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Information Requests for

Agnico Eagle Mine's In-Pit Tailings Disposal Modification (NIRB File No. 03MN107)

Natural Resources Canada

Submission to the Nunavut Impact Review Board

July 9, 2018

1. Introduction

Natural Resources Canada (NRCan) conducted a technical review to assess the completeness and technical merit of the information presented in Agnico Eagle Mine's In-Pit Tailings Disposal Modification. NRCan also considered the additional information provided by the proponent on June 26 and July 05, 2018 in response to direct requests for documents by NRCan. NRCan is providing fifteen information requests for the NIRB's consideration in this submission.

1.1. NRCan's Mandate

NRCan seeks to enhance the responsible development and use of Canada's natural resources and the competitiveness of Canada's natural resources products. We are an established leader in science and technology in the fields of energy, forests, and minerals and metals and use our expertise in earth sciences to build and maintain an up-to-date knowledge base of our landmass. NRCan develops policies and programs that enhance the contribution of the natural resources sector to the economy and improve the quality of life for all Canadians. We conduct innovative science in facilities across Canada to generate ideas and transfer technologies. We also represent Canada at the international level to meet the country's global commitments related to the sustainable development of natural resources.

1.2. NRCan's Participation in the review of the In-Pit Tailings Disposal Modification

NRCan has been participating in the review of the proposed In-Pit Tailings Disposal Modification in the context of our role as a federal department with expertise in permafrost and hydrogeology.

2. Information requests

2.1. Hydrogeology

2.1.1. Introduction

Agnico-Eagle Mines Limited (AEM) operates the Meadowbank Mine in Nunavut. AEM has proposed to modify the storage of mine tailings at the site by disposing them in the Goose and Portage pits. The Nunavut Impact Review Board (NIRB) has requested that Natural Resources Canada (NRCan) review the proposal and provide Information Requests (IRs). The following thirteen information requests further information on hydrogeology.

NRCan has been asked to review the hydrogeological issues related to proposed changes in tailings deposition at the Meadowbank Mine. The current deposition of tailings in the North and South Cells is designed to isolate potential contaminants by the eventual freezing of tailings. In contrast, the tailings deposited in the Goose and Portage A and E pits will remain unfrozen and, therefore, will be subject to potentially long-term transport by groundwater flow.

SNC Lavalin (2017a) indicates in their modelling that contaminant plumes will migrate in the order of 100 to 250 m in 2500 years. NRCan is not in agreement with this assessment and has requested clarification/justification on issues with the model boundaries, the boundary conditions, the extent of permafrost in model scenarios, the extent of waste rock, the defined contaminant source, the contaminant transport scenarios, and the assessment of contaminant migration to natural receptors, including Second and Third Portage Lake. Consequently, in addition to specific information requests (IR#1 to IR#11), NRCan has also recommended updated hydrogeological modelling, based on IR#12.

NRCan is concerned that the groundwater monitoring plan may not adequately monitor potential contaminant migration after the dikes are breached and the pits are flooded. NRCan also recommends an updated groundwater monitoring plan (IR#13) that includes this period and considers all relevant natural receptors of contaminant migration following dike breaching.

Finally, NRCan also recommends the modification of the In-Pit Deposition strategy to ensure that groundwater monitoring after the dike breaching (and pit flooding) occurs before the post-closure period.

2.1.2. NRCan-IR #1: Model Extent

2.1.2.1. *Reference*

AEM, 2018. Meadowbank Gold Project, Groundwater Monitoring Plan. Version 8, January 2018.

AEM, 2017. Meadowbank Gold Mine, 2016 Mine Waste Rock and Tailings Management Report & Plan Update. November 2017 (Note: cover page indicates a date of November 2016 but subsequent footers and references in the document indicate 2017 dates).

Cumberland Resources Ltd., 2005. Meadowbank Gold Project, Mine Waste & Water Management, Final Report, October 2005.

Golder Associates Ltd., 2005. Technical Memorandum, Items #24A and 37 - Predictions of Regional Groundwater Flow Directions after mine Closure, Meadowbank. 05-1413-036A, October 5, 2005.

Golder Associates Ltd., 2004. Report on Hydrogeology Baseline Studies, Meadowbank Gold Project. 03-1413-078, February 3, 2004.

SNC Lavalin, 2018a. Environmental Impact Study Review – Meadowbank In-Pit Tailings Deposition. Technical Note. 651196-0000-4EER-0001-B01 Rev 01, February 15, 2018.

SNC Lavalin, 2018b. Groundwater Monitoring for In-Pit Tailings Deposition project – Meadowbank. Memorandum. 651196-3000-4WER-0002. July 3, 2018.

SNC Lavalin, 2017a. Hydrogeological Modelling for In-Pit Deposition of Tailings. Technical Note. 643541-3000-4WER-0001 Rev A00, November 30, 2017.

SNC-Lavalin, 2017b. In-Pit Tailings Deposition Water Balance and Water Quality Forecast. Technical Note. 643541-5000-40ER-0002, Rev. B00. September 12, 2017.

SNC-Lavalin, 2017c. 2D ground thermal modeling – Portage In-Pit Deposition Prefeasibility Study. Memorandum. 643541-5000-4GCA-0002 Rev 01, September 20, 2017.

SNC-Lavalin, 2016a. In-Pit Tailings Deposition Concept. Tailings Storage Facility Extension Project – Phase 2, 637215-1000-4GER-0001. Version A00. November 4, 2016.

SNC-Lavalin, 2016b. Multiple Accounts Analysis for the Tailings Facility Extension Project. Technical Note. 637215-5000-4GER-0001. Version A00. October 24, 2016.

2.1.2.2. *Issues/Concern*

The extent of the model is justified as follows (SNC Lavalin, 2017a): “The boundaries of the study area to be modelled have been established sufficiently far from the project main facilities and the hydrogeological model has been centered on the open pits.” As demonstrated by Golder (2004, 2005), talik and sub-permafrost groundwater flow systems are linked and controlled by the water levels in large lakes. Water levels form a critical control on groundwater fluxes and flowpaths. The model boundaries chosen by Golder (2004, 2005) specifically included the surrounding large lakes that have both higher and lower elevations and result in both gaining and losing conditions within both Second and Third Portage Lakes.

2.1.2.3. *Information request*

IR#1a). NRCan requests that the Proponent (AEM) provide detailed justification for the spatial extent of the model and, specifically, for the decision not to extend model boundaries to include adjacent large lakes.
IR#1b). The finite element model (FEFLOW) allows the use of a variable mesh size. NRCan requests that AEM please provide reasons why a sparse mesh (large elements) on the exterior could not incorporate adjacent large lakes while retaining the fine mesh in the areas surrounding the pits, faults and contaminant transport pathways.

2.1.3. NRCan-IR #2: Description of flow boundary conditions

2.1.3.1. *Reference*

Please refer to NRCan-IR #1.

2.1.3.2. *Issues/Concern*

It appears that the 135-m boundary condition (BC) likely applies to the sub-permafrost groundwater (due to the presence of permafrost), whereas it is not clear to what depth range the specified BCs in the lakes are applicable (SNC Lavalin, 2017a). The BCs in the Goose Pit, Portage Pit A and Portage Pit E and Central Dike downstream (D/S) pond are described as “drain condition” (SNC Lavalin, 2017a).

2.1.3.3. *Information request*

IR#2a). NRCan requests that the Proponent specify the depths for which the specified head boundary conditions on the exterior of the model are applied. Additionally, please identify the locations and depths where no-flow boundaries are specified implicitly in unfrozen elements.

IR#2b). NRCan requests that the Proponent specify if the "drain condition" is intended to be a FEFLOW "seepage face" BC in which the specified head is set to the surface elevation with a maximum flow rate constraint of 0. If not, please specify the BC numerically.

2.1.4. NRCan-IR #3: Justification of flow boundary conditions

2.1.4.1. *Reference*

Please refer to NRCan-IR #1.

2.1.4.2. *Issues/Concern*

SNC Lavalin (2017a) states that the "fixed head of elevation 135 m was applied as the boundary condition for the northwest area. This value was estimated using the regional gradient and the main lake elevation on the north area of Portage Pit E." NRCan notes that it is not apparent how the delineation and value of this specified head BC was determined. The groundwater modelling results by Golder (2004, 2005) indicate decreasing head values along this BC with groundwater flow approximately parallel to it.

The specified head of 133.6 m along the Third Portage Lake is applicable within the lake. However, it appears that this BC may be a no-flow boundary at depth (SNC Lavalin, 2017a, Figure 19, slice 44 view). From the Golder (2004, 2005) models, it is apparent that there is groundwater flow from the west (lake with elevation 153 m) towards the east or NE beneath Third Portage Lake and, also, from Third Portage Lake ESE towards Lake Tehek. In contrast, sub-permafrost groundwater flow in the SNC-Lavalin (2017a) model is generally parallel to the boundary.

The specified head of 132.9 m across Second Portage Lake is applicable within the lake. It appears from Figure 20 (SNC Lavalin, 2017a) that this BC is also applied to the entire talik and sub-permafrost groundwater. As can be noted from Golder (2004, 2005) model results, there can be head differences between lake levels and deeper (sub-permafrost) groundwater, which results in vertical gradients and vertical groundwater flow (upward and downward) within the taliks beneath lakes. These vertical gradients have important implications for groundwater flowpaths and contaminant transport into and out of Second and Third Portage Lakes. A specified head BC would limit vertical flow.

The no-flow boundary along the NE border of the model is described as being along a flow line (SNC Lavalin, 2017a). However, the Golder model (2004) indicates regional groundwater flow from the NE towards Second Portage Lake and identifies this as the largest flux into Second

Portage Lake by an order of magnitude (Table 3). This groundwater flow crosses the NW-SW segment of the no-flow BC.

2.1.4.3. *Information request*

IR#3a). NRCan requests that the Proponent justify the delineation and value of the 135-m specified head in relation to the adjacent large lakes (141 m to NE and 115 m to NW) and the Golder (2004, Figure 5; 2005, Figure 1) modelling results.

IR#3b). NRCan requests that the Proponent justify the BC beneath Third Portage Lake in relation to the results from the Golder (2004, 2005) models.

IR#3c). NRCan requests that the Proponent justify the BC beneath Second Portage Lake in relation to the results from the Golder (2004, 2005) models. Evaluate the influence of nearby Lake Tehek on vertical gradients and groundwater flow near Second and Third Portage Lakes.

IR#3d). NRCan requests that the Proponent justify the NW-SE segment of the no-flow BC north of Second Portage Lake in relation to the results from the Golder (2004, 2005) models. NRCan requests that AEM evaluate whether the change in the western arm of the Second Portage Lake from talik to permafrost (beneath the North and South Cell Tailings Storage Facilities (TSF)) could change the groundwater flowpaths into Second Portage Lake.

2.1.5. NRCan-IR #4: Extent of permafrost in the groundwater model

2.1.5.1. *Reference*

Please refer to NRCan-IR #1.

2.1.5.2. *Issues/Concern*

The extent of permafrost in the groundwater model is briefly described in section 8.1 and Figure 12 of SNC Lavalin (2017a). It includes permafrost along the east side of Goose Pit, the northern end of Portage Pit E, and nearly all of Portage Pit A.

The extent of permafrost used for post-closure Scenario 3 and 4 models appears to be that of the baseline conditions (SNC-Lavalin, 2017a, Figure 12). Figure 25 specifically shows most of Portage Pit A to be frozen (permafrost) even when the pit has been excavated and replaced with tailings and an 8-m deep water cover. Similarly, northward groundwater flow from Portage Pit E to Second Portage Lake appears to be prevented by permafrost overlapping the Central Dump area. A map that estimates the extent of post-closure permafrost and talik could not be found. Figure 9.1 in AEM (2017) shows the post-closure flooded area with dikes breached. Although this figure does not necessarily indicate the extent of talik that will form, it could serve to estimate post-closure permafrost and talik (over 2500 years or more) more effectively than the baseline permafrost map. Figure 9.1 shows that water cover will be continuous from Portage Pits A and E to Second Portage Lake.

2.1.5.3. *Information request*

IR#4a). NRCan requests that the Proponent confirm whether the extent of permafrost indicated in Figure 12 is what has been used for each groundwater flow model and for each contaminant transport model scenario. Specify any differences in permafrost extent among the model scenarios.

IR#4b). NRCan requests that the Proponent provide a map showing the estimated extent of permafrost and talik for a post-closure scenario (i.e. with dikes breached).

2.1.6. NRCan-IR #5: Waste rock and tailings within pits

2.1.6.1. *Reference*

Please refer to NRCan-IR #1.

2.1.6.2. *Issues/Concern*

The calibrated hydraulic conductivity of the waste rock material stored in the Central Dump is specified as 1 X 10^{-3} m/s (SNC Lavalin, 2017a, Table 8), the second-most permeable unit in the model.

The hydraulic conductivity of the tailings deposited in the North and South Cells is specified to be 1 X 10^{-5} m/s. The hydraulic conductivity of tailings to be deposited in the Goose, Portage A and E Pits is not indicated.

2.1.6.3. *Information request*

IR#5a). NRCan requests that the Proponent indicate if waste rock has been deposited in Goose Pit. If so, estimate the hydraulic conductivity of these deposits and justify why they have not been included in the groundwater models. NRCan further requests that the Proponent should indicate whether all the waste rock deposited in the Portage pits (including the Central Dump) has been included in the hydrogeological model.

IR#5b). NRCan requests that the Proponent specify the hydraulic conductivity of the tailings deposited in the pits for the contaminant transport modelling scenarios.

2.1.7. NRCan-IR #6: Water level controls during in-pit deposition periods

2.1.7.1. *Reference*

Please refer to NRCan-IR #1.

2.1.7.2. *Issues/Concern*

The design of the in-pit tailings deposition includes 6 distinct periods described in section 4 of SNC-Lavalin (2017a) and in greater detail in section 3 of SNC-Lavalin (2017b). To assess the hydrogeological modelling, it is important to identify the controls on water levels during each period of in-pit deposition.

It appears that the large seepage into the Central Dike D/S Pond was being pumped back to the South Cell TSF (AEM, 2017).

From SNC-Lavalin (2017b) Table 3-1, it appears that water levels in all three pits will remain below those of Second and Third Portage Lakes during Periods 1 to 3 and probably also during Periods 4 and 5 since East Dike Seepage is considered to be an input to Portage Pits A and E (Table 3-1, SNC-Lavalin, 2017b). However, it is not apparent whether water levels in the Goose and Portage A and E will be actively managed in Periods 4 and 5.

Figure 9.1 in AEM (2017) indicates the extent of flooded area following the breaching of dikes. Although it is stated that dike breaching will occur once water quality meets site-specific closure criteria (SNC-Lavalin, 2017b), it is not clearly stated that dike breaching is intended to indicate the start of Period 6, post-closure.

Water levels in the Portage Pits and the Central Dike D/S Pond appear to be below that of Second Portage Lake during Periods 1 to 5. Therefore, the migration of contaminants in groundwater during these periods is directed towards artificial receptors that are all human-made and mine-related, such as the pits or the Central Dike D/S Pond. Migration of contaminants towards natural receptors, such as Second Portage Lake, will occur primarily when Pit levels exceed that of Second Portage Lake during Period 6 (post-closure) after the dikes have been breached. This is recognized in SNC-Lavalin (2017a, section 4.4), in which a citation is reproduced stating that Period 6 "could present higher risks associated with hydraulic gradients and groundwater flow which will be reversed and will no longer be toward pits as observed during pit dewatering."

2.1.7.3. *Information request*

IR#6a). NRCan requests that the Proponent specify: i) the anticipated duration of seepage into the Central Dike D/S Pond, ii) where this seepage will be pumped to (or flow to) during each in-pit deposition period, iii) when pumping of the Central Dike D/S Pond will cease, iv) will dike breaching proceed prior to complete TSF freezeback and v) all commitments to monitor and manage this seepage until the seepage dissipates following freezeback of the South Cell TSF.

IR#6b). NRCan requests that the Proponent specify how water levels will be managed in the Goose, Portage A and E pits during Periods 4 and 5. Evaluate how inputs, such as runoff and precipitation, will affect the magnitude of pit water level fluctuations. Finally, provide anticipated pit water level elevations during Periods 4 and 5 (especially relative to Second and Third Portage Lakes).

IR#6c). NRCan requests that the Proponent clearly identify the timing of the dike breaching with respect to the in-pit deposition periods.

IR#6d). NRCan requests that the Proponent specify whether water levels will be permitted to flood beyond the extent of the Goose, Portage A and E pits prior to dike breaching. Please specify the maximum elevations at which water will be contained within the footprint of each of the Goose and Portage pits.

IR#6e). NRCan requests that the Proponent explain why the primary time for outward migration of groundwater contaminants towards natural receptors, such as Second Portage Lake, has been assigned to the post-closure period (Period 6), as opposed to earlier (Period 5).

2.1.8. NRCan-IR #7: Tailings as a contaminant source

2.1.8.1. *Reference*

Please refer to NRCan-IR #1.

2.1.8.2. *Issues/Concern*

SNC-Lavalin (2017a, section 10.2) states that “the contaminant source was integrated in the first 6 layers, at the top of tailings where reclaim water will be in direct hydraulic contact with surrounding bedrock at the end of the tailings deposition period in each pit.” There is an implicit assumption here that the reclaim water is the only source of contaminant; the assumption precludes pore water in the tailings as a potential source of contamination. Migration of contaminants from tailings pore water or from groundwater flowing through the deposited tailings was not modelled in the contaminant transport scenarios. The assumption that groundwater contaminants originate only from the reclaim water also affects the definition of the in-pit deposition periods (SNC-Lavalin, 2017b) because the monitoring period (Period 5) is considered complete when reclaim water meets site-specific closure criteria. Therefore, this assumption delegates most of the transport of groundwater contaminants to the post-closure period (Period 6) as discussed in IR#6.

2.1.8.3. *Information request*

IR#7. NRCan requests that the Proponent justify why the tailings are not considered a potential source of contamination. If the Proponent’s assessment is that the tailings are not a potential source of contamination, supporting evidence is requested.

2.1.9. NRCan-IR #8: In-pit deposition periods and contaminant transport scenarios

2.1.9.1. *Reference*

Please refer to NRCan-IR #1.

2.1.9.2. *Issues/Concern*

The in-pit tailings deposition includes 6 distinct periods described in section 4 of SNC-Lavalin (2017a) and in greater detail in section 3 of SNC-Lavalin (2017b). The contaminant transport modelling simulates 4 scenarios described in SNC-Lavalin (2017a). Scenario 1 (Goose Pit filled with Tailings) apparently begins at the conclusion of Period 2 (Whale Tail Tailings Deposition in Goose Pit) and is intended to simulate a portion of Period 3 (3A and 3B; Whale Tail and Future Ore Bodies Tailings Deposition in Portage Pits A and E). The Scenario 1 model is run for 2 years, despite Period 3 lasting at least 8 years.

Scenario 2 does not appear to correspond to any specific tailings deposition periods. Scenario 2 assumes Portage Pit A and Goose Pit are filled with tailings, whereas Portage Pits A and E are to be filled alternately. Therefore, Portage Pit E will not be empty when Portage Pit A is filled. Since Scenario 2 simulates Portage Pit A as being full, it could represent the end of Period 3 and the beginning of Period 4.

Scenarios 3 and 4 are intended to simulate the post-closure conditions, presumably Period 6. Scenario 3 results are shown for time t = 2500 years, Scenario 4 for t = 6000 years. These scenarios assume that “water elevations in the pits have been simulated by the hydrogeological model”, and that there is “no dike breach” (SNC-Lavalin, 2017a). Scenario 3 and 4 results indicate very slow contaminant transport due to extremely small horizontal gradients. However, the assumed conditions of these scenarios do not correspond to those of Period 6 (post-closure) since the dikes will be breached and the water elevations in the pits and the flooded area surrounding the pits will be the same as in Third Portage Lake.

Figure 25 shows the predicted contaminant plume from the “unfrozen” portion of Portage Pit A to the Second Portage Lake (Scenario 3), as well as the location of the cross-section shown in Figures 26 and 32 (SNC-Lavalin, 2017a). The contours in Figure 26 show heads decreasing from approximately 133.57 m near Pit A to a value of 133.38 m east of the East Dike at the edge of the Second Portage Lake. However, this latter value differs from that of the Second Portage Lake, which is supposed to have a specified head of 132.9 m.

Figure 27 shows that permafrost separates Portage Pits A and E and prevents northward transport of groundwater contaminants towards Second Portage Lake during the post-closure period.

2.1.9.3. *Information request*

IR#8a). NRCan requests that the Proponent estimate the maximum duration of in-pit deposition. The proponent should also explain why a longer simulation was not conducted to consider the migration of contaminants from Goose Pit for the entire duration of Period 3. Finally, indicate which model layer is shown in Figure 21.

IR#8b). NRCan requests that the Proponent: i) specify whether permafrost existed in the groundwater model in the southern portion of the Central Dump area as indicated in Figure 23; ii) indicate which model layer is shown in Figure 23; iii) provide the precise in-pit deposition period that Scenario 2 is simulating and why this period is significant; iv) specify the boundary conditions in the Central Dike D/S Pond and Portage Pit E for Scenario 2; v) justify why Portage Pit A should be in equilibrium with regional groundwater flow and indicate the modeled head in Portage Pit A; and vi) justify the 2-year duration of the Scenario 2 model.

IR#8c). NRCan requests that the Proponent justify why the model was used to determine the water levels in pits, rather than using specified head BCs for the flooded area at the level of the Third Portage Lake. Please justify the assumption of no dikes breached for the post-closure period. Also indicate the model layer shown in Figures 25, 27, and 29.

IR#8d). NRCan requests that the Proponent explain why permafrost is shown within Portage Pit A in Figure 25 (inset) for the post-closure period and confirm whether this extent of permafrost was included in the Scenario 3 or 4 models.

IR#8e). NRCan requests that the Proponent specify the BC imposed on the surface of Second Portage Lake for Scenarios 3 and 4. Explain why the head value in Figure 26 is inconsistent with the stated BC of Second Portage Lake.

IR#8f). NRCan requests that the Proponent confirm whether permafrost was included on the north edge of Portage Pit E for modelling the post-closure period. If so, justify this extent of permafrost for Scenarios 3 and 4.

2.1.10. NRCan-IR #9: Assessment of contaminant migration to Third Portage Lake

2.1.10.1. *Reference*

Please refer to NRCan-IR #1.

2.1.10.2. *Issues/Concern*

NRCan notes that none of the current scenarios considers the contamination of the surface water overlying the Goose and Portage Pits following the dike breaches and the flooding of the pits. In areas where there is upward groundwater flow in the talik, groundwater flow through the tailings may discharge contaminated groundwater to the overlying surface water. Since the flooded portion of Third Portage Lake above the pits will become fish habitat, this area should be considered as a potential receptor to contaminant migration.

2.1.10.3. *Information request*

IR#9a). NRCan requests that the Proponent provide an assessment of potential discharge of contaminated groundwater from the tailings to the overlying surface water following the breaching of the dikes and the flooding of the pits.

IR#9b). NRCan requests that the Proponent justify why contaminant migration from the tailings pits to the overlying Third Portage Lake (during post-closure) was not included in the hydrogeological modelling (SNC-Lavalin, 2017a).

2.1.11. NRCan-IR #10: Groundwater monitoring following dike breaching

2.1.11.1. *Reference*

Please refer to NRCan-IR #1.

2.1.11.2. *Issues/Concern*

The migration of groundwater contaminants towards artificial receptors during Periods 1-5 and natural receptors in Period 6 was discussed in IR#6. A recent memorandum presents "the latest improvements for groundwater sampling practices at Meadowbank and the capability of the ongoing monitoring wells network expansion to track contaminants migration from the pits to the lakes during and following the IPD" *(In-Pit Tailings Deposition, SNC-Lavalin, 2018b)*. The proposed groundwater sampling frequency "could be reduced to one (1) sample per year" at the end of in-pit tailings deposition (SNC-Lavalin, 2018b). It is not stated how long such sampling would be conducted. NRCan notes that the frequency of groundwater sampling is to be reduced at a time when groundwater transport towards Second Portage Lake will likely increase.

All the monitoring wells indicated on Map 2 of SNC-Lavalin (2018b) appear to be located in areas that will be flooded when the dikes are breached.

2.1.11.3. *Information request*

IR#10a). NRCan requests that the Proponent indicate the intended duration of post-closure groundwater sampling. The Proponent should also provide a rationale for reducing the frequency of groundwater sampling when contaminant migration towards natural receptors increases.

IR#10b). NRCan requests that the Proponent specify the details of groundwater monitoring that will be conducted after the dikes are breached. If new monitoring wells need to be established, specify where will they be located and how the geochemical baseline will be established. If not, specify how potential groundwater contaminant migration will be monitored after the dikes are breached.

2.1.12. NRCan-IR #11: High permeability near the Central Dike

2.1.12.1. *Reference*

Please refer to NRCan-IR #1.

2.1.12.2. *Issues/Concern*

The large seepage beneath the Central Dike into the Central Dike D/S Pond appears to be attributed primarily to flow either through the "in-situ Till under tailings" (Table 6, SNC-Lavalin, 2017a) or through the "upper fractured bedrock at Central Dike location" (Table 7, SNC-Lavalin, 2017a). A hydraulic conductivity value of 1.7 X 10^{-3} m/s has been assigned to these units in the groundwater model. This value is representative of a gravel deposit or a highly permeable fractured bedrock and is several orders of magnitude higher than what would be expected for a till with a 30-40% silt and clay content. The Second Portage Lake Fault also underlies the Central Dike and was assigned a hydraulic conductivity of 1 X 10^{-5} m/s in the groundwater model. This fault also extends through the Central Dump area and into Second Portage Lake.

2.1.12.3. *Information request*

IR#11. NRCan requests that the Proponent identify which unit is responsible for the high groundwater flow beneath the Central Dike and justify why flow is attributed primarily to this unit and not the Second Portage Fault. Discuss potential implications for groundwater flow and contaminant transport through till, fractured bedrock and the Second Portage Lake Fault into the Second Portage Lake.

2.1.13. NRCan-IR #12: Updated hydrogeological modelling

2.1.13.1. *Reference*

Please refer to NRCan-IR #1.

2.1.13.2. *Issues/Concern*

Information requests #1, 3, 4, 5, 7, 8 and 9 deal with various aspects of the hydrogeological modelling. NRCan is suggesting that the IRs be addressed with updated hydrogeological modelling.

2.1.13.3. *Information request*

IR#12. NRCan requests that the Proponent update the hydrogeological modelling with the following modifications:

a) Extend the model boundaries to include surrounding large lakes, where the talik extends through the permafrost to sub-permafrost groundwater (e.g., Tehek Lake, Turn Lake, and lakes with elevations 117 m, 153 m and 144 m, and the lower elevation lake to the SW in Golder, 2004). This modification will ensure appropriate boundary conditions and simulate the vertical gradients that vary within the talik zone.

b) Use the post-closure extent of permafrost and talik for simulations of post-closure scenarios.

c) Include the waste rock that has been deposited in the Goose and Portage Pits as a hydrostratigraphic unit in the model. Waste rock in the Portage Pits (Central Dump) appears to have been included.

d) Include the entire extents of tailing deposition in the Goose and Portage Pits as sources of contamination.

e) Update modelling scenarios to represent planned conditions (and BCs) during and following in-pit deposition with a greater emphasis on predicting contaminant migration to natural receptors. At a minimum, specific scenarios should include:

1) Goose Pit filled with tailings for the entire duration of Portage Pit filling (Period 3).

Although this scenario represents flow and transport towards an artificial receptor (Portage Pit E), the hydraulic gradients are large during this period and could produce a plume that may subsequently migrate towards natural receptors during subsequent periods when gradients and flowpaths change. The source concentration should apply to the entire depth of the tailings and the Goose dump should be included since it may provide a more permeable flowpath. The duration of the simulation should be the entire duration of the Portage Pit deposition (Period 3) and, therefore, may require variable head BCs on the Portage pits. As the water level in Goose Pit is to be managed (i.e. pumped at times), a specified BC may be more appropriate.

2) Post-closure, all pits filled with tailings and with dikes breached (Period 6).
This scenario needs to assess the transport from each pit to possible natural receptors, including the surface water above the pits (which will become part of Third Portage Lake), Second Portage Lake and Lake Tehek. The source concentration should apply to the entire depth of the tailings in each pit. The extent of permafrost in the model and the hydraulic head BCs should be representative of post-closure conditions with dikes breached (i.e. flooded).

Other scenarios, such as variable source BCs over time, could be considered. However, evidence that the tailings act as a variable source should be provided.

Presentation of the pertinent results would allow for the assessment and review of the proposed project modification. In general, the approach used in the SNC-Lavalin (2017a) report is satisfactory in which plan and cross-sectional views show the dominant contaminant migration pathways and concentrations. Such figures should be provided along the flowpaths to each of the main receptors from each of the pits. Since the BCs used to simulate the groundwater flow in Figures 18 and 19 do not apply to the transport scenarios, hydraulic head maps for both shallow and deep (sub-permafrost) model layers should be provided for each contaminant transport scenario.

2.1.14. NRCan-IR #13: Updated groundwater monitoring plan

2.1.14.1. *Reference*

Please refer to NRCan-IR #1.

2.1.14.2. *Issues/Concern*

Based on the information available to NRCan at the time of this review, it appears that the groundwater monitoring plan does not adequately consider the potential migration of contaminants from the tailings to natural receptors after the dikes are to be breached.

2.1.14.3. *Information request*

IR#13a). NRCan requests that the Proponent summarize the details of the groundwater monitoring plan that will occur after the dikes are breached and the pits are flooded (i.e. during Period 6, post-closure). Specifically, this should address the monitoring of potential contaminant migration from the pits to Third and Second Portage Lakes and, if appropriate, towards Lake Tehek.

IR#13b). In the event that current groundwater monitoring plans do not adequately address the post-closure period, NRCan requests that the Proponent update the groundwater monitoring plan to include the monitoring of potential contaminant migration from the pits towards natural receptors after the dikes are breached and the pits are flooded. The plan should indicate the expected duration of the additional groundwater monitoring and the conditions that must be met for the monitoring program to be concluded.

IR#13c). NRCan requests that the Proponent use the results of the updated hydrogeologic modelling (in particular Scenario 2 noted in IR#12) to ensure that the updated management plan includes appropriate sampling locations and that the frequency and duration of sampling are based on modelling results, appropriate for protection of potential natural receptors.

IR#13d). NRCan requests that the Proponent present potential contingency plans should the transport of contaminants by groundwater become problematic following the dike breach.

IR#13e). NRCan requests that the Proponent justify why the dike breaching appears to be the condition that ends the monitoring period (Period 5) and begins the post-closure period (Period 6). This suggests that potential contaminant migration, initiated by the flooding of the pits, is part of the post-closure rather than part of the monitoring period.
NRCan suggests the modification of the in-Pit Tailings Deposition strategy to ensure that dike breaching and subsequent monitoring are moved to Period 5, such that potential contaminant migration from the pits after dike breaching has been adequately monitored and assessed prior to the post-closure period (Period 6)

IR#13f). NRCan requests that the Proponent present a modified in-Pit Tailings Deposition strategy that includes dike breaching and subsequent monitoring prior to the post-closure period.

2.2. Permafrost

2.2.1. Introduction

NRCan reviewed the documentation provided on the subject of permafrost. NRCan requests some clarification on the formation of new permafrost and the effect of water levels post-closure on the long-term stability of permafrost.

2.2.2. NRCan-IR #14: Water levels post-closure

2.2.2.1. *Reference*

Environmental Impact Study Review – Meadowbank In-Pit Tailings Deposition. Tailings Storage Facility Extension Project – In-Pit Tailings Deposition. SNC Lavalin Technical Note, Feb. 2018

Hydrogeological Modelling SNC Lavalin Technical Note for In-Pit Tailings Deposition Prefeasibility Study, Nov. 2017.

2D Ground Thermal Modeling – In-Pit Tailings Deposition Prefeasibility Study, SNC Lavalin, Sept. 2017.

Agnico-Eagle Mines 2016 Mine Waste Rock and Tailings Management Report & Plan Update, Nov. 2016.

Multiple Accounts Analysis for the Tailings Facility Extension Project – Trade off Study for the Tailings Facility Extension Project. SNC Lavalin Technical Note, Oct. 2016

In-Pit Tailings Deposition Water Balance and Water Quality Forecast - TSFE Project – In-Pit Deposition Prefeasibility Study. SNC Lavalin Technical Note, Sept. 2017.

Meadowbank FEIS Baseline Physical Ecosystem Report. Cumberland Resources, Oct. 2005.

2.2.2.2. *Issues/Concern*

AEM's proposed revision to the tailings management plan for the Meadowbank Mine includes deposition in the Goose and Portage A and E Pits (2016 Tailings Management Update). Closure plans include a minimum 8 m water cover over the tailings to reduce oxidation and prevent acid generation and re-suspension of tailings. The three pits are partially located within the Second and Third Portage Lakes. Portions of the pit areas are likely underlain by open taliks based on analysis of thermal data as shown in the 2005 FEIS Baseline Physical Ecosystem Report. Construction of dykes and dewatering were required during operations and ground freezing likely occurred in previous submerged areas. Flooding of pits following operation, based on thermal modelling results, will likely lead to re-establishment of open taliks and thawing of permafrost (and talik formation) in portions of the pits previously within permafrost resulting in connections between surface and groundwater.

NRCan understands that breaching of dykes will occur when water quality in the pits is acceptable to join pit water bodies to the surrounding receiving environment (2016 Tailings Management Update). Based on the information provided, tailings will be deposited to a maximum elevation of approximately 125 masl and covered by 8 m of water (Hydrogeological Modelling Report). This results in a final water level of about 133 masl which is similar to pre-mining conditions. NRCan assumes that this means that areas outside of the pits that were dewatered during operations will be submerged at closure, resulting in warmer ground conditions and thawing of permafrost that may have formed during the operating period. However, the results of the thermal modelling analysis indicate that areas outside the pits, which used to be below the lake, will continue to freeze-back until equilibrium is reached (Sept. 2017 Thermal Modelling Report). NRCan agrees that freezing at depth may continue to occur for some time even though warmer surface conditions occur with flooding. However, warming of the ground will eventually occur which may result in permafrost thaw. NRCan seeks clarification regarding the final water levels and the areas that will be submerged following closure and the resulting thermal regime and talik extent.

2.2.2.3. *Information request*

NRCan requests that the Proponent please clarify final water levels following closure and areas outside the pits that will be submerged.

2.2.3. NRCan-IR #15: Long-term stability of submerged permafrost

2.2.3.1. *Reference*

Please refer to NRCan-IR #14.

2.2.3.2. *Issues/Concern*

Referring to NRCan-IR #14, if areas outside the pits are submerged, then there is a risk that permafrost formed in dewatered areas could gradually thaw.

2.2.3.3. *Information request*

NRCan requests that the Proponent please clarify whether permafrost that may have been formed in dewatered areas outside the pits will be maintained following closure or gradually thaw.