Final Draft Report

Assessment Summary

Hydro One Networks Inc.

Longlac TS: Refurbish 115/44 kV, 25/33/42 MVA DESN Station

CAA ID Number: 2007-EX360

1.0 General Description

Hydro One is proposing to replace the existing three 5/6.67/8.33 MVA 115/44 kV singe phase step down transformers at Longlac TS with two new 115/44 kV 25/33/42 MVA three winding transformers. The tertiary winding of these three winding transformers will be buried. These new transformers will have under load tap changers and as such, the existing 44 kV voltage regulator will be removed from service. The installation of 2x5 MVar capacitor banks, SC1 and SC2, has also been proposed as part of this connection. SC1 will be connected to a series reactor to help mitigate the voltage surges due to "back-to-back switching" of the capacitors. The proposed in-service date of the refurbishment is May 31, 2010. This assessment was performed in accordance with the Transmission Assessment Criteria.

2.0 Proposed Connection Arrangement

Longlac TS is located on the radial A4L line along with Beardmore DS, Jellicoe DS and EPCOR Nipigon CGS. The proposed connection arrangement is shown in **Figure 1**.

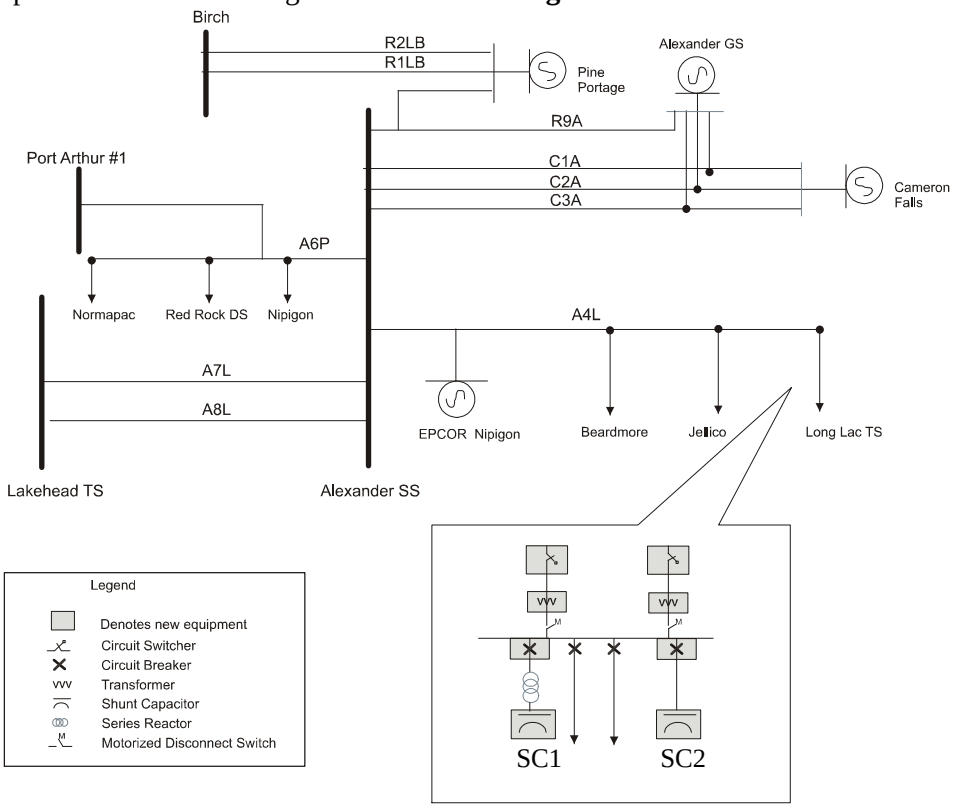

FIGURE 1 – PROPOSED CONNECTION

3.0 Data Verification

(a) Interrupting Devices

Hydro One will install two HV circuit switchers and four LV breakers (two feeder breakers and two capacitor breakers). The following lists the specifications of these interrupting devices:

	HV	LV
Rated Current	≥ 350 A	1200 A
Type	SF6	SF6
Nominal Voltage (kV)	115 kV	44 kV
Maximum continuous voltage	145 kV	46.6 kV
Interrupting time (cycles)	5	5
Short circuit interrupting capability (symmetrical)	20 kA	20 kA

The Transmission System Code typically requires that 115 kV and 44 kV system fault levels not exceed 50 kA (Sym) and 20 kA (Sym) respectively. As indicated above, the HV circuit switchers are rated lower than this requirement. The proponent, however, has indicated that 115 kV fault levels at Longlac TS are well within the short circuit interrupting capability of the circuit switchers (20 kA - symmetrical).

It is expected that Hydro One will upgrade the circuit switchers in the future if short circuit levels at Longlac 115 kV bus exceed 20 kA.

(b) Disconnect Switches

The following table lists the specifications of the LV disconnect switches. These specifications are applicable to the LV motorized disconnect switches and well as the capacitor disconnect switches.

Disconnect switch	Values
Rated continuous current	1200 A (rms)
Nominal operating voltage	44 kV rms
Minimum short circuit withstand capability (symmetrical)	20 kA (rms)

(c) Transformer

The following table lists the specifications of the new transformer provided by the applicant:

<table>
<tr><td>Transformation</td><td colspan="5">115.5/44 kV (tertiary winding buried)</td></tr>
<tr><td>Rating (ONAN/ONAF/OFAF)</td><td colspan="3">25/33/42 MVA</td><td>Configuration</td><td>Wye-Wye</td></tr>
<tr><td>Winter Station Capability
(10 day LTR of one transformer)</td><td colspan="3">60.2 MVA</td><td>Summer Station Capability
(10 day LTR of one transformer)</td><td>54.2 MVA</td></tr>
<tr><td rowspan="4">Impedance</td><td></td><td>R(%)</td><td>X(%)</td><td>MVA_{base}</td><td rowspan="4">Tapping</td><td rowspan="4">±8.8 kV achieved in 32 steps</td></tr>
<tr><td>HL</td><td>0.200</td><td>7.6790</td><td>25</td></tr>
<tr><td>HT</td><td>0.333</td><td>12.794</td><td>10</td></tr>
<tr><td>LT</td><td>0.082</td><td>3.1490</td><td>10</td></tr>
</table>

(d) Shunt Capacitor

The following table lists the specifications of capacitor banks SC1 and SC2 provided by the applicant.

Rated Capability	5 MVAr	Bank arrangement	Wye-Wye ungrounded
Rated Voltage	44 kV	Symmetrical Short Circuit Level	20 kA

The following table lists the specifications of the series reactor connected to capacitor SC1.

Series Reactor	Values
Number per phase	3
Rated reactance	0.5 mH
Rated voltage / maximum rated voltage	44 kV / 46.6 kV
System frequency	60 Hz
Continuous current	600 A
Symmetrical short circuit level	20 kA

4.0 Background Information

(a) Existing System:

EPCOR Nipigon CGS

Figures 2A and **2B** represent the EPCOR Nipigon CGS active power output curve and the EPCOR Nipigon CGS generation duration curve for the period of October 1, 2006 to October 1, 2007. The generation duration curve shows the percentage of the time at which the generation was greater than a certain value (minimum generation). As shown, EPCOR Nipigon is usually at least 35 MW, 50% of the time. **Figure 2C** shows the EPCOR Nipigon reactive output in 1 Hr average samples during the period of October 1, 2006 to October 1, 2007. It can be seen that the reactive output is on average 0 MVar.

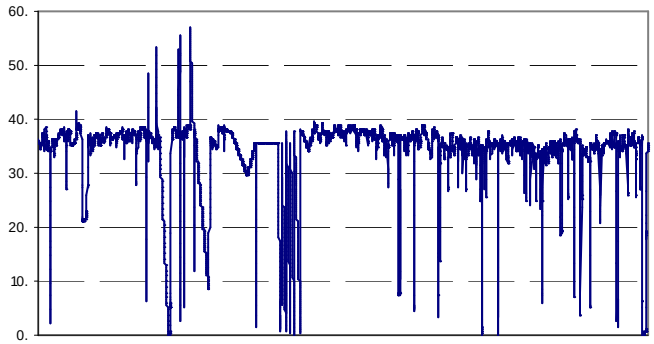

FIGURE 2A – EPCOR NIPIGON OUTPUT (MW)

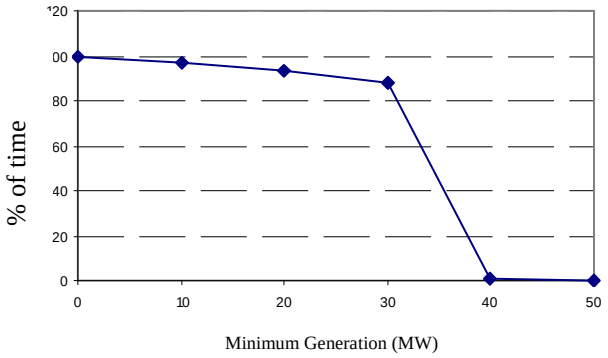

FIGURE 2B – EPCOR NIPIGON GENERATION DURATION CURVE

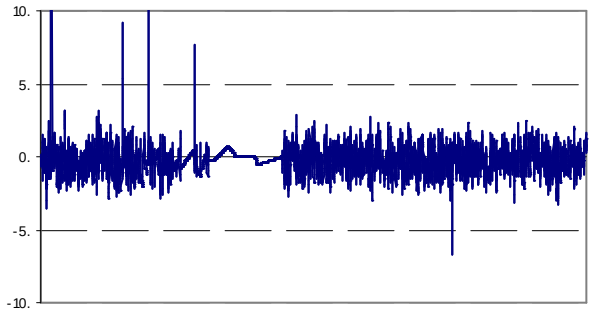

FIGURE 2C – EPCOR NIPIGON OUTPUT (MVAR)

A4L Flow

Figures 2D and **2E** show the MW and MVar flows on A4L at Alexander SS in 1 Hr average samples for the period of October 1, 2006 to October 1, 2007. Positive flow is leaving the bus. For most of the time, there is a net active power injection into Alexander SS. Reactive power varies within the range ± 8 MVar.

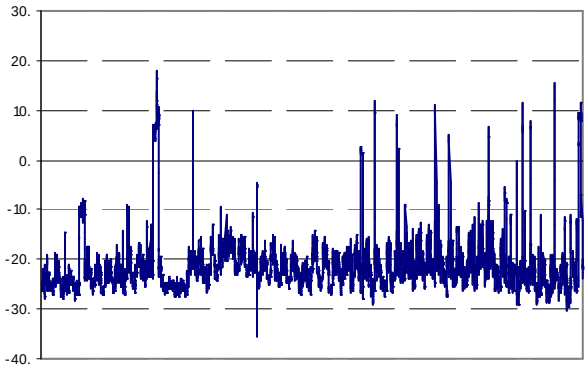

FIGURE 2D – MW FLOW IN A4L @ ALEXANDER SS

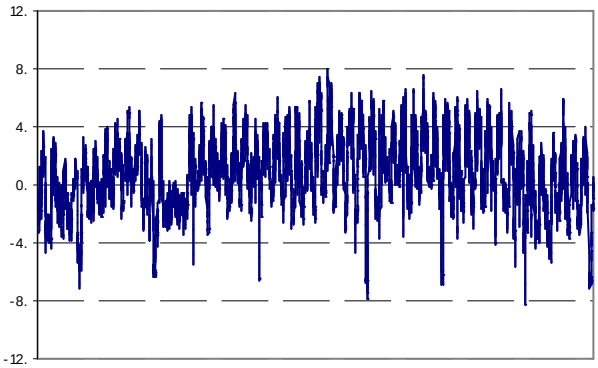

FIGURE 2E – MVAR FLOW IN A4L @ ALEXANDER SS

Longlac TS

The A4L loads at Beardmore and Jellicoe generally range between 0.6 to 1.4 MW. Ignoring the loads at Beardmore and Jellicoe, the load at Longlac can be determined approximately by adding the output at EPCOR Nipigon and the A4L flow out at Alexander SS. **Figure 2F** shows the estimated Longlac TS load in 1Hr average samples for the period of October 1, 2006 to October 2007. Under normal conditions, the load at Longlac is about 15 MW.

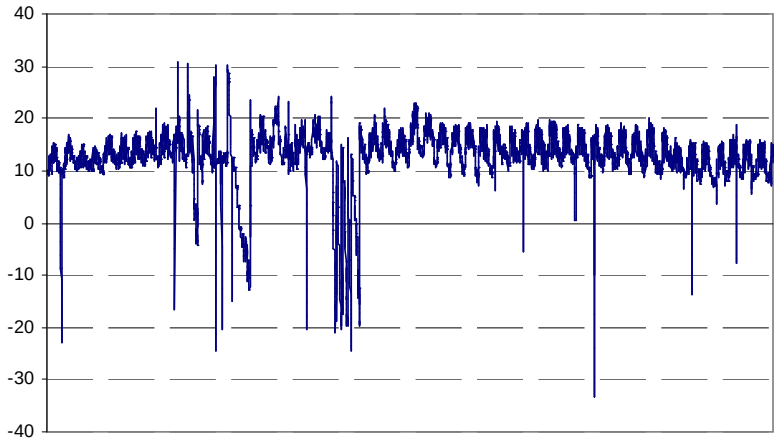

FIGURE 2F – ESTIMATED LONGLAC TS LOAD (MW)

Voltages

Figures 2G and **2H** show the 115kV Alexander SS and 44 kV Longlac TS voltages in 1 Hr average samples during the period of October 1 2006 to October 1 2007. It can be seen that the 115 kV voltage at Alexander SS is about 125.5 kV and LV voltage at Longlac TS about 46 kV under winter conditions.

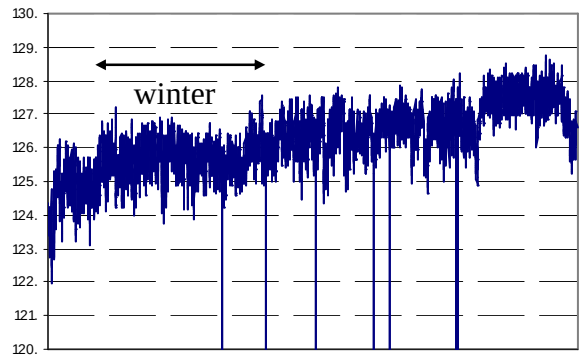

FIGURE 2G – ALEXANDER SS 115 KV VOLTAGE

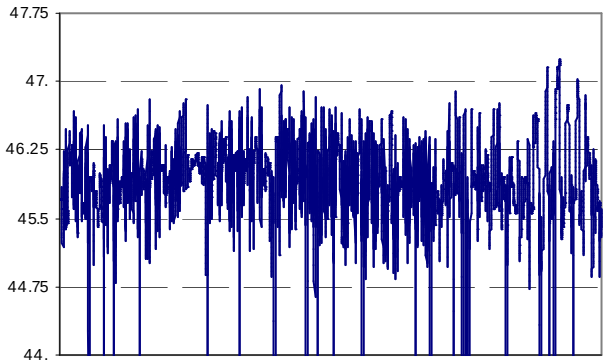

FIGURE 2H – LONGLAC TS 44KV VOLTAGE

(b) Load Forecast:

The following table shows the Longlac TS peak load forecast provided by Hydro One in MW. Longlac TS is a winter peaking station. The values below indicate that the load profile for the next 13 years will remain relatively constant. Winter and summer loads are well within station capabilities as outlined in **Section 3.0**. Therefore, the transformer capacity is adequate as per the Transmission Assessment Criteria.

Year	Load Forecast	
	Summer (MW)	Winter (MW)
2007 (current)	19.14	25.10
2010 (in-service date)	19.45	25.42
2014 (in-service date + 4 years)	19.82	25.81
2020 (in-service date + 10 years)	20.34	26.85

As indicated previously, the load along A4L is primarily composed of Longlac TS. Accounting for the given Longlac load forecast, it can be concluded that A4L will satisfy the Load Security Criteria as per the Transmission Assessment Criteria for the study period. The Load Security Criteria requires that not more than 150 MW of load may be interrupted by configuration with any one element out of service. In the event that A4L is lost, it is expected that all load will be restored within time frames outlined by the Load Restoration Criteria as per the Transmission Assessment Criteria.

5.0 Assessment

(a) Study Scenario

Three scenarios S1, S2, and S3 representing winter conditions were examined. Due to the relatively flat load forecast, analysis for 2010 peak load was ignored.

Scenario	Description
S1	Represents a non-peak winter load scenario at Longlac TS
S2	Represents a 2014 peak winter load scenario at Longlac TS
S3	Represents a 2020 peak winter load scenario at Longlac TS

The following table lists the load and generation conditions of each scenario:

Scenario	EPCOR Nipigon Output[c]		Longlac TS Load		Jelico DS #3[b]		Beardmore DS #2 [b]	
	MW	MVar	MW	MVar[a]	MW	MVar[a]	MW	MVar[a]
S1	35	0	15	7.26	0.7	0.34	1.3	0.63
S2	35	0	25.81	12.50	0.7	0.34	1.3	0.63
S3	35	0	26.85	13.00	0.8	0.39	1.4	0.68

Notes:
(a) MVar obtained assuming 0.9 power factor on LV side
(b) Load forecast provided by Hydro One.
(c) Active and reactive output reflect typical values observed from the existing system.

(b) Voltage Study

Pre-Contingency

The following are the pre-contingency voltages with 10 MVar of LV reactive compensation at Longlac TS in-service observed under scenarios S1, S2 and S3. Note, Market Rules allow for a maximum pre-contingency voltage of 132 kV within the Northwest area.

Pre-Contingency Voltages: Longlac TS Static Capacitor = 10 MVar I/S @ 0.9 pf						
	Longlac TS Load	Alexander SS 115 kV	EPCOR Nipigon 115 kV	Jelllico 115 kV	Longlac TS 115 kV	Longlac TS 44kV
S1	15.0 MW	125.4	127.6	126.3	125.0	46.0
S2	25.81 MW	125.5	125.3	119.1	114.3	46.1
S3	26.85 MW	125.5	125.0	118.1	113.0	46.0

The results show that pre-contingency voltages meet IESO criteria.

Post-Contingency

The following table summarizes the computer results obtained from the voltage decline analysis (%) for the loss of EPCOR Nipigon under scenarios S1, S2 and S3. A constant MVA load model was used pre-ULTC and post-ULTC conditions. The results show that all voltage declines are within IESO criteria.

Post-Contingency Voltage Declines (%)										
	Alexander SS 115 kV		EPCOR Nipigon 115 kV		Jellico 115 kV		Longlac TS 115 kV		Longlac TS 44 kV	
	pre	post	pre	post	pre	post	pre	post	pre	post
S1	0.03	0.00	2.32	2.21	2.57	2.31	2.75	2.37	2.81	-0.20
S2	0.09	0.06	2.60	2.46	3.20	2.84	3.65	3.11	3.80	-0.31
S3	0.09	0.07	2.64	2.51	3.29	2.96	3.78	3.28	3.95	-0.07

(c) Switching Study

The IESO allows a voltage change ΔV on a single capacitor switching to be no more than 4% at delivery point buses. A switching study was carried to investigate the effect of switching in 5 MVar on the voltage changes at Longlac TS under S1, S2 and S3 scenarios. The results of this study are summarized in the following table. As shown from the results, the change on the 115 kV Longlac TS bus is no more than 4%, which is within IESO criteria. Hydro One should note that the change on the 44 kV Longlac TS bus is greater than 4%.

Steps	Bus	ΔV%
S2: Longlac TS Load = 15.00 MW		
Switching 5 MVar	Longlac 115 kV	3.24
	Longlac 44 kV	4.12
S2: Longlac TS Load = 25.81 MW		
Switching 5 MVar	Longlac 115 kV	3.50
	Longlac 44 kV	4.63
S3: Longlac TS Load = 26.85 MW		
Switching 5 MVar	Longlac 115 kV	3.32
	Longlac 44 kV	4.45

(d) Power Factor

The IESO requires that wholesale customers and distributors connected to the IESO-controlled grid shall operate at a power factor within the range 90% lagging to 90% leading as measured at the defined meter point. Assuming a LV power factor of 0.9, results of the power factor analysis obtained from load flow studies under S1, S2, S3 scenarios are shown in the following table with the 10 MVar capacitors in-service. Results show that the power factor on the HV side of the Longlac TS transformers would meet IESO requirements.

Longlac TS	Load Forecast		
	S1 (Normal)	S2 (2014)	S3 (2020)
P_{load} (MW)	15	25.81	26.85
Qload at 0.9 pf (MVar)	7.26	12.50	13.00
$Q_{load}+Q_{transformer\_loss}$ (MVar) *	-3.4	2.6	3.2
Power Factor at HV side	0.975 lead	0.99 lag	0.99 lag

Note: * Negative value represents injection into the IESO controlled-grid.

(e) Thermal Analysis

The following table shows the percentage loading on the line A4L measured against summer continuous ratings under 2020 winter conditions (i) pre-contingency and (ii) post-contingency for the loss of EPCOR Nipigon for scenario S3. Although in theory, these loadings should be measured against winter ratings, summer continuous ratings were used to provide insight on the capability of the line.

All sections were found to be within continuous ratings. This conclusion can also be made for S1 and S2.

S3: A4L Thermal Loading Analysis Under 2020 Winter Peak Loads				
A4L Line Section		Continuous Rating (A)[1]	% Loading	
From	To		Pre Contingency	Loss of EPCOR Nipigon
Alexander SS	EPCOR Nipigon JCT	310	10.8	48.7
EPCOR Nipigon JCT	Beardmore JCT	260	56.5	58.4
Beardmore JCT	Jellicoe DS #3 JCT	260	54.1	55.9
Jellicoe DS #3 JCT	Roxmark JCT	260	52.8	54.6
Roxmark JCT	Longlac TS	260	53.1	55.0

Note: (1) Ratings provided by Hydro One.

6.0 Conclusions

The following was concluded for the transformer refurbishment and installation of 2x 5 MVar capacitor banks at Longlac TS:

(1) The transformer refurbishment and installation of capacitor banks at Longlac TS will not have a material adverse effect on the IESO-controlled grid.
(2) The transformer capacity is adequate as per the Transmission Assessment Criteria for the study period.
(3) All pre and post contingency voltages were found to satisfy the Transmission Assessment Criteria.
(4) Load Security Criteria is satisfied on A4L for the study period.
(5) The switching of the 5 MVar capacitor meets the 4% IESO voltage change requirement at the Longlac TS delivery point bus. It should be noted that the corresponding voltage change on the Longlac LV bus may slightly exceed 4%.
(6) Power factor at the HV side of the transformers meet IESO criteria.
(7) Line A4L is thermally adequate to service loads.

7.0 Requirements for Connection

(1) Hydro One is required to commit to install voltage reduction capability that provides 3%-5% voltage reduction in 5 minutes
(2) Hydro One is required to install a UFLS facility at Longlac TS that meets the Market Rules requirements.
(3) Hydro One Networks is required to provide on-line monitor of the status of all isolating disconnect switches and breakers at the Longlac TS, active and reactive power flows over the transformers, and voltage on the low side of transformers on a continuous basis.
(4) Under load tap changing facilities at the station must be available
(5) The 115 kV circuit switchers are rated lower than required by the Transmission System Code. Short circuit levels for the period, however, show that 115 kV fault levels are well within the short circuit interrupting capability of the circuit switchers. The short circuit interrupting capability is not expected to be exceeded in the foreseeable future.

    Hydro One would be required to upgrade its high voltage interrupting device at Longlac TS if, in the future, short circuit level exceeds 20 kA.
(6) All equipment must be capable of operating continuously with a system voltage as high as 132 kV
(7) The proponent must notify the IESO as soon as it becomes aware of any changes to the assumptions made in the connection assessment. The IESO will determine whether these changes require a re-assessment.

8.0 Notification of Approval

This expedited System Impact Assessment concludes that the Longlac TS refurbishment and installation of 2 x 5 MVar capacitor banks is not expected to have a material adverse effect on the IESO-controlled grid. It is therefore recommended that a Notification of Conditional Approval of the Connection Proposal be issued, subject to the requirements detailed above.