Information requests directed to the proponent

Howse Property Project
EIS Technical Review: Part I
June 3, 2016

IR Number	Dept Number	Effects Link to CEAA 2012	Link to EIS guidelines	EIS Reference	Context and Rationale	Specific Question/ Request for Information
CEAA 16	NRCan IR 3	Information and data	7.3.6	Chapter 7, section 7.3.6 Appendix B GEOFOR Hydrogeology and MODFLOW Modelling Appendix XVII Ground Water Modelling Climate Variability Nicholson, F.H. 1979. Permafrost spatial and temporal variations near Schefferville, Nouveau-Québec, Géographie Physique et Quaternaire, volume XXXIII, no 3-4, Special issue on permafrost in Quebec – Labrador, les Presses de l'Université de Montréal, p. 265-277. Grandberg, H.B. 1989. Permafrost mapping at Schefferville, Quebec, *Physical Geography,* 1989,10, 3, pp. 249-269.	The following questions related to information required for a basic understanding of the hydrogeology of the area have major implications for assessing the impacts of open pit dewatering: - How can lakes, streams and swampy areas be so frequent in the Howse region if groundwater is only present at depths greatly below lake and wetland levels? -How can groundwater levels be only found at these depths (between 40 to 90 m below the surface in the future open pit) if surficial sediments are composed of relatively permeable sandy till and if annual precipitation is on the order of 700 mm? In such a context, lakes and swampy areas cannot be disconnected from groundwater. Their presence suggests that there is another shallower water table, much closer to the surface than the one observed in the deep boreholes. Two hypotheses could explain this context: the presence of either permafrost underneath the planned open pit or that of a much lower permeability unit within the surficial sediments (i.e. overburden) or in the Sokoman (iron) Formation. This would allow water to infiltrate down to this nearly impermeable unit, and then flow horizontally at its surface to "feed" lakes and wetlands. However, available data does not point to either of these hypotheses. On one hand, thermal sensors seem to indicate that temperature is above 0˚C below the planned open pit. Nonetheless, Nicholson et al. (1979), who has extensively studied this region for a number of years, had indicated that, there is widespread permafrost just north of Schefferville. Vertical temperature profiles from these regions presented in Nicholson (1979) and Granberg (1989) show that negative temperatures are much more common than positive ones. On the other hand, borehole logs, although not detailed, do not report the presence of a nearly impermeable stratum that could underlie a large area and hydraulic conductivity values do not seem to be available for the Sokoman Formation, except near its bottom which was found to be the most fractured and thus permeable zone. The fact that a groundwater level was found in one of the wells drilled into surficial sediments (HW-RC-15-WE01B) and close to the top of bedrock, is a good indication that a shallower "aquifer" is present and that a much less permeable horizon within the Sokoman Formation could be present somewhere between its top and bottom. Indeed, almost no fractures were reported above the zone close to the interface between the Sokoman and Wishart formations. Granberg (1989) noted that iron formations in the Schefferville area are poorly cemented and "can be crumbled by hand", but maybe iron formations can be much less permeable when located well below ground surface. In addition, the aquifer within the Wishart Formation appears to be confined, the piezometric surface being higher than the fractured horizon and mostly above the roof of the Wishart Formation (page 7-108 of Chapter 7 "The observed groundwater table shown in Figure 7-14 is everywhere over the water bearing fractures indicating a confined aquifer in artesian condition."), supporting the hypothesis of the presence of a much less permeable unit above.	• A) Provide additional evidence and better explain the presence of lakes, streams, and wetlands in the Howse region (i.e. LSA/RSA). • B) Confirm whether the Sokoman Formation (whose thickness ranges from 110 to 120 m) is less fractured and thus less permeable between its top (interface with the surficial sediments) and bottom (its interface with the Wishart Formation)? The hydraulic conductivity (K) values provided by fieldwork (9×10^{-6} m/s on average) appear to make it a rather permeable unit. Provide additional information to support information and conclusions on the Sokoman Formation from these statements.

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					Contrary to what is written on p. 39 of Appendix B (“wetland do not have a link with groundwater”), NRCan does believe that wetlands and lakes are fed by shallow groundwater, not by groundwater from a “deep” formation (the Wishart Formation and its interface with the Sokoman Formation).	

HML Response

A) Additional information is provided in SNC-Lavalin’s December 2016 report. Refer to section 2.2.3 on Pinette Lake, Triangle Lake and wetlands of this report, as well as Geofor’s reponse (on behalf of HML) to NRCan concerns, dated December 2016.
B) Additional information is provided in SNC-Lavalin’s December 2016 report. Refer to section 2.2.2 (Local Geology and Hydrgeology on Aquifer Hydraulic Characteristics) for the information.

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CEAA 17	NRCan IR 4	Information and data	7.3.6	Chapter 7, section 7.3.6 Appendix B GEOFOR Hydrogeology and MODFLOW Modelling	Even if the “lower aquifer” located in the Wishart Formation is confined, dewatering of the open pit will likely create a link with the upper aquifer. Shallow groundwater could circulate through faults or percolate through lake and wetland bottoms as well as through the Sokoman Formation, as a very large hydraulic gradient will be created, especially when the open pit floor reaches its lowest level (160 m below the ground surface). Contrary to what is written on p. 39 of Appendix B (“The dewatering will have a null effect on those wetlands.”), Natural Resources Canada has advised that it believes that open pit dewatering, while drawing from the “deep” confined aquifer, would have an impact on wetlands and lakes. The maximum drawdown obtained during pumping tests performed for this environmental assessment is on the order of 10 m, while the maximum drawdown during dewatering will be on the order of 70 m. There may also be impacts on lands around the site, since this intensive pumping in a confined aquifer could result in compaction.	• A) Conduct tests and provide information on more wells, both in the surficial deposits (or first few meters of bedrock) to investigate on the potential shallow aquifer and in the unfractured part of the Sokoman Formation to identify a potential confining unit. Hydraulic tests in these wells should be performed, with other available wells used as observation wells. Water levels in lakes and creeks should also be monitored during these tests. The unfractured part of the Sokoman Formation could also be tested using available wells with packers if they are not cased all along. • B) Redraw the piezometric map of Figure 8 in Appendix B (showing values from the deep aquifer) close to Irony Mountain, which is considered a recharge area (p. 7-100 of Chapter 7); hence piezometric contours would be perpendicular to flow coming from the Mountain).

HML Response

A) Following a meeting between NRCan, SNC-Lavalin, Geofor and the proponent in July 5th of 2016, it was agreed that no additional fieldwork was required from the proponent. See also the following answer from Geofor letter dated July 4th 2016.

Shallow Aquifer

The presence of a shallow aquifer has not been observed in any hydrogeological holes except into the well HW-RC-14-WE01OB. This aquifer was interpreted as a perched aquifer of small extend. If a water bearing zone is met during the wells drilling, the driller will observe an increase of the flow in the return of the drilling fluid which was used at a lowest possible rate. The following ascertainment based on direct observation of the Howse or surrounding areas support the absence of a superficial aquifer:

- During drilling of a large number of exploration holes, no shallow aquifer was observed by the geologists and the drillers. Golder did not point out the presence of a surficial aquifer in their report.
- The observation of old pits in the Timmins area shows that the part over the deep phreatic level visible in the bottom of the pit is dry the vast majority of the time. Any runoff is visible on the sub vertical faces of the pits (see appended photos).
- Geofor did not observe superficial aquifer during previous well drilling s in the Timmins area. During the mining of Kivivic 4 north and south no dewatering was needed as predicted by the pre-mining drilling. No infiltration along the walls of the pits are visible.
- Mining is in progress in the Kivivic area which is at about 30 km north of Howse deposit. The Kivivic 2 pit was dry until the intersection of the deep water level as observed in the pre-mining piezometers and no groundwater dewatering was necessary.
- Hydrogeological wells were drilled into the Goodwood deposit few kilometers north of Kivivic area. All wells drilled to more than 100 m deep were dry. Only one showed a water bearing zone at 120 m below the surface. Few years after their drilling measurements the shallow and deep piezometers indicate the wells are still dry.

Based on the observations carried out in Howse area and his experience in the large mining area, Geofor does not believe in the presence of a surficial aquifer in the Howse area. Based on this assumption, Geofor does not recommend drilling of more wells or conducting more testing on existing wells. In our opinion, the presence of wetlands around the Howse deposit, is the effect of accumulation of surface water in low-lying lands. Since we do not have observed the presence of a surficial aquifer, it cannot be integrated in the model. Although we do not believe that the wetlands are fed by superficial aquifer, we can suppose that the dewatering of the deep aquifer may have an impact on the wetlands. This hypothesis is stated in the EIS document in the sections concerning the impacts. To prove this impact in the field by pumping, testing would require the drilling of wells of large diameter and very long term pumping at high flow rate combined with the installation of a piezometric network. The results of these pumping test should not mimic the dewatering of the pit which will use a large number of wells distributed in the Howse area and create the large hydraulic gradient expected.

B) The regional piezometric map was up-dated and presented in section 2.2.3 of SNC-Lavalin report, December 2016.

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CEAA 18	NRCan IR 5	Information and data	7.3.6	Chapter 7, section 7.3.6	Recharge is considered to be 20% of the precipitation minus evapotranspiration and sublimation, based on a reference for a similar area (p. 7-101 from Chapter 7: “The runoff value of 80 % of the total precipitation has been taken from the waste management plan section of SNC-Lavalin”). The basis for this estimate is not provided and no other justification is presented. Recharge could likely be	• A) Provide a water budget based on values acquired in the study area that would take into account the possibility for recharge to the shallow and deeper aquifers.

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				Appendix B GEOFOR Hydrogeology and MODFLOW Modelling	larger than 109 mm/y (Table 7-40, Chapter 7) given the composition of the surficial deposits, generally described as sandy or even gravelly (likely till, although not described that way). However, given the widespread occurrence of lakes and wetlands, it is probable that most of the infiltrated water supplies these features in topographic lows and that recharge in the deeper formations (in the Wishart Formation and its interface with the Sokoman Formation) is limited to areas where the Wishart Formation outcrops or lies directly below surficial sediments (see geological map of Figure 7-13 from Chapter 7). While the EIS (p. 35 Appendix B) states that: "In summary, the groundwater recharge is occurring in the Fleming 7 deposit area where the highest groundwater elevations are found and from the high elevation terrains along the Quebec-Labrador boundary", NRCan wishes to remind the proponent that recharge is not restricted to where piezometric levels are high. These zones often indeed correspond to preferential recharge areas, but it also depends on the permeability of the surficial sediments and underlying geological formations.	• B) Appendix B (p.35) also states that: "Groundwater probably discharges through a southwest set of fractures southwest of Triangle Lake." Please explain how the proponent came to this conclusion and provide supporting documentation or references if applicable.

HML Response

A) On July 20 2016, HML presented a memo produced by SNC-Lavalin (report no. 636766-0000-4HER-0002, July 18, 2016) approved by Environment Canada which updates the water balance tables in the Howse EIS and provides an analysis to validate that the regional hydrology differs from the regional one.

Based on this water budget, a variable recharge was applied to the hydrogeological model, with a lower recharge rate during winter (8 months per year) to simulate the frozen soil conditions and a higher recharge rate (four months per year) during thaw season so that the annual average recharge is equal to 150 mm (Refer to section 3.4.3 on Recharge Rate of SNC-Lavalin report, December 2016)

In addition, Geofor presented the following discussion on water balance in its letter dated July 4th 2016:

Water Balance

The only reference about the water balance is from Fracflow Consultant inc. (2006). This company conducted a hydrogeological study for the Labmag project close to the Howse deposit but in a different geological context. The Labmag deposit is of taconite type consisting of lightly dipping undisturbed parallel layers. A DSO deposit results from the alteration of a taconite formation. SNC-Lavalin also performed hydrogeological study including modelling but the results are still confidential. Due to the scarceness of references, it was recently decided to establish a water balance using the hydrological data acquired by Groupe Hémisphères Inc. during the surface water flow monitoring of specific water curse of the Howse area. SNC-Lavalin is currently carrying out the analysis of the data.

The recharge of the deep aquifer occurs preferentially through high elevation zones as stated in the report and obviously also through local permeable zones. As can be observed in figure 5 of the hydrogeological report of annex B of EIS, the thrust faults and geological formation are dipping almost vertically. The groundwater flow through the quartzite or its contact with the Sokoman. Locally we can suppose that the water infiltrate into permeable sector of the overburden and subsequently into the bedrock through local fault parallel to the main thrust fault and geological formation.

The partial discharge of groundwater through a southwest set of thrust faults in the Burnetta Creek area is a valuable hypothesis although not supported by references which are rare in the area. The hypothesis is based on the following:

- The large increase of the specific runoff at a downstream station of the Burnetta Creek in relation with an upstream one;
- The confirmation of the possibility of southwest set of thrust faults by an experienced geologist. Henry Simpson is a credible geologist who has worked for over 30 years as chief exploration geologist for DSO project conducted by Iron Ore Company, New Millenium Limited and Silver Yard (TSMC's subcontractor). For him, the creeks of the Timmins area often follow the surficial location of thrust faults because they are erodible lineaments. The sudden change of direction of the Burnetta Creek toward southwest parallel to an unusual orientation of the geological formations west of Irony Mountain support the hypothesis of a southwest fault zone.
- The low water temperature of Burnetta Lake in summer can also be a clue to the possible groundwater discharge. The temperature of groundwater in the Howse area is around 2 degrees Celsius. For the same period, temperature of Pinette Lake's water was over 12 degrees Celsius compare to 6 degree Celsius for Burnetta Lake.
- The groundwater flow seems to focus toward the Triangle lake area

B) An answer is presented in Geofor letter dated July 4th 2016, and in section 2.2.3 of SNC-Lavalin report, December 2016.

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CEAA 19	NRCan IR 6	Information and data	7.3.6	Chapter 7, section 7.3.6 Appendix B GEOFOR Hydrogeology and	*General* There are a few things that are not clear about the current numerical model. Figures 3-2 and 3-5 of Appendix B show that surficial sediments do not cover the entire model and that they are absent from the future open pit. The absence of cover is surprising since all the well logs provided in	a. Based on new knowledge that will be acquired to better understand and assess the hydrogeological context, provide a revised numerical model.

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				MODFLOW Modelling Appendix XVII Ground Water Modelling Climate Variability	Appendix I (Well diagrams with simplified geology) and Appendix II (Geology of overburden wells) of Appendix B show a thickness of surficial sediments ranging from 6 (HW-RC-15-WE08R) to 54 m (HW-RC-15-WE05R). Is it because this area will eventually be excavated? However, the model needs to be calibrated with present conditions to be able to match measured hydraulic heads. *Recharge* Recharge of the deep aquifer within the Wishart Formation cannot come from the surface at the location of the open pit through the thick Sokoman Formation. The "deep" aquifer is likely being recharged where 1) the Wishart Formation is at or near the surface or just below the surficial sediment cover and 2) the overlying Sokoman Formation is thin and therefore, likely quite permeable. Recharge of the Wishart Formation could be larger than 100 mm/y, but over a much smaller area. *Model boundaries* In the report, the Attikamagen Formation is said to be impermeable and to act as a barrier to groundwater flow (p. 23 of Appendix V in Appendix B). However, the calibrated hydraulic conductivity values provided in Table 4-1 from Appendix V in Appendix B show that between the overlying Wishart Formation (8 x 10^{-7} m/s) and the Attikamagen Formation (1 x 10^{-7} m/s), the difference is less than one order of magnitude, which is not enough to consider it an impermeable base. Does that mean that at lower depths, this formation is considered to be more permeable? Otherwise, the model should be extended deeper. In addition, it is not clear why the Wishart Formation is not present at the base in Figures 3-4 and 3-5? It looks as though the base of the model corresponds to a given (constant) depth, not to the base of the Wishart Formation (or top of the Attikamagen shale Formation). The surface area of the modelled domain appears to be too small because drawdown curves provided in the reports (Chapter 7, Appendix B and Appendix XVII) show that a 10 m drawdown is obtained very close to the model limits to the east and west, where a constant head boundary has been assigned, suggesting that a larger domain should have been modelled. Indeed, a constant head boundary forces drawdown to be zero at these limits. A much larger domain would not "force" the results and would likely show even larger drawdowns in the lakes. However, the introduction of a much less permeable layer (if relevant and applicable, based on the acquisition of new information) in the model would likely reduce this drawdown. These really restricted constant head boundaries might also be the reason why, although assigning K values that are not very low, the model is able to reproduce the very low "water table" found in the Wishart Formation. *Faults* The numerical modelling report (page 24 of Appendix V in Appendix B) states that "Fault zones with intermediate permeable values [were] assigned due to low permeability materials" . However, the role of the faults is not well known. Some seem to be more permeable and others less permeable than the surrounding formation (p. 11 of Appendix B). The K value assigned to these features (close to the other K formation values) does not, in any case, significantly influence groundwater flow.	b. Provide a map of the thickness of surficial sediments, along with the available control points. c. Provide rationale to justify the choice made for the model base. d. In Figure 3-5, explain what the gray color corresponds to. e. In Figure 4-1 which shows the results of the calibration process (Appendix V in Appendix B), explain how well HW-RC-15-WE08R can be located in layer #6, as indicated in the legend. It is only 73 m deep, while most other wells are much deeper and seem to be located in layer #5? f. Appendix V in Appendix B states the Attikamagen Formation is said to be impermeable and to act as a barrier to groundwater flow (p. 23 of Appendix V in Appendix B). However, the calibrated hydraulic conductivity values provided in Table 4-1 from Appendix V in Appendix B show that between the overlying Wishart Formation (8 x 10^{-7} m/s) and the Attikamagen Formation (1 x 10^{-7} m/s), the difference is less than one order of magnitude, which is not enough to consider it an impermeable base. Explain whether this means that at lower depths, this formation is considered to be more permeable; otherwise, the model needs to be extended deeper and analysis revised accordingly. g. Clarify why the Wishart Formation is not present at the base in Figures 3-4 and 3-5? It looks as though the base of the model corresponds to a given (constant) depth, not to the base of the Wishart Formation (or top of the Attikamagen shale Formation).

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					Upper and lower aquifers It appears that the model was not built to take into account both the upper water table observed in HW-RC-14-WE10B (in surficial deposits) and the deeper piezometric surface observed in the other wells of the future open pit. The modelled piezometric map obtained for mine dewatering shows drawdowns on the order of 10 to 20 m in the areas of the two lakes (Triangle and Pinette), indicating that there is a direct link between the surface and deeper formations in the numerical model. The hydraulic conductivity values assigned for the different formations do not allow the presence of a confining layer. However, the Wishart Formation appears to be, at least in part, a unit under confined conditions.	

HML Response

A) Refer to new model up-dates presented by SNC-Lavalin, in December 2016 and in May 2017.

B) Figure 7-27 of the Howse EIS by Groupe Hémisphères shows the surficial sediments in the area of the Howse deposit. The information on the thickness of these sediments was deduced from borehole logs. Overburden ranges over the Howse deposit from 20 to 50 m of thickness; Figures 3-4 and 3-5 in SNC-Lavalin report of November 2015, show the empty pit at its final phase. The model has considered surficial sediments on the deposit as shown in Figure 3-2 of the same report.

C) In the model updates (December 2016 and in May 2017), the model base was extended deeper to include Wishart Formation and Shale Formation, See Figures 3-2 to 3-7 of SNC-Lavalin report, December 2016 and May 2017.

D) Gray color in Figure 3-5 in report of November 2015 corresponds to an empty pit.

E) In Figure 4-1 on the results of the calibration process, the well HW-RC-15-WE08R is only 73 m deep, but its elevation is relatively lower than the other deeper wells which in terms of elevation falls it in layer #6 and the other wells in layers 5 or 4.

F) The model has been extended deeper in the model up-dates by SNC-Lavalin, of December 2016 and May 2017.

G) The model has been extended deeper to include the Wishart Formation and the Attikamagen shale Formation in the model up-dates by SNC-Lavalin, of December 2016 and May 2017

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CEAA 20	NRCan IR 7	Information and data	7.3.6	Chapter 7, section 7.3.6 Appendix B GEOFOR Hydrogeology and MODFLOW Modelling Appendix XVII Ground Water Modelling Climate Variability	*Model calibration* In Figure 4-1 of Appendix V in Appendix B, only 21 data points are presented (that can be seen at least), while 28 groundwater elevation values are provided in Table 2-3 (Piezometric results) of the same document. None of the values are above elevation 610 m in the Howse area (HW-RC-14-WE10B), while Figure 4-1 shows 9 points (from the Timmins area). It is unclear whether some of these points (boreholes) are missing from the figure. In addition, the borehole drilled into surficial sediments for which a water table value is available has been disregarded. It should be used in the next version of the model. The proponent should provide modeled values for all observed values. *Sensitivity scenarios* The scenarios for the sensitivity analysis should have used a much larger coefficient for the variation of K, as this parameter is known to vary quite significantly within a given area, especially in fractured bedrock formations. At least one order of magnitude (coefficient of 10) should have been used for "extreme" scenarios instead of only a factor of 2 to get a better range of potential pumping rates.	a. Explain why some data points (boreholes) are missing from Figure 4-1 of Appendix V or provide a rationale for not including them on the figure. b. Provide modeled values in a table similar to Table 2-3 of the same document (or Table 7-38 of Chapter 7), for all observed values (including the well HW-RC-WEo10B drilled into surficial sediments). c. Given that flow rates are available at different sites, use these for model calibration, in addition to hydraulic heads. d. Provide scenarios using a factor of 10 to increase and decrease K values in the next version of the model.

HML Response

a) Data points (boreholes) that are missing from Figure 4-1 of Appendix V are outside the modeled area. These wells are basically the wells located outside of the model domain (east of the model domain), in the area of Timmins 1 and Timmins 3.
In the model up-dates by SNC-Lavalin, of December 2016 and May 2017, more wells are used for the calibration process, 24 well (are within the modeled areas) out of 27 wells were used.

b) Modeled values for all observed values that fall within the new modeled area are presented in table of Appendix B of SNC-Lavalin report, May 2017. For the well HW-RC-WEo10B drilled into surficial sediments, it was not used because its water elevation was very high in contrast with all the wells in the area. According to Geofor, this well was drilled deeper shortly after and the water elevation couldn't be verified. As mentioned in SNC-Lavalin report, of December 2016 (section 2.2.3 Groundwater Flow and Elevation), two other shallow boreholes, between 29 and 35 m in depth (HW-RC14-WE02OB & HW-RC14-WE03OB) were dry and suggest the absence of a shallow and local aquifer. During drilling campaigns in a large number of exploration holes no shallow aquifer was observed by the geologists and the drillers (Geofor, July 2016).

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c) For the model calibration, new hydraulic heads representing natural physical boundaries were used (such as Howells River and Elross Creek) in the model update by SNC-Lavalin, May 2017.

d) In model up-dates by SNC-Lavalin, of December 2016, sensitivity analyses (scenarios) were carried out on the model increasing the hydraulic conductivity by a factor of 10 of the hydrostratigraphic units in one scenario and by increasing the recharge rate in another scenario (Table 4-1 of report and Appendix F1)