Review of
Diavik Diamond
Final Closure and Reclamation Plan, Version 1.0

Prepared for Environmental Monitoring Advisory Board

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- Integral Ecology Group
- Core Geoscience Services

Contents

Executive Summary

Slater Environmental Consulting (SEC) reviewed Diavik Diamond Mines Inc.'s Final Closure and Reclamation Plan, Version 1.0. Integral Ecology Group (IEG) and Core Geoscience Services (CGS) assisted SEC with the review: IEG reviewed landform design, land reclamation and re-vegetation. CGS review climate change projections.

The FCRP advances the designs and closure plans for many mine components. It is an important step in closure planning, particularly as mining nears completion. Nonetheless, there is still additional effort required to finalize the closure plan. There are concerns about some of the proposed closure criteria and uncertainty about whether the proposed closure plan will achieve all of the closure objectives.

Key findings of the review include the following:

- Even after closure and reclamation activities, the Diavik Diamond Mine site will have long-term monitoring and maintenance requirements. For example, monitoring and maintenance will be required for the foreseeable future for dams, spillways, water channels and soil covers. The FCRP should describe expectations for these activities and identify how they will be financed and managed in the long-term.
- Initial achievement of closure criteria should be considered as only a first step in evaluating and confirming long-term performance of the closure plan and post-closure landscape. Monitoring of conditions and performance needs to continue until conditions have stabilized and risks are substantially eliminated. Risks associated with climate change and oxidation of reactive rock for example, will continue for a very long time. Monitoring will be needed to detect potential changes from these risks.
- DDMI proposes to rely on natural breakdown for reclamation of hydrocarbon contamination in sediments in the North Inlet. Monitoring indicates that this will likely be successful but the timing is uncertain. Contingencies should be identified for what measures will be taken if the natural breakdown takes longer than expected or is not successful.
- Re-vegetation is only proposed for some infrastructure areas, not for waste rock storage areas or the Processed Kimberlite Containment Facility (PKCF). As a result, there will be approximately 9 square kilometres of area that will remain barren at the end of reclamation activities – including pits, waste rock storage areas and the PKCF. This seems inconsistent with the closure goal of having a final landscape that is neutral to wildlife. The approach to land reclamation and re-vegetation is not consistent with current practices in the mining industry.
- Proposed monitoring of re-vegetation success relies on monitoring of approximately 0.001% of the re-vegetated area. This is much less than standard reclamation monitoring where 0.5% to 10% of the area is monitored.
- There are a number of uncertainties about the water quality predictions for the PKCF. Predictions for the depth of the active layer have not considered climate change projections. Water balance models may be inconsistent with assumptions about seepage and runoff. The thickness of the active layer will influence post-closure water quality, but analysis has not considered climate change. Additional modelling or sensitivity analysis is needed to understand

potential effects, for example thermal conditions at the PKCF and North County Rock Pile (NCRP), and waste rock seepage quality.

- DDMI has proposed a much narrower scope of parameters for closure criteria for surface water quality. Instead, it has proposed a “Surface Water Action Level Framework” to managed water quality during closure. The removal of specific parameters from the closure criteria leaves uncertainty about what water quality is acceptable during post-closure.
- DDMI is proposing to dispose of soils contaminated with hydrocarbons and other contaminants (e.g., glycol) in the landfill that was designed for inert materials. It asserts that this landfill will provide suitable long-term containment for these contaminated materials.
- The proposed approach for managing long-term water quality could result in water quality within mixing zones in Lac de Gras with concentrations that exceed Canadian drinking water standards.
- The rock fill cover design for the PKCF has not considered the potential for migration of PK materials up through the cover. This could result in PK being exposed at surface in the long-term. Analysis is needed to confirm whether filters are required as part of the cover design.
- Settlement of PK material in the centre of the PKCF is expected. This settlement will affect slopes of PK material and may cause ponding of water. DDMI proposes that this can be addressed by adding additional rock fill in some areas. Even with rock fill, there will still be ponding of water on the surface of PK within the rock. This may affect the performance of the proposed closure plan, including water quality outcomes.
- Construction of the cover and the spillway outlet channel on top of fine and extra-fine PK will present challenges. Future stability and performance is uncertain. Additional information and analysis are needed to confirm whether the proposed plan is feasible and practical.
- Prediction of consolidation of PK materials in the PKCF is based on a model that is a poor representation of the expected physical conditions. As a result, the model results do not provide confidence about expected consolidation.
- Closure criteria related to dustfall should be based on surrounding conditions rather than on territorial standards.
- The methodology used for assessing climate change is adequate. However, the choices for inputs and assumptions mean that the estimates may underpredict climate warming. These predictions influence future predictions for performance of mine closure structures and waste containment measures, for example covers.

1.0 Introduction

Slater Environmental Consulting (SEC) has completed a review of Diavik Diamond Mines Inc.'s (DDMI's) Final Closure and Reclamation Plan (FCRP), Version 1.0. SEC was assisted in this review by the following subcontractors:

1. Integral Ecology Group (IEG) reviewed FCRP aspects related to landform design, land reclamation and re-vegetation. Attachment 1, a memo from Mr. Justin Straker, provides the comments and recommendations from IEG.
2. Core Geoscience Services (CGS) reviewed the FCRP aspects related to climate change projections and implications on the FCRP. Attachment 2, a memo from CGS, provides the comments and recommendations resulting from the CGS review.

The FCRP is an important advancement in the closure planning continuum for the Diavik Diamond Mine, especially as mining nears completion and the need to implement final closure measures approaches. The FCRP includes advancements in design for many mine components. Nonetheless, there are some important aspects where there substantial additional effort is still required to finalize designs. For example, final designs are not complete for closure of the Processed Kimberlite Containment Facility (PKCF). This leaves remaining uncertainty about the effectiveness of proposed closure approaches for achieving closure objectives.

Comments and recommendations provided in this report are organized according to the structure of the FCRP document, beginning with comments on the FCRP Main Document, followed by comments on specific appendices.

2.0 FCRP Main Document

2.1 Closure Objectives and Criteria

DDMI's cover letter for the FCRP describes a proposed change to closure criterion P3-1 for the PKCF. Closure Objective P3 states: "*Prevent processed kimberlite from entering the surrounding terrestrial and aquatic environments*" with a criterion that required there be "*no visible fine processed kimberlite either inside or outside the PKC facility*." In the FCRP, DDMI proposes that "*The overarching and approved Objective is to prevent processed kimberlite from entering the surrounding terrestrial and aquatic environments and success is more appropriately measured by confirming PK is not leaving the PKCF*." Based on this assertion, DDMI proposes that the existing criterion be revised to remove reference to exposed PK inside the PKCF, instead referring only to exposure outside the PKCF. This proposal clearly does not achieve the intended outcome for the closure plan, that there should be no PK exposed at surface where animals, plants or people may be in direct contact or where the material could be moved by wind or water. A successful closure plan will result in conditions where no PK is exposed at surface whether in the PKCF or outside it. The need to avoid exposure of PK inside the PKCF in an important consideration for design and long-term performance of the cover for the PKCF.

Recommendation 1: DDMI's proposed change to closure criterion P3-1 should not be accepted. Instead, a closure criterion that requires no exposure of PK either inside or outside of the PKCF should be retained.

Closure objective SW5 is stated as "*Re-vegetation efforts targeted to priority areas*." As noted in previous reviews, the objective does not describe a desired closure outcome. Instead, it is solely process related – that re-vegetation effort should take place in areas that someone sets as priorities. The question of who sets these priorities is not defined. Additional comments about this objective are provided in the IEG memo.

Recommendation 2: The objective should be revised to define an expected re-vegetation/land reclamation outcome.

Closure objective SW9 is stated as "*Landscape features (topography and vegetation) that match aesthetics and natural conditions of the surrounding natural area*." The list of closure activities intended to achieve the objective are provided in Table 5-6 but do not include any activities related to topography. As a result, it appears that the FCRP has not taken any measures to achieve outcomes related to topography.

Recommendation 3: The FCRP needs to provide descriptions of the measures that have been or will be taken to achieve topography that matches the aesthetics and natural conditions of the surrounding natural area.

2.2 Misclassified Waste Rock

Section 4.4.3.3 of the FCRP discusses misclassified waste rock from the A-Portal. This Type III rock has potential for acid-generation and metal leaching, but was used for construction activities in some areas of the site. Based on subsequent investigations and sampling, DDMI concluded that "*the bulk geochemical characteristics of the areas that incorporated A-Portal waste rock into construction (and specifically the worst-case surface construction scenarios) are still constructed with Type I or non-PAG rock"* and that *"acid rock drainage and metal leaching is expected to remain within the normal range for Type I Rock."*

As shown on FCRP Figure 4.4, the misclassified rock is concentrated in a few drainages. Even though the bulk characteristics of the material used for construction may be non-acid generating/non-metal leaching, the Type III materials could cause increased concentrations of contaminants at a local scale and could affect runoff quality in some catchments. For example, materials are not necessarily well mixed with other neutralizing materials, and flow paths of runoff/seepage may not contact neutralizing materials or may contain contaminants that are not removed by contact with the available natural neutralizing material (i.e., they remain in solution at pHs higher than neutralizing material will develop). Elevated contaminant concentrations caused by oxidation of reactive materials may not be apparent in current sampling and may take many years to develop because the effects will not be apparent until reactions consume the effective neutralization potential in the materials. For catchments that contain misclassified rock, it will be important to continue monitoring for at least as long as it would take for the reactive materials to produce ARD and metal leaching, and for any contamination to be measurable in the drainage path if it were to occur.

In its response to comments on this matter in its recent water licence application DDMI asserts that "*Impact on water chemistry would be expected sooner rather than later and particularly by now*" but it doesn't provide any evidence to support this statement. At the technical session for the water licence application DDMI referenced kinetic test work for Type III waste rock indicating that it generates acid quickly. However, it did not provide or refer to test work and/or analyses to confirm that the rock would have currently released sufficient acidity to consume its inherent neutralizing potential and that contaminants would have travelled to monitoring locations. In the absence of this type of information, there is remaining uncertainty about performance.

Recommendation 4: DDMI should revise monitoring durations for catchments in which misclassified Type III rock was used for construction. Monitoring durations should be sufficient to detect any contamination that arises from potential ARD and metal leaching, based on predictions of the time for the specific materials to react and consume neutralizing materials, and for contaminants to be measurable at seepage sampling locations.

2.3 Post-Closure Activities

In Section 5.1 DDMI describes post-closure activities as:

> *"activities, such as monitoring and maintenance, are those that will occur following the closure actions. These could occur before the end of commercial operations (in the case of progressive reclamation) or after the end of commercial operations and are expected to be complete with the acceptance of the final Performance Assessment Report (Part J Item 6)."*

The FCRP asserts that "*The site closure has been designed with the view to no long-term maintenance requirements*" (e.g., Sections 5.2.5.7, 5.2.6.6). For a site of this scale and with permanent structures for conveyance of water and containment of PK (i.e., tailings dams), there should be no expectation that long-term maintenance will not be required. Monitoring will certainly be required to observe the conditions of dams, spillways, conveyance channels and covers (e.g., waste rock, PK). Severe events, for example extreme floods or earthquakes, greater than expected climate change or changes caused by permafrost, may lead to adverse effects on facilities that are critical to maintaining physically and chemically stable post-closure conditions. Because this site has permanent structures for containment of tailings and water, and conveyance of water, there will be permanent requirements for ongoing monitoring and likely occasional maintenance.

Recommendation 5: The FCRP should be revised to recognize and describe requirements for long-term monitoring and estimates of maintenance requirements. Mechanisms for financing and managing these long-term requirements should be identified.

2.4 Fish Habitat Enhancement

In Section 5.2.1.5 DDMI states that it no longer intends to construct the previously planned fish habitat within the dike areas of the pits:

> *"Fish habitat construction within the dike areas has been reconsidered with DFO and Indigenous communities and the decision has been made to avoid encouraging fish into the pit lakes and not construct the designed fish habitat enhancement."*

The rationale for this proposed change is found in Section 5.2.5.3:

> *"Concerns have been raised by communities and the TK Panel regarding construction of fish habitat enhancements in a Mine-affected area that may not be used by people in the future rather than alternative offsetting approaches that could be more beneficial to affected Indigenous communities."*

Instead of constructing fish habitat at East Island in Lac de Gras, DDMI now proposes habitat enhancement at Frame Lake in Yellowknife. Frame Lake currently does not support any fish populations, a condition thought to be due to low oxygen levels especially under ice. Frame Lake is far from the site, Lac de Gras and the Coppermine River watershed. It also has arsenic concentrations which have led GNWT to designate it as a lake that would not be suitable for consumption of harvested fish.[1]

- Frame Lake is identified as having arsenic concentrations in the range of 100-499.99 parts per billion, falling in the "red" category with the following description: "*Lakes with orange, red or purple points: Arsenic levels are elevated (52 parts per billion and above). Water should not be consumed from these lakes. It is also recommended to avoid fishing, swimming, and harvesting berries, mushrooms and other edible plants within this zone. However, walking through this area does not pose a health hazard*."
- Specifically for Frame Lake, GNWT states: "*People should continue to avoid swimming, fishing and harvesting berries, mushrooms and other edible plants around David Lake, Fox Lake, Frame Lake, Gar Lake, Handle Lake, Jackfish Lake, Kam Lake, Niven Lake, Peg Lake, Meg Lake, and Rat Lake*."

As a result, any fishing conducted in Frame Lake could only be catch-and-release. It is not clear whether the proposed habitat enhancement achieves the desired outcome of being "*more beneficial to affected Indigenous communities*." This should be confirmed before approving the proposed change in approach for fish habitat enhancement.

Recommendation 6: Further description should be provided about the benefits expected from the Frame Lake fish habitat enhancement and the relationship to the Diavik project.

2.5 North Inlet

With respect to the North Inlet, the FCRP proposes consideration for reconnection to Lac de Gras over a longer period of time than in recent versions of the Interim Closure and Reclamation Plan. This will allow a longer period for natural degradation of petroleum hydrocarbons (PHCs) in sediments before DDMI proposes to make a final decision about reconnection. This is a positive change, but may still not go far enough. DDMI still identifies the possibility of a hydraulic connection without access for fish as described in Section 5.2.1.8: "*Should the NI sediment not bioremediate within the timeframe of closure construction then the contingency option of a hydraulic connection is proposed to be executed*." The time frame of closure construction may be too short to

[1] Arsenic in Lake Water Around Yellowknife. Government of Northwest Territories. Accessed on February 27, 2023 at https://www.hss.gov.nt.ca/en/newsroom/arsenic-lake-water-around-yellowknife

allow adequate remediation. If this is the case, and if sediment quality is on a trajectory towards suitable conditions then there would still be significant benefit of fully re-connecting the North Inlet once sediment is remediated. Aside from costs for mobilization of equipment to carry out the work, there is no other impediment to completion of the work at a later time.

Recommendation 7: Revise the FCRP to provide a contingency for continued monitoring of North Inlet sediments after completion of closure construction and later completion of the reconnection, if sediment quality is on a trajectory towards suitable quality at the end of closure construction.

Section 5.2.4.4.5 describes alternatives analysis for previously considered closure alternatives for sediment in the North Inlet. Prior to consideration of natural remediation, options for covering and dredging sediments were evaluated. Not surprisingly, alternatives that involved dredging were ruled out due to concerns about practicality. Covering, on the other hand, was removed primarily due to concerns about cost. As a result, DDMI abandoned any alternatives that involved active measures to address the contamination, and concluded that nothing beyond natural remediation of PHCs would be done. In reaching this conclusion, DDMI asserts that if natural remediation is unsuccessful, then it should be acceptable to leave the contamination in place. This does not appear to be consistent with the closure goal "*Land and water that is physically and chemically stable and safe for people, wildlife and aquatic life*." If monitoring of North Inlet sediment demonstrates that natural remediation of PHCs is not likely to be effective (i.e., not on an improving trajectory), then covering of the contaminated sediments or other remedial measures should be implemented.

Recommendation 8: The FCRP should be revised to include a contingency for covering or other remedial measures for North Inlet sediments if monitoring demonstrates that natural remediation is unlikely to be effective in achieving suitable sediment quality conditions.

2.6 Collection Pond Breaches

Section 5.2.1.8 proposes breaching of ponds based on water quality of surface runoff reporting to ponds: "*Breaching of the collection ponds will only be conducted if the surface water runoff reporting to these ponds has been confirmed to be acceptable for direct discharge to Lac de Gras*." Decision-making about breaching of ponds is not, however, tied to whether there may be future activities including land disturbance or earth-moving activities in the catchment. These types of activities could adversely affect water quality in collection ponds. Table 3 in DDMI's February 24, 2023 response to Information Requests confirms that many ponds are to be breached before reclamation activities in catchments are complete. For example, grading and re-vegetation activities will continue within most pond catchments after the proposed dates for breaching. Until grading is complete and vegetation established, there is ongoing potential for sediment release from disturbed areas. Breaching of ponds for which operation and closure-related earthworks are incomplete should be reconsidered.

DDMI argues that ponds can be re-established if needed. However, re-establishment will be difficult, especially at times when water quality conditions are most likely to deteriorate, due to high flow events. Temporarily keeping pond functionality in place (i.e., not breaching) while allowing controlled discharge of water that meets licence limits for discharge from Collection Ponds provides another alternative.

While the retaining structures remain in place, discharge of water in accordance with licence requirements could be undertaken using pumps, siphons or spillways.

However, in Section 5.2.8.3.2 DDMI argues that approaches that maintain the integrity of collection pond containment are not practical: "*DDMI has determined that it is not practical to create a controlled discharge that will accurately represent passive, diffuse and discontinuous post-closure discharge conditions*." As DDMI suggests, using pumps, siphons or spillways will create discharge rates and timing that are different than discharge in a stream with no control pond. Nonetheless, discharge while retaining the pond dams in place would still entail discharge of water via stream channels, a condition that is much more similar to post-closure conditions. It provides an opportunity to reduce the costs of pumping/treatment and consider the effects of direct discharge, while maintaining the ability to rapidly respond if water quality conditions deteriorate.

Recommendation 9: Limit breaching of Surface Water Ponds until after completion of operation and closure-related earthworks and erosion control closure measures (e.g., re-vegetation) in the specific catchments while providing for controlled discharge of surface runoff that meets licence limits (for discharge from Collection Ponds), numerical closure criteria and thresholds in the SWALF.

2.7 Pit Lake Stratification

The FCRP provides some contradictory information about predicted stratification of pit lakes. Section 5.2.5.3.3 appears to indicate that all three pit lakes will be permanently stratified: "*This lake configuration should result in stable permanently stagnant lower monolimnion underlying an upper mixolimnion that circulates regularly*."

On the other hand, Section 5.2.1.10.4 appears to indicate that the A154 and A21 pits will fully mix annually, while the A418 pit will be stratified: "*The A154 Pit Lake is predicted to mix annually to have full or near full vertical mixing. The A21 Pit Lake is predicted to fully mix annually. A permanent chemocline establishes in the A418 Pit Lake at a depth of approximately 235 m*."

Recommendation 10: Clarify the expected conditions in the pits with respect to stratification, and provide explanation and analysis to demonstration why the pits are expected to behave differently from each other.

2.8 A21 Causeway

Section 5.2.5.3.4 describes the proposed removal of the A21 Causeway. It appears that this would make the A21 pit and associated laydown area inaccessible during the post-closure period and therefore monitoring would be very difficult.

Recommendation 11: Describe the implications (e.g., cost, practicality, frequency) on post-closure monitoring and maintenance for the A21 area and the SCRP if the A21 Causeway is removed.

2.9 South Country Rock Pile

Section 5.2.6.3 describes the closure plan for the SCRP as follows:

"Re-sloping of the SCRP is not expected for closure. However, localized re-sloping to construct an access/egress wildlife ramp is currently planned. The ramp will be constructed at the north end of the SCRP-WRSA and will be at a slope of 3H:1V to allow caribou access and egress. The remainder of the SCRP slopes will be left at the waste rock angle of repose (1.3H:1V)."

DDMI's proposed closure plan will leave the SCRP as a permanent landscape feature – a pile of rock with angle of repose slopes. While DDMI expects the slopes to meet physical stability design criteria, the final condition does not appear to be consistent with closure objectives related to landscape and aesthetics (e.g., SW9 – "Landscape features (topography and vegetation) that match aesthetics and natural conditions of the surrounding natural area"), or closure goals including:

- Final landscape guided by pre-development conditions.
- Final landscape that is neutral to wildlife – being neither a significant attractant nor significant deterrent relative to pre-development conditions.

The surface of the SCRP will not receive any measures to support re-vegetation, leaving a barren rock surface that will likely remain for many decades to centuries, possibly permanently. For the most part, the SCRP will have a permanent landscape appearance that is similar to that during mining. Leaving an un-reclaimed waste rock dump as a permanent landscape feature does not meet current best practice for mine reclamation.

Additional comments about this issue are provided in the IEG memo.

Recommendation 12: Revise the FCRP to include reclamation measures for the SCRP that are consistent with mine reclamation best-practice, consistent with closure goals, and expected to achieve closure objectives.

2.10 PKCF Seepage

In Section 5.2.6.5 DDMI predicts that seepage from the PKCF will be eliminated at closure:

"At closure, the PKC pond will be pumped down and the beaches and surrounding seepage flow pathways allowed to freeze back once the hydraulic head driving the active seepage flow is eliminated."

Appendix X-15, Section 4.7 makes a similar prediction:

"During operations, the PKC Facility has experienced seepage rates on the order of 38 L/s to 55 L/s. These rates are mostly related to the presence of the supernatant pond that forms as part of FPK deposition. Once deposition ceases at the PKC Facility in November 2022, it is expected that seepage from the facility will reduce to limited flow as the supernatant pond is dewatered and the FPK and EFPK deposit drains."

While seepage will decrease if the FPK and EFPK drain, this may occur over a very long period of time and therefore seepage may continue at a diminishing rate for a long period of time. Also, if the water balance in the PKCF catchment is a positive water balance, then the phreatic surface in the PKCF will continue to be close to or at the spillway invert – i.e., the FPK and EFPK will not drain. In this case, the driver for seepage (head) would not change and seepage would continue, although it is possible that freezing may limit flows in some areas. The presence and amount of seepage from the PKCF is not related to whether there is a pond at the surface, but rather about the level of the phreatic surface in the PK materials.

Section 5.2.7.6 identifies uncertainty about the extent to which seepage may be limited by freezing conditions: identified uncertainties include "*post-closure thermal conditions, particularly as they relate to long-term seepage control*."

Without a water balance for the PKCF it is not possible to confirm whether seepage will be eliminated. Even if the water balance is negative, additional information is needed about the drainage characteristics of the FPK and EFPK in order to understand the expected durations and rates of seepage.

Recommendation 13: Provide additional water balance information for the PKCF to confirm that seepage will not occur during closure/post-closure, and conduct sensitivity analyses to evaluate how seepage at different rates may affect water quality.

2.11 Water Quality Modelling

Section 5.2.8.3.2 describes results of water quality modelling in Lac de Gras, including that "*Hydrodynamic model results for Arc 1, located approximately 100 m to 200 m from modelling discharge points, indicate that for all mass conservative constituents the 95th percentile of the daily depth averaged concentrations at Arc 1 are below AEMP benchmarks at all times*." Exceedance of AEMP benchmarks in up to 5% of predicted conditions would usually be considered unlikely to cause chronic effects if these events occur randomly and do not have long durations. However, the use of daily time step, probabilistic modelling may not accurately portray the actual conditions, especially the duration of exceedance events. Water quality conditions in Lac de Gras will change slowly and AEMP exceedance events that make up less than 5% of predictions may occur on many recurrent days – potentially lasting months or years. These long duration changes in water quality may not be reflected in the model results. In these conditions, chronic effects are more likely to occur as a result of the exceedances event though the modelling predicts that the conditions occur with low frequency.

Recommendation 14: DDMI should consider the potential implications of lengthy exceedances of AEMP benchmarks at the mixing zone boundary, assuming that water quality in Lac de Gras will change slowly and that AEMP exceedances will occur repeatedly over longer periods of time.

2.12 Control Pond Sediment

FCRP Section 5.2.18 proposes that "*Sediment remaining in the ponds will be tested for contamination and covered, if required*." In the response to comments on its recent water licence application, DDMI confirms that one sediment sample was collected from each of 10 Collection Ponds and the E21 sump with results provided in FCRP Appendix X-27. These samples were analyzed for moisture, hydrocarbons, and metals.

In the response to comments DDMI stated that it would use a Total Petroleum Hydrocarbon (TPH) threshold of 1,500 mg/kg as a trigger to require mitigation of sediments – in this case placement of a cover over the sediments. At the Technical Session, DDMI clarified that the 1,500 mg/kg threshold was intended to apply to F3 hydrocarbons, not TPH. It also confirmed that this is the same threshold that is has proposed for sediments in the North Inlet. DDMI has not provided any specific rationale for selection of this threshold, or for why only one parameter (F3 hydrocarbons) is considered in decision-making about sediment quality. Based on the proposed threshold, DDMI identifies Ponds 5 and 10 as exceeding the threshold and proposes a rock cover on these sediments.

The data in Appendix X-27 demonstrate that control pond sediments in several ponds exceed the closure criteria for hydrocarbon contaminated soils specified in Table 3 of Appendix V, which includes criteria for F1, F2, F3 and F4 hydrocarbons (respectively 210, 150, 300 and 2,800 mg/kg). For example, Ponds 1, 5, 10, and 11 and Sump E21 all have concentrations of F3 (C16-34) hydrocarbons exceeding the closure criteria of 300 mg/kg that applies for contaminated soils.

Once the ponds are drained, the control pond sediments will no longer typically be submerged. In the post-closure environment these materials will be in conditions more similar to contaminated soils than submerged sediments (e.g., North Inlet). Where these materials exceed the closure criteria for contaminated soils, they should be managed as contaminated soils in accordance with the FCRP – excavated and landfarmed to reduce hydrocarbon contamination.

Recommendation 15: DDMI should revise the thresholds and remediation plans for sediment in control pond areas to consider the material as contaminated soil rather than sediment that will remain submerged.

There was discussion at the Technical Session about the need for additional criteria to address other contaminants of concern for sediments in control ponds. DDMI argued that work done for the North Inlet confirmed that hydrocarbons were the only relevant contaminant of concern. However, the mechanism for sediment contamination and the source of contamination in the North Inlet (i.e., pumping of water from active mining areas) are likely not the same as those for contamination in the control pond sediments (runoff from mine waste storage and mine disturbed areas). As a result, the evaluation of the need for sediment remediation should consider a broader range of contaminants. For example, if there are sources of metal contamination in pond catchments, sediment should be evaluated for relevant metal contaminants.

Recommendation 16: DDMI should conduct an analysis of contaminants of concern for Collection Pond sediments to consider the range of contaminants consistent with the potential sources and mechanisms of contamination for the materials present in each catchment.

2.13 Surface Water Action Level Framework

DDMI proposes that management of surface runoff from the site will rely on the proposed SWALF. The Technical Session included substantial discussion about the SWALF and IR#4 required DDMI to provide a revised SWALF or options that DDMI is prepared to consider. DDMI's Response to IR#4 provided options for further consideration.

With respect to both Wildlife and Human Health, the revised SWALF proposes that the response to Action Level 1 triggers (exceeding 80% of a criterion) would entail a "detailed risk assessment to confirm or adjust" the criterion/criteria. Investigation of cause and implementation of control mitigation are identified as responses to Level 2 triggers – i.e., when water quality exceeds any adjusted/confirmed criteria.

At a fundamental level, the proposed framework begins with the assumption that it is the criteria that are the problem, not the measured conditions. In the context of a mine closure project an adaptive response plan should initially be focused on whether the closure plan is performing as expected, not on whether the measurement criteria need to be relaxed. To achieve this, the response to Action Level 1 triggers should include investigation of cause. This would form the basis for subsequent decisions about responses. For example, if the cause is not mine-related and is expected to continue, then reconsideration of criteria may be warranted – but that may or may not be to rely on a risk assessment methodology depending on conditions. On the other hand, if the cause is mine-related appropriate, practical mitigation (e.g., runoff management, source control) should be developed and implemented. Only after practical measures have been implemented but exceedance of criteria continues, should there be consideration of risk assessment to adjust criteria. The consideration of adjusting criteria could be addressed as a response to a revised Action Level 2 trigger.

Recommendation 17: Revise the SWALF to provide for investigation of causes of SW1-1 or SW1-2 exceedance, and consideration and implementation of maintenance/mitigation before considering revision of closure criteria. Revision of closure criteria could be considered as a potential response to a revised Action Level 2, but should not be a response for Action Level 1.

Initial triggers under the SWALF are related to AEMP benchmarks and closure criteria. However, these triggers are not proactive triggers for water quality conditions. For many parameters and locations, these triggers represent changes in water quality and conditions that are substantially different than what is predicted through modelling.

The first indication that water quality is different than expected arises when measured conditions exceed the predictions. If this occurs, the framework should trigger, at the least, some investigation of causes. Then, if trends continue then there should be action to curtail the changes, rather than waiting until triggers associated with AEMP benchmarks before taking actions.

Recommendation 18: Conditions that are statistically different from predictions should be an action level trigger, rather than waiting for triggers specifically defined by the AEMP benchmarks and closure criteria.

2.14 Buildings and Mobile Equipment

Section 5.2.9.3.1 describes plans for handling of building materials and equipment:

> *"Materials and equipment with no sale or net salvage value will be decontaminated, if required, broken down, and disposed of in the designated waste rock landfill or underground tunnels."*

DDMI indicates that sale/reuse of buildings and equipment is preferrable, followed by recycling. However, it notes that if there is no net salvage value, then material will be left on site and buried. Despite there being no net value to DDMI, some of the materials and equipment may be valuable resources that should be saved or recycled. Recycling rarely results in net salvage value to the owner. There is a cost to completing reclamation, including potentially costs for recycling of materials and equipment.

Recommendation 19: Decision-making about recycling of materials and equipment should consider a broader range of factors than just having a positive net salvage value.

2.15 Hydrocarbon Contaminated Soils

In Section 5.2.9.3.3 DDMI proposes that for petroleum hydrocarbon (PHC) contaminated soils identified during operations, it will make "*best efforts to reduce hydrocarbon levels in collected surficial material through active landfarming*." Following these best efforts it proposes to bury the contaminated material on site whether it meets Canada-Wide Standards or not. DDMI also proposes that "*During decommissioning, any surficial material in areas where hydrocarbons were stored or spilled will be sampled. Materials that are found to exceed the Canada-Wide Standards for PHCs will be either excavated for specific disposal in the landfill or encapsulated in situ by placement of an approximately 1 m thick A21 waste rock cover*."

DDMI appears to only commit to landfarming PHC contaminated soils identified during operations. Soils identified during closure are to be buried, regardless of contamination levels. Also, "best efforts" is not defined – it appears that this means active landfarming while closure construction is underway but not for longer. There should be commitment to continue landfarming until it is proven to be no longer effective, or until standards have been met. This should be for all PHC contaminated material that is identified during both operations and closure.

Recommendation 20: DDMI should be required to landfarm all PHC contaminated material regardless of the mine phase when it is identified. Landfarming should continue, including whatever active measures are appropriate (e.g., aeration, addition of reagents) to meet Canada wide standards for PHCs.

The FCRP and Appendix X-11 the Remedial Strategy propose that contaminated material that does not meet the Canada-Wide Standards could be disposed of in the on-site landfill. For example, Appendix X-11 states:

> *"The affected surficial material is excavated and transferred to the onsite landfarm facility for bioremediation. No surficial material has been removed from the landfarm to date. Should surficial material remain contaminated at the completion of the landfarming process, these materials will either be disposed of within the onsite inert waste landfill; or transported off-site with other contaminated materials."*

The FCRP indicates that the inert landfill in the North Country Rock Pile (NCRP) is and will be used for disposal of inert material consistent with that approved by the WLWB (i.e., inert material from buildings, machinery and equipment). Appendix X-13, the Landfill Cover Design confirms that the design only considers containment for inert materials:

> "*The landfill is currently used for disposal of inert waste and will be used for disposal of site infrastructure during closure*."
>
> *"Waste types will include wood, metal, plastic, concrete, and other debris."*

This indicates that the landfill design only considered inert materials, not PHC contaminated soils. DDMI confirmed at the Technical Workshop that the landfill design did not consider containment of materials other than inert materials. In the response to IR#1 following the Technical Workshop, DDMI refers to a 2012 options analysis for management of contaminated soils which concluded that exposure to PHC contamination could be mitigated through placement at depths where permafrost is expected to form. The same Response notes that the Human Health and Ecological Risk Assessment concluded that there "would not be an operable terrestrial exposure pathway for people or wildlife for scenarios where contaminated surface materials are capped in-situ or stored at depth in the landfill." Neither of these responses address the specific question in the IR: whether the landfill was designed, constructed and operated in a way that is appropriate for disposal of contaminated materials. However, the design analysis suggests that materials below the cover will freeze below the active layer. Decisions to store contaminated material in the landfill will leave post-closure risks that were not considered in planning for the landfill.

Recommendation 21: Consider the long-term risks associated with permanent storage of contaminated materials in the on-site landfill.

2.16 Progressive Reclamation

Section 6.3 lists many potential progressive reclamation activities but does not provide a schedule or plan for conducting these activities.

Recommendation 22: Provide a plan and schedule for conducting progressive reclamation activities, and require reporting on achievement of the schedule, including rationales for failing to complete progressive reclamation activities on schedule.

2.17 FCRP Schedule

The FCRP provides some conflicting information about the plans for development of a detailed schedule for closure implementation. Section 8 states "*A refined schedule will be possible once final designs and decommissioning plans have been completed*." This indicates that the schedule can't be defined until designs are complete.

With respect to engineering design, the same section states "*Design drawings and construction specifications for closure activities would be provided 45 days prior to implementation of the construction activity*." Contrary to the previous statement, this appear to indicate that the completion of designs will be driven by the schedule.

The two statements appear contradictory with respect to defining the schedule and completion of designs. One indicates that the schedule will be driven by completion of design, while the second indicates that the designs will be driven by the schedule.

It is also notable that the cover letter states that 29 designs have been issued "*for construction*." If the designs are needed to support scheduling, these 29 designs should allow scheduling for most of the FCRP activities.

Recommendation 23: Provide additional clarity about the approach for scheduling of the activities in the FCRP. Where design information is available, update the FCRP schedule to provide additional detail about the sequence and timing of proposed closure activities.

2.18 Human Health Risk Assessment – Drinking Water

Section 9.2.3 describes Indigenous Receptors considered in the Human Health Risk Assessment (HHRA). The receptor description assumes that Indigenous users will rely on Lac de Gras as a drinking water source. However, DDMI proposes water quality criteria for mixing zones that are based on recreational water quality – allowing water quality in these areas to be considered acceptable if it reaches levels as high as 20 times the drinking water guidelines – based on the assumption that people do not drink the water but only have incidental intake associated with recreational activities. The revised SWALF options propose an Action Level 3 trigger that would be reached only when water quality at the mixing zone boundary exceeds drinking water criteria.. This means that water quality within the mixing zone – but still in Lac de Gras – could exceed drinking water standards before corrective action is taken.

Recommendation 24: Describe how the use of 20X drinking water standards as water quality criteria for mixing zones was considered in the HHRA, and what implications there may be for Indigenous users who may use drinking water from within the mixing zone areas. Given that water quality within the mixing zones is expected to exceed drinking water criteria, DDMI should identify how it plans to manage long-term constraints on use of water within the mixing zone areas for drinking water purposes.

3.0 Appendix V – Closure Objectives and Criteria

3.1 Water Quality – Aquatic Effects

Closure objective SW2 requires that water quality from the mine site will not cause adverse effects on aquatic life or water uses in Lac de Gras or the Coppermine River. The proposed closure criteria only address sublethal toxicity (SW2-1) and acute toxicity (SW2-2).

Sublethal toxicity is to be evaluated using a single species of invertebrate (*Ceriodaphnia dubia)* using 12.5% strength of effluent – i.e., 8:1 dilution. DDMI's rationale for selecting 8:1 dilution is that it provides an indication of potential toxicity at a lower dilution ratio than the 10:1 dilution that DDMI expects to have at the mixing zone boundary. The selection of this dilution ratio for evaluation of achievement of the closure objective means that sublethal toxicity may occur in effluent streams and large parts of mixing zones, while still meeting the closure criteria and achieving the closure objective. Also, the decision to rely on a single species to evaluate sublethal toxicity means that potential sublethal effects on other species are not considered in the evaluating performance.

Recommendation 25: Closure criterion SW2-1 should be revised to consider a broader range of species. Typically testing would be completed on relevant sensitive fish, invertebrate and algae/aquatic plant species.

Previous versions of the closure criteria included thresholds for specific parameters of concern. These have now been removed and thresholds for specific parameters are contained in the SWALF. The proposed removal of thresholds for specific parameters from the Closure Criteria would allow DDMI to argue that it has achieved closure objectives and criteria even if AEMP benchmarks are being exceeded in Lac de Gras. This should not be considered a suitable closure outcome unless there is further discussion about the long-term implications. To avoid this situation, the closure criteria for SW2 should be revised to retain thresholds for specific parameters of concern. This could be achieved by including specific thresholds, or by requirements to achieve thresholds set out in the SWALF.

Recommendation 26: Revise the closure criteria for SW2 to include thresholds for specific parameters of concern in addition to the toxicity criteria. These could be specific thresholds for relevant parameters, or appropriate references to achieving thresholds set out in the SWALF.

At the Technical Session DDMI explained that for some parameters, the predicted background (i.e., non-mine related) water quality loading can lead to concentrations that are very close to the AEMP benchmarks in post-closure conditions. In the Response to Information Request #1 following the technical session, DDMI states that this arises from an "artifact of conservative modelling assumptions." This may be a reasonable conclusion given the approach for modelling and the assumptions about background water quality.

However, the issue does raise some questions about the methods for evaluating achievement of the proposed closure criteria, specifically toxicity testing methods. The proposed testing may not provide an accurate characterization of the actual conditions, depending on the source of dilution water used for toxicity testing. Lab toxicity testing typically relies on dilution water that is low in contaminant concentrations. In this case, the lab dilution water may not be representative of the actual dilution water that will be present in Lac de Gras. Therefore, the toxicity testing at 8:1 dilution using lab water may have contaminant concentrations lower than what will be present at the actual mixing zone boundaries and therefore underpredict the toxicity conditions that are present in Lac de Gras.

Recommendation 27: DDMI should consider whether toxicity testing protocols for evaluating achievement of closure criterion SW2-1 should be revised to require use of Lac de Gras water as dilution water for lab testing.

Closure criterion SW2-2 sets a threshold of "*no acute toxicity observed*." Acute toxicity is to be evaluated by toxicity testing of full-strength effluent using 96-hour tests for Rainbow Trout and 48-hour tests for *Daphnia magna*. In its response to comments on the recent water licence application, DDMI confirms that it intends to use the same testing threshold as the MDMER for defining acute toxicity – that no more than 50 percent of test organisms die during the test procedure. While this is a common threshold for defining acceptable acute toxicity for regulatory purposes, it does not mean that the effluent will not result in toxic effects even if it passes the toxicity criterion. Because the streams on East Island may often have flows that are almost entirely made up of site runoff, the proposed criterion means that some acute toxicity effects may occur throughout streams while meeting the proposed closure criteria. Ongoing acute toxicity even at levels that are lower than 50 percent lethality during the test procedure may have adverse effects on the aquatic environment.

Recommendation 28: The use of the MDMER acute toxicity threshold as a closure criterion should be reconsidered for any streams that may provide aquatic habitat. More restrictive acute toxicity thresholds should be identified so that the conditions are protective of aquatic values.

3.2 North Inlet Sediment

DDMI has proposed that the closure criteria for sediment quality in the North Inlet be revised to remove all numerical criteria except one for F3 hydrocarbons. Previous versions have included numerical criteria for metals and a variety of hydrocarbons.

Recommendation 29: Retain numerical closure criteria for metals and other hydrocarbons in North Inlet sediments or provide rationale for why other contaminants do not need to be included.

3.3 Demonstrating Success – Achievement of Closure Criteria

In Appendix V, Section 4 DDMI proposes 5 years as generally being a "*reasonable amount of time to demonstrate closure success*." Achievement of closure success and the achievement of closure criteria will depend on the type of activity, the expected outcome and the level of acceptable post-closure risk. Also, while it may be administratively possible to confirm achievement of closure criteria at a point in time, success in completing a CRP (i.e., closure success) is not something that can be measured and confirmed at a single point in time. Initial achievement of closure criteria should be considered the start of demonstrating that the CRP has been successful, a condition that will require continued confirmation throughout post-closure, and correction/mitigation where necessary.

The reliance on 5 years to demonstrate achievement of closure criteria and as a duration for monitoring is repeated in Appendix VI, the Closure and Post-Closure Monitoring Plan, for example:

- Section 3.1.1.3 – "*After 5 years of confirmed stability, the closure criteria will be met, and monitoring of the mine areas, and collection ponds will be ceased*." Physical performance of collection pond breaches is primarily related to size of flow events. Monitoring needs to continue in the long-term, especially after extreme events.
- Section 3.1.4.3 – Seepage and Runoff: "*Five years after decommissioning, and with adherence to closure criteria, monitoring may cease*." Section 3.6.2.3 – Collection Ponds: "*Five years after decommissioning, and with continued adherence to closure criteria, monitoring may cease*." Water quality monitoring downstream of any waste storage facilities must continue in the long-term – development of ARD/metal leaching and migration of contaminants can be very slow processes. Discontinuation of monitoring after 5 years is unlikely to capture any potential effects.
- Section 3.4.3.3 – Seepage and Runoff from PKCF: "*Five years after decommissioning, and with adherence to closure criteria, monitoring may cease.*" The water balance and thermal conditions in the PKCF will take a long time to stabilize after closure – EFPK for example, will take a very long time to drain if the water balance is negative. Evolution of water balance and thermal conditions will affect seepage quantities and possibly qualities. Global climate warming will influence thermal conditions in the PK and the dams over the long-term, also potentially affecting seepage conditions. Monitoring needs to continue throughout this period of transition as the conditions in the PKCF stabilize ,which could take decades.

In all cases, monitoring to evaluate initial closure success (i.e., achievement of closure criteria) needs to continue until closure elements demonstrate stable, predictable, acceptable performance over a period that is sufficient to substantially reduce uncertainty about continued long-term performance. In most cases, the level of uncertainty about long term performance will be reduced by having monitoring over extended periods that demonstrates ongoing acceptable performance.

Once the initial achievement of closure criteria has been confirmed, monitoring for closure success still needs to continue for closure facilities and elements where conditions and performance may change over time, or where the facilities/elements provide critical, permanent post-closure functions (e.g., containment dams, water conveyance structures). Section 1 of Appendix VI, the Closure and Post-Closure Monitoring Plan addresses monitoring after initial achievement of closure criteria and shows limited monitoring continuing for 20 years, for planning and costing purposes. There are many cases where monitoring will be required well beyond 20 years, and where periodic maintenance will also be needed, for example:

- The PKCF will be permanently contained by dams with spillways to manage surface water flows including floods. The dams and conveyance structures will require permanent monitoring and periodic maintenance to ensure their permanent performance.
- Successful closure of the NCRP relies on eliminating contaminant loading from the Type III waste rock by ensuring that water does not move through the Type III material. Maintaining the material in a frozen state and building a cover that is thicker than the active layer are important features of the closure design. The uncertainty associated with global climate warming creates uncertainty about the long-term performance of the NCRP closure. Understanding performance will require long-term monitoring of the cover and thermal conditions in the waste rock.
- Potential migration of contaminants from mine components into water is a primary driver for the closure plan. The release of contaminants can be a slow process due to the time for oxidation reactions to happen, consumption of neutralizing materials, and contaminant transport. Water quality conditions could take many years to stabilize, and they could also change after many years of stable conditions as geochemical thresholds are reached. Water quality monitoring for all mine waste storage facilities will be required for at least several decades until conditions are stable and there is a good understanding of expected long-term water quality outcomes.

Recommendation 30: DDMI should revise the time frames identified for achievement of closure criteria to more accurately reflect the time to observe and confirm acceptable outcomes, and reduce uncertainty about ongoing, long-term performance of each closure facility and element. Monitoring durations for confirming achievement of closure criteria should be specific and relevant to the closure elements.

Recommendation 31: The FCRP should be revised to acknowledge that achievement of closure criteria as only one step – albeit an important one for administrative purposes – in the process of demonstrating and confirming closure success.

Recommendation 32: The post-closure monitoring and maintenance plan should be updated to provide a realistic description of the duration of expected post-closure monitoring for all facilities and closure elements.

Recommendation 33: DDMI should describe how it intends to address its responsibilities for long-term monitoring and maintenance of closure success, even after achievement of closure criteria, including how it will address costs and implementation.

4.0 Appendix VI – Closure and Post-Closure Monitoring Plan

4.1 Monitoring – Hydrology

Appendix VI, Section 3.1.3.1 proposes that monitoring of hydrology can be discontinued once collection ponds are breached. Hydrology information continues to be relevant after breaches, including to understand the timing and scale of high flow events, including as they may be changing as a result of climate change. Also, hydrology information is critical for understanding loading in relation to water quality effects.

Recommendation 34: Retain hydrology monitoring as part of the post-closure monitoring program to support understanding of effects of high flow events, and to support adjustment of designs if necessary.

4.2 Monitoring – Seepage and Runoff

Appendix VI, Section 3.1.4.3 describes monitoring programs for seepage and runoff from the site. In some cases, the frequency of closure monitoring is quite low, and in all cases, the plan proposes substantial reductions in the scope and frequency of monitoring early in the post-closure phase, for example:

- "*After the completion of closure activities on site, monitoring will be reduced to twice annually for both chemical analysis and toxicity*."
- "*Sampling at the edges of mixing zones around the East Island will occur once annually*."
- "*Sampling will occur for two years following decommissioning of the associated collection pond; these mixing zone stations would then be deactivated*."

Annual or twice annual sampling of water quality during closure is unlikely to be sufficient to characterize and understand water quality conditions and variability. Discontinuing sampling of mixing zones after two years (i.e., two samples) is also unlikely to provide a good understanding of post-closure water quality conditions.

Recommendation 35: DDMI should be required to demonstrate that the proposed monitoring frequency and schedule will provide statistically relevant information about water quality conditions. If not, then the duration and frequency of monitoring should be revised to provide adequate understanding.

Appendix VI, Section 3.1.4.3 proposes that monitoring of site runoff and in mixing zones would be discontinued unless sampling shows exceedance of closure criteria or AEMP benchmarks:

> *"If SNP source water samples collected from the pond breach location did not meet closure criteria, or if concentrations at the edge of the mixing zone exceeded AEMP effects benchmarks then sampling would continue."*

For many parameters, the triggers proposed for continued sampling represent substantially higher concentrations than have been experienced in the past or modelling predicts will occur. As described in Section 2.13 of this report, statistically significant variance from predicted conditions should be considered as an early indicator of changes in water quality conditions and should lead to continued monitoring of water quality conditions.

Recommendation 36: Sampling of water quality in Collection Pond locations and Mixing Zones should be continued if concentrations exceed predictions, are at the upper end of predicted values, or if increasing trends are observed. Note that the proposal to only collect two samples (once a year for two years) in mixing zones will not allow for evaluation of trends, so higher sampling frequencies or longer sampling periods will be required.

4.3 Monitoring – North Inlet

Appendix VI, Section 3.1.4.4 proposes that Five years of data will be used to determine achievement of SW1 and SW2 (i.e., water quality criteria) for the North Inlet and that these criteria "*will be assessed based on a weight of evidence approach*." It is not clear what evidence will be used to undertake a "weight of evidence approach" for these objectives. The criteria for these objectives are numerical and definitive in nature, so there does not appear to be need for additional information to interpret the outcomes.

Recommendation 37: The approach for evaluating achievement of SW1 and SW2 and the associated criteria for the North Inlet should be clarified. If the numerical and definitive closure criteria will not be used, additional or alternative criteria should be defined. If the criteria will be interpreted using a weight of evidence approach, DDMI should provide details about what information it intends to consider and how it will make decisions about achievement of criteria.

4.4 Monitoring – Pit Reconnection to Lac de Gras

Appendix VI, Section 3.2.3.4 describes the sampling that will be used to make decisions about reconnection of pit lakes to Lac de Gras (i.e., breaching of dikes): "*Water quality will be required to meet closure criteria during the intensive sampling event that will occur immediately prior to breaching the dikes*." Sampling in an intensive one-time sampling effort is necessary and important because it will help to characterize spatial variability of water quality at that time. However, reconnection should also consider temporal variability – especially over the course of the year, but also inter-annually. Once breaches are excavated it will be difficult to reverse the reconnection so it is important to understand variability across both space and time before reconnections are established.

Recommendation 38: Decisions about re-connection of pit lakes to Lac de Gras should be based on an understanding of water quality conditions including temporal and spatial variability. Sampling should be designed to develop this understanding, and the decision-framework should include consideration of results from a more comprehensive sampling program that addresses both spatial and temporal variability.

4.5 Monitoring – Waste Rock Thermal Conditions

Appendix VI, Section 3.3.1.3 proposes discontinuation of physical monitoring of waste rock storage areas after five years: "*After five years meeting the closure criteria, monitoring of the waste rock storage and till areas will be ceased*." This appears to include both thermal monitoring and surveying. Understanding of thermal conditions in the North WRSA is critical to understanding whether the mitigation and design are working as proposed. Without frozen conditions, the potential for adverse seepage quality is increased – a condition that likely would not be observed in seepage quality for years to decades. Monitoring of thermal conditions provides a more proactive measure for understanding whether the facility is performing as expected. Given climate change, thermal performance remains as a substantial uncertainty. Also, the climate change predictions indicate that the active layer could reach the full thickness of the cover within the next century. Monitoring is needed to confirm that this does not happen more quickly.

From a broader physical stability perspective, the movement of frozen slopes, especially those with fine grained materials, can be slow rather than catastrophic. This could include creep of frozen materials, or deformation caused by solifluction. These types of changes may not be observed within the proposed time frame of five years. This issue was discussed at the Technical Workshop and DDMI asserted that the cover has been designed so that no long-term maintenance would be required, including as a result of solifluction. This, of course, is the intent of the design. Nonetheless designs have uncertainty and monitoring is the correct tool for evaluating that uncertainty over time.

Recommendation 39: Thermal and physical monitoring of the NCRP should continue until there is no longer a water quality risk associated with the facility and permafrost conditions in the facility have stabilized.

4.6 Monitoring – PKCF Cover

Appendix VI, Section 3.4.1.3 proposes that monitoring of the PKCF cover will cease after five years: "*After five years of meeting the closure criteria P2-3 and P3-1, monitoring of the PK cover will cease*." Closure criteria P2-3 and P3-1 are related to physical condition of the cover and exposure of PK materials. Consolidation of the EFPK will take a very long time and will affect cover performance. Monitoring of the PK cover must continue until consolidation is essentially complete. At the Technical Workshop, DDMI argued that the cover has been designed to require no long-term maintenance and therefore failure mechanisms like solifluction are not realistic. While robust designs are necessary for long-term closure projects, they do not guarantee performance. Long-term monitoring needs to include specific approaches for measuring consolidation. Also, the monitoring plan does not include an annual inspection of the cover by the Engineer of Record for the PKCF facility.

Recommendation 40: Revise the monitoring plan for the PKCF to including annual inspections by the Engineer of Record for the PKCF facility, and to include long-term monitoring of thermal and consolidation conditions.

5.0 Appendix X-3 – A418 Pit Crest Ramp Design

Appendix X-3 describes the design of a ramp to mitigate potential hazards for caribou associated with the steep pit slope terminating in the pit lake. The design entails a ramp with a slope no steeper than 3H:1V. However, the design proposes that side slopes of the ramp in overburden materials can have slopes as steep as 1.5H:1V. Appendix X-3, Section 4.0 indicates that the top of the ramp is at approximately 425 masl, while overburden/bedrock interface is at an elevation of approximately 420 masl. With limited movement of additional overburden materials, the side slopes of the overburden section could also be flattened to 3H:1V, providing better access to the ramp for caribou and less potential for erosion of overburden materials.

Recommendation 41: Flatten side slopes of overburden section of ramp to 3H:1V to provide better access to and from the ramp.

Section 5.1.2 proposes that rock excavated during ramp construction will likely be Type I rock (i.e., non-acid-generating), and that any Type III rock encountered would be disposed of in accordance with the procedures in the Waste Rock Management Plan – disposal in the NCRP. Submerging any Type III rock in the pit rather than moving it to the NCRP would likely be a suitable alternative since submergence of acid-generating rock is an effective method for mitigating concerns about acid-generation and metal leaching. While this approach is not practical for Type III waste rock produced during operations, it may be appropriate for any Type III rock produced during closure.

Recommendation 42: Consider the practicality and effects of disposing Type III rock from the pit ramp into the pit for permanent storage under water.

6.0 Appendix X-4 – Pit Fill Piping Design

Appendix X-4 describes the design of piping for siphoning of water from Lac de Gras into pits, for the purpose of filling pits. Neither the design nor the FCRP provide any information about planning and design to avoid erosion of pit wall materials. Appendix X-4 specifically notes that erosion control and mitigation is outside the scope of the design. Also, the design and FCRP do not discuss any measures in A418 Pit to avoid or minimize mixing of fresh lake water with the supernatant water from tailings disposal that may already be contained in the pit, or suspension of tailings into the water column.

The proposed design envisions siphons operating with a hydraulic gradient of approximately 5 m, meaning that siphon pipes would terminate at elevations only a few metres below the surface level of Lac de Gras – potentially hundreds of metres up the pit wall and above water and tailings already present in the pits. At this elevation, the pipes will be discharging in areas that are located within overburden or constructed dike materials, creating risks of erosion of these materials and potential stability concerns for the dikes. Appendix X-4, Table 1 estimates that flow velocities at the pipe exits will be more than 4 m/s, conditions that could be highly erosive.

The design asserts that "*It is the responsibility of DDMI to confirm the suitability of the proposed discharge locations, to confirm local effects of erosion as well as confirm any civil constraints such as structural, geotechnical, or environmental design concerning the pit back-filling operation*." It further states that "*If the discharge location, as identified in this final report, is deemed unsuitable by DDMI due to erosion concerns or any other factors such as dike integrity, additional design evaluation will be required considering the changes in line lengths, elevations, and final siphon placement*." Decisions about discharge locations need to be made in order to finalize designs for the pipes and siphons. The design also proposes that spillways be constructed at siphon exit points.

The FCRP does not provide any additional information about discharge locations, or how these concerns will be addressed. It also does not identify the need for further designs if discharge locations are changed.

Recommendation 43: DDMI should provide additional information about how it plans to address erosion of pit walls, and mixing of inflows with tailings and supernatant. It should also describe the process for updating designs if discharge locations are changed.

7.0 Appendix X-6 – Openings to Surface Closure Design

As noted in Appendix X-6, the closure designs for openings to surface are intended to address Objective SW11 – mine areas are physically stable and safe for use by people and wildlife. The mine areas are not just the pits and the openings to surface, but the overall underground workings as well. The design addresses issues related to stability and safety for openings to surface, but does not address the overall stability of underground workings. Failures of underground workings, whether at openings or in other areas, can affect safety for people and wildlife if those failures propagate to surface. The scope of the design should include information about any risks related to stability of underground areas, whether at openings or in other areas. If necessary, closure measures should be identified to address long-term effects arising from underground workings.

Recommendation 44: Expand the scope of the Openings to Surface Closure Design so that it addresses potential stability issues in all areas of underground, not just opening to surface.

Appendix X-6, Section 6.1.4 notes that design for closure of the A154/A418 Bulk Sample Drift has not been completed: "*The A154/A418 Bulk Sample Drift, located on the A154/A418 side of the mine, is currently filled with water and a site inspection has not been able to be completed. As such, closure designs have not been developed for this portal and the design drawing (Drawing D-DV-3621-B-DRG-00006 in Appendix A) is Issued for Use*."

Recommendation 45: The water licence should require submission of designs for the A154/A418 Bulk Sample Drift once water levels allow collection of necessary information to support design.

8.0 Appendix X-11 – Remedial Strategy Report, Contaminated Soils

Appendix X-11, Section 4.0 identifies strategies for management of contaminated soils: "*The following four potential remedial/risk management options have been identified for both PHC or non-PHC impacted surficial material*." The four strategies include rockfill caps; excavation, landfarm and re-use/landfill disposal; excavation and landfill disposal; and, off-site disposal. The Report indicates that these general strategies may be applied for management of materials contaminated with non-PHC contaminants. However, the Remedial Strategy Report does not provide any information about what monitoring will be done to identify other relevant contaminants.

Section 4.0 does note that glycol contaminated soils would be disposed of in the inert landfill. As discussed above (Section 2.16 of this report) for PHC contaminated soils, these materials may not be appropriate for disposal in an inert landfill.

Proposed post-closure monitoring does not include contaminants other than PHC. Other contaminants would be relevant if disposed of in the landfill.

Recommendation 46: Revise the Remedial Strategy Report to address monitoring for relevant contaminants in addition to PHC – both for identification of contamination, and for post-closure conditions.

Recommendation 47: Provide design information to demonstrate that the inert landfill is appropriate for containment of glycol contaminated materials.

9.0 Appendix X-12 – Surface Water Management

Appendix X-12, provides designs for the breaches of most Collection Ponds – all except Pond 3 which is to be addressed through design for the PKCF. The design basis assumes a design life of 100 years from the start of closure. The design criterion for floods is conveyance of peak flows from a 1:200-year 24-hour storm event.

The closure landscape at Diavik must perform adequately in perpetuity, not just for 100 years. As a result, facilities designed to convey 1:200-year events will, over the life of the project, certainly sustain some damage from events larger than the design events. In some cases, this may be tolerable, provided that the damage expected: (1) is consistent with the level of channel evolution that may happen in natural channels during similar return-period events, and (2) does not create risks for mine waste storage facilities. If failure of any breach could lead to progressive erosion that may affect a mine waste storage facility, then more robust designs should be required.

In response to comments on its recent water licence application, DDMI argues that failures at breach locations are unlikely to affect adjacent infrastructure:

> "Collection pond breaches are located downstream of mine waste facilities. Upslope progression of erosion to mine waste facilities is unlikely given the distance between collection pond breaches and these facilities. Thus, the performance of the post-closure design of the breaches is not expected to impact mine waste facilities."

In the response, DDMI refers to FCRP Appendix X-12 Sub-Appendix A, Table 1, Item 4. The referenced item addresses incremental consequences of failure and provides a design basis relating to erosion. However, it does not confirm that upslope progression of erosion near other structures was considered. Sub-Appendix D of Appendix X-12 provides a geomorphological assessment for the pond breaches and Task 2 characterizes terrain downstream of the breaches, but does not consider potential upstream progression. Figures in the Sub-Appendix confirm that some breaches are located within close proximity to the toes of other mine structures (e.g., Pond 4). DDMI has not provided evidence that upstream progression of erosion from pond breaches has been specifically addressed at relevant breach locations.

Recommendation 48: DDMI should provide evidence for each proposed breach about the potential erosion that may result from failure during events larger than the design event. As part of this, it should consider whether that erosion is consistent with erosion rates in similar natural channels during similar events and whether progressive erosion at any of these locations could adversely affect mine waste storage facilities. Where erosion could affect mine waste storage facilities, more robust closure designs would be required. Where erosion greater than that expected in natural channels may occur, post-closure maintenance should be expected and required.

10.0 Appendix X-14 – Landfill Cover Design

Appendix X-14, Section 3.1 lists closure criteria and objectives relevant for the Landfill Cover Design. SW1 and SW2 are not identified, but water quality is relevant for the landfill facility.

Recommendation 49: Ensure that the landfill cover design considers the need to meet water quality related closure objectives and criteria.

Appendix X-14, Section 4.1 describes consideration of climate change in design of the proposed landfill cover, including use of the 50^{th} percentile long-term climate projections to evaluate the potential for the active layer to thaw to depths greater than the cover thickness. Table 3 indicates that even under these median climate change projections, the active layer will almost penetrate the whole thickness of the cover after a period of 100 years. As per comments from CoreGeo, the use of the 50^{th} percentile results likely does not provide a conservative analysis of thermal conditions. Also, the cover must perform well beyond 100 years.

Recommendation 50: Take into consideration more adverse climate projections when analyzing thermal performance of the landfill cover. Revise the cover design if necessary to address more adverse climate projections.

Appendix X-14, Section 5.1.1, describes the design expectations for operation of the landfill when disposing of demolition waste during closure: "*In general, waste material should be chipped, crushed, and/or ground prior to placement and compacted using a dedicated landfill compactor*." DDMI should confirm that it will have equipment (e.g., chipper or grinder for large building waste and concrete) on site to achieve these requirements during closure, and that the landfill will be operated according to this and other requirements specified in the design. If these operational requirements cannot be met, then long-term settling of landfill materials is more likely and could be more severe. This type of settling would affect the long-term performance of the cover, and the effectiveness of landfill containment.

Recommendation 51: Confirm that the landfill can be operated as proposed in the design, given constraints on equipment and conditions at the site.

11.0 Appendix X-15 – PKCF Rockfill Option Closure Design

11.1 Closure Criteria

Table 5 lists closure objectives and criteria related to the PKCF closure design. The criteria are not consistent with those listed in Appendix V.

Recommendation 52: The PKCF design should be revised to reference the updated closure criteria, and the design should be revised as necessary to achieve the updated criteria.

11.2 Cover Thickness

Appendix X-15, Section 4.4.2 describes the cover design for the PKCF and states that "*There is no minimum cover thickness as long as there is sufficient cover material to meet the closure objectives of providing a barrier between the environment and the PK*." Similarly, FCRP Section 5.2.7.3 states:

> *"The Zone 2 cover thickness may vary between 0.5 and 2 m, depending on the particle size of the rockfill material. Additional cover thickness may also be provided in areas that are more susceptible to differential settlement or rockfill loss into FPK/EFPK under thawed conditions."*

These sections leave uncertainty about the design and thickness of the cover, with little supporting rationale. The FCRP, Section 5.2.7.4 further states:

> *"The CPK, FPK, and EFPK will be covered by enough Type I (non-PAG) waste rock or rock fill material to be sufficient for erosion protection of the underlying PK. The rock cover will parallel the final PK surface. DDMI expects a 1.5 m thick cover to be adequate and constructible. A thinner cover would also be acceptable but would require a crushed rock product."*

The statements leave uncertainty about what cover will actually be built and what the rationale will be for its thickness and design.

SEC provided comments about the cover thickness for PKCF covers in a memo to EMAB dated September 12, 2022 about the Zone 1 cover design. These comments, as copied below, remain relevant for both the Zone 1 and Zone 2 covers.

> DDMI proposes that the approval of Interim Closure and Reclamation Plan (CRP) Version 4.1 included approval of the proposed cover, now proposed as a nominal 1.5 m thick cover of Type 1 rock over beach areas of the PKCF. Interim CRP Version 4.1 included as Appendix X-5 the "*Diavik Diamond Mine PKC Facility, Revised Closure Concept*" (AMEC, 2013). That concept included a 2 m rock cover over the beach areas of the PKCF and also incorporated geotextile over much of the area (e.g., transition area from beach FPK to semi-fluid FPK) to address concerns about "*piping of PK into the waste rock open voids.*" During discussions about Interim CRP Version 4.1, "*DDMI committed to providing the cover design details, including rational for the selected thickness, within the PKC Facility Closure Design*" (WLWB. 2021. Reasons for Decisions Interim CRP Version 4.1). The WLWB required that the Closure Design "*Include the analysis to support the selection of the rock cover configuration (e.g., how the rock cover thickness influences the post-closure water quality and quantity)*." The Cover Placement Methodology does not provide any detailed analysis to support the

proposed cover thickness or configuration – whether related to water quality or any other matters. Instead, it states that cover thickness was selected "*based on the expected maximum particle size of the ROM rockfill*." The Cover Placement Methodology proposes that the engineer may adjust the thickness during construction but does not provide any constraints on the range of thickness or any parameters that would be used to decide about the need for adjustment.

Appendix X-15, the Rockfill Option Closure Design does not provide additional analysis or rationale to support the proposed cover thickness. The only rationale provided to-date is related to the practicality of material placement due to the size of the largest boulders in the cover material. This rationale does not address the question of how cover thickness influences water quality and quantity. It also does not address whether the proposed cover design will avoid piping of PK into the waste rock open voids or potentially to surface. The water quality modelling and thermal modelling indicate that the decision about cover thickness will have a substantial influence on water quality because the active layer is expected (even under existing climate conditions) to penetrate into the PK materials. Contaminant loading from the PK material is expected to be substantially higher than from cover materials.

Recommendation 53: Provide additional design detail and rationale to support cover thickness and for not including any filter component between tailings and rock fill. Characterize the relationship between cover thickness and predicted contaminant loading from PK materials.

11.3 Migration of PK Through the Cover Materials

The proposed cover design does not include any elements aimed at preventing migration of PK through the rockfill cover. This migration is commonly observed with placement of rockfill covers on liquefiable tailings materials and is usually addressed by including appropriate granular or synthetic filters to maintain appropriate separation between rockfill and tailings. Appendix X-15 does not include any analysis or discussion of potential PK upwelling. If PK migrates up though the cover, it will result in exposure to the terrestrial environment, and potential wind/water erosion.

Recommendation 54: DDMI should revise the Rockfill Option Closure Design to include consideration of migration of PK material into and through rockfill cover materials.

11.4 Mitigation for Settlement of EFPK

Appendix X-15 Section 4.4.2 proposes mitigation for areas where PK settles after placement of cover materials: "*Increased cover thickness in select areas provides a tool to minimize long-term maintenance requirements. The areas that could benefit from increased cover thickness will be identified during rockfill placement, informed by historical and future site investigations, analysis of monitoring data collected from cover trials and rockfill installation. If maintenance is required, it would likely involve localized reshaping of the cover in areas affected by differential settlement and possibly the addition of rockfill*." The proposed approach for mitigation of settlement will likely not be very effective because it will be difficult to predict settlement amounts accurately across the PK surface and place the appropriate amounts of additional rock in all areas. Also, placing rock fill in areas with excess settlement will not address the important issue of ponding on the surface of PK.

Instead, the ponding will just occur within the rock fill, but the implications on infiltration into PK are the same as if the pond were visible on surface – there is no change in the head whether the water is on surface or in rockfill. As a result, the proposed mitigation is unlikely to be effective for addressing the concerns related to ponding.

Recommendation 55: Describe methods that will be used to accurately predict settlement across the PK surface and place different thicknesses of rock fill in areas according to expected settlement. Also, describe how the proposed mitigation will address ponding on the surface of these materials, whether that ponding occurs on surface or within the rockfill cover.

11.5 Spillway Inlet Channel

Appendix X-15, Section 4.5 describes construction of the spillway inlet channel that is intended to provide conveyance of water from the centre of the PK materials to the PKCF spillway: "*Considering the weakness of the EFPK, the channel will be excavated out of the EFPK and FPK once the material is frozen to sufficient depth (conceptually 5 m freeze depth, to be refined in feasibility design study). This will support the excavation during construction and create stable conditions for the side slopes throughout closure*." The design proposes a spillway with side slopes of 20H:1V in order to address the stability of PK under thawed conditions. For a spillway with the 4 m proposed depth, this will result in a spillway width of at least 160m. The design proposes a rockfill lining, but does not include filters. In this case, the underlying thawed EFPK and FPK is likely to be subject to erosion and migration through the rock fill.

Appendix X-15, Section 5.4.2 describes results of stability analysis for slopes in FPK overlying EFPK. Slopes within EFPK were not analyzed but some portions of the proposed channel will be within EFPK. EFPK can be expected to be weaker than the FPK that was analyzed. As a result, the stability analysis may be overly optimistic about expected performance.

To address larger than expected settlement of EFPK materials and associated ponding, the design proposes addition of rockfill, similar to that proposed for other areas where settlement may occur (see Section 11.4 of this report). The same concerns about ponding within rockfill are relevant for the proposed addition of rockfill over the EFPK materials. In this case, it is not clear how the proposed channel would continue to convey flow if settling occurs in the centre portion of the PKCF (where more settling is expected). Even if rock fill is placed in this area, the coarse fill will not convey water on its surface, so the proposed mitigation does not change the invert of the channel at locations where rock fill is proposed.

With respect to physical stability for the inlet channel, Section 3 of the Stability Assessment in Appendix C of Appendix X-15 notes that "*The peak undrained shear strength of the EFPK in the centre of the facility, measured during the 2019 site investigation, was between approximately 0.3 and 0.6 kPa (Golder 2020a), and the undrained shear strength ratio is estimated to range from approximately 0.05 to 0.1. These values are lower than the modelling indicates is required to achieve the required FoS*." This indicates that the modelling for stability of the inlet channel is likely not conservative and the factors of safety may be overestimated.

Recommendation 56: Reconsider the proposed spillway inlet channel design including the need for filters under rockfill, the use of more conservative parameters in analysis of stability, and how to address settlement of the channel invert due to consolidation of PK material.

11.6 Thermal Analysis

Figure 6 of Appendix X-15 illustrates that the thermal modelling predicts thawing of PK within the 100-year modelling period for some climate change scenarios. As described in comments provide by CGS, the climate change analyses may not provide a conservative characterization of potential climate warming. As a result, thermal analysis of the conditions in the PKCF may underestimate the potential for thawing, and the associated effects on consolidation.

Recommendation 57: Conduct updated analysis of thermal conditions after addressing CGS comments.

11.7 Appendix C – PKCF Cover Design Basis Memo

Table 2 in Appendix C of Appendix X-15 lists design criteria for the PKCF cover, including "*No visible CPK or FPK exposed at end of cover construction*." Exposure of CPK or FPK at any point in time should also be considered unacceptable – whether inside or outside the PKCF.

Recommendation 58: Revise design basis to clarify that there should be no exposure of CPK or FPK at any time after construction. If necessary, revise the design to address this change in design basis.

11.8 Appendix D – Thermal and Consolidation Modelling

Appendix D of Appendix X-15, Section 4.2.5 describes thermal modelling and asserts that frozen EFPK will create a nearly impermeable zone. However, this condition creates some challenges for the choice to use a 1-D model for consolidation: "*Under saturated conditions, freezing of EFPK would create a nearly impermeable zone. However, due to the 1-D nature of the model, a nominal hydraulic conductivity value was required to be assigned to the frozen EFPK zone or water would not leave the model geometry because only upward flow is considered*."

The report goes on to suggest that the use of nominal hydraulic conductivity in this apparent impermeable zone addresses the contradiction between the selected model and the frozen conditions at the upper surface: "*This situation would theoretically represent 3-D conditions where pore-water during consolidation of thawed EFPK would drain not through the frozen zone but laterally toward portions of the PKC Facility that may not be fully frozen in the long term*."

1-D modelling as conducted does not appear to be appropriate for estimating consolidation of the EFPK. The 1-D model is founded on an understanding that water extracted due to consolidation can only move upwards through the PK, but the setup assumes that water cannot move upward through frozen materials. Instead, the model applies a permeability to the upper frozen zone, intended to represent the movement of water in a lateral direction. However, there is no explanation of why or how the selected permeability is related to the lateral movement of water or why the model is representative of expected conditions. At the Technical Workshop DDMI acknowledged that the 1-D model does not represent expected physical conditions, but argued that the model is "useful." It further acknowledged that a more complex 2-D model was not contemplated.

Section 4.2.6 of the report describes model limitations: "*The very high in situ void ratio profile estimated for the upper 10 to 15 m of EFPK based on field investigation programs suggests, however, that uncertain site conditions are delaying or limiting the consolidation process*." The model is primarily based on testing in the lab, but existing field conditions indicate that lab tests may be overestimating consolidation rates. As a result, consolidation may take longer than predicted.

Recommendation 59: A revised modeling approach should be undertaken to evaluate consolidation of EFPK materials. The model should more accurately reflect the understanding of expected physical conditions for consolidation.

11.9 Consolidation Assumptions for Design

The PKCF cover design is based on an assumed maximum consolidation of 4 m over the life of the PKCF. However, modelling predicts consolidation of 4.3 to 10 m, depending on which scenario. It is unclear why the design makes a more optimistic assumption about design than any of the consolidation model results.

Recommendation 60: Revise the design basis to include a more conservative consideration of consolidation.

11.10 Appendix E – PKCF Stability Assessments

Appendix E of Appendix X-15, Sections 3.1/3.2 describe ice rich frozen materials in both dam foundations and dam fill. These materials may cause performance issues if/when they thaw.

Recommendation 61: Monitoring programs should include long-term monitoring of ground temperatures, and response plans (e.g., monitoring of porewater pressure) to address conditions if these materials approach thawing conditions.

Appendix E of Appendix X-15, Section 4.1 describes an assumption, for stability analysis and consolidation purposes, that freezing and thawing will occur at the rates currently observed. No rationale is provided for the assumption that thaw rates would be the same as those currently experienced. Greater thaw rates could arise due to climate change, or due to changes in phreatic surfaces.

Recommendation 62: Provide additional rationale for the selected freeze/thaw rates assumed for stability analysis re: frozen materials.

11.11 Monitoring of Creep Movement

Section 4.4.2 recommends instrumentation and monitoring to provide more consistent monitoring of potential dam foundation movement.

Recommendation 63: Clarify whether DDMI has made or intends to make adjustments to monitoring equipment and plans to incorporate recommendations.

12.0 Appendix X-17 – SCRP Closure Design, Thermal Analysis

Appendix X-17, Section 2.1.1 describes the thermal analysis considered for stability of the SCRP: "*The impact of climate change was modelled by assuming a uniform increase in ground surface temperatures over the long term. A predicted mean temperature warming rate of 5.6°C per 100 years was adopted for the thermal model scenarios starting at the beginning of placement in the pile (Golder 2017)*." The thermal analysis for performance of SCRP foundations has not been updated with most up-to-date recent climate predictions.

Recommendation 64: Update thermal analysis to consider more up to date climate change predictions.

13.0 Appendix X-19 – Closure Site-Wide Water Balance Model

13.1 Average Conditions

Appendix X-19 Table 2 and Section 3.1 describe scenarios for the water balance model. The model scenarios all rely on average conditions – with scenarios to consider average conditions after incorporation of climate change predictions. No wet or dry conditions are considered in the scenarios.

The implications of relying on average conditions are illustrated by validation results in Appendix X-21, Section 5.1 pdf 100 and Figure 16: "*During the validation period, the observed water level data suggests that lake water levels were higher in 2020 and 2021 compared to the previous 10 years (Figure 16), which is more representative of wet climate conditions. The maximum observed water elevation during the validation period is 416.35 masl, which is approximately 0.61 m higher than the maximum water elevation observed during the calibration period. Modelled water elevations do not follow the same pattern as the observed water elevations during these two years, because model inputs (i.e., all inflows to the lake) are based on average climate conditions*."

As confirmed by the validation results, conditions can be more adverse during wet or dry scenarios.

Additional comments on this issue are provided in the attached memo from CGS.

Recommendation 65: Include wet and dry scenarios in water balance modelling.

13.2 Runoff Coefficients

As described in Table 2 of Appendix X-19, the water balance uses a single (varied by season) runoff coefficient used for all land types. Runoff from all land types is not likely to be consistent – e.g., waste facilities with bare rock covers are likely to have different runoff characteristics than vegetated areas. This may be important because chemical loading from rock covers may also be higher than from natural or vegetated areas.

Recommendation 66: Provide explanation of why runoff characteristics are expected to be similar for all land types. Also describe potential implications on modelling of the decision to use a single runoff coefficient. Consider sensitivity analyses to evaluate water quality impacts if runoff from rock cover areas is higher than expected. Confirm whether previous research on test piles supports the decision to use a single runoff coefficient for modelling.

14.0 Appendix X-20 – Water Quality Model

14.1 PKCF Seepage

Appendix X-20, Section 3 states the model assumption that there will be no seepage from the PKCF: "*The model results presented in this report are representative of an unsaturated PK scenario, for which only the water quality of runoff from the PKC Facility has been considered. The model assumes there is no seepage from the PKC Facility, and all water sourced from the PKC Facility will report as runoff to Lac de Gras via Pond 3 in catchment C3*." If the PKCF water balance is positive, then water must be accounted for somewhere, as runoff, seepage or evaporation. If the standard runoff coefficients are used here, but the model assumes no seepage, then the remainder of the water would have to evaporate. Appendix X-19 (Table 2) states that runoff coefficients account for evapotranspiration, infiltration, and storage losses over land. When combined with an assumption that the PKCF will have no seepage, the long-term water balance can only include evapotranspiration and runoff because infiltration would lead to seepage and storage in the long-term must reach an equilibrium to support the no seepage assumption. Based on the numbers presented in Appendix X-19 (Site-Wide Water Balance), runoff makes up approximately 43% of precipitation inputs for catchment C-3 (which includes the PKCF). In order to balance the water inflows/outflows, this would require evaporation of 57% of incident precipitation. This is unlikely on a rock cover. If the water balance behaves as predicted (i.e., no infiltration and seepage), then runoff quantities may be higher than predicted, leading to greater loading and concentrations of contaminants.

Also, if the PK behaves as DDMI predicts and becomes unsaturated over time, then seepage must occur (likely at diminishing rate for lengthy period of time) to lower phreatic surface.

Recommendation 67: Provide additional rationale to support the PKCF water balance to corroborate assumptions about seepage. Describe how assumptions about frozen PK preventing seepage are accounted for by use of site-wide runoff coefficients.

Recommendation 68: If runoff from the PKCF may be greater than that associated with site-wide runoff coefficients, update water quality predictions to account for greater runoff.

14.2 Water Quality Model – Source Term for PKC

The water quality model assumes that, in the long-term that loading from the PKCF only occurs from water contacting PK that is in the active layer. The total active layer is estimated to be 2.2 m, of which 0.7 m will be unfrozen PK (the remainder is in the cover), meaning that modelling assumes that there is no long-term loading from most of the PK stored in the PKCF. This is likely a substantial uncertainty in the model and if more PK contributes load, then the modelling could underpredict the long-term contaminant loading to the relevant Collection Pond catchments. The modelling does not consider any potential increase in active layer thickness as a result of climate change. The 2.2 m estimated active layer thickness compares with 3.9 m predicted for the North Country Rock Pile (NCRP) by the year 2110. The potential contributions from PK could be quite important because, as noted in Section 6.1 of Appendix X-20, loading rates for many contaminants are at least an order of magnitude higher in PK than in Type I rock material.

The thickness of the predicted active layer for the PKCF was discussed at the Technical Session. DDMI confirmed at the Technical Session and in response to IR#6 that the estimate of 2.2 m active layer thickness was provided in a thermal analysis that is in ICRP v4.1, Appendix X-5, Sub-Appendix

B. The Sub-Appendix is a 2013 memo from Golder Associated titled "Diavik PKC Facility Thermal and Seepage Analyses to Support the Revised Closure Concept." The closure concept at the time entailed a cover similar to that now proposed for the PKCF, so the analyses represent an appropriate physical configuration.

In the Response to IR#6 DDMI provided estimates of water quality in runoff from the PKCF after consideration of an assumed maximum 4 m active layer. It asserts, based on the 2013 analysis, that the PK would otherwise remain frozen and therefore no further modelling or consideration of water quality conditions is warranted, even though this modest increase in the amount of PK contributing to loading results in predicted concentrations up to 3.5 times greater.

There are remaining concerns about whether the analyses provide a conservative, up-to-date estimate of post-closure conditions, especially when considering the implications of climate change. The more recent thermal modelling for the NCRP also provides an example for comparison including consideration of material properties used in the analyses.

Attachment 2, a memo from CGS, provides comments and recommendations related to the climate change projections updated to support the FCRP. As noted in the memo, the FCRP analysis relied on the Intergovernmental Panel on Climate Change (IPCC) 5th Assessment Report (AR5, 2013) because climate projections for the more recent 6th Assessment Report (AR6, 2021) have not been downscaled. Core identifies that "there is potential for predicted climate parameters to be different (potentially hotter temperatures) than under AR5." The thermal analysis for the PKCF was conducted before IPCC AR5 was available, and therefore relies on even older climate projections.

Recommendation 69: The thermal analysis and related seepage and water quality predictions for the PKCF should be updated based on conservative, current projections of climate change.

The thermal analyses for the PKCF rely on estimates of material properties in order to predict temperature profiles over time – for example the thermal conductivity of materials, and their capacity to hold heat both influence the temperature profiles over time. Table 3 in the 2013 Golder memo lists properties of materials, including Type I rock fill that will be part of the cover. The source of these properties is referenced to earlier work completed by Golder in 2007 – design reports for the PKCF. Appendix XI for the NCRP Final Closure and Reclamation Plan v1.1 (2017) is a thermal analysis conducted by TetraTech to support the cover design for the NCRP. Table 7 of that report provides thermal properties for Type I rock fill that is part of the cover. The properties were "determined indirectly from well-established correlations with soil index properties" and were verified by comparison to measurements made in test piles at Diavik and other locations reported in literature. Table 1 below provides comparisons of material thermal properties for Type I rock fill used in the two analyses.

Table 1: Comparison of Thermal Properties for Type 1 Rock Fill

	Moisture Content (%)	Bulk Density (Mg/m³)	Thermal Conductivity (W/m-ºC)		Specific Heat (kJ/kgºC)	
			Frozen	Unfrozen	Frozen	Unfrozen
Golder 2013	5	1.9	1.9	1.6	0.89	1.05
TetraTech 2017	3	2.06	1.32	1.57	0.77	0.83

There are some substantial differences between the thermal properties used for Type I rock fill in the two analyses. It is not clear whether the differences reflect a better understanding of the properties for the later study, or if there is significant uncertainty about the actual properties. Nonetheless, the difference in material properties could have a significant influence on the predictions of temperature profiles and freeze/thaw characteristics. Therefore, it would be useful to understand whether the 2013 thermal model accurately portrays the conditions that have developed in the facility to verify the modelling and its assumptions.

Recommendation 70: Use existing conditions to validate whether the PKCF thermal model provides an accurate prediction of current thermal conditions in the Facility, and consider whether the model and its assumptions and inputs (e.g., material properties) should be refined.

14.3 Water Quality Source Terms – Acid-Generating Materials

Appendix X-20, Section 4.2 states a general assumption that current water quality conditions for mine wastes are representative of future conditions: "*The inherent assumption in the model is that geochemistry data obtained through field testing, and surface water quality data obtained as part of the baseline programs adequately and conservatively represent the input sources and will continue to do so in the future*." This assumption is reasonable for materials that are not acid-generating or subject to oxidation processes. For ARD materials it is unlikely that current water quality data is representative of water quality after oxidation occurs. Unless remediation measures will stop oxidation (e.g., submergence of ARD material in water) then the assumption is likely not conservative.

Recommendation 71: Reconsider water quality model assumptions for material that is considered potentially acid-generating. If potentially acid-generating material can contribute loading, long-term source terms should account for acid-generating characteristics of the material.

15.0 Appendix X-21 – Hydrodynamic Model

15.1 Lac de Gras Model Domain vs. Collection Ponds

Figures in the hydrodynamic model report (Appendix X-21) illustrate runoff from locations and catchments on East Island to Lac de Gras. Unfortunately, the numbering system for the model is different from that used for Collection Ponds. As a result, it is very difficult to correlate the model and the physical locations of ponds.

Recommendation 72: Provide clear information to describe the relationship between pond locations and the model.

15.2 Range of Climate Conditions

Appendix X-21, Section 3.2 describes inputs for hydrodynamic modelling: "*For future simulations (i.e., 2022 onward), the hourly time series of meteorological parameters from January 2009 to December 2021, except for precipitation, were repeated to cover the simulation period for the Lac de Gras 3D Model. The monthly precipitation data were obtained from the Site Water Balance Model for an average climate year to provide consistency between the water balance and hydrodynamic components.*" Given the short record used for climate parameters (13 years) and use of average precipitation, the model likely does not consider extreme wet or dry conditions. Water quality outcomes could be different in these conditions – which are likely to extend over long periods of time (i.e., not daily events, see Section 2.11 of this Report) and could lead to chronic effects.

Recommendation 73: Conduct sensitivity model runs to assess conditions in wet/dry years.

15.3 PK Porewater Quality

Appendix X-21, Section 3.5.2 provides information about source terms used for porewater from PK, referencing DDMI 2020c – Pit Lake Chemical Source Definition – FPK Porewater Component_R0. Technical Memorandum Prepared by Lianna Smith for Gord Macdonald 29 February 2020. SEC provided comments about this source term in a November 2020 memo to EMAB. The following comments are still relevant.

> The model documentation provided in the application lacks detail about the basis for the water quality source term for porewater. Section 2.4.2 of "*Hydrodynamic and Water Quality Modelling of Pit Lake and Lac de Gras*" (Golder, October 2020), states that the water quality in porewater is represented by the "*median measured constituent concentration*" and refers to DDMI, 2020a, a memo prepared by Lianna Smith titled "*Pit Lake Chemical Source Definition – FPK Porewater Component*" dated February 2020. The notes in Table 5 in the same document, perhaps in error, refer to a "*geomean value*" from DDMI, 2020c, a draft memo prepared by Lianna Smith titled "*Pit Lake Chemical Source Definition – Dike and Pit Components*" dated March 2020.
>
> DDMI provided an addendum to its modelling submission, including a November 2019 memo from Lianna Smith, including graphs of porewater chemistry measurements from four different sources of information: the PKC Pond, PK tank drains, expelled porewater from fine PK consolidation tests, and expelled porewater from slimes consolidation tests. In an email dated November 4, 2020, DDMI stated that the fine PK porewater source term was a calculation from water chemistry (e.g., median and mean) from the raw data in the November 2019 memo. However, DDMI did not clarify what data were used to make this calculation – was it all four sources of information, or one of the sources, or some other

combination? The IRP report indicates that the source term for porewater was developed based on a single sample.

After several requests, DDMI provided the referenced February 2020 memo on November 13, 2020. The memo confirms that the estimates of porewater quality used in the modelling are based on results from porewater extracted from a single sample of fine PK obtained directly from the process plant.

Model documentation provided as part of the Summary Impact Statement in May 2019 provided data of five different types that could be considered in the development of source terms for PK porewater. The July 28, 2019 Slater Environmental Consulting review memo concluded the following with respect to DDMI's selection of source terms at that time:

> *"Table B-2 in the Summary Impact Statement provides data for five different characterizations of porewater. Of these five, DDMI has optimistically selected the two characterizations that have the lowest concentrations to support its predictions of porewater quality for PK deposited from the processing facility, and EFPK deposited from the PKC facility. Given the available data, and the interpretation provided in Moncur and Smith (2014), it appears likely that the predictions may underestimate the contributions of porewater to contaminant loading."* (Slater Environmental Consulting memo to EMAB, July 28, 2019)

DDMI acknowledged at the time that its reliance on data from fresh PK slurry may underestimate the concentrations of parameters in porewater. Data from porewater extracted from samples of in-situ PK (i.e., PK that had aged in the PKCF) had substantially higher concentrations of many parameters, with average values often exceeding the assumptions used even in the sensitivity analysis for the updated modelling (75^{th} percentile of the data from samples extracted from the single fine PK sample).

The February 2020 memo provides data from the PKC pond for comparison with the porewater data used in the modelling. DDMI provides rationale for why the PKC pond water may not be representative of porewater concentrations. However, there is no rationale provided with respect to other data, especially data from porewater extracted from in-situ samples.

In Appendix X-21, Golder states that the porewater quality for PK was represented by the "geometric mean of measured constituent concentration, based on data provided by DDMI" referring to the February 2020 Smith memo. As noted in the earlier comments repeated above, the results are all from a single FPK sample, where there were 11 water quality samples analyzed from a consolidation test. Because the testing was completed on a fresh PK sample, the results are not likely to be indicative of conditions in the PK over time. Results from other testing appear to confirm this.

Also, there is no rationale provided for the decision to rely on the geometric mean, other than it is "consistent with previous modelling exercises"[2]. The geometric mean is always lower than the arithmetic mean (average), and therefore its application in this case means that constituent concentrations used in modelling are lower and may not be conservative estimates of the future average conditions. Geometric mean can be appropriate in certain circumstances including where data sets include large outliers. Unfortunately, the Smith memo does not provide all of the data or the maximum and minimum values. However, the results for the 25th, 50th and 75th percentiles seem to indicate quite consistent data for most parameters.

The decisions about the source of data and the application of geometric mean to estimate source term concentrations compound to create an estimate of porewater quality that is likely not conservative for future predictions, even for the "average" conditions that are modelled. As a result, loading from porewater could be higher than predicted.

Recommendation 74: Conduct additional sensitivity analysis, considering more adverse concentrations of contaminants in porewater. This analysis should incorporate data from other relevant test methods, including data from porewater extracted from in-situ samples.

Recommendation 75: Undertake additional characterization programs to understand expected porewater conditions, including testing of fresh PK as proposed by the IRP and also additional testing of porewater from PK that has aged in saturated conditions within the PKCF.

15.4 Predictions in Lac de Gras

Appendix X-21, Section 5.3, describes calibration of modelling of water quality conditions based on comparison of predictions to measured conditions in Lac de Gras. For location MF3-1 the report describes that the model is underpredicting concentrations at the bottom of the lake: "*Figure 19 and Appendix D show that at MF3-1, modelled bottom TDS concentrations are generally lower than the observed concentrations (calculated based on measured specific conductivity) during most April and May surveys*." The model calibration indicates that concentrations of contaminants in Lac de Gras in under ice conditions could be worse than the model is predicting at some locations (e.g., MF3-1).

Recommendation 76: The report should discuss the potential effects of water quality conditions worse than predicted where calibration results indicate that the model is underpredicting concentrations.

16.0 Appendix X-22 – Rationale for Assessed Mixing Zones

Appendix X-22, Section 3.6, Table 7 lists predicted loading of lead and uranium from specific Collection Pond catchments as compared to existing loading from the North Inlet Water Treatment Plant (NIWTP). The table only presents predicted future loads from individual catchments but not the cumulative load. The sum of the predicted future loadings is substantially higher than the existing load, but this is not presented or discussed in the report. This differs notably from Table 8

[2] Smith, L. 2020. Pit Lake Chemical Source Definition – FPK Porewater Component_RO. Memo to Gord Macdonald, February 29, 2020.

which presents results for other parameters (Nitrogen, Phosphorus, Total Dissolved Solids) where the cumulative future loading is predicted to be lower than existing loads and the cumulative results are provided in the table and noted in the text.

Recommendation 77: Discuss and address implications of much higher total predicted loadings for lead/uranium as compared with loading from the NIWTP.

17.0 Appendix X-23 – Effects of Pumping During Pit Filling

Appendix X-23 describes potential effects of pumping for pit filling on water levels in Lac de Gras. The analysis conducted in is not consistent with the pumping rates and pumping design proposed in Appendix X-4. Pumping rates now proposed are much higher. Appendix X-4, the 2022 Pit Fill Piping Design, recommends the 6-month filling period with pumping rates of 5,006 to 14,066 m^3/hr depending on which pit. Appendix X-23, the 2021 analysis of effects of pit filling on the other hand, considers effects of pumping rates ranging from 2,742 to 9,400 m^3/hr. The higher pump rates would have greater effects on water levels than estimated in 2021

Recommendation 78: Redo analysis of effects of pumping for pit filling to consider new proposed pumping rates and durations.

Attachment 1

Memorandum

Integral Ecology Group

April 16, 2023

Integral Ecology Group
iegconsulting.com

MEMORANDUM

April 16, 2023

TO:	Bill Slater, Slater Environmental Consulting
FROM:	Justin Straker
RE:	Review of Diavik Final Closure and Reclamation Plan
COPY:	Meghan Nickels, IEG

Introduction

Per your email request of January 23, 2023, please find below the main comments and questions resulting from my review of the Diavik Final Closure and Reclamation Plan (FCRP). This memo has been revised to address follow-up questions received via email on April 10, 2023—this new content is presented at the end of the memo.

Scope of review

My review is restricted to my areas of practice as a Professional Agrologist (BC, AB, SK, MB, ON), i.e., topics related to terrestrial ecology and mine reclamation. My review included the following list of documents—this information was primarily accessed from the Wek'èezhìi Land and Water Board's Online Review System.[1] Where other sources were used, these sources are noted:

- Diavik Diamond Mines (2012) Inc. (DDMI) Final Closure and Reclamation Plan Version 1.0, December 2022 (Document #: D0007-2320-H-REP-00001);
- Diavik FCRP Appendixes I-IV—glossary, acronyms, abbreviations, units and symbols;
- Diavik FCRP Appendix V—Detailed Tabulation of Closure Objectives and Criteria;
- Diavik FCRP Appendix VI—Monitoring and Maintenance;
- Diavik FCRP Appendix VII—Expected Cost of Closure and Reclamation;
- Diavik FCRP Appendix IX—Traditional Knowledge Panel Reports and Community Engagement Summaries;

[1] https://new.onlinereviewsystem.ca/review/AF47FB08-C47F-ED11-AC20-CC60C843D8AF

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- Diavik FCRP Appendix X—Closure Design Reports, particularly Appendix X-8—Site-Wide Grading Plan, and Appendix X-9—Reclamation Closure Feasibility Design;
- Diavik Diamond Mines (2012) Inc. Closure and Reclamation Plan – V4.1, Appendix X-16—University of Alberta Final Revegetation Report (provided by Bill Slater);
- Rio Tinto Standard E16 – Biodiversity protection and natural resource management; and
- Rio Tinto – Our approach to closure.[2]

Review comments

My review is largely organized by the categories of closure objectives and associated criteria, as this provided a useful framework for addressing different topics. However, my findings are applicable to the broader scope of the FCRP, and not just to its objectives and criteria.

- **Lack of contingencies**—DDMI should be asked to explicitly identify contingency measures associated with each closure criterion, with these measures to be deployed if monitoring indicates that the closure criterion has not been met. This has not been done, as far as I can find, and its absence is a substantial shortcoming for an objectives-and-criteria framework.
- **Objective/criterion SW3**—criterion SW3-1 continues to use a "pollute-to-guidelines" approach (i.e., setting the criterion at the Government of Northwest Territories residential/parkland threshold), which is not precautionarily protective during the post-closure phase. For post-closure, it would be more appropriate to use a criterion based on reference dustfall levels (e.g., dustfall in post-closure should show no significant difference between the 12 mine-site locations and the 2 background ["C1" and "C2"] locations). It seems that the proposed criterion, which I am interpreting as 1.75 $\mu g \cdot dm^{-2} \cdot day^{-1}$, is ~4 times higher than the upper 95th confidence interval of the geometric mean of dust deposition at reference sites from 2003 to 2021 (Appendix VI, Section 3.1.5). What is the justification for having a criterion that is substantially higher than ambient dust levels in the post-closure phase? Slater Environmental Consulting (SEC) commented on this same issue in its September 2017 review of CRP V4.0. A few other items of note:

[2] Rio Tinto documents accessed on February 20, 2023 at: https://www.riotinto.com/en/sustainability/environment

In Appendix V1 Section 3.1.2, DDMI states, "Post-closure emissions of fugitive wind-blown dust from the NCRP waste rock storage area and from the PKC facility area are likely low to negligible due to the size/composition of the proposed cover materials (i.e., granitic gravels). The cover material is considered stable and will likely become dust-limited over time. (Watson et al. 2014). Any vegetation growth over time would likely further reduce the potential for wind erosion of the permanent landforms." However, DDMI has also chosen not to actively revegetate these facilities. There is a conflict between the criterion SW3-1 and these revegetation decisions, and I suggest that DDMI adopt a reference-condition approach to the post-closure dust criterion (as discussed directly above), and reconsider revegetating the rock storage areas and PKC facility to actively lower fugitive dust emissions.

I believe it would be appropriate to amend the objective statement of SW-3 from "dust levels safe for people, vegetation, aquatic life, and wildlife" to "dust levels safe for people, vegetation, aquatic life, and wildlife, and do not contribute to a degraded air-quality environment in the post-closure phase."

Objective/criterion SW4— The criterion "monitoring evidence of post-closure wildlife use of area" does not "describe the conditions when the objective has been achieved" (DDMI's definition of a criterion), given the associated objective "dust levels do not affect palatability of vegetation to wildlife."[3] As written, the criterion is not a testable statement, and must be written as such. Again, this issue was raised in SEC's 2017 review of CRP V4.0. It would be preferable to base this criterion on a Zone-of-Influence (ZOI) analysis. Section 3.4.4.1 of the CRP states that the most recent ZOI analysis for caribou (2019) indicates that it "did not detect a ZOI." Continued confirmation of this finding of absence of a ZOI would be a much stronger criterion. Analysis of lichen element concentrations per SEC's Sept. 2017 review would be a good additional criterion.

Objective SW5/criterion SW5-1—the rationale for restricting active revegetation to infrastructure areas remains unclear. DDMI states that priority areas for active revegetation have been "established with communities and approved by WLWB." However, in a more expansive statement in Section 5.2.9.3.5, DDMI reports

"The closure plan includes the re-establishment of partially vegetated land to the extent practical. DDMI's primary goals in relation to re-vegetation are to increase

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[3] Should the current wording be taken to indicate that one caribou traversing the mine site once in the five years of monitoring proposed for the post-closure phase would verify that dust levels had not affected/were not affecting palatability of vegetation to wildlife?

vegetation growth as compared with natural recovery processes, maximize vegetation cover in re-vegetated areas, and promote soil development and sustainable vegetation growth.

> DDMI engaged with Indigenous communities and the EMAB in 2019 to further discuss if and where revegetation efforts should be targeted at closure (Appendixes IX-3 and IX-5). There were many and varied views on this subject. No reviewers disagreed with the suggestion from the TK Panel of avoiding re-vegetation of areas where fuel had been stored and may have contaminated the surface material and the PKC facility to give these areas as much time as possible to heal before encouraging wildlife to these areas. Views on the benefits of revegetating the WRSAs were diverse, and no consensus was reached even after further engagement. DDMI's preferred areas for re-vegetation are shown in Figure 5-27 and include roads, the airstrip, and laydown excluding areas that have been confirmed to have petroleum hydrocarbon contamination. DDMI has not included revegetation of WRSAs. Including the large WRSAs as targeted areas for re-vegetation would likely create an unnecessary attractant to wildlife that is contrary to closure goal #5, "Final landscape that is neutral to wildlife."

This raises two issues for me as a reviewer:

1. Does the current plan of conducting active revegetation only in select infrastructure areas meet community desires for the post-mine landscape? If this is the case, then it is clearly an appropriate objective—I have technical objections to it, but these should be overridden by the expertise and objectives of local Indigenous Groups. However, it is not clear to me that this is the case. It is relatively unusual in the Canadian context (more common north of 60 degrees latitude, essentially unheard-of south of that) to accept no active revegetation with very little rationale. DDMI does not state that there are concerns related to element uptake etc. that mean that revegetation should be limited, just that they have decided that active revegetation should only occur in small "priority areas."[4] Appendix IX suggests that the justification to not revegetate the rock

[4] Appendix IX-2, Section 3.1.1 states "The TK Panel suggested that rock piles be vegetated and provided recommendations on how best to deter wildlife from those areas until reclamation has moved toward a more natural state. However, based on feedback from the TK Panel over time, the plan has changed for these areas to the objective of a neutral presence, neither attracting nor deterring wildlife, on site while moving towards a more natural state." It is not clear what caused these changes in objectives over time. Table 3-2 of this appendix indicates that TK Panel recommendations on revegetating the rock pile(s) and PKC area were "not accepted" by DDMI.

piles and PKC facility is based on not attracting wildlife to those areas, and allowing them to heal. But there is no discussion on the risks to wildlife using those areas, particularly if rock and PK were isolated with a till cover, nor on the specific healing that needs to occur before use would be acceptable.

2. I find the statement "including the large WRSAs as targeted areas for re-vegetation would likely create an unnecessary attractant to wildlife that is contrary to closure goal #5, 'Final landscape that is neutral to wildlife'" incongruent with the more fulsome explanation of this objective provided in Table 2-1 of the CRP:

   > "Final landscape that is neutral to wildlife – being neither a significant attractant nor significant deterrent relative to pre-development conditions."

   Satellite imagery of the Diavik area (Figure 1) clearly shows a vegetated landscape, with the mine being a relatively large, unvegetated area. Unless the surrounding vegetated landscape provides no habitat value to animals, I do not understand how revegetating the above-ground and non-contaminated components of the mine would be an "unnecessary" or "significant attractant…<u>relative to pre-development conditions</u>" (emphasis mine). Rather, that would result in a vegetated landscape similar to the pre-development landscape, and thus one that is "neutral to wildlife." In contrast, I believe that the current plan of leaving most of the above-ground disturbance unvegetated results in a landscape that is more of a deterrent relative to pre-development conditions, in that it will provide no habitat value. The mine disturbance that will not be actively revegetated represents a long-term deletion from habitat of over 9 km^2. This may be relatively small for large animals that move around and through this landscape, but more substantial for smaller animals with smaller ranges.

Figure 1. Satellite imagery of the Diavik mine obtained from Google Earth. Imagery date is reported as 9/9/2006.

DDMI summarizes the reclamation research completed by Dr. Anne Naeth and the University of Alberta, but very little of this work seems to be used in the reclamation plan. In particular, the lack of salvage and retention of surface soils and organics for use in reclamation and revegetation is incongruent with current practices in the mining industry, despite the obstacles to such salvage listed in Section 4.5 of the CRP. Further, it is strange that there is no reported work on use of till as a component of rooting-zone layers of reclamation cover systems, given the surplus of 1.0 Mm^3 of till reported in the reclamation materials balance. This till is the dominant surficial material in the area—and thus the basis for the vegetated ecosystems established in the area—and could be used to support revegetated covers on the rock piles and PKC facility.

Overall, I find the decision to not conduct active revegetation on the NRCP, SCRP, and PKC facilities to be inconsistent with standard mining-industry practices over the period in which Diavik has been developed and operated, and not supported by the weight of presented evidence in the FCRP.

Objective SW5/criterion SW5-3— there appears to be no justification for what appears to be an arbitrary criterion of establishing a minimum of 10 stems/m^2 in areas of active revegetation. Further, the monitoring supporting the evaluation of this criterion is inadequate. Appendix VI, Section 3.1.5.2 states that "revegetation monitoring plots of 1 m by 1 m will be established at a density of 1 plot per 10 ha in mine infrastructure areas that have been contoured and seeded." This planned monitoring intensity results in sampling 0.001% of the actively revegetated area. Standard reclamation monitoring practices involve substantially higher sampling intensities, e.g., sampling of 0.5 to 10% of the treated area. Appendix X-9 indicates that the area of active revegetation (scarification and seeding) is 311 ha (including the airstrip). This would result in the establishment of approximately 31 revegetation monitoring plots, representing 31 m^2 of monitored area. The associated criterion then indicates that identification of at least 310 total stems of germinating vegetation across this sampled area will be taken as demonstrating achievement of the revegetation objective. This represents an observation of not many plants over not much sampled area, and is thin evidence on which to base an assertion of successful revegetation.

Overall, for SW5, my impression as a reviewer is that DDMI's revegetation approaches do not align with industry standard practices, and that suggested performance criteria have low thresholds.

Objective SW9—SW9 speaks to the objective of having topography and vegetation that "match aesthetics and natural conditions of the surrounding natural area." Its associated criteria indicate the need for inspections by engineers, and the need to meet the vegetation criterion described above, i.e., establishment of at least 310 plants on the mine site. As discussed above, the revegetation criterion is inadequate, and would not be indicative of closure actions that have achieved the objective of matching the conditions of the surrounding natural area. In addition, the CRP V4.0 contained a criterion with respect to an evaluation of change in biodiversity across the Regional Study Area. SEC's review of that CRP noted that this criterion as stated was mathematically problematic, and asked for either a justification of or amendment to the proposed value. Instead, this criterion has been deleted. This is not a positive advancement of the FCRP closure criteria. I would prefer that the biodiversity criterion be maintained with an amended appropriate threshold, particularly by a mine operator that has historically been an industry leader in acknowledging the importance of protecting biodiversity values.

Response to follow-up questions

On April 10, 2023, I received follow-up questions via email from Bill Slater. These questions, and corresponding responses, are listed below:

1. Elaborate on the assertion that the lack of active revegetation is inconsistent with standard mining industry practices (e.g., review of objective SW5 in point 1 on p. 4, and in point 2 on p. 6).

Response: the *Yukon Mine Site Reclamation and Closure Policy* (2006)[5] indicates an expectation of "the reclamation and re-vegetation of the surface disturbances wherever practicable", and the later (2013) document *Reclamation and Closure Planning for Quartz Mining Projects—Plan Requirements and Closure Costing Guidance*[6] states that plans should include re-vegetation activities for all mine features, including tailings facilities and mine rock dumps. DIAND's 2002 *Mine Site Reclamation Policy for the Northwest Territories*[7] echoes the Yukon's goal of "revegetation of the site where practicable" (and includes on its cover a photo of revegetation test plots at the Ekati mine, illustrating practicable revegetation of diamond-mine facilities near Lac de Gras). The complementary *Mine Site Reclamation Guidelines For The Northwest Territories* (2007)[8] include the objective of re-establishing the pre-mining ground cover on all areas affected by mining activities. DDMI has not asserted that it is not practicable to revegetate the mine rock dumps, just that they are not "priority areas" for revegetation. The *Health, Safety and Reclamation Code for Mines in British Columbia*[9] states that the only disturbed lands exempt from revegetation requirements are facilities constructed prior to 1969, pit walls and benches constructed in rock, and steeply sloping footwalls. As an Alberta example typical of oil-sands reclamation in the northeast of the province, Syncrude Canada Limited's *Environmental Protection and Enhancement Act* Approval 00000026-03-00[10] requires Syncrude to "reclaim disturbed land to a self-sustaining, locally common boreal forest ecosystem, integrated with the surrounding area, unless otherwise authorized in writing." The only sizeable terrestrial areas exempt from this requirement would be tailings dams where alternate revegetation practices may be required for geotechnical reasons.

2. What are current industry practices/expectations in terms of percent of area revegetated, and whether rock piles and tailings areas are revegetated?

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[5] https://yukon.ca/en/yukon-mine-site-reclamation-and-closure-policy

[6] https://yukon.ca/en/reclamation-and-closure-planning-quartz-mining-projects-plan-requirements-and-closure-costing

[7] https://rcaanc-cirnac.gc.ca/eng/1100100036038/1547657739486

[8] https://publications.gc.ca/collections/collection_2014/aadnc-aandc/R74-13-2007-eng.pdf

[9] https://www2.gov.bc.ca/gov/content/industry/mineral-exploration-mining/health-safety/health-safety-and-reclamation-code-for-mines-in-british-columbia

[10] https://avw.alberta.ca/pdf/00000026-03-00.pdf

Response: current industry practices and expectations in Canada are generally that all areas be revegetated, except for:

- areas needed for long-term or permanent infrastructure, such as water-treatment plants, water-management features, access roads, etc.;
- pit highwalls and steep footwalls; and
- pit lakes.

Sub-aerial rock piles and tailings areas are almost invariably revegetated in Canada. I checked four recent examples of reclamation plans in BC to calculate areas of revegetation as a portion of total disturbance area, and found a range of 75-87%, representing almost 13,500 ha of disturbance, and almost 11,000 ha of area planned for revegetation.[11] This is substantially more than the 28% of the footprint currently proposed for revegetation by DDMI. Active revegetation of the rock piles and PKC facility would bring this proportion up to 70%, which is approaching the industry ranges reported above. The 1.0 Mm^3 of surplus till reported in the reclamation materials balance could be used to place an approximately 20-cm-thick cover across the areas of the rock piles and PKC facility.

I know personally of two exceptions to these standard practices:

A. The Mount Nansen mine in Yukon, where a 2019 closure plan proposed active revegetation of approximately 15% of the mine footprint. Following review and objection by the Little Salmon Carmacks First Nation, this plan was revised with a recommended objective of actively revegetating the majority of the mine site. The Mount Nansen mine was developed in an earlier era than Diavik, and was abandoned in 1999.

B. Ontario's regulations governing mine reclamation appear to be less rigorous than those in western Canada. I know of a current operating mine in Ontario that is proposing to not actively revegetate external rock-armoured shells of tailings dams, and some steeper areas of mine rock stockpiles. However, this is an exception isolated to that jurisdiction, rather than a widespread occurrence in Canada, and even in the case, the area planned for revegetation covers 75% of the total disturbance area.

[11] A publicly available report for one of these examples, the Blackwater Gold project in central BC, can be found at https://www.blackwatergoldmine.com/_resources/eac/Reclamation-and-Closure-Plan-Mines-Act-Environmental-Management-Act-Permit-Plan.pdf?v=0.959. In this example, approximately 87% of a 2,100-ha footprint is planned for revegetation.

3. Elaborate on the assertion that revegetation monitoring approaches do not align with industry standards and that performance criteria have low thresholds (criterion SW5-3).

   Response: it is somewhat difficult to provide this information, as most jurisdictions in Canada do not specify reclamation monitoring requirements and criteria, and these are developed by individual operators, who may not report them publicly. However, as an example, the Blackwater Reclamation Plan referenced in footnote 11 includes installation of one 100-m^2 permanent sample plot per 2 ha, which is equivalent to the lower end of the asserted standard range of sampling 0.5-10% of the revegetated area. This sampling intensity proposed at Blackwater results in sampling 50 times more area per total revegetated area than the monitoring program proposed by DDMI.[12] In addition, a criterion based on stems per unit area is odd for revegetation where seeding of grasses and forbs is the primary establishment method, as stems counts are usually used for single-stem woody plants, and abundance (estimate of cover) is usually used for grass and forb species. Finally, DDMI should have an ecological basis for its proposed revegetation performance criteria, rather than what appears to be an arbitrary criterion of 10 stems/ha—this basis was not provided in the FCRP. A standard method for developing such a basis would be use of a reference-condition approach, where a revegetation criterion would be derived from sampling adjacent, ecologically comparable non-mined ("undisturbed") areas.

   Based on the above information, I believe that an approach in alignment with standard industry practices would involve sampling a minimum of 100 m^2 per 2 ha, and deriving performance criteria from vegetation characteristics of adjacent reference plots sampled using similar methods and intensities, and/or to using remote-sensing approaches per footnote 12.

[12] The debate on sampling intensity is becoming somewhat obsolete due to the increasing use of remote sensing for revegetation monitoring. In remote-sensing applications, it is feasible to obtain a census of the entire population of reclamation areas, rather than sampling a portion of those areas and inferring results across the non-sampled area. For instance, multi-spectral imagery could be used to derive vegetation indices for all revegetated areas and compare those results to indices derived from reference areas.

Closure

Thanks you for the opportunity to contribute to this review of the Diavik FCRP. I trust the information provided in this review meets your requirements. To discuss the contents of this memo, please do not hesitate to contact me at jstraker@iegconsulting.com, or at 250 701 0600.

Attachment 2

Memorandum

Core Geoscience Services

May 3, 2023

MEMORANDUM

Date:	**May 2, 2023**
To:	**Bill Slater, Slater Environmental**
From:	**Core Geoscience Services Inc.**
Subject:	**Diavik Mine Final Closure and Reclamation Plan - Climate Change Considerations**

1. INTRODUCTION

Slater Environmental retained Core Geoscience Services (CoreGeo) to review the Diavik Mine Final Closure and Reclamation Plan submitted to the Wek'èezhìi Land and Water Board (WLWB), with specific focus on climate change considerations, including climate change projections and implications for site water balance, water quality model and major site infrastructure closure design. This memo summarizes findings and recommendations.

2. DOCUMENTS REVIEWED

CoreGeo reviewed the following documents, provided as Appendices to Diavik Mine Final Closure and Reclamation Plan:

- Appendix X-10: Diavik Mine Site - Current and Projected Climate Parameters (Golder, 2021)
- Appendix X-15: Diavik Processed Kimberlite Containment Facility Rockfill Option Closure Design (Golder, 2022)
- Appendix X-16: Diavik Diamond Mine North Country Rock Pile Closure Design (Golder, 2017)
- Appendix X-19: Diavik Closure Site-Wide Water Balance Model (Golder, 2021)
- Appendix X-20: Diavik Diamond Mines Closure Feasibility Study Water Quality Model, 1:100 Dry Year Scenario, and Climate Change Scenarios (Golder, 2022)
- Appendix X-24: Diavik Diamond Mines Climate Change Assessment (Golder, 2021)

CoreGeo referred to guidance documents as needed; those can be found in the reference section of this memo.

3. FINDINGS AND RECOMMENDATIONS

Overall, the climate change assessment used adequate methodology. The assessment follows the methods outlined in *A Guide on Incorporating Climate Change Adaptation into Decision Making for the Mining Sector* (MAC, 2021). Although this document was also prepared by Golder, it relies on an extensive refence list. However, CoreGeo identified concerns regarding the climate change assessment and how projections were used in the closure planning, which are presented below. In addition, CoreGeo identified concerns regarding climate change considerations in cover designs for the North Country Rock Pile and the Processed Kimberlite Containment Facility.

3.1 Climate Projections

Because bias-corrected, and downscaled climate projections were not yet available from the Intergovernmental Panel on Climate Change (IPCC) 6th Assessment Report (AR6, 2021) for the site at the time of writing the climate change assessment, future climate projections from publicly available statistically downscaled daily future climate projections used were based on the Fifth Assessment Report (AR5, 2013).

> *"AR6 uses the latest generation of climate models, coordinated by the World Climate Research Programme's Coupled Model Intercomparison Project, version 6 (CMIP6). […] The CMIP6 climate models are based on updated emissions pathways. In CMIP5 (the previous set of models), Representative Concentration Pathways (RCPs) were used as sample trajectories of radiative forcing which relate to the greenhouse gas effect and trapping of heat in the Earth's atmosphere ultimately resulting in global temperature increases. While useful approximations for understanding a range of climate impacts under different emissions pathways, it was difficult to link RCPs with real-world scenarios for emissions, land use and change and political interventions. As a result, the new climate models use RCPs coupled with Shared Socioeconomic Pathways (SSP-RCPs) which include more robust "storylines" of factors intrinsically linked to climate change, such as population growth, urbanization, and technologic advancements to mitigate climate change. These generally relate to the RCPs used in CMIP5, with RCP8.5 and RCP4.5 still being used (in addition to new RCPs), but now in conjunction with SSPs to provide additional context. SSP-RCPs also more closely align with certain end-of-century temperature targets, such as the 1.5° set forth in the Paris Agreement and provide insight into the timing of crossing certain thresholds. With these new pathways, it becomes easier to understand how different actions could manifest in the form of future climate impacts. In total, five SSP-RCPs will be available for use in climate risk assessment […]. While generally comparable to CMIP5 generation models, CMIP6 has taken a step forward by improving the overall quality of climate projections. […] Projected end-of-century temperature anomalies within SSP-RCPs have a narrower uncertainty range than in AR5, but generally also run slightly hotter compared to previous models."* (Gannon & Boonanich, 2021)

Because AR6 climate projections have not been downscaled for the Project site yet, it is unknown how this will translate locally, but there is potential for predicted climate parameters to be different (potentially hotter temperatures) than under AR5. **Recommendation:** Based on this, it is recommended to run sensitivity analyses to understand the potential implications of a greater temperature increase on the Project Closure Plan. Sensitivity analyses were run for the Processed Kimberlite Containment Facility (PKCF) thermal cover design, but not site-wide. The plan should also include contingency mitigations associated with a greater temperature or precipitation increase.

Diavik's climate change assessment presents climate projections obtained using 24 different Global Climate Models (GCMs) focused on three AR5 Representative Concentrations Pathways (RCPs; RCP 2.6, RCP 4.5, and RCP 8.5). Projections across the multi-model ensemble are summarized in terms of percentiles where the 50th percentile represents the median value and the 95th percentile represents extreme projections for the site. Since the RCP 6.0 pathway is not included (downscaled projections are not available for this pathway), we are concerned that the 50th percentile and to a lesser extent the 95th percentile have a low bias.

Also, Appendix A of the climate change assessment states:

> *"Downscaled outputs are based on GCM projections from the Coupled Model Intercomparison Project Phase 5 (Taylor et al. 2012) and historical daily gridded data across the globe (Sheffield al. 2006) and are available for 21 GCMs. Two scenarios (RCP 2.6 and RCP 4.5) are available for each of the 21 GCMs which results in 42 individual climate scenarios." (Section 2.1.2, p.10).*

It is unclear if the use of the two lower representative concentrations pathways only (RCP 2.6 and RCP 4.5) is also introducing bias in the range of predictions.

Recommendation: Describe any possible bias in climate projections and discuss implications.

Climate projections are available up to 2100, and Diavik's climate change assessment includes a semi-qualitative approach allowing for monthly timeseries of precipitation and temperature variables to be generated up to 2126, along with estimates of the climate projection statistics for the 2120s future period (2106-2135). Certain aspects of the Project closure design are however expected to be maintained in perpetuity (e.g. North Country Rock Pile frozen cover). **Recommendation:** A discussion of the different emissions pathways and of their implications for the Project design in the long-term (beyond 2120s) should be included to better understand if the closure design can be expected to be sustainable over that time horizon.

3.2 Climate Parameters

The current climate parameters were sourced from the baseline climate analysis update (Golder, 2021) in the Current and Projected Climate Parameters compilation document (Appendix X-10). This is different than the current climate parameters used in the climate change assessment which used a longer infilled time series (Appendix X-24). For certain parameters, future climate is presented as % change from current climate, but the "current climate" reference is different in the two documents. This inconsistency could introduce discrepancies and/or inaccuracies and missing data (e.g. some values not available from Golder 2021). **Recommendation:** A reference baseline dataset should be established and used consistently for all models, analyses and projections.

3.3 Water Balance

The water balance model approach evaluates conditions under three closure scenarios (around 2025, without considerations for climate change, around 2125 with consideration for climate change using the 50th percentile projections and around 2125 with consideration for climate change using the 95th percentile projections), but only for an average precipitation year. **Recommendation:** It is recommended that the three closure scenarios also be modeled for a dry (1:100) and for a wet (1:100) year.

3.4 Water Quality Model

The water quality model was run for a 1:100 dry year under current climate and for and average precipitation year under climate change projections (50th and 95th percentile). **Recommendation:** Similar to the water balance, it is recommended that the three scenarios (current climate and two climate change scenarios) be modelled for a dry year (1:100), average year, and wet year (1:100). While a dry year would result in higher contaminant concentrations for a given mass loading, a wet year could result in storm surges and increased flushing of contaminants.

In addition,

> *"The climate change scenarios resulted in lower predicted concentrations, overall. This is due to the cumulative annual mass loading being released over a longer period of time each year (early May through October or November), which results in a smaller amount of mass being released on a daily basis relative to the base case scenario. It is also a function in the increase in the runoff volume. Predicted concentrations decrease with increasing percentile climate change projections." (Appendix X-20, p. 18)*

Recommendation: It would therefore be prudent to also model the lower percentile end of climate change projections (e.g. 5th percentile which predicts a decrease in precipitation).

3.5 North Country Rock Pile Closure Design

Section 4.2 discusses thermal analyses conducted on the closure design of the North Country Rock Pile (NCRP) including climate change scenarios for a simulation period of 100 years. Little information is provided within this report, as the design specifications of the cover, test piles and climate change scenarios were all completed in 2013 as part of a PhD thesis by Hoang Pham entitled *"Heat transfer in waste-rock piles constructed in a continuous permafrost region"*. It is assumed that no other more recent studies have been conducted. As part of the study, Pham took in situ ground temperature measurements within a waste rock dump at the Diavik Mine in 2010 and 2011. These measurements are more than ten years old. It was also assumed that the mine site overlies continuous permafrost. It is unknown whether current ground temperatures at varying depths, and seasonally, are the same as the temperature measurements taken more than 10 years ago, and whether the site still overlies continuous permafrost. It is also unknown whether the active layer zone depths, seasonally, are the same, and if the permafrost layer is the same thickness.

Golder's 2018 report "*Diavik Diamond Mine North Country Rock Pile Closure Design"*, Attachment E: "*TDR Probe Data"* provides seasonal temperature measurements within the till layer between 2019 and 2020. The *"2021 Reclamation Completion Report Waste Rock Storage Area- North Country Rock Pile"*, Appendix H: *"2021 TDR Readings"* also provide one year of seasonal temperature measurements from the till layer. It is not known at which depth these measurements are taken. Further measurements are needed to provide a complete understanding of seasonal temperature changes within and below the NCRP over time.

Recommendation: These measurements (ground temperature at varying depths, and seasons; active layer and permafrost layer thicknesses; continuous permafrost zone confirmation) should be re-taken for the NCRP.

Currently the cover design consists of 3 m coarse run-of-mine rockfill (ROM) overlaying 1.5 m till. Numerical simulations of climate change scenarios predicted that this cover design would result in the 0°C isotherm (active layer) at a depth of 3.9 m to the year 2110. By using coarse ROM rockfill to allow convection through the cover, and ensuring that the till remains saturated, this depth to the 0°C isotherm is predicted to be reduced. These are standard thermal cover design methods as outlined by Stevens et. al., 2018. The climate scenarios case studies for the cover designs were based on climate modeling analyses conducted by Environmental Modeling and Prediction P/L Australia, who conducted these analyses in 2008. Climate modeling scenarios predicted annual mean temperature increase of 0.056°C/yr. This value was used in the case studies/thermal analyses of the cover design. However, warmest temperature scenarios were predicted to be 0.061°C/yr, with the highest increase predicted in January at a mean increase of 0.086°C/yr. These predicted increases were not factored into the climate change scenario case studies for thermal cover design analyses.

Based on the information above, CoreGeo has the following concerns:

- The climate change prediction scenario ranged from 1970 to 2060, which is 37 years from now. The predictions do not go far enough in the future to consider closure and post-closure 100 years from now. In addition, this prediction was completed in 2008. Fifteen year later, there is more information known, and updated, more accurate climate change scenario predictions available. Climate change parameters obtained in the recent Diavik Diamond Mines Climate Change Assessment (Golder, 2021) should be used in the thermal modelling. Also, Pham (2013) used only ten years of site-specific ground temperature measurements to apply the climate change scenario to the thermal cover design case studies, whose numerical simulations modelled 100 years. **Recommendations**: The updated climate change assessment, Diavik Diamond Mines Climate Change Assessment (Golder, 2021), should be applied to thermal modelling cover design analyses. Warmest temperature scenarios (95th percentile) should be applied to thermal cover climate change numerical analyses.

- The case study numerical simulations of the thermal cover design only considered predicted temperature changes over time, and not precipitation projections. Pham (2013) recommended that the till layer in the cover remain at 90% saturation (90% volumetric water content). There was no discussion or analyses completed on the effect of increased precipitation over time due to climate change, and how that could affect the saturation level of the till layer, including the possibility of over-saturation. Additionally, there was no discussion on how increased predicted precipitation, including extreme events such as storm surges and flooding, could affect water management and increased ponding along the sides of the North Country Rock Pile.
  Recommendations: Updated thermal modelling of the NCRP cover should incorporate predicted precipitation changes from the Diavik Diamond Mines Climate Change Assessment (Golder, 2021). These predictions should be applied to the till design layer of the thermal cover, and water management designs of the NCRP.

Finally, Pham provided follow-up recommendations, as there were still gaps in his study of the NCRP thermal cover design, summarized here:

- Test piles were much smaller than the NCRP, and so measurements should be taken from the NCRP, to measure the thermal regime of the bedrock beneath the pile and within:

- Additional thermistors beneath and within the pile should be installed.
- Additional heat flux plates should be installed.

Currently, Golder and Rio Tinto took temperature measurements in 2019, 2020 and 2021 within the till. It is unknown at what depths within the till layer these measurements were taken (Golder, 2018; Rio Tinto, 2021).

- Additional numerical simulations are needed to examine the influence of water transport on the thermal behaviour of the cover.

  Recommendation: These additional actions should be completed if they have not been already.

3.6 Diavik Processed Kimberlite Containment Facility: Rockfill Option Closure Design

Section 5.1 of the report discusses thermal modelling of the Processed Kimberlite Containment Facility (PKCF) cover- rockfill option closure design. The following concerns were identified:

- The report does not provide geochemical characterization of the material within the facility, and there is no consideration for how this material will be managed and the facility designed based on geochemical characterization. The 2022 "*Processed Kimberlite Management Plan, Version 7*" describes geochemical characterization work that has previously been conducted with reference to the 2011 "*Interim Closure and Reclamation Plan, Version 3.2*". Section 4.3 of the PK Management Plan explained that geochemical and mineralogical characterization of kimberlites has been completed along with pore water sampling and geochemical analyses, including from shallow thawed zones and ice lenses. Pore water sampling is to continue annually. No information was provided as to how PAG material is stored in the facility. Discussion of monitoring the facility post closure was not included.

  Recommendations: Discussion of the ARD/ML characterization of the materials in the facility should be discussed, along with how this informs the material placement and design of the facility. Monitoring (including groundwater monitoring) planning at closure, including cover performance should be discussed.
- There is no discussion of the active layer and permafrost depths underlying the facility. Ground temperature measurements, and measurements within the Extra Fine Processed Kimberlite (EFPK) were not taken.

  Recommendation: Ground temperature measurements below the facility and within should be measured seasonally, to characterize the extent of permafrost and active layer, as well as temperatures within the facility year-round.
- Cover trials were short-term and only conducted in the spring and summer months. There were no year-round trials conducted.

  Recommendation: Cover trials should be conducted year-round to understand the cover performance year-round.
- Precipitation changes (increases) due to climate change is not considered in the climate change scenarios within the thermal cover modelling.

Recommendations: Thermal cover modelling climate change scenarios should include precipitation changes. This modelling should include moisture transport within the facility. Water management should address potential increases in precipitation due to climate change.

- Climate change scenarios use a temperature increase of 5.6°C over 100 years. This value is likely taken from the 2008 study from Environmental Modelling and Prediction P/L Australia.
  Recommendations: Climate change scenarios for thermal cover modelling should be re-run with up-to-date climate change prediction values. Long-term site-specific data should be incorporated into climate change predictions.
- Thermal modelling was conducted in 1D. Stevens et. al. 2018 recommend 2D modelling to allow for analyses of slopes, geometric effects, boundary conditions modified to meet surface conditions.
  Recommendation: Thermal modelling should be conducted in 2D.

4. CLOSURE

If you require any additional information or clarification, please do not hesitate to contact us.

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