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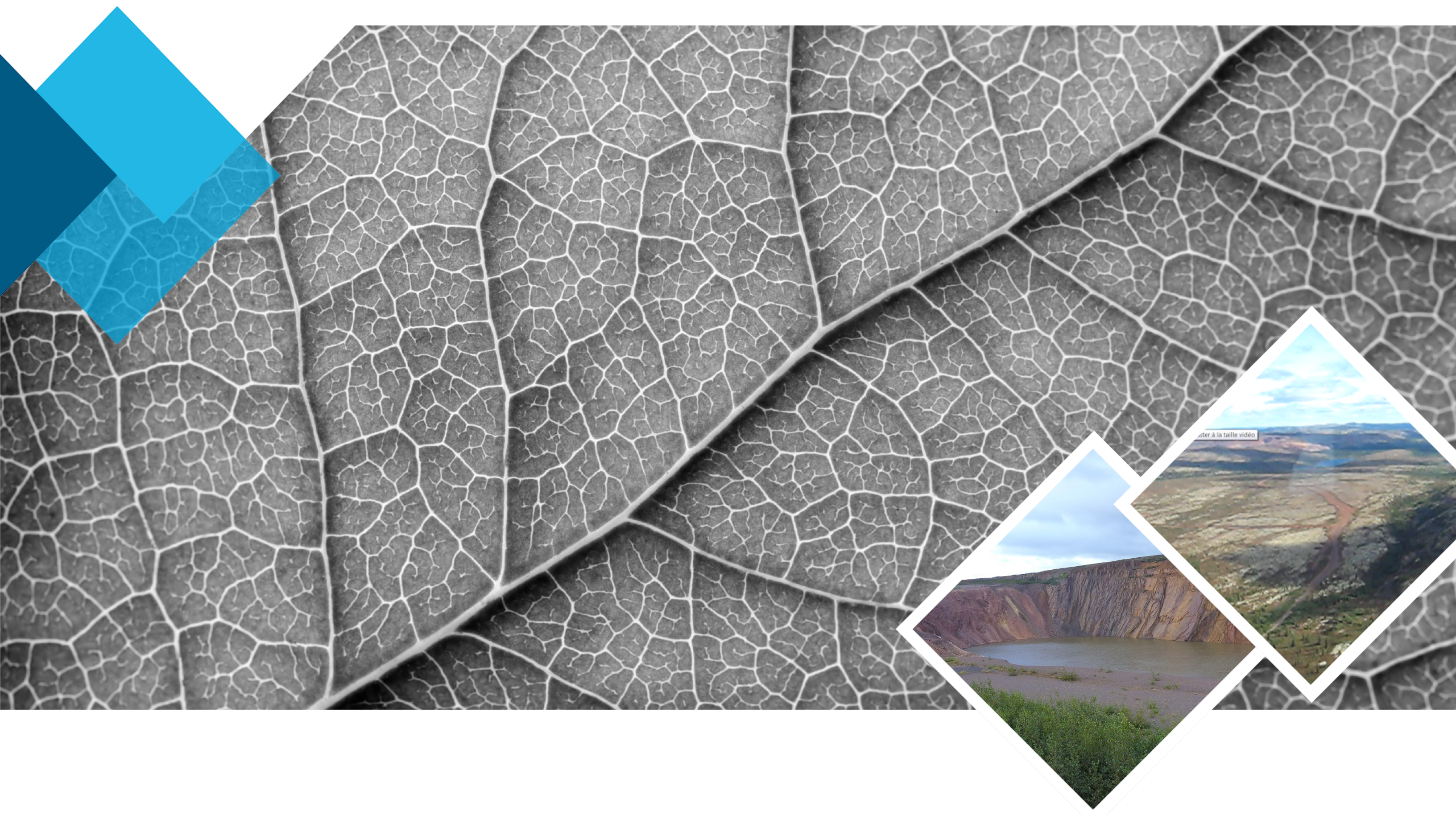
Hydrogeology Numerical Modeling for the Howse Deposit Project

TATA STEEL MINERALS CANADA LTD



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Hydrogeology Numerical Modeling Update for the Howse Deposit Project

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Table of Contents

List of tables

List of figures

List of appendices

1 Introduction

For the Howse deposit project, SNC-Lavalin was involved in the realization of hydrogeological modeling of the pit dewatering based on result investigations conducted by others and available data.

In autumn of 2014, SNC-Lavalin conducted a first hydrogeology numerical modeling for the Howse deposit dewatering. This first model was based on results from hydrogeological studies conducted by Golder (2014) and Geofor (2014). Following NRCan comments on the conceptual model elaborated and the model results, a complementary hydrogeological program was conducted in the fall of 2015 by Geofor in order to collect additional geological and hydrogeological data. The numerical model was then refined and updated (SNC-Lavalin, November 2015).

In December 2016, SNC-Lavalin presented a major update of the model following NRCan new comments received in June 2016 and later (October and November 2016) (SNC-Lavalin, December 2016). In March 2016, the model was enlarged to include some natural physical boundaries and to evaluate the approximate natural water table depth and eventual relation to surface waterbodies based on these new boundaries. The model results of regional groundwater conditions for four scenarios were presented to NRCan for review prior to further dewatering simulations. Finally, one of these scenarios was selected to conduct the dewatering simulations.

This report presents the groundwater flow scenarios that were tested and dewatering simulation results.

2 Regional Groundwater Flow conditions

2.1 Conceptual Model

A regional model under steady-state conditions covering a larger area as proposed by NRCan is presented. The objective of this model update is to reevaluate groundwater flow under physical boundaries such as the Howells River along SW limit of the model and Elross Creek to the SE limit of it.

Under these conditions, the modeling strategy is conducted in two steps: firstly, the model is run under steady-state conditions to evaluate the approximate natural water table depth and eventual relation to surface waterbodies within and outside the project area. Secondly, the mine pit is introduced to the model to simulate three dewatering phases and their impact on groundwater drawdowns.

It is understood that the new model limits include extended areas where no geological and hydrogeological data are available. Surface geology map was used to extrapolate the geological formations in new modeled areas.

All the other model parameters such as hydraulic conductivities of the geological units and recharge were the same as those used in the previous model (SNC-Lavalin, December 2016).

2.2 Groundwater flow initial conditions

Four model boundary conditions were tested in the new regional model in order to simulate the regional groundwater flow. The boundaries conditions are described in Table 2-1.

Table 2-1 Summary of the model boundary conditions

Parameter Conditions		Model 1	Model 2	Model 3	Model 4
Recharge (mm/y)		150			
North East boundary		No flow			
North West boundary		No flow			
South West boundary	West side	Constant head: 500m (Howells river)			
	East side	No flow (along ridge of Irony Mountain)			
South East boundary	East side	No flow	No flow	Constant head: 665m (piezometric value)	Constant head: 665m (piezometric value)
	Center side	No flow			
	South side	H = z (Elross Creek) 560 < h < 610m	H < z (Elross Creek) 550 < h < 600m	H = z (Elross Creek) 560 < h < 610m	H < z (Elross Creek) 550 < h < 600m

Note H: hydraulic Head; z = ground elevation.

The simulated hydraulic heads for the four scenarios using MODFLOW are presented in figures 2-1 to 2-4. Table 2-2 summarizes the simulated hydraulic heads in the areas of Pinette Lake and Triangle Lake for each scenario. The error percentage calculated by means of the normalized Root Mean Squared (RMS) between the simulated and observed hydraulic heads is also presented in Table 2-2.

Table 2-2 Simulated Hydraulic heads in the areas of Pinette Lake and Triangle Lake

Results	Model 1	Model 2	Model 3	Model 4
RMS (%)	21	25	15	13
hs (m) Triangle Lake, with zlake about 580m	573 < h < 579	570 < h < 577	584 < h < 593	584 < h < 592
hs (m) Pinette Lake, with zlake about 640m	586 < h < 597	580 < h < 592	595 < h < 611	588 < h < 607

Note h_s: simulated hydraulic head; z_{lake}: lake elevation.

The results indicate that in most scenarios:

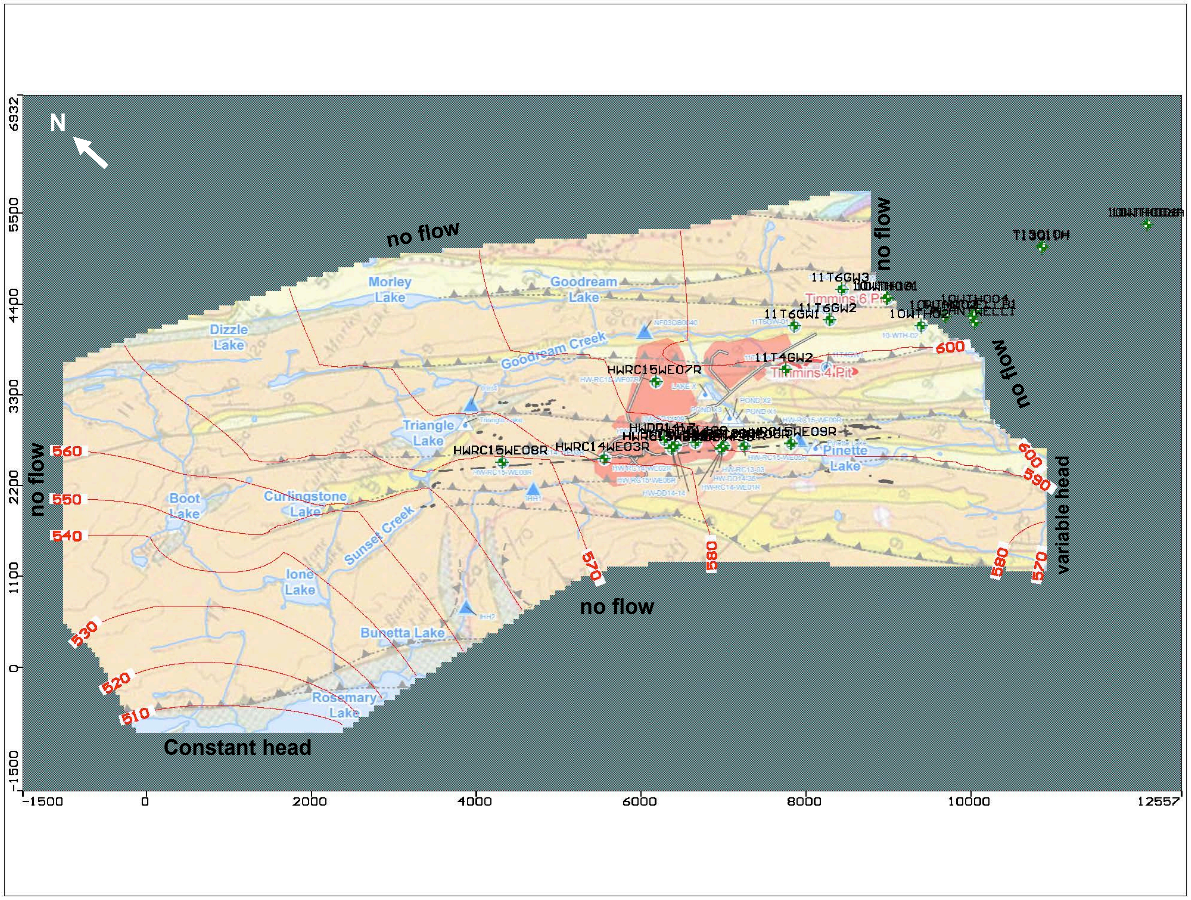
- Simulated hydraulic heads are close to ground surface at Triangle Lake;
- Simulated hydraulic heads are deeper at Pinette Lake.

According to RMS results, groundwater flow is better reproduced in scenarios 3 and 4. Models 1 and 2 generally underestimated the hydraulic heads.

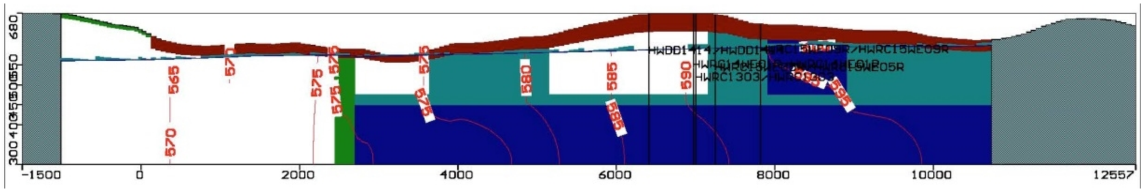
The calibration lines of RMS graphs show though that models 3 and 4 overestimate locally observed hydraulic head with a discrepancy reaching 20 m. In comparison with previous model of December 2016, these higher simulated heads are due to the position and the value of hydraulic head boundary to the SW (for example constant head boundary of 500 m in recent model vs 460 in previous one).

Figure 2-1 Simulated hydraulic heads for Model 1

a)



b) Longitudinal Cross-section of the Howse deposit:



c)

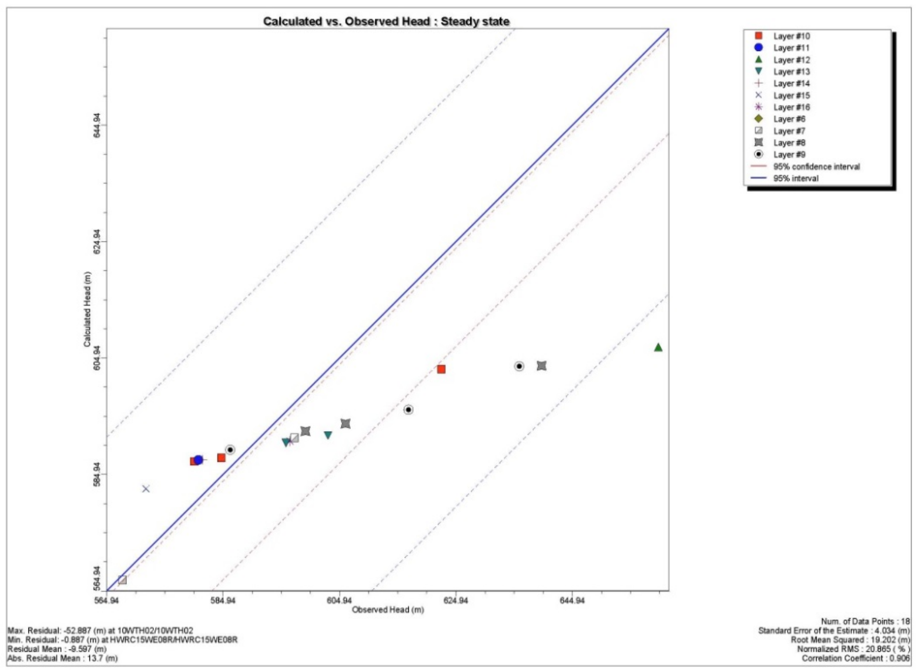
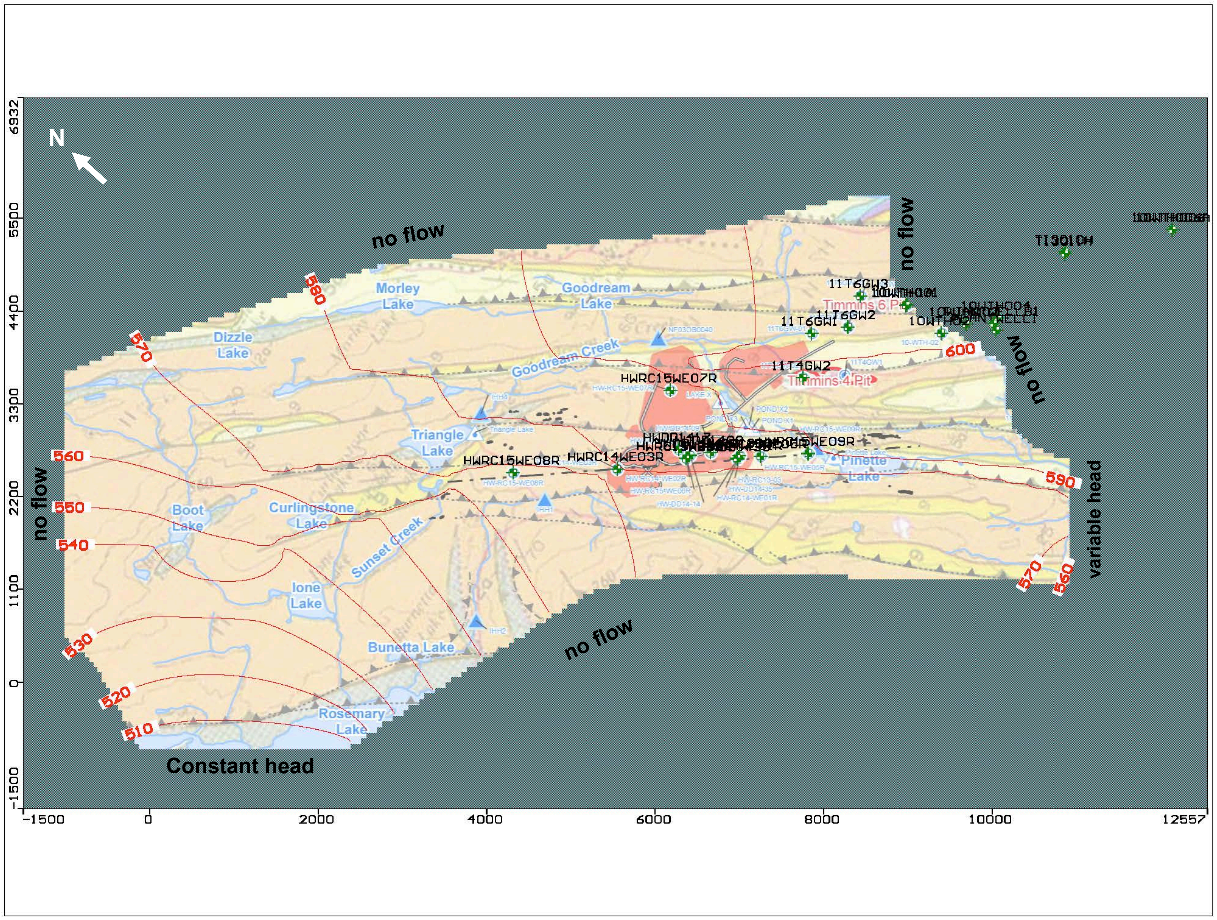
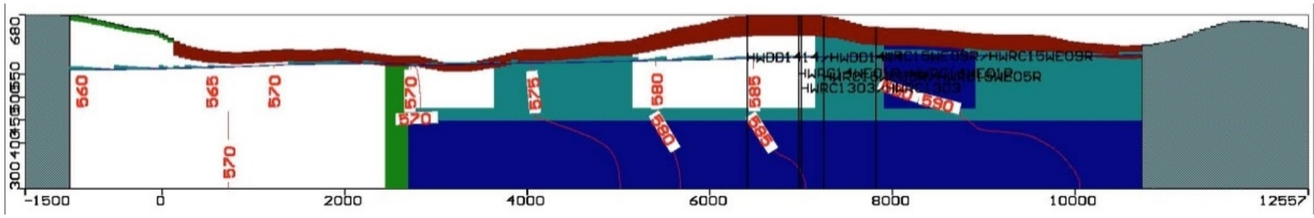


Figure 2-2 Simulated hydraulic heads for Model 2

a)



b) Longitudinal Cross-section of the Howse deposit:



c)

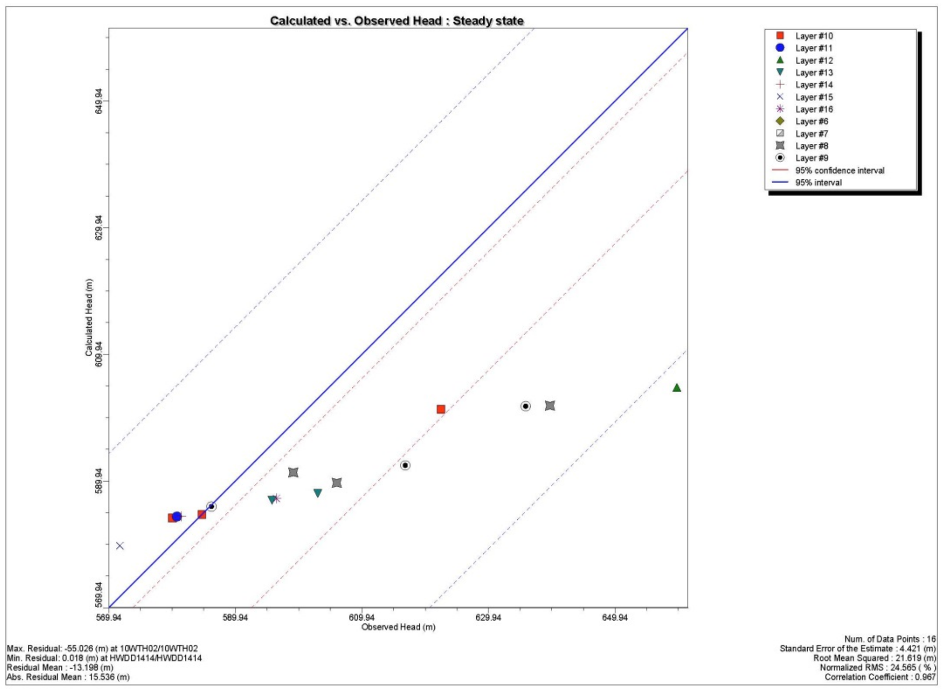
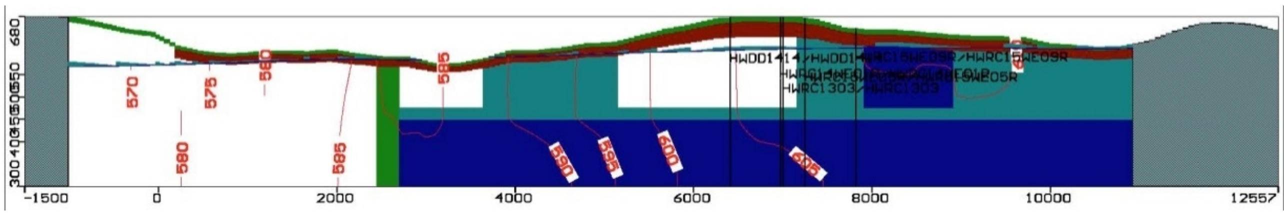


Figure 2-3 Simulated hydraulic heads for Model 3

a)

b) Longitudinal Cross-section of the Howse deposit:



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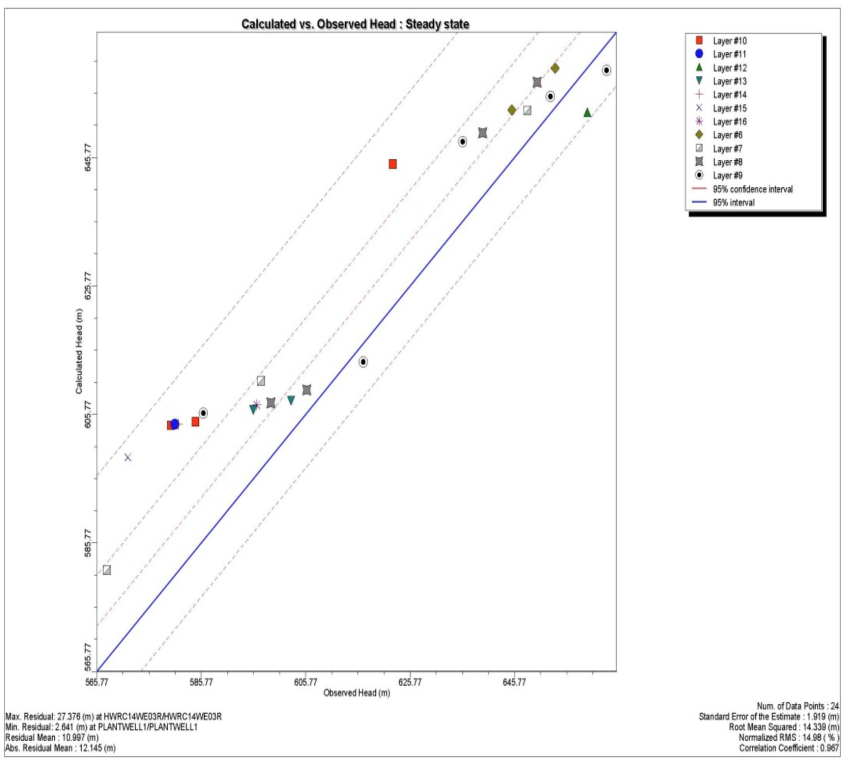
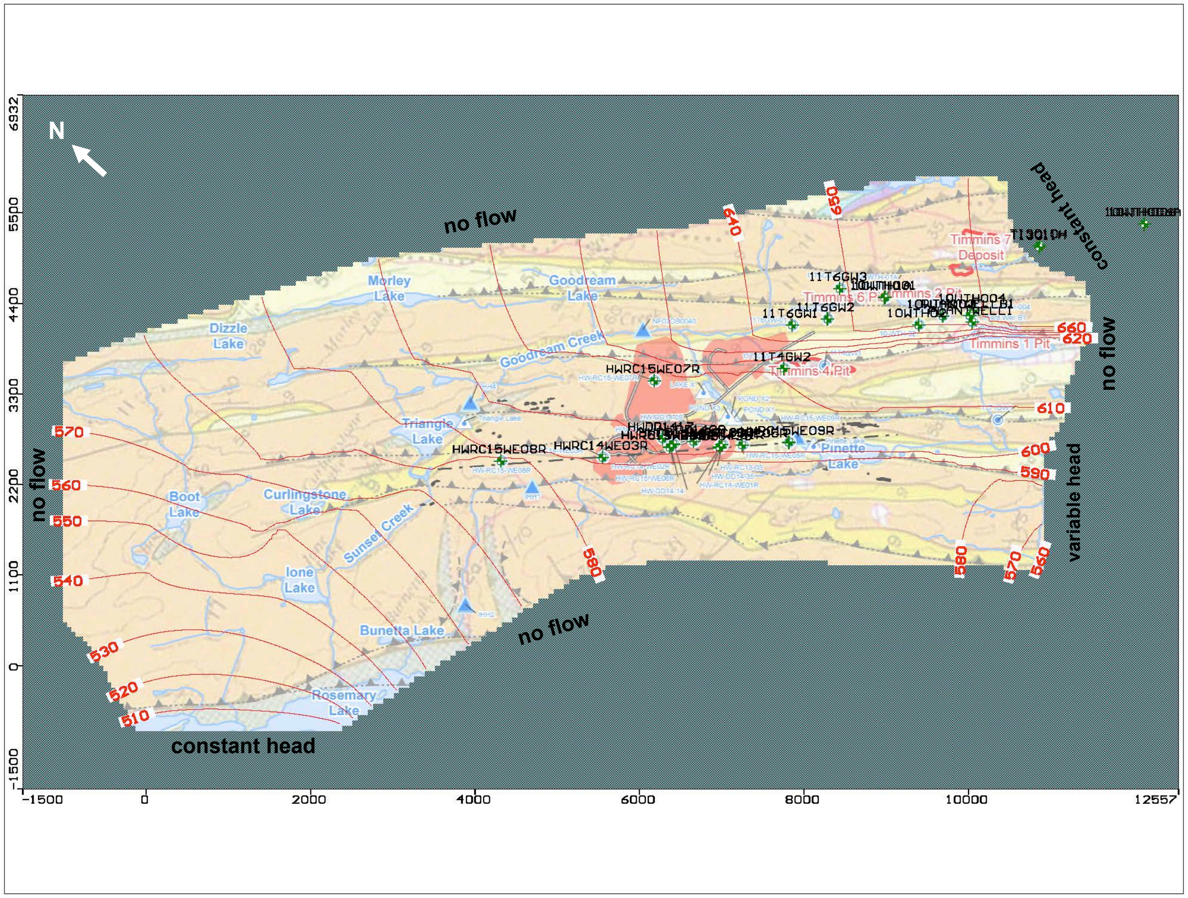


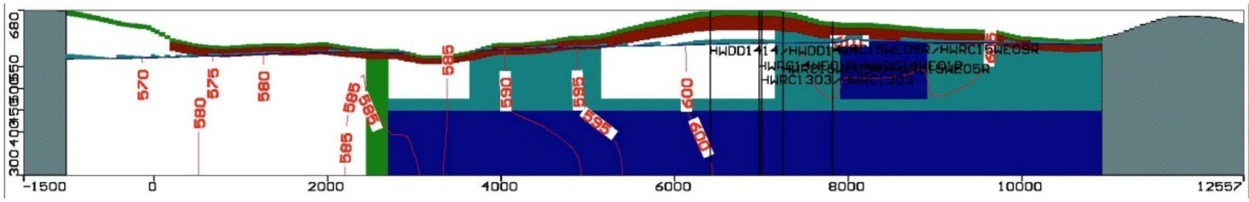
Well	Norting (m)	Easting (m)	Head Obs. (m)	Head Calc. Model of December 2016	Head Calc. Model 3, May 2017
10WTH001	622387	6085191	645,25	647,26	653,17
10WTH003	622639	6084499	650,10	653,83	657,49
10WTH004	622926	6084244	653,53	657,16	659,65
10WTH02	622372	6084662	659,71	647,94	652,82
10WTH1A	622376	6085195	648,19	647,14	653,10
11T4GW2	620945	6085630	616,78	601,50	613,95
11T6GW1	621425	6085872	622,43	634,69	644,74
11T6GW2	621746	6085581	635,82	639,87	648,24
11T6GW3	622131	6085690	639,65	641,89	649,60
HWDD1409	619571	6085950	586,16	590,00	605,98
HWDD1414	619393	6086123	584,63	587,68	604,63
HWDD1417	619367	6086270	579,97	586,51	604,06
HWDD1435	619706	6085652	599,09	594,93	607,57
HWRC1303	619755	6085655	596,41	592,84	607,25
HWRC14WE01R	619715	6085660	595,72	592,54	606,50
HWRC14WE02R	619338	6086138	580,71	587,14	604,24
HWRC14WE03R	618737	6086703	571,70	579,68	599,08
HWRC15WE05R	619903	6085454	602,95	594,86	607,92
HWRC15WE06R	619339	6086132	581,40	587,18	604,25
HWRC15WE07R	619859	6086780	597,21	588,37	611,01
HWRC15WE08R	617942	6087650	567,68	563,91	581,55
HWRC15WE09R	620275	6085028	605,96	598,99	609,59
PLANTWELL1	622800	6084167	652,63	652,82	655,27
PLANTWELLB1	622843	6084242	663,40	656,71	659,35

Figure 2-4 Simulated hydraulic heads for Model 4

a)

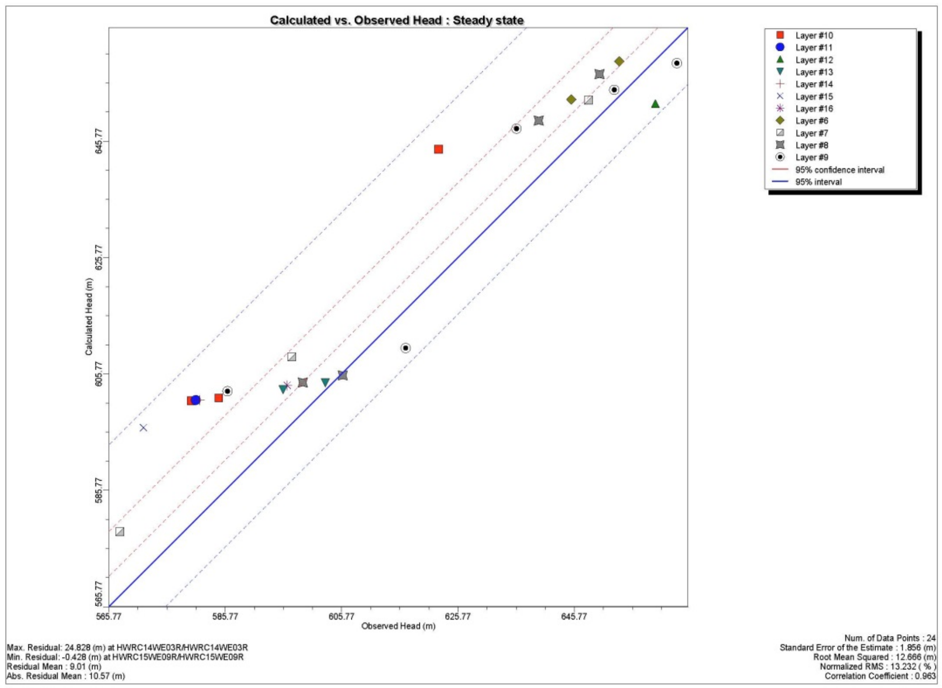


b) Longitudinal Cross-section of the Howse deposit:



-1500
0
2000
4000
6000
8000
10000
12557
570
575
580
585
590
595
600

c)



Calculated vs. Observed Head : Steady state
Calculated Head (m)
Observed Head (m)
565.77
585.77
605.77
625.77
645.77
Layer #10
Layer #11
Layer #12
Layer #13
Layer #14
Layer #15
Layer #16
Layer #6
Layer #7
Layer #8
Layer #9
95% confidence interval
95% interval
Max. Residual: 24.828 (m) at HWRC14WE03R/HWRC14WE03R
Min. Residual: -0.428 (m) at HWRC15WE09R/HWRC15WE09R
Residual Mean : 9.01 (m)
Abs. Residual Mean : 10.57 (m)
Num. of Data Points : 24
Standard Error of the Estimate : 1.856 (m)
Root Mean Squared : 12.666 (m)
Normalized RMS : 13.232 (%)
Correlation Coefficient : 0.963

2.3 Howse Deposit Dewatering Model

Based on the scenario results for the different groundwater initial conditions, Model 3 was selected to run the dewatering simulations of the Howse deposit. Model 3 appears to represent a conservative scenario and shows a relatively lower RMS (15%). In this model, hydraulic heads are considered to be at the ground level in the area of Triangle Lake.

The open pit phases were incorporated into Model 3 to simulate the dewatering rate and radius of influence due to groundwater drawdowns. According to TSMC's mining schedule, the Howse deposit will be mined in several steps. For the purpose of the modeling, three mine phases were selected based on pit size main changes (see Appendix A: Howse Deposit mining phases). Table 2-3 presents the three mining phases, their planned periods and final pit floor elevations.

During Phase I (expected period from 2018 to 2022), mainly the northwest side of the deposit will be mined to an elevation of about 580 m. During Phase II (expected period from 2022 to 2025), mining will go deeper in the northwest part of the deposit to reach an elevation of 550 m whereas the mining of the center part will start, to reach an elevation of 580 m. During Phase III (expected period from 2025 to 2033), both the center and the southeast of the deposit will be mined respectively to final depth elevations of 480 m and 520 m. In the meantime, the northwestern part of the deposit will be filled with available mine waste, which will reduce the need of dewatering for this part of the pit.

The drain package method of Modflow was used to simulate the drawdown at each of the final pit phases under pumping conditions.

Table 2-3 Selected Mining Phases of the Howse Deposit

	Phase I	Phase II	Phase III
Howse deposit mining periods	5 years	6 years	6 years
Final northwest pit elevation (m)	580	550	680
Final central pit elevation (m)	600	580	480
Final southeast pit elevation (m)	-	-	520

Dewatering simulations were carried out in a transient state flow regime to evaluate the flow rates and the radius of influence of the dewatering activities at the final pit floor of each mine phase. The transient state flow regime was also used to represent seasonal recharge variations as it was presented in the SNC-Lavalin report of December 2016. Table 2-4 summarizes the dewatering rate achieved to simulate the pit at the end of each mine phase. The dewatering results are presented in terms of piezometry (Figures 2-5 to 2-7) and drawdown (Figures 2-8 to 2-10). Table 2-5 summarizes the drawdown results for each mine phase.

Simulation results show that dewatering rate increases with the pit size and floor depth (Phases I, II and III). It can be seen in Figure 2-8 (Phase I), Figure 2-9 (Phase II) and Figure 2-10 (Phase III) that larger drawdowns are observed in the vicinity of the pit and decrease with distance from it. Due to the presence of longitudinal thrust faults and less permeable units both to the NE and SW of the pit, drawdowns seem to be oriented NW-SE.

Table 2-4 Dewatering Simulation Results

Scenario	Flow rates (m^3/day)				Note (see Appendix C on sensitivity analysis for more details)	Pumping rate increase
	End of Phase I	End of Phase II	End of Phase III	Safety factor of 1.25 on Phase III		
Base case: Calibrated	**7,418**	**16,872**	**19,533**	**24,416**	› Kx, Ky, Kz › Variable recharge of 150 mm/y	n/a

For Phase I of mining, the final simulated drawdown of the deep aquifer at the center of the pit reaches 20 m. The drawdown is negligible beyond a distance of 1,500 m from the pit center. Consequently, no aquifer drawdown is expected in the areas of Triangle Lake and Pinette Lake located about 2.7 km and 1.8 km respectively from the pit center. The dewatering rate is estimated to 7,418 m^3/day.

The groundwater at the Howse deposit is deep. So, during the first years of mining, dewatering will be basically due to accumulated water in the pit from direct precipitations and infiltration through unsaturated zone. When mining reaches the saturated zone (water table), dewatering will start to increase gradually with pit size and floor depth. Consequently, dewatering will be less than expected, and will increase with pit depth until it reaches the estimated value at the final pit depth of Phase I.

For Phase II of mining, the final simulated drawdown of the deep aquifer at the center of the pit reaches 50 m and decreases with distance (for example in the longitudinal axis, drawdowns are respectively 30 m and 20 m at 500 m and 1,000 m from the pit).

Projected drawdown of the deep aquifer (Sokoman) is less than five meters underneath Pinette Lake and Triangle Lake areas. The final dewatering rate is estimated to 16,872 m^3/day at the end of Phase II.

For Phase III of mining, the final simulated drawdown of the deep aquifer reaches its maximum at the center of the pit of about 120 m and decreases with distance (for example in the longitudinal axis, drawdowns are about 80 m and 45 at 500 m and 1,000 m from the pit center).

Projected drawdown of the deep aquifer (Sokoman) is between 10 m and 20 m underneath Pinette Lake area (distance of 1,800 m) and between 5 m and 10 m underneath Triangle Lake area (distance of 2,700 m). However, in the area of Pinette Lake, the Sokoman underlies a less permeable unit (Shale), which will reduce any eventual impact of the dewatering on lake. The final dewatering rate is estimated to 19,533 m^3/day at the end of Phase III.

Figure 2-5 Piezometric Map at the end of Phase I of Pit Dewatering

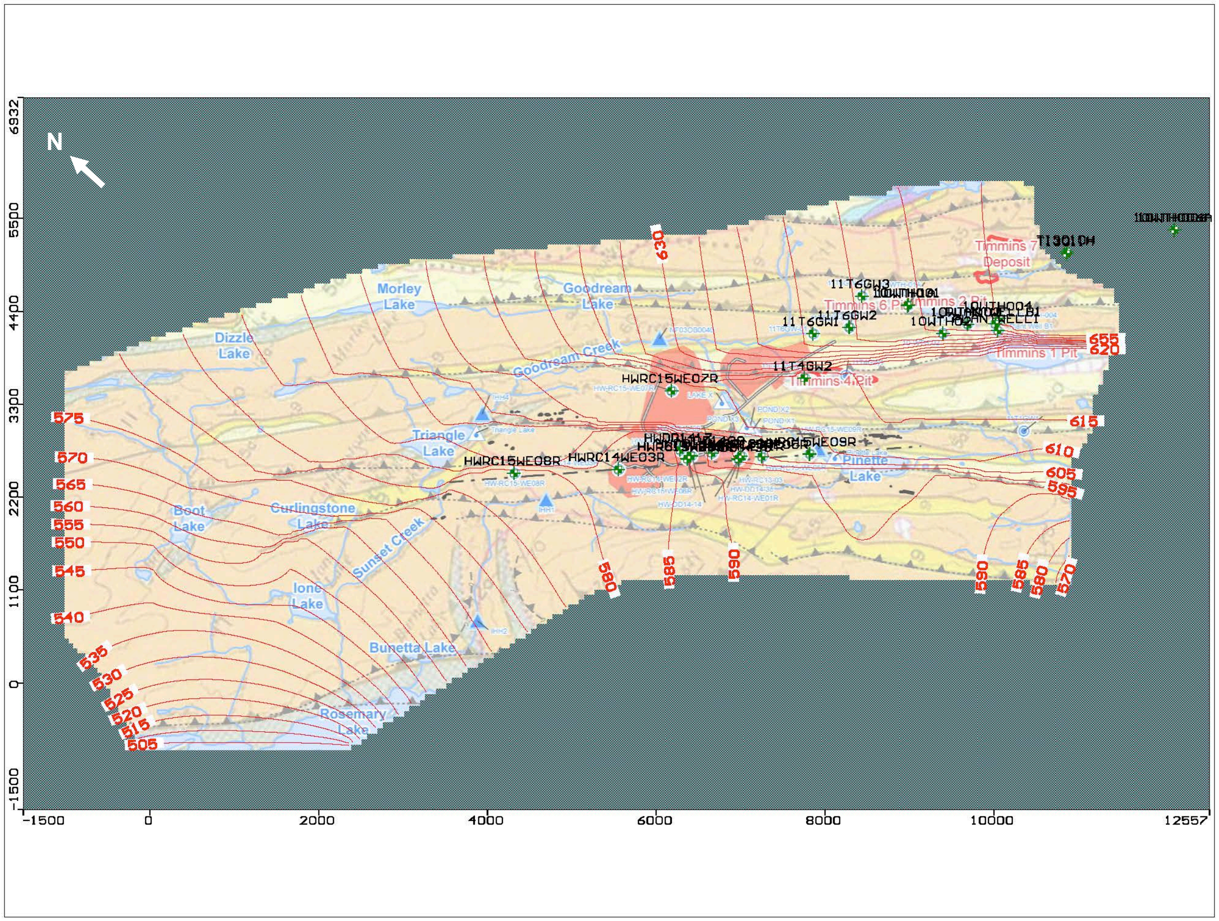


Figure 2-6 Piezometric Map at the end of Phase II of Pit Dewatering

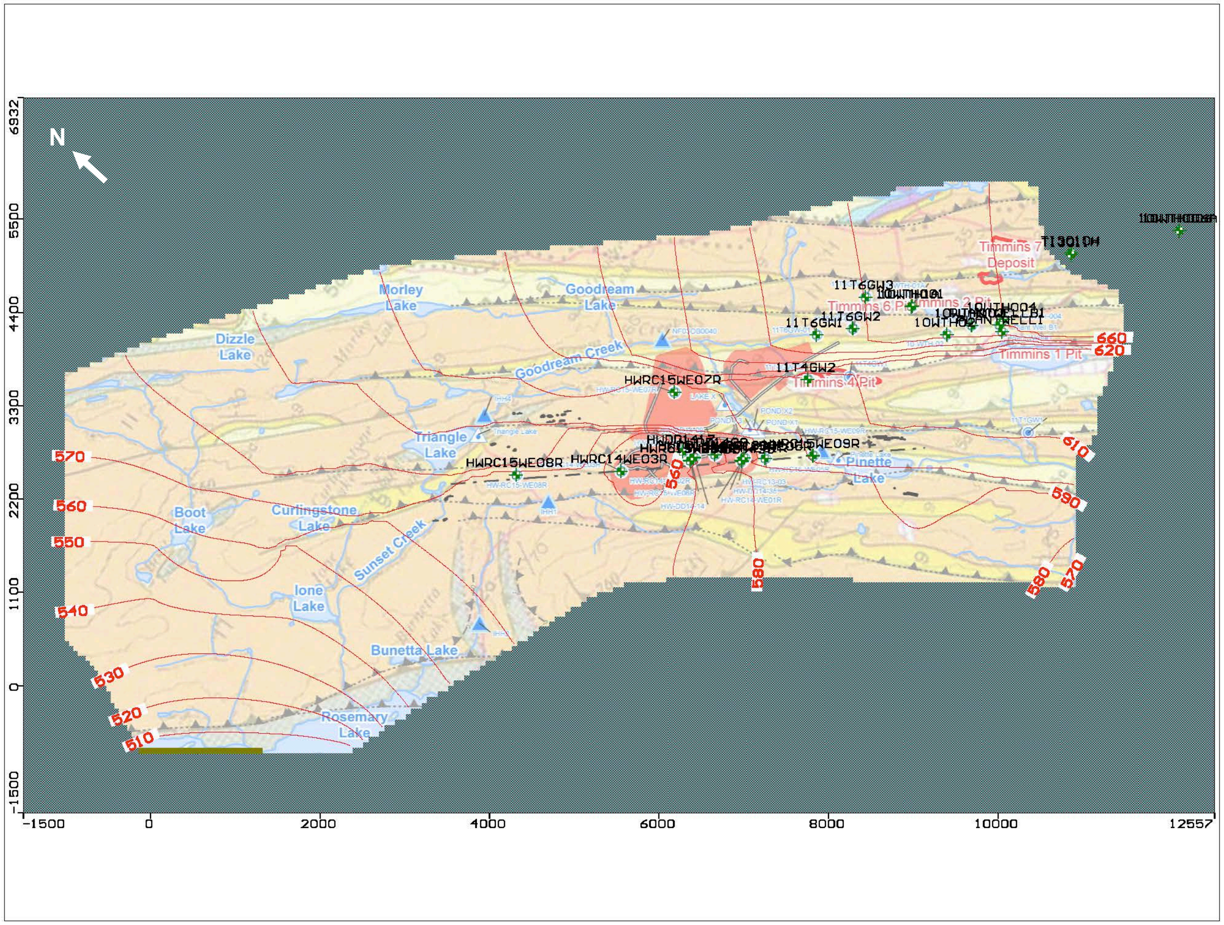


Figure 2-7 Piezometric Map at the end of Phase III of Pit Dewatering

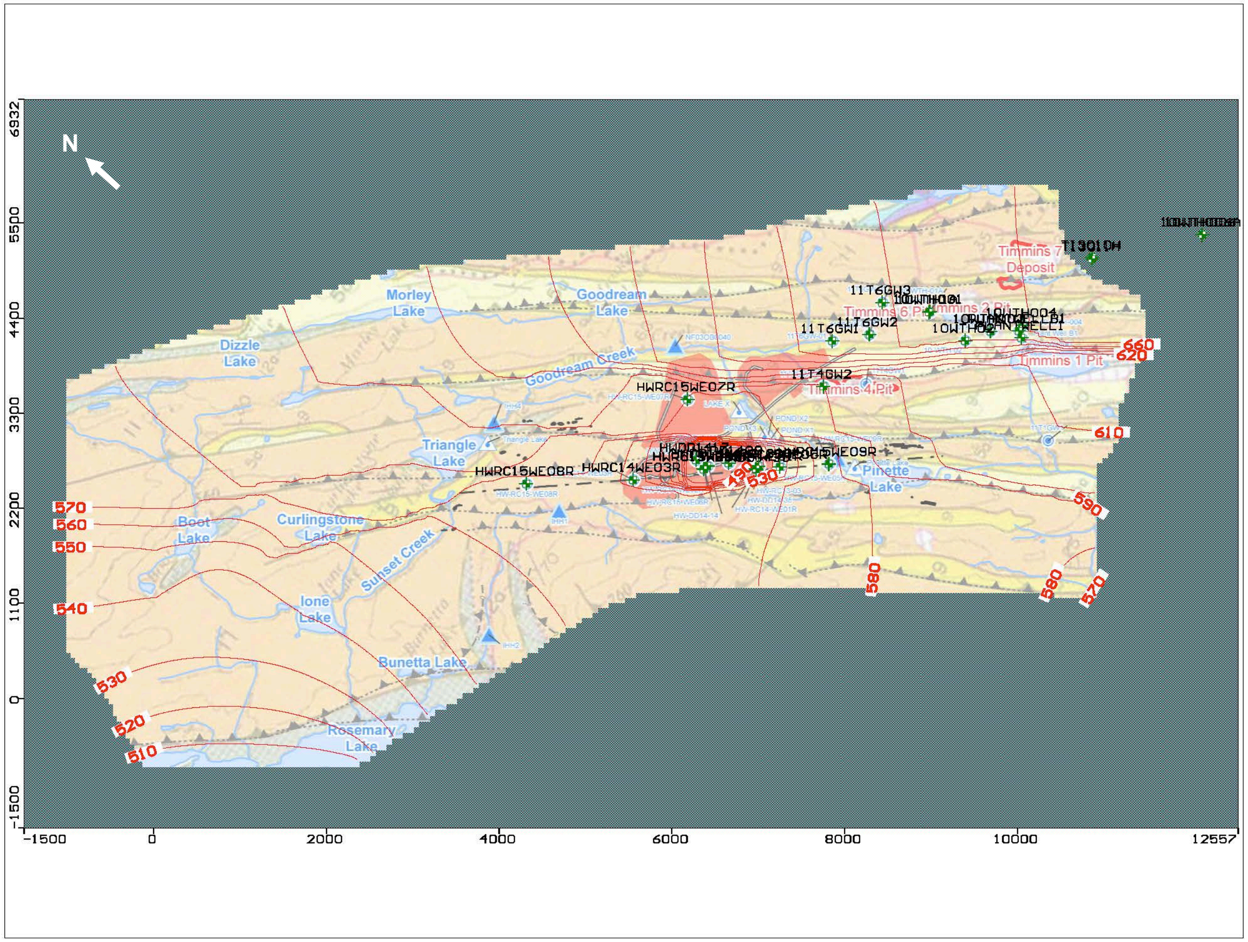


Figure 2-8 Groundwater Drawdown at the end of Phase I of Pit Dewatering

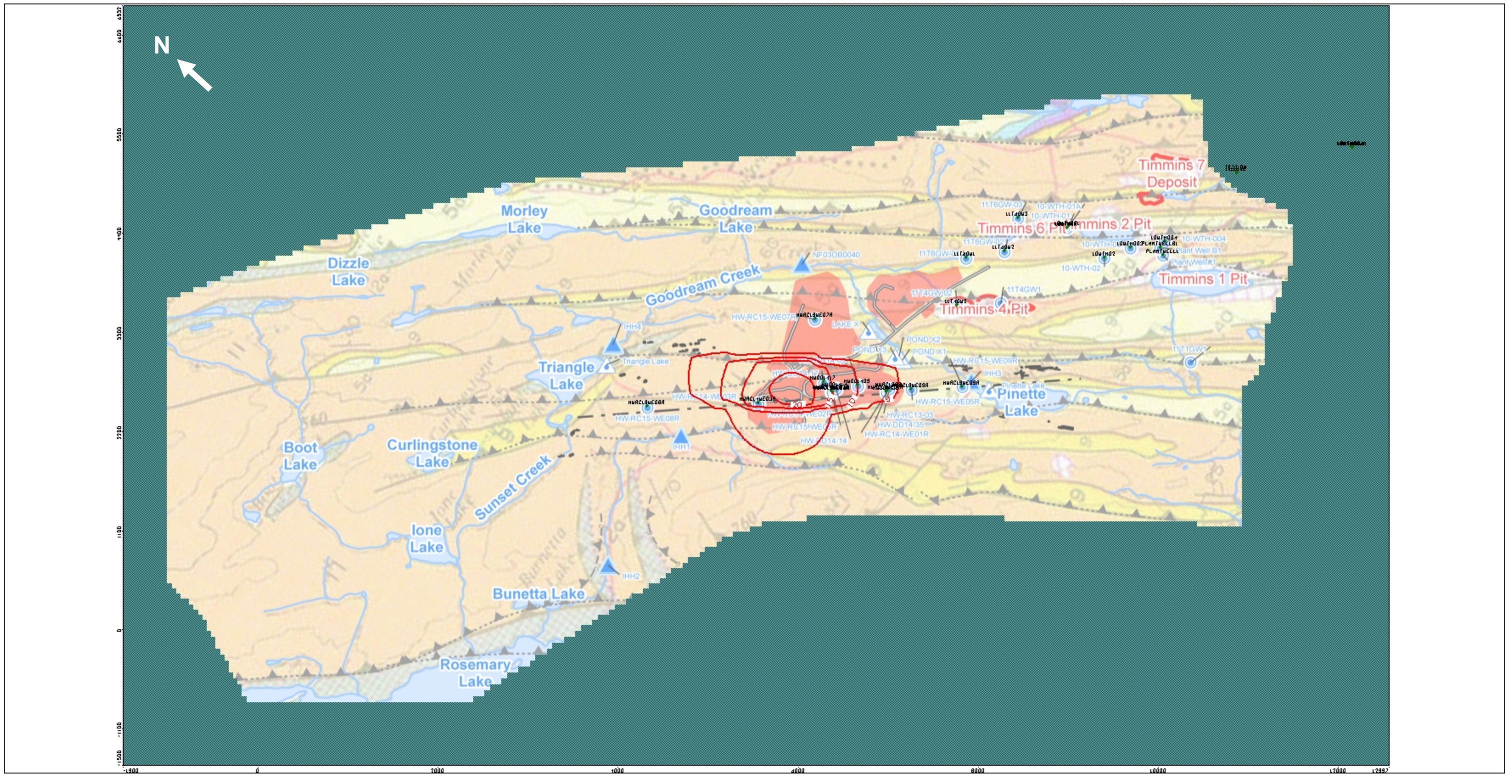


Figure 2-9 Groundwater Drawdown at the end of Phase II of Pit Dewatering

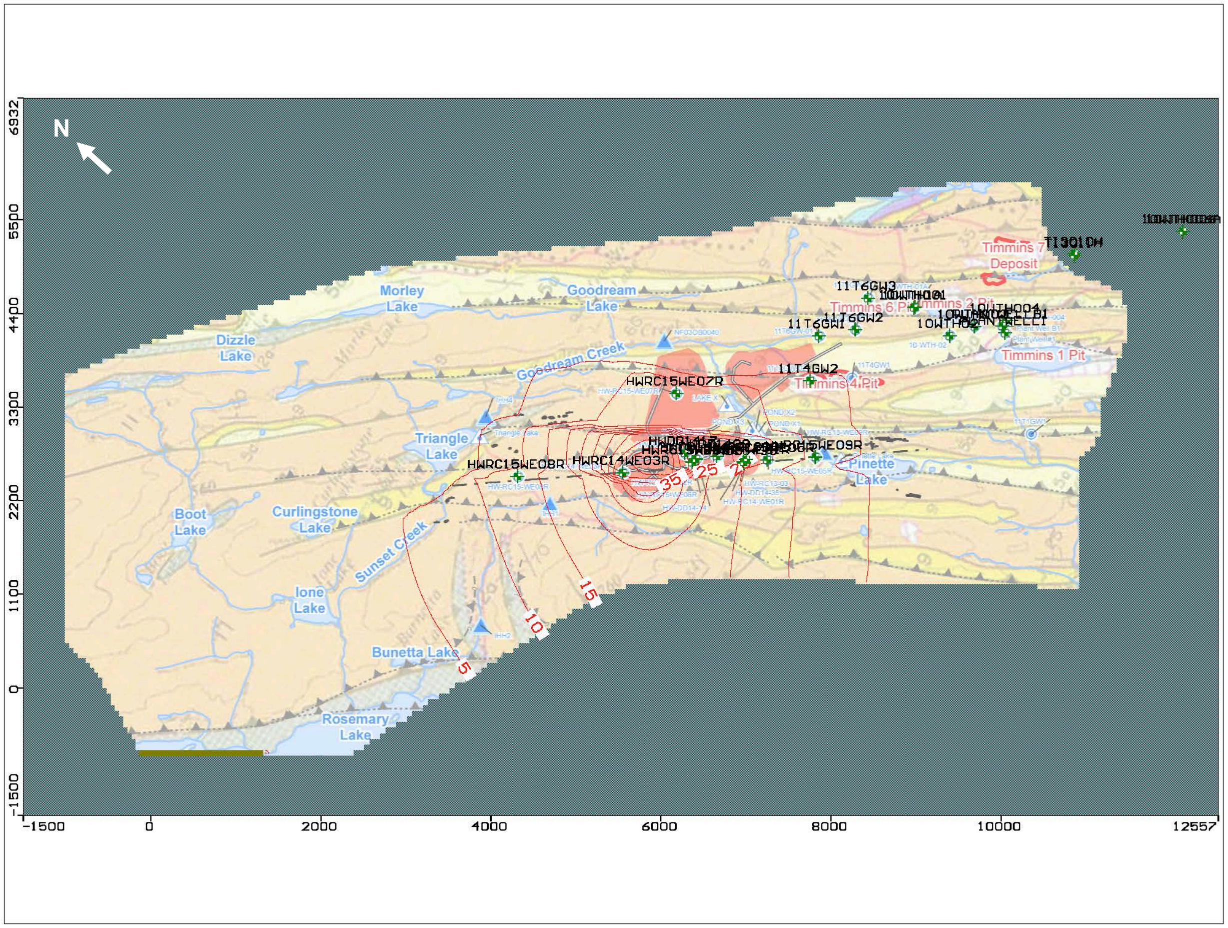


Figure 2-10 Groundwater Drawdown at the end of Phase III of Pit Dewatering

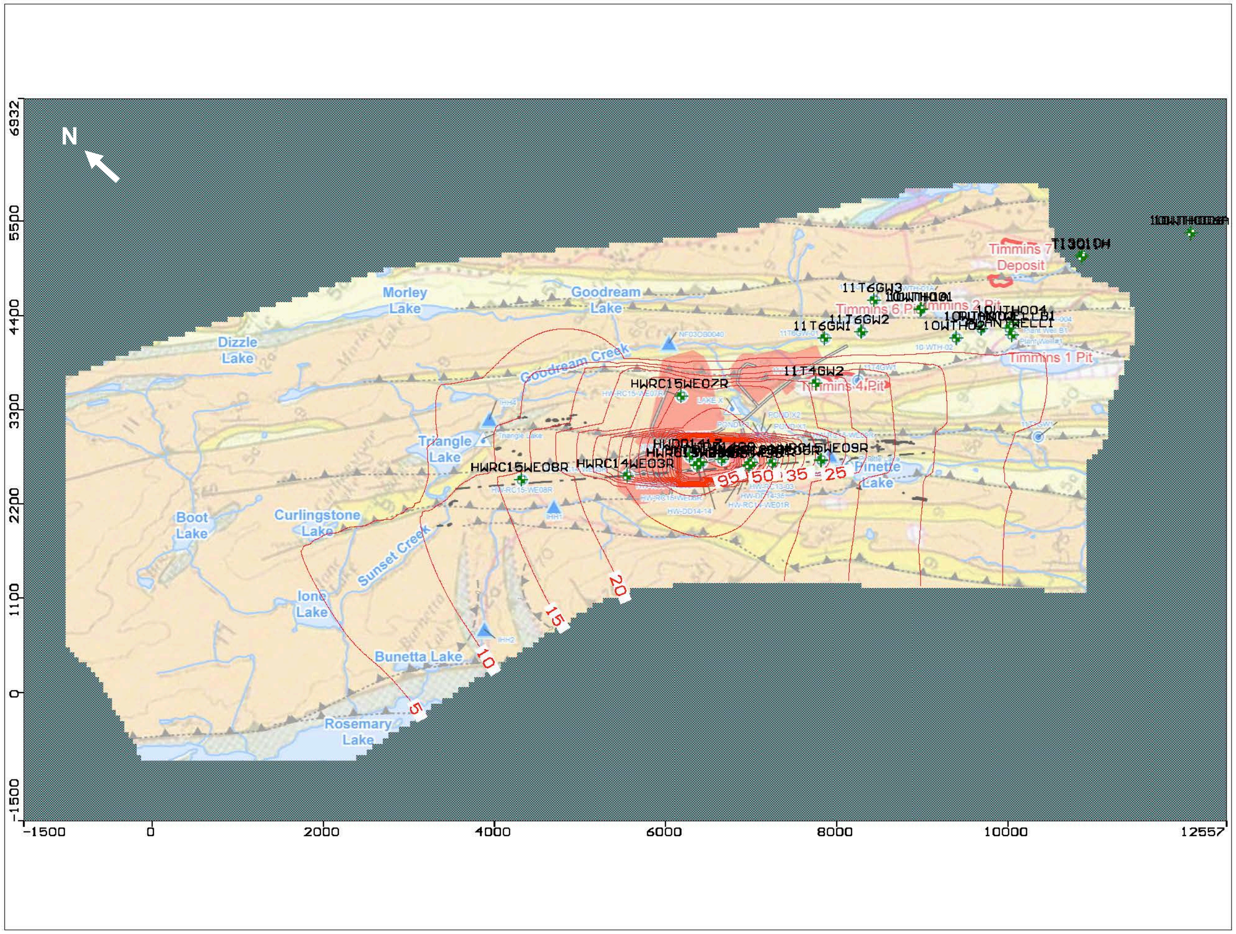


Table 2-5 Projected Drawdown at Three Mining Phases

	Approximate Drawdown (m)						
	At the Pit Center	At Distance of 500 m		At Distance of 1,000 m		Underneath Triangle Lake	Underneath Pinette Lake
		Downgradient	*Upgradient*	*Downgradient*	*Upgradient*	*Downgradient*	*Upgradient*
Phase I	20	10 < D < 15	10 < D < 15	5 < D < 10	5 < D < 10	< 1	< 1
Phase II	50	30	30	20	20	< 5	< 5
Phase III	120	80	80	45	45	5 < D < 10	10 < D < 20

2.4 Model Challenges and limitations

Conceptual Model & Boundary conditions

The enlargement of the model has reduced the stress of boundaries on simulation results. However, it does increase some level of uncertainty by including new domains with unknown hydrogeological parameters.

In order to reduce the effect of boundary conditions on drawdown results, particularly near Triangle Lake, the model was enlarged along the longitudinal axis of the open pit. In fact, a NE-SW enlargement was not realistic in a conceptual point of view due to the presence of topographic ridges (Irony Mountain to the SW and the Goodream watershed ridges to the NE).

The presence of observation wells located near the Flemming 7 and Timmins deposits has allowed attributing a fixed head boundary condition for the eastern limit of the model. At the SE limit of the model, a boundary of no flow was applied along topographic ridge. At the southern limit of the model, a variable hydraulic charge, equal to the topography (610 m to 560 m), was used along the Elross Creek. Only one observation well was available in this area (11TGW1), therefore insufficient to determine a piezometric pattern.

The NW enlargement of the model beyond Triangle Lake represented a challenge due to the absence of observation wells beyond this lake. The eastern limit of the model was considered as no flow boundary along topographic ridges in this area (presumed flowpath). The model also assumes a hydraulic head of 500 m to the West of the model, corresponding to a presumable groundwater discharge into the Howells River.

The new boundary conditions considered in the new model update allowed determining the approximate natural water table depth and eventual relation to surface waterbodies within the project area

Piezometric Data

The groundwater model was constructed using several assumptions which have an influence on the results. While hydrogeological data was available in the immediate vicinity of the deposit, other areas of the groundwater domain were limitedly investigated, for which extrapolation of hydraulic characteristics had to be conducted. Therefore, the model domain had to be limited to the predetermined Goodream and Elross creek watersheds where the hydrogeological data could be determined. Beyond these areas no scientific references were available to further extend the model. Few piezometric values of past surveys were used to fill up the gap between actual available piezometric readings. In fact, several pre-existing piezometers and wells in the area modeled were not available during recent hydrogeological investigations. They were either frozen, abandoned, in pumping conditions for water supply purposes, or destroyed by construction activities (Geofor, 2015). For this model, no additional wells were available.

Surface Water and Deep Aquifer

The groundwater model represents the aquifer hydraulic conditions, based on available data, with no interaction with surface water. It is a 3D simplified representation of a complex environment such as the one of the Howse deposit.

Many lakes are present within the study area. Simulated drawdowns of the pit seem to indicate extended drawdown in the geological units underneath the lake areas (Pinette Lake and Triangle Lake). However, the model does not simulate the interactions between these surface waters and the aquifer. The direct effect on lakes due to dewatering cannot be confirmed without knowing for instance the real groundwater elevation in the lake's area or underneath it, the sediment nature at the bottom of the lakes and hydraulic properties of the geological unit underneath.

Distribution of Hydraulic Conductivity

Hydraulic conductivity distribution of the model is based on hydraulic tests conducted in the area of the Howse deposit and on the regional geological map. A unique hydraulic conductivity value is used for each hydrostratigraphic unit. However, in reality the permeability of a formation can vary depending on several factors (nature and configuration of the deposits, dip and direction of formation, heterogeneity, anisotropy, horizontal and vertical extension of faults, etc.). Variability of the hydraulic conductivity can affect simulation results. Moreover, geology of the region is particularly complex (deep faults which impact flow, high hydraulic conductivity contrasts) and the model can only represent a simplified version of the true picture.

3 Conclusions and Recommendations

The current groundwater flow modeling exercise study has allowed for the evaluation of the dewatering rates for the Howse deposit and of the projected groundwater drawdowns in the project area under new modelling limit conditions. This new regional model is mainly an enlargement of the previous model of December 2016 with the following new parameter conditions:

- Enlarging the model size to include new natural physical boundaries : the Howells River along western limit of the model and Elross Creek to the SE limit of the model;
- All other parameters and conditions of previous models were kept unchanged, such as recharge and permeability values for the model unit layers;
- Under the new conditions, modeling was conducted in two steps: firstly, the model was run under steady-state conditions to evaluate the approximate initial water table depth and eventual relation to surface waterbodies within and outside the project area. Secondly, the mine pit was introduced into the model to simulate three dewatering phases and their impact on groundwater drawdowns.

Model results allowed the following conclusions:

- Dewatering rate increases with the pit size and floor depth (Phases I, II and III);
- Larger drawdowns are observed in the vicinity of the pit and decrease with distance from it;
- The radius of influence (projected drawdown) due to dewatering is oriented generally NW-SE and seems to be influenced by the longitudinal structures in the area of study;
- During Phase I of mining (expected period 2018-2022) mainly the northwest part of the deposit will be mined to a final depth elevation of 580 m. The final simulated drawdown of the deep aquifer at the center of the pit reaches 20 m. Drawdown is negligible beyond a distance of 1,500 m from the pit center. The dewatering rate is estimated to 7,418 m^3/day;
- During Phase II of mining (expected period 2022-2025), mining will go deeper in the northwest part of the deposit to reach an elevation of 550 m whereas the mining of the center part will start, to reach a final elevation of 580 m. The final simulated drawdown of the deep aquifer at the center of the pit reaches 50 m and decreases with distance. In the longitudinal axis of the pit, drawdowns are respectively 30 m and 20 m at 500 m and 1,000 m from of the pit center;

  Projected drawdown of the deep aquifer (Sokoman) is less than five metres underneath Pinette Lake and Triangle Lake areas. The final dewatering rate is estimated to 16,872 m^3/day;
- During Phase III of mining (expected period 2025-2033), both the center and the southeast of the deposit will be mined respectively to final depth elevations of 480 m and 520 m. In the meantime, the northwestern part of the deposit will be filled with available mine waste. The final simulated drawdown of the deep aquifer reaches 120 m at the center of the pit and decreases with distance;

  In the longitudinal axis of the pit, drawdowns are respectively about 80 m and 45 at 500 m and 1,000 m from the pit center;

- Projected drawdowns of the deep aquifer (Sokoman) are between 10 m and 20 m underneath Pinette Lake area (distance of 1,800 m) and between 5 m and 10 m underneath Triangle Lake area (distance of 2,700 m). However, in the area of Pinette Lake, the Sokoman underlies a less permeable unit (Shale), which will reduce eventual impact on the lake;
- The final dewatering rate is estimated to 19,533 m^3/day at the end of Phase III.

Recommendations from previous report (SNC-Lavalin, December 2016) are reiterated.

For the purpose of the mining operations, an adequate groundwater monitoring is recommended in order to validate the simulated radius of influence and to detect any potential link between surface water (lakes) and the aquifer.

- Monitoring of the groundwater would include:
  - Installation of at least one observation well near Triangle Lake (less than 500 m);
  - Continuous water level monitoring in these wells should be conducted with permanent water pressure instrument in order to evaluate the drawdown progression during the mine lifespan and detect any impact on groundwater underneath lakes.
- Monitoring of the water level of the lakes and flows of its tributaries (lake inflow and outflow) to evaluate any real impact due the dewatering;
- Monitoring of the wetlands: Installation of shallower wells in the wetland areas to characterize and monitor any potential aquitard underneath;
- Monitoring of the dewatering flow rate variation with the seasons and mining phases (optimization of the pump well locations and pumping only when necessary upon the seasons to reduce the drawdown cone outside the pit area);
- Biannual report on data collected during the monitoring and pertinent observations on the pit size evolution, lakes and wetlands;
- Hydrogeological model update at the end of each of the mining phases (Phase I and Phase II) using new data (recorded flowrates and drawdowns, new well logs) collected during the monitoring to better evaluate the impact of the next pit phase.

4 References

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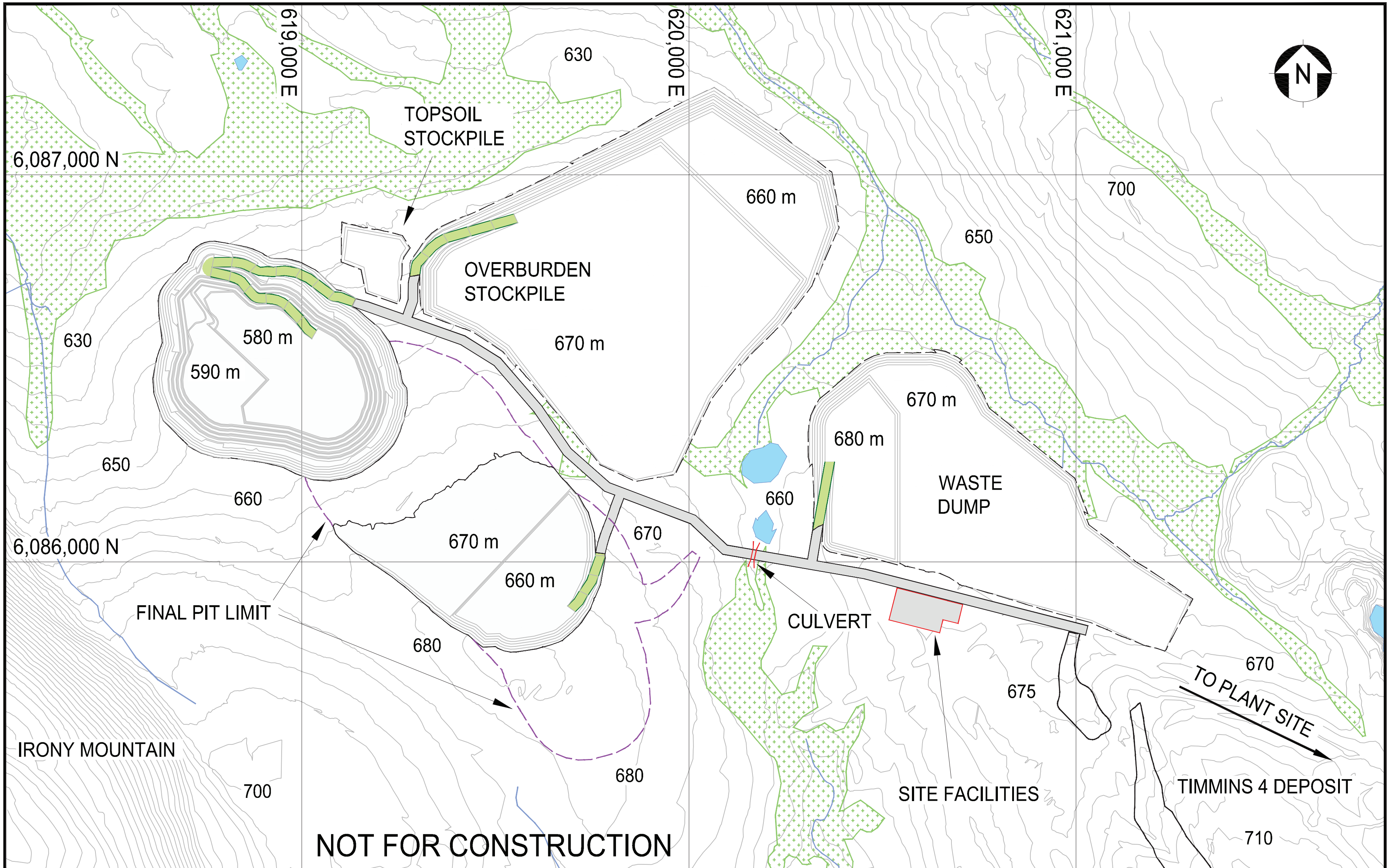
APPENDIX A

Howse Deposit Mining Phases

Howse Deposit Mining Phases

	Phase I 2018 - 2022_Winter	Phase II 2022 - 2028_Summer	Phase III 2028 - 2033_Final
Mining periods	5 years	6 years	6 years
Relative pit position	NW + slightly on the center	NW + center	Center + SE
Natural elevation - no pit (m)	635 - 675	635 - 680	660 - 680
Average bottom pit elevation (m)	NW : 580-590 / C: 660-670	NW: 550 / C: 580	NW 680 almost entirely/ C: 480/SE: 520 m



LEGEND

- FINAL PIT LIMIT
- CURRENT PIT LIMIT
- PIT / DUMP RAMP
- DUMP / STOCKPILE FOOTPRINT
- TOPOGRAPHY CONTOURS (5 m)
- MINE HAUL ROAD
- WETLANDS
- CREEKS
- CULVERT

125 250 500

Metres

UTM NAD83 ZONE 19

TATA

MET-CHEM

HOWSE DSO DEPOSIT

FEASIBILITY STUDY
END OF FY-2022 (Winter)

NO.	DATE/BY	TITLE / NAME
B	01/09/15 JEFFREY CASSOFF, Eng.	MODIFIED MINE PLAN
A	10/08/15 JEFFREY CASSOFF, Eng.	FOR FEASIBILITY STUDY REPORT

REVISIONS

RESPONSIBLE ENGINEER JEFFREY CASSOFF, Eng.	DATE 05/08/15	CHECKED RICHARD BONICI, Eng.	DATE 10/08/15
DESIGNED JEFFREY CASSOFF, Eng.	DATE 05/08/15	APPROVED ANDRE BOILARD, Eng.	DATE 10/08/15
DRAWN JEFFREY CASSOFF, Eng.	DATE 05/08/15	SCALE n/a	
CLIENT APPROVAL	DATE	DEPARTMENT MINING	

DRAWING NO. A4-2014-049-520-MN

REV. B

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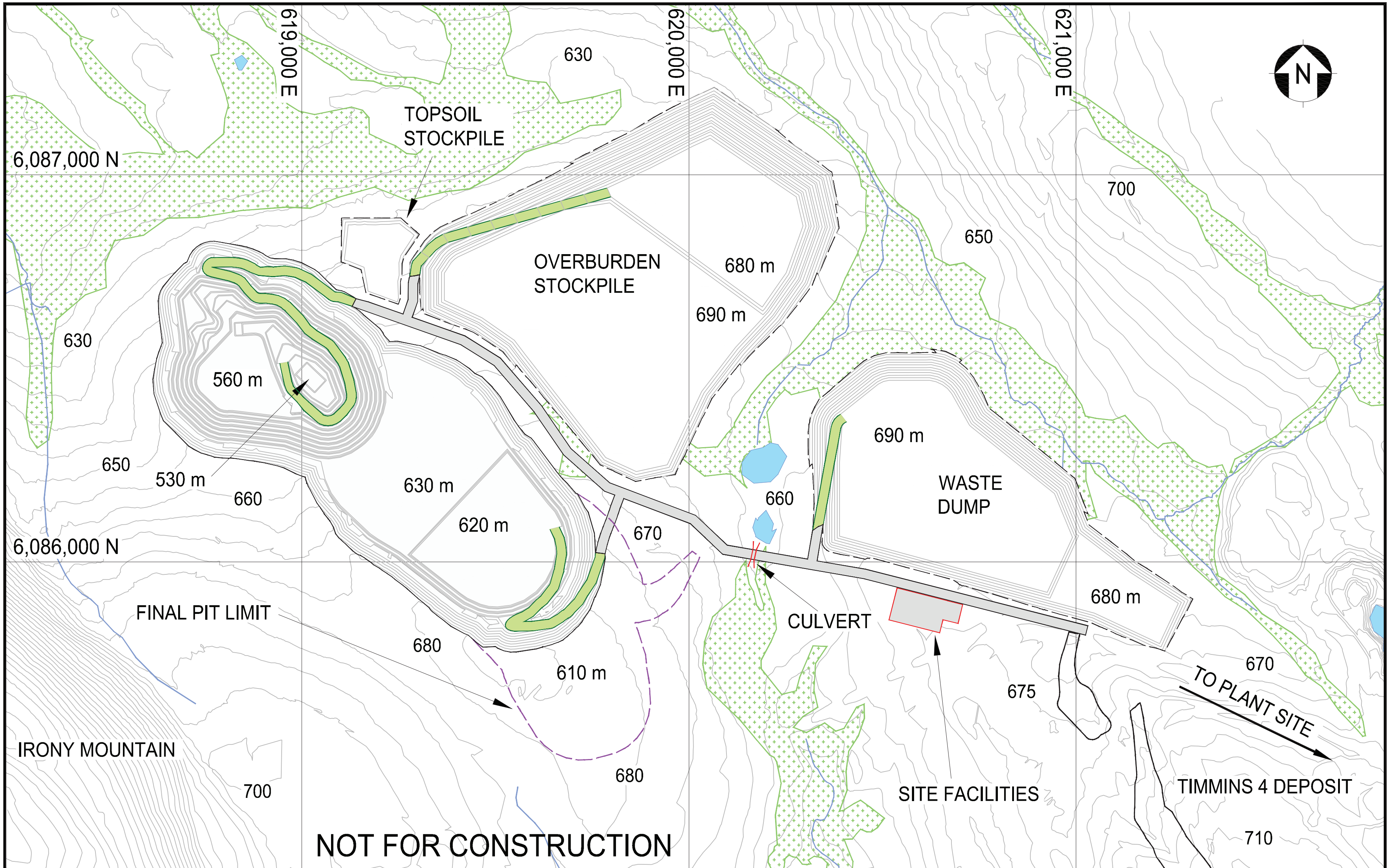

LEGEND

- FINAL PIT LIMIT
- CURRENT PIT LIMIT
- PIT / DUMP RAMP
- DUMP / STOCKPILE FOOTPRINT
- TOPOGRAPHY CONTOURS (5 m)
- MINE HAUL ROAD
- WETLANDS
- CREEKS
- CULVERT

125 250 500
Metres

UTM NAD83 ZONE 19

TATA

MET-CHEM

HOWSE DSO DEPOSIT

FEASIBILITY STUDY
END OF FY-2025

NO.	DATE/BY	TITLE / NAME
B	01/09/15 JEFFREY CASSOFF, Eng.	MODIFIED MINE PLAN
A	10/08/15 JEFFREY CASSOFF, Eng.	FOR FEASIBILITY STUDY REPORT
	REVISIONS	

RESPONSIBLE ENGINEER JEFFREY CASSOFF, Eng.	DATE 05/08/15	CHECKED RICHARD BONICI, Eng.	DATE 10/08/15
DESIGNED JEFFREY CASSOFF, Eng.	DATE 05/08/15	APPROVED ANDRE BOILARD, Eng.	DATE 10/08/15
DRAWN JEFFREY CASSOFF, Eng.	DATE 05/08/15	SCALE n/a	
CLIENT APPROVAL	DATE	DEPARTMENT MINING	

DRAWING NO. A4-2014-049-521-MN REV. B

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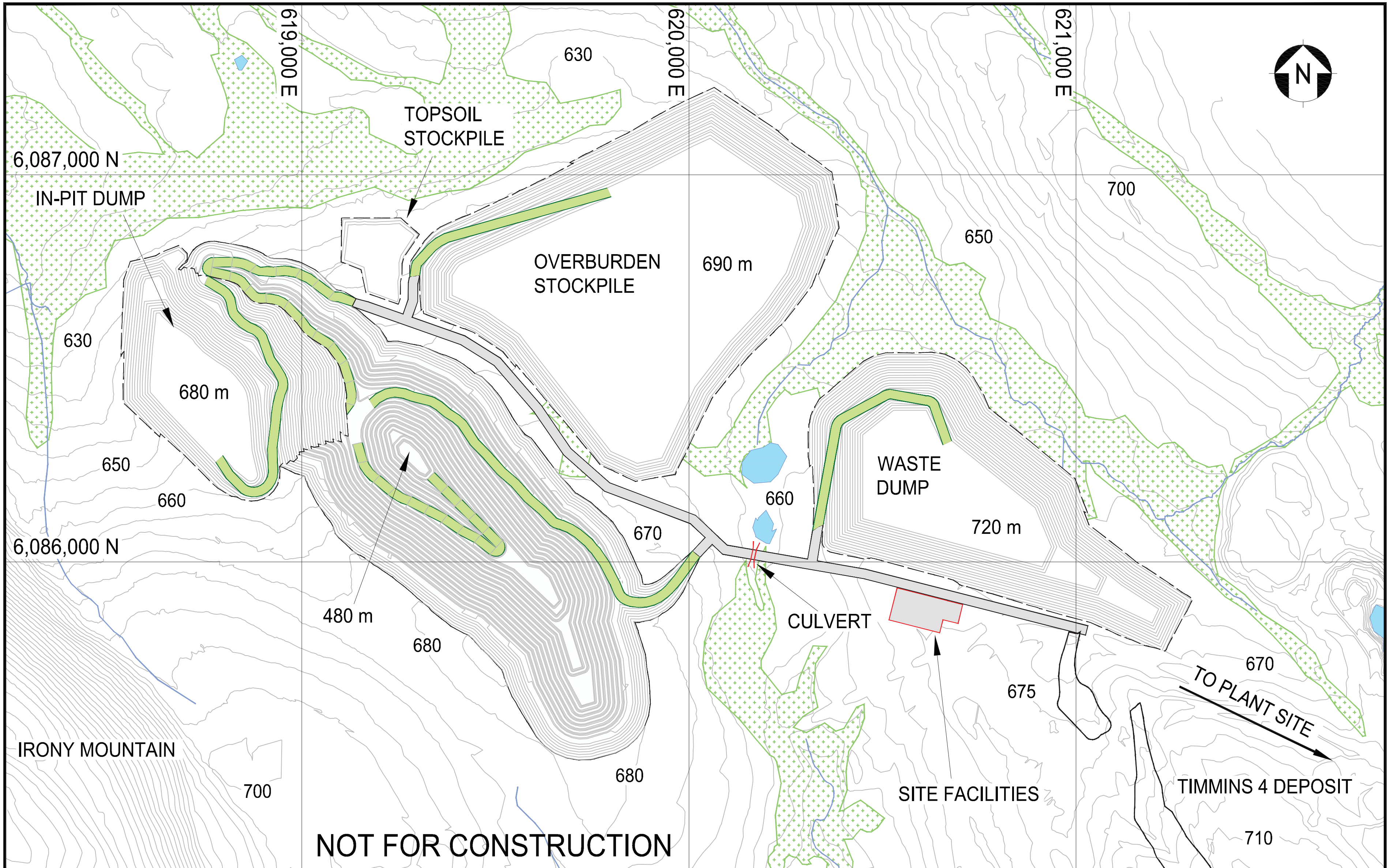

LEGEND

- FINAL PIT LIMIT
- CURRENT PIT LIMIT
- PIT / DUMP RAMP
- DUMP / STOCKPILE FOOTPRINT
- TOPOGRAPHY CONTOURS (5 m)
- MINE HAUL ROAD
- WETLANDS
- CREEKS
- CULVERT

125 250 500
Metres

UTM NAD83 ZONE 19

TATA

MET-CHEM

HOWSE DSO DEPOSIT

FEASIBILITY STUDY
END OF FY-2033

NO.	DATE/BY	TITLE / NAME
B	01/09/15 JEFFREY CASSOFF, Eng.	MODIFIED MINE PLAN
A	10/08/15 JEFFREY CASSOFF, Eng.	FOR FEASIBILITY STUDY REPORT
	REVISIONS	

RESPONSIBLE ENGINEER JEFFREY CASSOFF, Eng.	DATE 05/08/15	CHECKED RICHARD BONICI, Eng.	DATE 10/08/15
DESIGNED JEFFREY CASSOFF, Eng.	DATE 05/08/15	APPROVED ANDRE BOILARD, Eng.	DATE 10/08/15
DRAWN JEFFREY CASSOFF, Eng.	DATE 05/08/15	SCALE n/a	
CLIENT APPROVAL	DATE	DEPARTMENT MINING	

DRAWING NO. A4-2014-049-524-MN REV. B

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APPENDIX B

Scope of Report

1. Use of report

a. Use of report

This report has been prepared, and the work mentioned herein was carried out by SNC-Lavalin GEM Québec Inc. (SNC-Lavalin) exclusively for the client (the Client), to whom the report is addressed, and who took part in developing the scope of work and understands the limitations. The methodology, findings, recommendations and results cited in this report are based solely on the scope of work and are subject to the requirements of time and budget, as described in the offer of services and/or the contract under which this report was issued. Use of this report or any decision based on its content by third parties is the sole responsibility of the third parties. SNC-Lavalin is not responsible for any damage incurred by third parties due to the use of this report or of any decision based on its content. The findings, recommendations and results cited in this report (i) have been prepared in accordance with the skill level normally demonstrated by professionals operating in similar conditions in the sector, and (ii) are determined according to the best judgment of SNC-Lavalin, taking into account the information available at the time the report was prepared. The professional services provided to the Client and the findings, recommendations and results cited in this report are not subject to any guarantee, express or implied. The findings and results cited in this report are only valid on the date of the report and may be based in part on information provided by third parties. This report may require modifications in case of inaccurate information, discovery of new information or changes in project parameters. The results of this study are in no way a guarantee that the site in the study is free of contamination. This report must be considered as a whole and its parts or sections must not be taken out of context. If discrepancies were to appear between the draft and the final version of this report, the final version shall prevail. Nothing in this report is mentioned with the intention to provide or constitute legal advice. The content of this report is confidential and proprietary. It is prohibited for any person other than the Client to reproduce or distribute this report, to use or take a decision based on its content, in whole or in part, without the express written permission of the Client and SNC-Lavalin.

b. Modifications to project

The evidence, interpretations and recommendations contained in this report relate to the specific project as described in the report and do not apply to any other project or any other site. If the project is modified from a perspective of design, dimensioning, location or level, SNC-Lavalin must be consulted to confirm that the recommendations already given remain valid and enforceable.

c. Number of soundings

The recommendations in this report are intended only as a guide for the design engineer. The number of soundings to determine all subsurface conditions that may affect construction (costs, techniques, equipment, schedule) should normally be greater than that for the purpose of design. The number of sample sites and chemical analyzes as well as the sampling frequency and choice of parameters can influence the nature and extent of corrective actions as well as treatment or disposal technology and cost. Contractors bidding or subcontracting the work should rely on their own research and their own interpretations of the surveys' factual results to assess how underground conditions can affect their work and the cost of work.

d. Interpretation of data, comments and recommendations

Unless otherwise noted, data and results interpretation, comments and recommendations contained in this report are based, to the best of our knowledge, on environmental policies, criteria and regulations in force at the location of the project and on the production date of the report. If these policies, criteria and regulations are subject to change after submission of the report, SNC-Lavalin must be consulted to review the recommendations in the light of these changes. When no policy, criteria or regulation is available to allow for the interpretation of data and analytical results, comments or recommendations expressed by SNC-Lavalin are based on the best knowledge of the rules accepted in professional practice. The analyzes, comments and recommendations contained in this report are based on data and observations collected on the site, which come from sample work on the site. It is understood that only the data collected directly at the survey sites, sample sites and on the sample date are accurate and that any interpolation or extrapolation of these results to all or part of the site carries the risk of errors, which may themselves influence the nature and extent of the actions required on the site.

2. Sounding reports and interpretation of subsurface conditions

a. Soil and rock descriptions

The soil and rock descriptions given in this report are from classification and identification methods commonly accepted and used in the practice of geotechnical engineering. The classification and identification of soil and rock involves judgment. SNC-Lavalin does not guarantee that the descriptions will be identical in all respects to those made by another geotechnician possessing the same knowledge of geotechnical rules, but ensures accuracy only to what is commonly used in geotechnical practice.

b. Condition of soil and rock at sounding sites

The sounding reports only provide subsurface conditions and only at sounding sites. The boundaries between different layers on sounding reports are often approximate, rather corresponding to the transition zones and therefore subject to interpretation. The precision of subsurface conditions depends on the sounding method, frequency and method of sampling and consistency of the terrain encountered. The spacing between surveys, the sampling frequency and the type of sounding also reflect budgetary considerations and timelines that are outside the control of SNC-Lavalin.

c. Condition of soil and rock between sounding sites

The soil and rock formations are variable over a considerably large area. Subsurface conditions between sounding sites are interpolated and may vary significantly from the conditions encountered at sounding sites. SNC-Lavalin can guarantee the results at the site where sounding are conducted. Any interpretation of the conditions presented between sounding sites carries risks. These interpretations can lead to the discovery of conditions that are different from those that were expected. SNC-Lavalin cannot be held responsible for the discovery of different soil and rock conditions from those described elsewhere than at the site where soundings are conducted.

d. Groundwater levels

The groundwater levels provided in this report only correspond to those observed at the site and on the date indicated in the report and depends on the type of piezometric installation used. These conditions may vary based on the season or due to construction work on the site or on adjacent sites. These variations are beyond the control of SNC-Lavalin.

3. Contamination levels

The contamination levels described in this report (if within the scope) correspond to those detected at the site and on the date indicated in the report. These levels can vary based on the season or due to activities on the study site or on adjacent sites. These variations are beyond our control. Contamination levels are determined from the results of chemical analyzes of a limited number of soil, surface water or groundwater samples. The nature and degree of contamination between sample site may vary greatly. The chemical composition of groundwater at each sample site is likely to change due to groundwater flow, surface recharge conditions, stress of the formation investigated (i.e. pump or injection wells near the site) and natural seasonal variability. The accuracy of groundwater contamination levels depends on the frequency and the number of analyzes. The list of parameters analyzed is based on our best knowledge of the history of the site and the contaminants likely to be found on the site and is also a reflection of budgetary considerations and timelines. The fact that a parameter has not been analyzed does not exclude its presence at a concentration above the background noise or the detection limit of this parameter.

4. Study and work monitoring

a. Final phase verification

All design and construction details are not known at the time of issue of the report. It is therefore recommended that SNC-Lavalin's services be retained to provide light on the possible consequences of construction on the final work.

b. Inspection during execution

It is recommended that SNC-Lavalin's services be retained during construction to verify and confirm that groundwater conditions throughout the site do not differ from those given in the report and that the construction work will not have an adverse effect on the conditions of the site.

5. Changing conditions

The soil conditions described in this report are those observed during the study. Unless otherwise stated, these conditions are the basis for recommendations in the report. Soil conditions can be significantly affected by construction work (traffic, excavation, etc.) on the site or on adjacent sites. Excavation may expose the soil to changes due to humidity, drying or freezing. Unless otherwise indicated, the soil must be protected from these changes or rearrangements during construction. When conditions encountered at the site differ significantly from those provided in this report, due to the heterogeneous nature of the subsurface or due to construction work, it is the responsibility of the Client and the user of this report to notify SNC-Lavalin of changes and give SNC-Lavalin the opportunity to review the report's recommendations. Recognizing a change in ground conditions requires experience. It is therefore recommended that an experienced geotechnical engineer be dispatched to the site to see if conditions have changed significantly.

6. Drainage

Groundwater drainage is often required for both temporary and permanent project facilities. An incorrect drainage design or execution can have serious consequences. SNC-Lavalin cannot under any circumstance take responsibility for the effects of drainage unless SNC-Lavalin is specifically involved in the detailed design and monitoring of the drainage system's construction.

7. Environmental characterization – Phase I

This report was written after diligent research and evaluation of point data sources or information obtained from third parties that may present uncertainties, gaps or omissions. These sources of information are subject to change over time, for example, according to the progress of activities on the site and surrounding area. Phase I includes no testing, sampling or characterization analysis by a laboratory. Subject to exceptions, Phase I is based on the observation of visible and accessible components on the property and those nearby and could bring environmental harm to the quality of the land in the study. The property titles mentioned in this report are used to identify the former owners of the study site and cannot under any circumstance be considered as an official document for reproduction or other uses. Finally, any sketch, plan view or diagram appearing in the report or any statement specifying dimensions, capacities, quantities or distances are approximate and are included to help the reader visualize the property.

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