meets the IESO guidelines for station layout as specified in Appendix B of “Ontario Resource and Transmission Assessment Criteria (ORTAC)”. Specifically, each transmission element is terminated in a dedicated position of a 3 breaker diameter and a maximum of 6 HV breakers are tripped for any fault at a station.

The IESO requires high voltage 115 kV connection equipment operating in Northern Ontario to continuously operate in the range between 113 kV and 132 kV (Appendix 4.1, Reference 2 of the Market Rules). In addition, connection equipment must remain in service, and not automatically trip, for voltages up to 5% above the maximum continuous rating or 138.6 kV, for up to 30 minutes, to allow the system to be re-dispatched to return voltages within their normal range. GLPL has indicated a continuous operating voltage capability of 145 kV for all 17 circuit breakers, 34 manual disconnect switches, 6 MOAB line disconnect switches, 2 MOAB transformer disconnect switches and 6 manual ground disconnect switches which meet the IESO requirements.

Great Lakes Power Limited – Transmission Division must ensure that the conductors used for the Main and Breaker Buses for Third Line 115 kV TS meet thermal capabilities for pre-contingency and post-contingency power flows at Third Line TS.

The Transmission System Code (TSC), Appendix 2 states that 115 kV fault levels can have maximum symmetrical value of 50kA. GLPL has indicated that the proposed circuit breakers have a capacity of only 40kA.

The installation of 40 kA short circuit capability circuit breakers instead of 50 kA circuit breakers is a risk assumed completely by Great Lakes Power Limited – Transmission Division. Should future system changes result in fault currents greater than 40 kA, Great Lakes Power Limited – Transmission Division will be required to change the circuit breakers at their expense.

The TSC also requires that 115 kV breakers have a rated interrupting time of five cycles (83 ms) or less. GLPL has indicated rated interrupting times of less than 50 ms (3 cycles) for all proposed breakers, which satisfies the TSC requirement and is acceptable to the IESO.

Protection systems must be designed to meet all the requirements of the Transmission System Code (TSC). They must be fully duplicated and supplied from separate batteries, and coordinated with the existing schemes.

– End of Section –

## 4. Fault Level Assessment

With no added transmission elements proposed for this project, fault current levels and local system impedances will not change. However, since GLPL has proposed to install circuit breakers with 40 kA short circuit ratings which do not meet the Transmission System Code criteria of 50 kA, fault current assessments were completed.

Previous fault level studies were completed by GLPL and included in the AELP Generation SIA. Since no transmission changes have occurred in the local GLP area since the completion of that report, the fault level results completed by GLPL and provided in that SIA have been included in this section of the report. The short circuit studies were performed with the following assumptions:

- All transmission elements, Prince Wind Farm, Algoma Steel GS and all local generation in service
- Transmission Reinforcement project and new Gartshore TS complete
- Pre-fault bus voltage: 260 kV for 230 kV buses and 132 kV for 115 kV buses
- Breaker opening time = 50 ms for asymmetrical

Table 1 summarizes the fault levels including both symmetric and asymmetric fault currents in kA at Third Line TS.

BUS BAR	Symmetrical Fault Current in kA		Asymmetrical Fault Current in kA	
	3-phase	L-G	3-phase	L-G
Third Line 230 kV	8.67	9.78	8.90	9.93
Third Line 115 kV	15.64	20.74	16.14	21.30

**Table 1 – Existing Fault Levels At Third Line TS**

The results in Table 1 show that the 40 kA breakers at Third Line TS will be able to meet current system requirements. However, any future projects incorporated into the GLP system may cause increases in fault currents, which may eventually exceed the 40 kA capability of the new breakers.

The proposed 40 kA breakers are capable of interrupting the fault current levels of the existing system at Third Line TS. Should future system changes result in fault currents greater than 40 kA, Great Lakes Power Limited – Transmission Division will be required to change the circuit breakers at their expense.

– End of Section –

## 5. Further Analysis

This connection assessment study concentrated on identifying the effects of the proposed Third Line TS 115 kV refurbishment on thermal loadings of the transmission elements at Third Line TS and system voltages for pre and post contingency situations.

### 5.1 Study Assumptions

The winter 2008-2009 base case was used as a starting point for the study. The new and existing Algoma Steel generators were modeled and then added to the Patrick St. bus. The base case was then adjusted to reflect the normal flow of power from west to east in Northern Ontario. These adjustments were made by altering system generation and load MW dispatch patterns and by phase shifter adjustment.

The amount of generation output and load demand was adjusted to stress the GLP system as greatly as possible, while still respecting local area interface flow limits. The base case was altered until both of the following operating conditions were simulated:

1. Max. 550 MW flow east at Mississagi TS on circuits A23P, A24P and X74P (MISSE Interface)  
OR  
Max. 490 MW flow east at Wawa TS on circuits P25W and P26W (WMFE Interface)  
OR  
Max. 275 MW flow east at Wawa TS on circuits W21M and W22M (EWTE Interface)
2. Max. 250 MW GLP Inflow (flow west at Mississagi on P21G and P22G plus flow into Third Line TS on K24G)

For thermal studies, the base case was altered until operating condition 1 was simulated, while for voltage studies, the base case was altered until both operating conditions 1 and 2 were simultaneously simulated. For thermal studies, the generation units at Clergue GS, Lake Superior Power, Algoma Steel GS and Prince WGS were at full output. For voltage decline studies, the Clergue GS units were at full output, the Algoma Steel GS units were operating at 80 MW output, while Lake Superior Power and Prince WGS were out of service.

The final interface flow values for each study are summarized in Table 2.

Interface	Thermal Study Flows (MW)	Voltage Study Flows (MW)	Limit (MW)*
GLP Inflow	31.7	250	250
Wawa-MacKay Flow East (WMFE)	377	368	490
East West Transfer East (EWTE)	267	270	275
Mississagi East (MISSE)	550	327	550

**Table 2 - Interface Flows**

\*Note: These values assume base limits with all elements in service and no L/R armed.

After achieving the desired interface flows, the status of reactive shunt elements and transformer tap ratios were adjusted to achieve acceptable bus voltage levels. The minimum 115 kV and 230 kV bus voltages as indicated in IESO SCOs for the GLP and NW areas are shown in Tables 3 and 4.

115 kV Station	Minimum Voltage (kV)
Third Line, MacKay	118
Wawa, Anjigami, Marathon	120

**Table 3 - Minimum 115kV Station Voltage**

230 kV Station	Minimum Voltage (kV)
Third Line, Marathon, Wawa, Mississagi, Algoma, MacKay	235

**Table 4 - Minimum 230kV Station Voltage**

The GLP area is classified as non-Bulk Power System (non-BPS) and as such only the following single contingencies are recognized:

- (i) the loss of an element without a fault, and
- (ii) a phase-to-phase to ground fault on any generator, transmission circuit, transformer or bus section with normal fault clearing.

All single element loss contingencies which were studied under steady state conditions are defined in Table 5.

No.	Definition
VC1	Loss of No. 1 Algoma (Patrick St-Third Line, 115 kV)
VC2	Loss of No. 2 Algoma (Patrick St-Third Line, 115 kV)
VC3	Loss of No. 3 Algoma (Patrick St-Third Line, 115 kV)
VC4	Loss of No. 3 Sault (Goulais Bay-Third Line 115 kV)
VC5	Loss of P21G (Third Line-Mississagi, 230 kV)
VC6	Loss of P22G (Third Line-Mississagi, 230 kV)
VC7	Loss of K24G (Third Line-MacKay, 230 kV)
VC8	Loss of Third Line Transformer T1 (230/115 kV)
VC9	Loss of Third Line Transformer T2 (230/115 kV)

**Table 5 - Single Element Contingencies**

For contingency VC5, the Wells G2 unit is removed from service by configuration while for contingency VC6 the Wells G2 unit and Echo River TS are removed from service by configuration. For contingency VC7, all the units at Prince WGS will be out of service by configuration due to the loss of K24G. The various GLP SPSs such as Under-Voltage L/R schemes and Instantaneous L/R scheme were not assumed to be armed and thus were not simulated in the studies.

## 5.2 Thermal Analysis

This section covers an investigation of the thermal capabilities of 230 kV and 115 kV circuits in the GLP area with the proposed refurbishment.

The criteria applied in assessing the thermal loading capability of the 230 kV circuits is the following:

- With all elements in-service, loading of any line or transformer shall be within their continuous rating.
- For the single circuit contingency, post-contingency flow on any circuit or transformer shall not exceed the limited time rating (LTR).

The ratings used to evaluate the thermal capability of the local transmission system were provided by GLPL and Hydro One and are shown in Tables 6 and 7.

Circuit	Continuous (A)	Continuous (MVA)	LTR (A)	LTR (MVA)
Algoma No. 1 (115 kV)	538	110	578	118
Algoma No. 2 (115 kV)	672	137	751	154
Algoma No. 3 (115 kV)	672	137	751	154
Sault No. 3 (115 kV)	464	95	479	98
P21G (230 kV)	983	392	1089	434
P22G (230 kV)	983	392	1089	434
K24G (230 kV)	1265	504	1955	779

**Table 6 – Circuit Thermal Ratings**

Transformer	ONAN (MVA)	ONAF1 (MVA)	ONAF2 (MVA)	LTR (MVA)
Third Line T1	150	200	250	340
Third Line T2	150	200	250	375

**Table 7 – Third Line Transformer Thermal Ratings**

The continuous ratings for the overhead conductors were calculated at 90°C operating temperature, with 30°C ambient temperature and 4 km/h wind speed (summer conditions). The short term emergency ratings or 15-minute Limited Time Rating (LTR) were calculated for a pre-load of 75% of the continuous ratings of the transmission lines, at 90 °C, with a 30°C ambient temperature and 4 km/h wind speed. Conversion from Amps to MVA was done using voltage bases of 118.1 kV and 230 kV.

The thermal study results including pre and post contingency flows are summarized in Table 8. The percentage of continuous ratings for pre contingency and percentage of LTRs for post-contingency flow are also shown in Table 8.

	No. 1 Algoma	No. 2 Algoma	No. 3 Algoma	No. 3 Sault	P21G	P22G	K24G	Third Line T1	Third Line T2
Pre. C.	30.4	30.4	30.4	38.7	112.2	134.0	313.7	55.2	56.8
	27.6%	22.2%	22.2%	40.7%	28.6%	34.2%	62.2%	22.1%	22.7%
VC1	-	45.0	45.0	38.7	112.1	134.0	313.7	54.9	56.5
	-	29.3%	29.3%	39.5%	25.8%	30.9%	40.3%	16.1%	15.1%
VC2	45.0	-	45.0	38.7	112.1	134.0	313.7	54.9	56.5
	38.1%	-	29.3%	39.5%	25.8%	30.9%	40.3%	16.1%	15.1%
VC3	45.0	45.0	-	38.7	112.1	134.0	313.7	54.9	56.5
	38.1%	29.3%	-	39.5%	25.8%	30.9%	40.3%	16.1%	15.1%

VC4	31.3	31.3	31.3	-	111.9	134.0	338.6	58.5	59.7
	26.5%	20.3%	20.3%	-	25.8%	30.9%	43.5%	17.2%	15.9%
VC5	27.7	27.7	27.7	35.0	-	217.4	292.5	51.7	52.8
	23.4%	18.0%	18.0%	35.7%	-	55.5%	37.5%	15.2%	14.1%
VC6	27.7	27.7	27.7	34.2	212.1	-	287.7	51.7	53.5
	23.4%	18.0%	18.0%	34.9%	48.9%	-	36.9%	15.2%	21.4%
VC7	27.6	27.6	27.6	82.6	36.4	44.8	-	50.7	53.1
	23.4%	17.9%	17.9%	84.2%	8.4%	10.3%	-	14.9%	14.2%
VC8	25.8	25.8	25.8	40.4	112.6	134.4	311.8	-	94.4
	21.8%	18.8%	18.8%	41.2%	25.9%	31.0%	40.0%	-	25.2%
VC9	25.9	25.9	25.9	40.8	112.7	134.5	311.6	94.7	-
	21.9%	16.8%	16.8%	41.6%	26.0%	31.0%	40.0%	27.9	-

**Table 8 - Pre and Post Contingency Element Loadings for Thermal Study (MVA)**

The results show that under the assumed conditions, no continuous or LTR ratings are exceeded for the studied contingencies.

No thermal overloading of any Third Line TS transmission elements' continuous rating or LTR is foreseen.

## 5.2 Voltage Analysis

The following IESO criteria must be satisfied before any new equipment is connected to the transmission system:

1. The pre-contingency voltage on 230 kV buses cannot be less than 220 kV.
2. The post-contingency voltage on 230 kV buses cannot be less than 207 kV.
3. The pre-contingency voltage on 115 kV buses cannot be less than 113 kV.
4. The post-contingency voltage on 115 kV buses cannot be less than 108 kV.
5. The voltage change following a contingency cannot exceed 10% pre-ULTC and 10% post-ULTC.

Load flow studies have been carried out for each of the contingencies defined in Table 5 of section 5.1 of this report, to examine the voltage changes at various buses in the Third Line area. The results for all defined contingencies including pre-contingency voltages, pre-ULTC voltages and post-ULTC voltages are attached in Appendix A. The pre-ULTC voltage changes are the voltage changes before the automatic movement of transformer taps and the post-ULTC voltage changes are the voltage changes after automatic tap movement.

The results in Appendix A show that the contingency with the most severe voltage change is contingency VC8. Full pre/post contingency results for this studied contingency are provided in Table 9. Please note that minus signs indicate a voltage declines.

Bus	Pre-contingency (kV)	Post-contingency			
		Pre-ULTC (kV)	Voltage Change (%)	Post-ULTC (kV)	Voltage Change (%)
Third Line 115 kV	123.2	120.2	-2.4	120.4	-2.3
Patrick St. 115 kV	122.5	119.7	-2.3	119.9	-2.1
Northern Ave. 115 kV	123.2	120.2	-2.4	120.4	-2.3

Goulais Bay 115 kV	121.7	119.2	-2.0	119.4	-1.9
MacKay 115 kV	121.0	120.3	-0.6	120.4	-0.5
Wawa 115 kV	123.6	123.3	-0.3	123.3	-0.2
St. Mary's 1 115 kV	123.1	120.2	-2.4	120.4	-2.2
St. Mary's 2 115 kV	123.1	120.2	-2.4	120.4	-2.2
Tarentorus 1 115 kV	123.2	120.2	-2.4	120.4	-2.3
Tarentorus 2 115 kV	123.2	120.2	-2.4	120.4	-2.3
Third Line 230 kV	237.6	235.6	-0.9	235.8	-0.8
MacKay 230 kV	238.0	236.6	-0.6	236.8	-0.5
Mississagi 230 kV	242.6	241.6	-0.4	241.8	-0.3
Wawa 230 kV	241.1	240.2	-0.4	240.3	-0.3

**Table 9 - Voltage Study for Contingency VC8**

The results show that even the most severe studied contingency (VC8 - the loss of Third Line T1) results in pre/post ULTC voltage changes of less than 3%, well below the 10% voltage change criteria.

All pre-contingency and post-contingency voltage performance requirements are met. There are no voltage related reliability issues foreseen.

### 5.3 Breaker Fail Analysis

The IESO recognizes that the GLP area is classified as non-BPS and as such breaker fail contingencies are not respected. However, special breaker fail contingencies were analyzed in the interest of highlighting one of the reliability benefits of the proposed project. The purpose of the analysis was to show the reduction in the number of 115 kV elements that are lost with new breaker fail scenarios, as a result of the proposed configuration change from the existing switchyard to the new switchyard.

Table 10 examines all breaker fail scenarios at the existing switchyard and lists the corresponding 115 kV transmission elements which would be lost due to a breaker failure. Table 11 performs the same analysis for the newly proposed switchyard configuration.

X = Lost Element

Contingency w/ Breaker Failure	No. 1 Algoma	No.2 Algoma	No. 3 Algoma	No.3 Sault	Northern Ave.	GL1TA	GL2TA	GL1SM	GL2SM	T1	T2
Loss of No. 1 Algoma w/ breaker 435 failure	X						X		X		
Loss of No. 2 Algoma w/ breaker 445 failure		X			X	X		X			
Loss of No. 2 Algoma w/ breaker 450 failure		X	X								
Loss of No. 3 Algoma w/ breaker 450 failure		X	X								
Loss of No. 3 Algoma w/ breaker 455 failure	X		X				X		X		
Loss of No. 3 Sault w/ breaker 462 failure				X	X	X		X			
Loss of No. 3 Sault w/ breaker 472 failure	X			X			X		X		
Loss of Northern Ave. w/ breaker 465 failure					X	X		X			
Loss of GL1SM w/ breaker 505 failure					X	X		X			

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Loss of GL2SM w/ breaker 515 failure	X						X		X		
Loss of GL1TA w/ breaker 485 failure					X	X		X			
Loss of GL2TA w/ breaker 495 failure	X						X		X		
Loss of Third Line T1 w/ breaker 482 failure					X	X		X		X	
Loss of Third Line T1 w/ breaker 492 failure	X						X		X	X	
Loss of Third Line T2 w/ breaker 502 failure					X	X		X			X
Loss of Third Line T2 w/ breaker 512 failure	X						X		X		X

**Table 10 - Existing Switchyard Breaker Fail Scenarios**

X = Lost Element

Contingency w/ Breaker Failure	No. 1 Algoma	No.2 Algoma	No. 3 Algoma	No.3 Sault	Northern Ave.	GL1TA	GL2TA	GL1SM	GL2SM	T1	T2
Loss of No. 1 Algoma w/ breaker B6 failure	X										
Loss of No. 1 Algoma w/ breaker B7 failure	X								X		
Loss of No. 2 Algoma w/ breaker B9 failure		X									
Loss of No. 2 Algoma w/ breaker B10 failure		X						X			
Loss of No. 3 Algoma w/ breaker B12 failure			X								
Loss of No. 3 Algoma w/ breaker B13 failure			X				X				
Loss of No. 3 Sault w/ breaker B1 failure				X							
Loss of No. 3 Sault w/ breaker B2 failure				X						X	
Loss of Northern Ave. w/ breaker B15 failure					X						
Loss of Northern Ave. w/ breaker B16 failure					X	X					
Loss of GL1SM w/ breaker B10 failure		X						X			
Loss of GL1SM w/ breaker B11 failure								X			
Loss of GL2SM w/ breaker B7 failure	X								X		
Loss of GL2SM w/ breaker B8 failure									X		
Loss of GL1TA w/ breaker B16 failure					X	X					
Loss of GL1TA w/ breaker B17 failure						X					
Loss of GL2TA w/ breaker B13 failure			X				X				
Loss of GL2TA w/ breaker B14 failure							X				
Loss of Third Line T1 w/ breaker B2 failure				X						X	
Loss of Third Line T1 w/ breaker B3 failure										X	
Loss of Third Line T2 w/ breaker B4 failure											X
Loss of Third Line T2 w/ breaker B5 failure											X

**Table 11 - Proposed Switchyard Breaker Fail Scenarios**

The tables above show that with the proposed switchyard configuration change, breaker fail scenarios result in the loss of a maximum of two transmission elements at Third Line TS, while with the existing switchyard a maximum of four transmission elements can be lost. In particular, with the proposed arrangement, no two Algoma circuits are lost at any given time, hence the interruption of power supply to

the Sault Ste. Marie load area would occur less often. The most severe outage possible with the proposed connection arrangement is the loss of Transformer T1 and No. 3 Sault due to failure of breaker B2 (highlighted in red in Table 9). For completeness, a voltage study was done to specifically analyze this situation. The results are provided in Table 12. Please note that minus signs indicate a voltage declines.

Bus	Pre-contingency (kV)	Post-contingency			
		Pre-ULTC (kV)	Voltage Change (%)	Post-ULTC (kV)	Voltage Change (%)
Third Line 115 kV	123.2	121.1	-1.7	121.2	-1.6
Patrick St. 115 kV	122.5	120.6	-1.6	120.7	-1.5
Northern Ave. 115 kV	123.2	121.1	-1.7	121.2	-1.6
Goulais Bay 115 kV	121.7	-	-	-	-
MacKay 115 kV	121.0	119.4	-1.3	119.4	-1.3
Wawa 115 kV	123.6	123.2	-0.3	123.2	-0.3
St. Mary's 1 115 kV	123.1	121.1	-1.6	121.2	-1.5
St. Mary's 2 115 kV	123.1	121.1	-1.6	121.2	-1.5
Tarentorus 1 115 kV	123.2	121.1	-1.7	121.2	-1.6
Tarentorus 2 115 kV	123.2	121.1	-1.7	121.2	-1.6
Third Line 230 kV	237.6	235.8	-0.8	235.9	-0.7
MacKay 230 kV	238.0	235.9	-0.9	236.0	-0.8
Mississagi 230 kV	242.6	241.5	-0.4	241.6	-0.4
Wawa 230 kV	241.1	240.0	-0.5	240.0	-0.5

**Table 12 - Voltage Study for New Breaker Fail Scenario with New Configuration**

The study results for the highlighted scenario show that pre/post ULTC voltage changes at all monitored buses are below 2%, well below the maximum 10% voltage change criteria.

Reconfiguration of the existing switchyard will improve Third Line TS transmission element connectivity and improve the reliability of power supply for the Third Line area under various breaker fail scenarios.

- End of Report -

## Appendix A – Voltage Study Results

**Table A1: Pre-ULTC Voltage Changes (in kV)**

Bus	Pre-contingency	VC1	VC2	VC3	VC4	VC5	VC6	VC7	VC8	VC9
Third Line 115 kV	123.2	0.1	0.1	0.1	0.4	-1.3	-1.0	-2.4	-3.0	-2.6
Patrick St. 115 kV	122.5	-0.1	0	0	0.4	-1.2	-0.9	-2.2	-2.8	-2.4
Northern Ave. 115 kV	123.2	0.1	0.1	0.1	0.4	-1.3	-1.0	-2.4	-3.0	-2.6
Goulais Bay 115 kV	121.7	0.1	0.1	0.1	-	-1.2	-0.9	-2.9	-2.5	-2.2
MackKay 115 kV	121.0	0.1	0.1	0.1	-1.2	-0.8	-0.6	-0.1	-0.7	-0.6
Wawa 115 kV	123.6	0.1	0.1	0.1	-0.1	-0.5	-0.4	-0.5	-0.3	-0.3
St. Mary's 1 115 kV	123.1	0.2	0.2	0.2	0.5	-1.2	-0.9	-2.3	-2.9	-2.5
St. Mary's 2 115 kV	123.1	0.2	0.2	0.2	0.5	-1.2	-0.9	-2.3	-2.9	-2.5
Tarentorus 1 115 kV	123.2	0.1	0.1	0.1	0.4	-1.3	-1.0	-2.4	-3.0	-2.6
Tarentorus 2 115 kV	123.2	0.1	0.1	0.1	0.4	-1.3	-1.0	-2.4	-3.0	-2.6
Third Line 230 kV	237.6	0.2	0.2	0.2	0.1	-3.0	-2.3	-4.2	-2.0	-2.0
MackKay 230 kV	238.0	0.1	0.1	0.1	-1.0	-2.0	-1.6	-0.4	-1.4	-1.4
Mississagi 230 kV	242.6	0.1	0.1	0.1	-0.2	0	0.9	-2.8	-1.0	-1.0
Wawa 230 kV	241.1	0.1	0.1	0.1	-0.4	-1.3	-1.1	-1.3	-0.9	-0.9

**Table A2: Post-ULTC Voltage Changes (in kV)**

Bus	Pre-contingency	VC1	VC2	VC3	VC4	VC5	VC6	VC7	VC8	VC9
Third Line 115 kV	123.2	0.1	0.1	0.1	0.4	-1.1	-0.8	-2.7	-2.8	-2.4
Patrick St. 115 kV	122.5	-0.1	-0.1	-0.1	0.4	-1.0	-0.7	-2.5	-2.6	-2.2
Northern Ave. 115 kV	123.2	0.1	0.1	0.1	0.4	-1.1	-0.8	-2.7	-2.8	-2.4
Goulais Bay 115 kV	121.7	0.1	0.2	0.2	-	-1.0	-0.7	-3.3	-2.3	-2.0
MackKay 115 kV	121.0	0.1	0.1	0.1	-1.2	-0.6	-0.4	-0.5	-0.6	-0.6
Wawa 115 kV	123.6	0.1	0.1	0.1	-0.1	-0.2	0	-0.9	-0.3	-0.3
St. Mary's 1 115 kV	123.1	0.2	0.2	0.2	0.5	-1.1	-0.7	-2.6	-2.7	-2.3
St. Mary's 2 115 kV	123.1	0.2	0.2	0.2	0.5	-1.1	-0.7	-2.6	-2.7	-2.3
Tarentorus 1 115 kV	123.2	0.1	0.1	0.1	0.4	-1.1	-0.8	-2.7	-2.8	-2.4
Tarentorus 2 115 kV	123.2	0.1	0.1	0.1	0.4	-1.1	-0.8	-2.7	-2.8	-2.4
Third Line 230 kV	237.6	0.2	0.2	0.2	0.1	-2.7	-1.8	-4.8	-1.8	-1.8
MackKay 230 kV	238.0	0.1	0.1	0.1	-1.1	-1.5	-0.9	-1.4	-1.2	-1.2
Mississagi 230 kV	242.6	0.1	0.1	0.1	-0.2	0.4	1.4	-3.6	-0.8	-0.9
Wawa 230 kV	241.1	0.1	0.1	0.1	-0.4	-0.7	-0.1	-2.5	-0.8	-0.8

Note: Minus signs indicate voltage declines while no sign indicates voltage rise.