REPORT

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System Impact Assessment Report

Lac Des Iles Mine Expansion

CONNECTION ASSESSMENT & APPROVAL PROCESS

CAA ID 2006-226

Applicant: North American Palladium Ltd

Transmission Assessments & Performance Department

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System Impact Assessment Report

Increased Supply to Lac Des Iles Mine

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 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.

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Special Notes and Limitations of Study Results

The results reported in this study are based on the information available to Hydro One, at the time of the study, suitable for a preliminary assessment of a new generation or load connection 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 connection on facilities owned by other load and generation (including OPGI) customers.

In this study, short circuit adequacy is assessed only for Hydro One breakers and does not include other Hydro One facilities. The short circuit results are only for the purpose of assessing the capabilities of existing Hydro One breakers and identifying upgrades required to incorporate the proposed connection. These results should not be used in the design and engineering of new facilities for the proposed connection. The necessary data will be provided by Hydro One and discussed with the connection proponent 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 connection 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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SIA Findings

Summary

The Lac Des Iles mine in Northwestern Ontario is supplied from three 115/4.16 kV transformers T1, T2 and T3 which are connected to Hydro One owned 115 kV circuit S1C via a 63 km long transmission line which is owned by the customer. Prior to 2007 summer, the peak load in mine was 32 MW. In 2006, the proponent informed the IESO that the load connected to T3 will be increased by 5 to 10 MW in 2007 summer. In 2007 summer, the proponent informed the IESO that the load increase will not be as high as anticipated, but only by about 2 MW while there is potential for further increase in future.

The load connected to T1 and T2 are predominantly synchronous motors. Even prior to the 2 MW load increase, the mine was experiencing significant voltage declines during the start of synchronous motors, especially the first motor which was mitigated by having Silver Falls unit on-line at the time of the motor start. Thus, any increase of load potentially degrades the voltages further. The proponent has indicated that their load power factor is mostly 0.975 lag to 1.0 due to over excited synchronous motors and will remain same.

The proponent also informed the IESO that with current 2 MW load increase; it is not their intention to invest on installing a new DVAr to improve voltages.

Conclusions

(1) The following is the summary of voltage analysis results for current load conditions.

Voltage with Load = 34 MW								
at Steady State						**at First Motor Start**		
For load power factor = 1.0			For load power factor ≥ 0.975 lag					
Silver Falls	115 kV voltage		Silver Falls	115 kV voltage		Silver Falls	115 kV voltage	
	HONI	Customer		HONI	Customer		HONI	Customer
O/S	**Good**	**Good**	O/S	**Good**	**Poor**	O/S	**Good**	**Poor**
I/S	**Good**	**Good**	I/S	**Good**	**Good**	I/S	**Good**	**Good**

- The unavailability of Silver Falls unit which occur frequently would deteriorate the voltage at customer owned equipment. The IESO has informed of this risk to the customer, and the customer has accepted the risk associated with exposing his equipment to under-voltages.
- The unavailability of Silver Falls will not deteriorate voltages in any of the remainder of the 115 kV equipment.

(2) In the event of loss of Silver Falls GS, the voltages recover to within 10 % of pre-loss value.
(3) The load increase does not cause any thermal concerns in transmission system.

IESO's Requirements for Connection

The following requirement has been identified.

(1) Under present load conditions (peak is 34 MW), the customer has agreed to accept the risk and dangers associated with exposing their equipment to steady-state and transient under-voltages lower than IESO accepted levels occurring while Silver Falls unit is unavailable and any resulting consequences.

IESO's Recommendations for Connection

The following recommendation is made.

(1) If the load is increased any further, the customer must review the availability of dynamic reactive power including installing a dynamic reactive power compensation device of a suitable size.

Notification of Conditional Approval

From the information provided, our review concludes that the proposed changes will not result in a material adverse effect on the reliability of the IESO-controlled grid excluding customer owned equipment. It is recommended that a Notification of Conditional Approval be issued for Lac Des Iles Mine load increase project subject to the IESO receiving written acknowledgement that the requirements listed in this report will be implemented.

1. Project Description

Lac des Iles mine which is owned by North American Palladium Ltd. is Canada's only primary producer of palladium. It also produces by-products platinum, gold, copper and nickel. The Lac des Iles deposit contains one of the largest open pit bulk mineable palladium reserves in the world. The mine is located 85 kilometres northwest of Thunder Bay in northern Ontario, and has been in operation since 1993.

Prior to 2007 summer, the peak power consumption of the mine operations is about 32 MW, and is connected to Ontario power grid by a 63 km long privately owned 115 kV line that is tapped on to the circuit S1C near Silver Falls generating station. The circuit S1C is connected to the 115 kV circuit P5M from Port Arthur TS No. 1 and to the Silver Falls generating station.

Prior to 2001, the total electrical load at Lac Des Iles mine site was approximately 6 MW, and was supplied by a single 13 MVA, 120/4.16 kV transformer. In 2001, in order to expand the operations, the proponent extended their 115 kV line segment by 1.5 km and two new identical 33 MVA, 120/4.16 kV transformers were added to supply the increased load of 26 MW increasing the total peak up to 32 MW.

In 2006, the North American Palladium notified the IESO that their mining operations will be further expanded in 2007, as a result another 5 to 10 MW load will be added. The proponent has indicated that their present load power factor is mostly 0.975 lag to 1.0 due to existence of several synchronous motors in the mine which produce reactive power, and will continue to remain in that range after the expansion. In 2007 summer, the proponent informed the IESO that the load increase is only about 2 MW while a further minor increase in future is possible.

– End of Section –

2. Review of Connection Proposal

Lac Des Iles mines is presently supplied by a 115 kV circuit that is tapped on to Hydro One owned 115 kV circuit S1C at a point about 4 km from the Ontario Power Generation owned Silver Falls generating station. The S1C is connected to P5M which is about 33 km long and is supplied from Port Arthur TS No. 1. The supply arrangement is shown in Figure 1.

Prior to 2007 summer, the load at Lac Des Iles mines which is supplied by three 120/4.16 kV transformers T1, T2 and T3 is approximately 32 MW at peak. The proponent notified the IESO that a new load in the range of 5 to 10 MW will be added to the transformer T3 to serve the increase in mining operations.

The ratings of T1 and T2 are 20/26/33 MVA and the rating of T3 is 10/13 MVA.

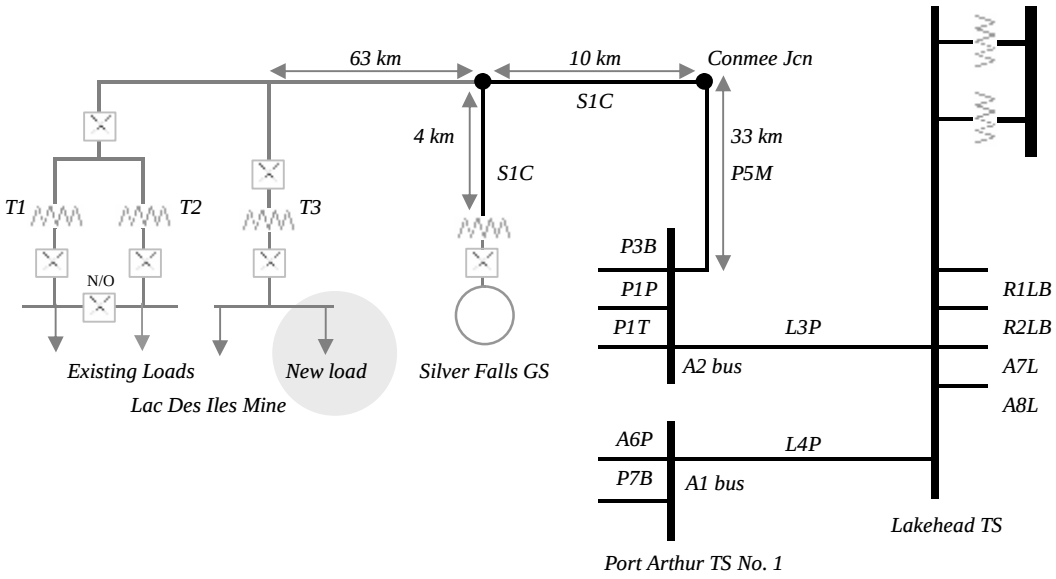

FIGURE 1 : CONNECTION ARRANGEMENT

2.1 System Conditions - 2005 Jan - Dec

The Figure 2A show following two quantities obtained from 1 Hr samples of 2005 real-time data.

(a) MW flow of P5M at Port Arthur to Conmee + MW generation at Silver Falls GS
(b) MVAr flow of P5M at Port Arthur to Conmee + the MVAr generation at Silver Falls GS.

Above two quantities should effectively represent the MW and MVAr load at Lac Des Iles Mine if line losses in S1C and P5M are omitted. Currently, there is no real-time monitoring available directly from the mine, thus above two quantities would provide a real-time approximation for the mine load.

The Figure 2B shows the real-time generation at Silver Falls GS for the same period as above. The Figure 2C shows the cos $[\tan^{-1}(b)/(a)]$ calculated from above (a) and (b). This can be regarded as an indication of the power factor at mine connection point to S1C. It must be noted that this power factor is only an approximation since (a) and (b) are not concurrent values.

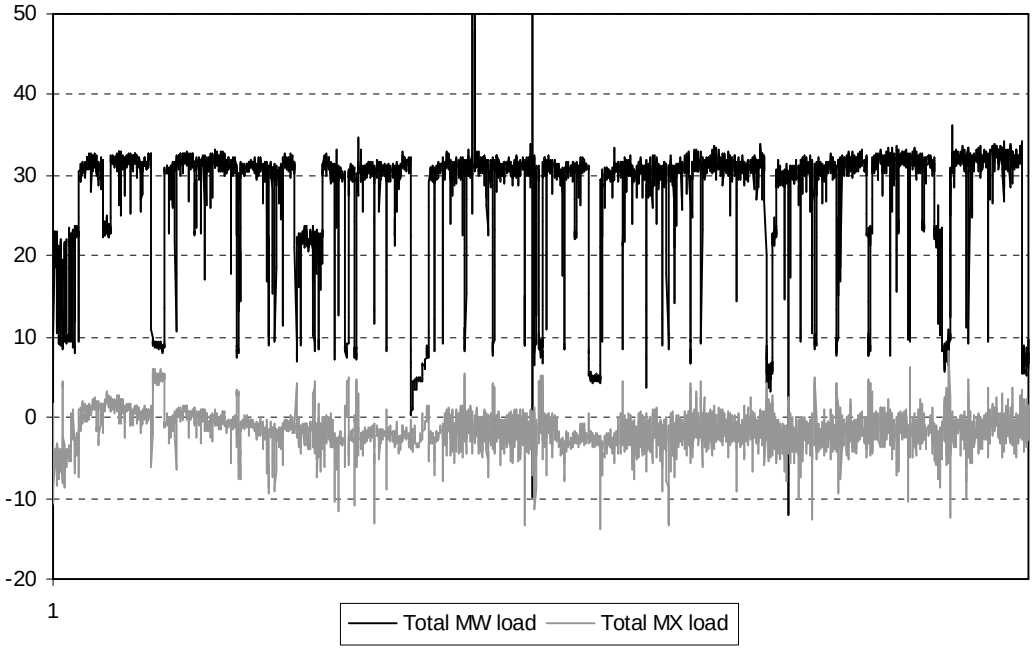

FIGURE 2A : P5M@P + SILVER FALLS GENERATION

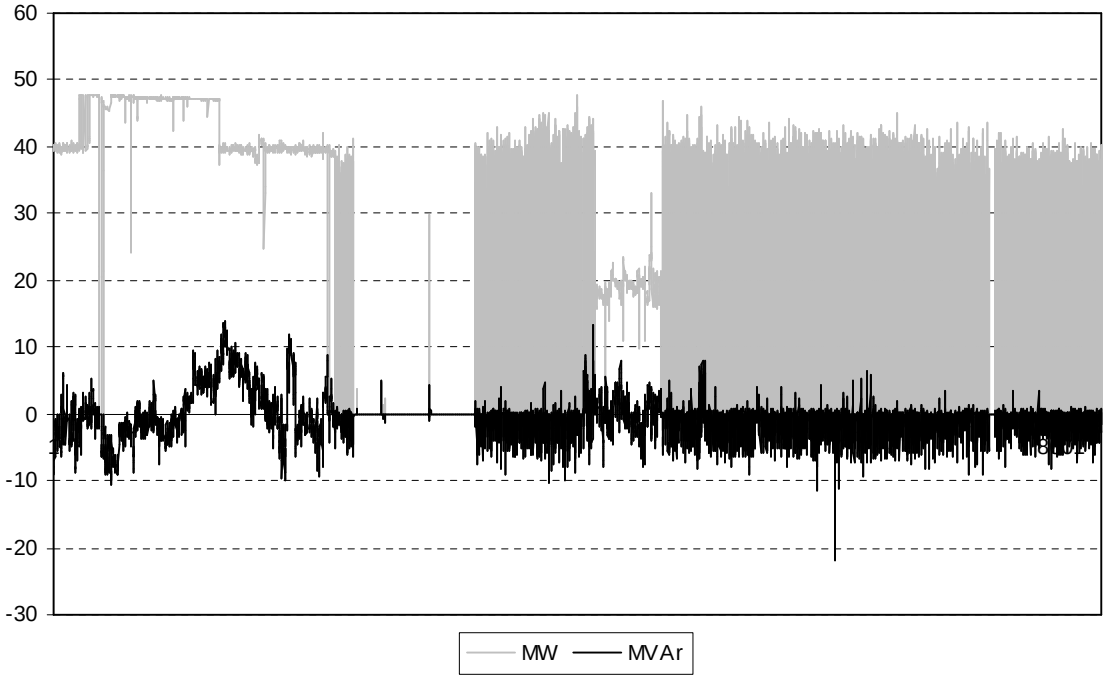

FIGURE 2B : SILVER FALLS MW AND MVAR GENERATION

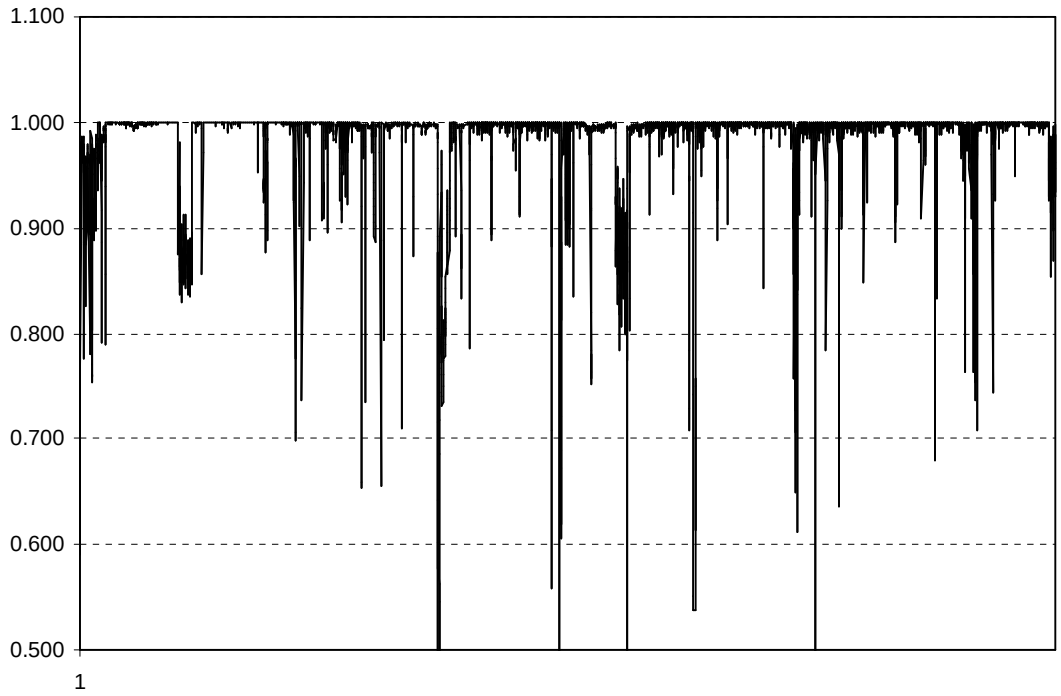

FIGURE 2C : POWER FACTOR CALCULATED FROM P5M@P + SILVER FALLS GENERATION

From Figure 2A, it can be concluded that the mine load was approximately 32 MW. This is roughly the same load level the proponent advised IESO as their load. The negative MVAr load in the Figure 2A suggests that the mine often injected net reactive power into the connection point on S1C due to existence of their large synchronous motors running with over-excitation.

From Figure 2B, it can be concluded that mostly the generation at Silver Falls is about 40 MW, but the peak is approximately 47 MW. Also there could be extended periods of time that this generation is unavailable, and thus can not be a constantly dependant for reactive support for the mine load.

From Figure 2C, it is evident that the power factor at the connection point was mostly unity.

2.2 System Conditions – 2007 Sept

The Figure 2D and 2E show the MW load and the power factor at Lac Des Iles Mine obtained from 1 Hr samples of 2007 Sept from real-time data and calculated same as in Section 3.1.

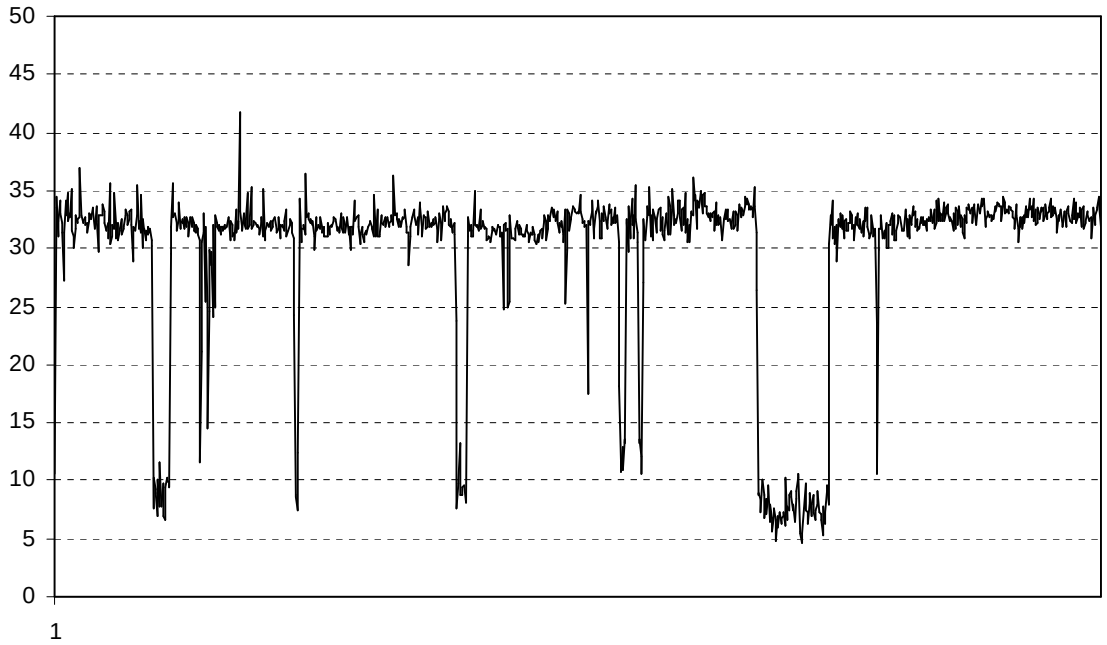

FIGURE 2D : MW (P5M@P + SILVER FALLS GENERATION)

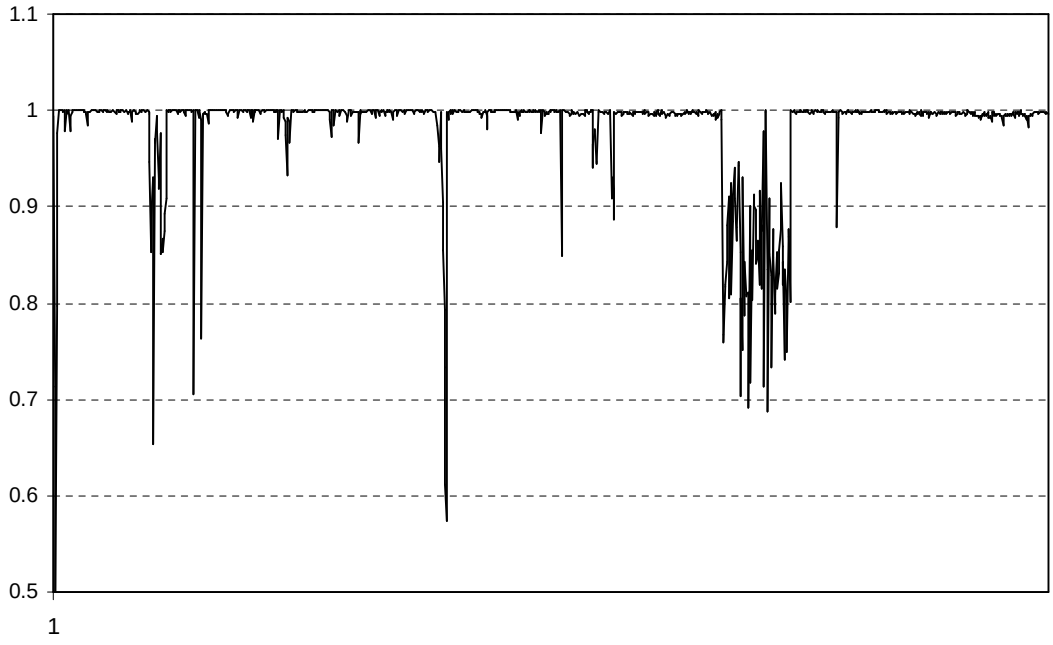

FIGURE 2E : POWER FACTOR CALCULATED FROM P5M@P + SILVER FALLS GENERATION

From Figure 2D, it is evident that the mine load is roughly 34 MW. From Figure 2E, it is evident that the power factor at the connection point was mostly unity.

– End of Section –

3. System Impact Studies

3.1 Assumptions

- The study was performed for a system with all transmission elements are in service.
- Loads reflected 2008 summer coincident peaks under extreme weather conditions where the total Ontario demand is 27,500 MW and the Northwest zone load is 923 MW. Since mine loads generally do not grow uniformly every year, no additional year was studied.
- Thunder Bay GS is in-service as its status has very little impact in analysis done for Lac Des Iles.
- For voltage decline studies, the loads are assumed constant MVA. This is based on the fact the proponent indicated that the mine load is predominantly synchronous motors. They draw greater current at reduced voltages, thus maintaining roughly a constant MVA.
- The Lakehead capacitor bank is in service.
- The Lac Des Iles Mine has manually switchable 1500 kVAr capacitor bank (with two steps of 500 and 900 kVAr) is available at 4.16 kV bus.

3.2 Study scenarios

The proponent indicated that the current load growth is 2 MW, and will be added to the transformer T3 and a further similar minor increase in future is possible. S_o represent the situation prior to current load increase, S_1 represent after the current load increase and S_2 represents a future load increase.

Scenario	*MW load on T1 + T2*			*MW load on T3*			*T1+T2+T3*
	Old Load	*Load Growth*	*Total*	*Old Load*	*Load Growth*	*Total*	*Total*
S_o (past)	26	0	26	6	0	6	32
S_1 (present)	26	0	26	6	2	8	34
S_2 (future)	26	0	26	6	5	11	37

3.3 Voltage Analysis

3.3.1 Pre-Contingency Voltages

For northern Ontario, the IESO requires that under normal conditions, the 115 kV voltage to be within 132 kV and 113 kV.

The Table below shows the projected 115 kV voltages with and without Silver Falls generation. When Silver Falls unit is available, the generator is controlling its terminal voltage to 1.05 pu. The power factors of the Lac Des Iles Mine loads connected to the transformers T1+T2 and T3 are assumed 0.975 lag or 1.0. That means the synchronous motors are already in-service producing reactive power. A part of 26 MW load connected to T1+T2 represents this synchronous motor load. The following are the voltage before and after the addition of new load.

The 4.16 kV tie-breaker between T1 and T2 is simulated opened with load equally split. Thus, the below voltages will have no change even if the LV tie-breaker is closed.

(a) With Silver Falls Generation in service

Scenario	So (past)		S_1 (present)		S_2 (future)	
Lac Des Iles (LDI) total load	32 MW		34 MW		37 MW	
Overall load power factor	1.0	0.975 lag	1.0	0.975 lag	1.0	0.975 lag
Silver Falls generation MW + j MVAr	47 + j10	47 + j14	47 + j14	47 + j15	47 + j14	47 + j17
Voltage @ Pt. Arthur 115 kV A2 bus	125	125	125	125	125	125
Voltage @ LDI tap to Hydro One	127	126	126	126	126	125
Voltage @ (T1+T2) 115 kV bus	120	116	116	115	118	114

(b) With Silver Falls Generation out of service

Scenario	So (past)		S_1 (present)		S_2 (future)	
Lac Des Iles (LDI) total load	32 MW		34 MW		37 MW	
Overall load power factor	1.0	0.975 lag	1.0	0.975 lag	1.0	0.975 lag
Voltage @ Pt. Arthur 115 kV A2 bus	125	124	125	124	125	124
Voltage @ LDI tap to Hydro One	122	121	122	120	121	119
Voltage @ (T1+T2) 115 kV bus	115	111	114	109	112	107

- When Silver Falls unit is available, the voltages in the IESO controlled grid are acceptable.
- When Silver Falls unit is unavailable, presently the voltages can be maintained to marginally acceptable levels only if power factor is close to unity. Any further load increase or any lower power factor necessitates reactive power compensation.

3.3.2 Post-Contingency Voltages

The loss of Silver Falls GS is tested with 34 MW load when the load power factor is 0.975 lag.

	Port Arthur A2 bus	*Lac Des Iles tap to S1C*	*LDI*	*LDI T1*	*LDI T2*	*LDI T3*
Pre-contingency	125	126	115	4.4	4.4	4.0
Post-contingency	124	119	108	4.1	4.1	3.7
ΔV %	0.8	5.5	6.1	6.8	6.8	7.5

Since the connection is radial, the worst contingency is the loss of Silver Falls GS which provides voltage support. In the event of loss of Silver Falls GS, above results show the voltages recover to within 10 % of pre-loss value.

3.4 Synchronous Motor Start-up

3.4.1 With Present Load

The operation of Lac Des Iles mine consists of using several 8500 HP synchronous motors for crushing and grinding. This section discuss the voltage decline occur that would occur when the first motor is started.

The 4.16 kV tie-breaker is simulated open. The proponent indicated that no synchronous motor will be connected to T3. Thus, the synchronous motor is to be connected to the LV bus of T1 when 2 MW initial load is already connected to T1 and another 2 MW is already connected to T2. The load in T3 is 8 MW which includes 2 MW newly increased load. These initial load levels were supplied to the IESO by the proponent. Before synchronous motor is on-line, the power factor of these loads is assumed low (0.85 lag).

The analysis focuses not on the period after the motor is synchronised which then takes 6.3 MW, but on the period prior to the synchronisation where the motor with no excitation accelerates as an induction motor until the synchronous speed is reached. The timing of the application of the excitation is determined by the speed of the motor and the final magnitude of the excitation is determined by the power factor prevailing without the synchronous machine. This temporary induction motor load is approximately 2400 A withdrawal from the LV bus of T1+T2 at a power factor of 0.85 lag that lasts for about 7.5 seconds. Therefore, the magnitude of this initial load is $\sqrt{3} \times 4160 \times 2400 \times 0.85 = 14.7$ MW (and 9.1 MVAr) which is more than the double of steady state load of 6.3 MW.

The assessment of voltages for subsequent synchronisation of rest of the motors is not necessary as by that time, the first motor is already in-service supplying sufficient reactive power for voltage support. It is assumed that there is not enough time for ULTC action to take place.

Pre-motor-start

MW load on T1 + T2			*MW load on T3*			*T1+T2+T3*
Old Load on T1	*Old Load on T2*	*Total*	*Old Load*	*Load Growth*	*Total*	*Total*
2	2	4	6	2	8	12

Pre-motor-synchronisation

MW load on T1 + T2				*MW load on T3*			*T1+T2+T3*
Old Load on T1	*Motor on T1*	*Old Load on T2*	*Total*	*Old Load*	*Load Growth*	*Total*	*Total*
2	14.7	2	18.7	6	2	8	26.7

Voltage Results

Silver Falls	Busbar	*Pre-motor-start*	*Pre-motor-synch.*	ΔV
O/S	Voltage @ Pt. Arthur 115 kV A2 bus	125	124	0.8
	Voltage @ LDI tap to Hydro One	123	118	4.0
	Voltage @ (T1+T2) 115 kV bus	118	105	11.0
	Voltage @ T1 4.16 kV bus	4.5	3.8	15.5
I/S	Voltage @ Pt. Arthur 115 kV A2 bus	125	125	0.0
	Voltage @ LDI tap to Hydro One	127	125	1.5
	Voltage @ (T1+T2) 115 kV bus	122	113	7.4
	Voltage @ T1 4.16 kV bus	4.6	4.1	10.8

- If Silver Fall unit is available during the first motor start, the voltage declines occurring in the IESO controlled grid are acceptable.
- If Silver Fall unit is unavailable during the first motor start, the voltage declines occurring in the IESO controlled grid are not acceptable.

3.4.2 With Future Load

In case the mine expands its total load to 37 MW (increase of 3 MW from present level), the following section examines the impact of motor starts while having Silver Falls unit on-line and having a 4 MVAr of DVAr connected to T1 4.16 kV bus.

Pre-motor-start

MW load on T1 + T2			*MW load on T3*			*T1+T2+T3*
Old Load on T1	*Old Load on T2*	*Total*	*Old Load*	*Load Growth*	*Total*	*Total*
2	2	4	6	5	11	15

Pre-motor-synchronisation

MW load on T1 + T2				*MW load on T3*			*T1+T2+T3*
Old Load on T1	*Motor on T1*	*Old Load on T2*	*Total*	*Old Load*	*Load Growth*	*Total*	*Total*
2	14.7	2	18.7	6	5	11	29.7

Voltage Results

	Busbar	*Pre-motor-start*	*Pre-motor-synch.*	ΔV
No Silver Falls, No DVAr	Voltage @ Pt. Arthur 115 kV A2 bus	124	123	0.8
	Voltage @ LDI tap to Hydro One	122	117	4.0
	Voltage @ (T1+T2) 115 kV bus	116	101	13.0
	Voltage @ T1 4.16 kV bus	4.4	3.6	18.1
Silver Falls I/S, No DVAr	Voltage @ Pt. Arthur 115 kV A2 bus	125	125	0.0
	Voltage @ LDI tap to Hydro One	126	124	1.6
	Voltage @ (T1+T2) 115 kV bus	121	111	8.2
	Voltage @ T1 4.16 kV bus	4.6	4.0	13.0
DVAr I/S, No Silver Falls		*DVAr switched out*	*DVAr switched in*	
	Voltage @ Pt. Arthur 115 kV A2 bus	124	124	0.0
	Voltage @ LDI tap to Hydro One	122	118	3.2
	Voltage @ (T1+T2) 115 kV bus	116	105	9.5
	Voltage @ T1 4.16 kV bus	4.4	3.9	11.3

- If Silver Fall unit is available during the first motor start, the voltage declines occurring in the IESO controlled grid are acceptable.
- If Silver Fall unit is unavailable during the first motor start, the voltage declines occurring in the IESO controlled grid are not acceptable.
- If Silver Falls unit is unavailable during the first motor start, at least a 4 MVAr of DVAr will be necessary.
- If the T1 and T2 4.16 kV buses are operated with tie-breaker open, depends on first motor is to be started on T1 or T2 4.16 kV bus, the arrangement of the DVAr must be further examined.

3.5 Thermal Analysis

Following are the ratings of the connecting equipment.

	Pt.Arthr to Conm	*Conm to Silver Falls tap*	*Silver Falls tap to Lac.D.Iles*
Continuous	265 A	265 A	378 A
STE	345 A	345 A	393 A

Followings are the loading and the percentage loadings of the connecting equipment compared to continuous rating with and without Silver Falls GS in service. The scenario examined is S_2 where T1+T2 has 26 MW and T3 has 11 MW which includes 5 MW new load with 0.975 lag power factor.

Silver Falls GS	*Pt.Arthr to Conm*	*Conm to Silver Falls tap*	*Silver Falls tap to Lac.D.Iles*
O/S	206 A, 0.77	206 A, 0.77	206 A, 0.54
I/S	34 A, 0.11	34 A, 0.11	192 A, 0.50

The ampacity rating of all the Hydro One facilities associated with the Lac Des Iles mine are found to be adequate for the increased load.

3.6 Enhanced Supply Arrangement

The proponent has recognized the issues related to voltage problems emerging from increasing loads in the mine, especially when Silver Falls unit is unavailable. In order to avoid the reliance on Silver Falls GS to mitigate voltage problems, in addition to a solution of having a new local dynamic reactive power source, the proponent is also encouraged to consider having a separate connection to the mine from the 230 kV system.

– End of Section -