Memorandum

To: John McCullum, Environmental Monitoring Advisory Board

From: Bill Slater

Date: January 20, 2023

Re: Diavik Water Licence Amendment
Progressive Reclamation – Re-establishing Natural Drainages

As requested, I have reviewed Diavik Diamond Mines Inc.'s (DDMI's) water licence amendment application requesting authorization for progressive reclamation by decommissioning of some collection ponds and direct discharge of runoff to Lac de Gras. As described in my estimate dated December 16, 2022, my review included the following documents:

- Water Licence Amendment Application Form and Draft Licence
- Relevant portions of Appendix E, Final Closure and Reclamation Plan
- Appendix VI-1, Closure and Post-Closure Monitoring
- Appendix VI-2, Closure and Post-Closure AEMP Design Plan
- Appendix X-12, Surface Water Management
- Appendix X-19, Closure Site-Wide Water Balance Model
- Appendix X-20, Sitewide Water Quality Model Update
- Appendix X-21, Hydrodynamic and Water Quality Modelling of Pit Lakes and Lac de Gras
- Appendix X-22, Rationale for Assessed Runoff Mixing Zone During Post-Closure

DDMI describes the rationale for the progressive reclamation of some Collection Ponds, where water quality conditions allow, as follows: "*to enable progressive reclamation in this Application will allow us to get a head start to closure performance monitoring, support the validation of planning to date and use new results to adaptively manage the next phases of our Reclamation work.*"

Progressive reclamation at mine sites is generally beneficial because it can reduce the reclamation liability at the mine site and the time required to carry out final reclamation measures once mining is complete. Progressive reclamation typically is undertaken in areas of mine sites that are no longer active, where reclamation measures are complete and the areas will not be subject to further disturbance. This type of progressive reclamation is often aimed at source control and stabilization of disturbed areas.

The progressive reclamation proposed by DDMI however, is focused on removal of the surface water management facilities that are present at the site, while mining and reclamation activities still remain to be completed. Typically, mining companies retain these types of facilities through closure phases to manage and provide contingencies for any sediment releases or surface water

issues that may arise from the reclamation activities in upstream areas. As such, the proposed approach to progressive reclamation is somewhat unconventional. However, DDMI has concluded that it is practical and has proposed a monitoring and response framework aimed at evaluating performance and water quality conditions after removal of the water management infrastructure. Comments provided in this memo are aimed at ensuring that the proposed progressive reclamation approach, monitoring and responses will result in suitable water quality conditions as closure and post-closure progress.

1.0 Regulatory Concept

DDMI proposes that direct discharge of runoff from the mine site to Lac de Gras be authorized as approved in the Final Closure and Reclamation Plan (FCRP) or a Decommissioning Plan for a specific Collection Pond (Part G, Clause 33 of the Draft Licence). With respect to water quality of runoff, DDMI appears to propose two mechanisms for regulation. First, it proposes that the water licence include limitations on pH of effluent and requirements for the effluent not to be acutely toxic to aquatic organisms (Part G, Clauses 36 and 37 of the Draft Licence). Second, it proposes that Decommissioning Plans for Collection Ponds must include, as per Schedule 8, Section 3:

> *"Identification, with rationale, of new or updated Closure Objectives and/or Closure Criteria being proposed, including:*
>
> 1. *SW1 and SW2 criteria for the decommissioned catchment that include a list of contaminants of potential concern with rationale;*
> 2. *Consideration of new closure criteria and/or objective(s) to assess effects in the Receiving Environment, including sediment quality, with rationale; and*
> 3. *Consideration, with rationale, of a SW2 criterion to address extent of sublethal effects*."

If applied adequately, the proposed approach may be effective for managing the closure and post-closure discharge of mine runoff. However, there are some concerns with the application as it is currently proposed.

First, the proposed water quality limits in the licence only include pH and acute toxicity. Clear licence limits should be established now for parameters that are likely to be consistently relevant for all of the runoff locations and where effects are also consistently relevant. For many dissolved contaminants (e.g., metals, major ions), the concentrations and mixing zone characteristics mean that appropriate numerical criteria will vary between catchments. In these cases, developing criteria as part of individual Decommissioning Plans is an acceptable site-specific approach. Also, many of these contaminants would contribute to toxicity which is included as one of the proposed licence limits. Total Suspended Solids (TSS), however, is a significant contaminant of concern for all mine site runoff, especially as reclamation activities proceed. It is often one of the first indicators of problems with reclamation measure performance. Without modifications to standard toxicity testing, TSS is not likely to have much influence on results of lab toxicity tests and therefore is not addressed by the proposed licence limits. Nonetheless, it can have adverse effects on aquatic life and aquatic habitat.

Recommendation 1: In addition to effluent quality limits for pH and acute toxicity, the Water Licence should include limits for TSS. These should either be consistent with the MDMER, or if MDMER do not apply to the runoff, then CCME Guidelines should be used.

Second, the proposed wording for Schedule 8 does not provide clear, definitive requirements to develop numerical criteria for contaminants of potential concern (COPCs) as part of a Decommissioning Plan. The wording, as drafted requires a list of COPCs as well as consideration of criteria for sediment and extent of sublethal effects, but it does not specifically require the Decommissioning Plan to include numerical water quality criteria for runoff discharges from each Collection Pond catchment.

Recommendation 2: Revise the wording in Schedule 8 to include a definitive requirement for Decommissioning Plans to include development and inclusion of numerical water quality criteria for discharge of runoff.

2.0 Decision-making for Pond Decommissioning

The FCRP Closure and Post-Closure Monitoring Plan (Section 3.1.4.4) states that SNP monitoring will be used to make decisions about reconnecting drainages to Lac de Gras, and that "*water quality will be required to meet closure criteria during a final sampling event immediately prior to reconnecting the closure drainages to Lac de Gras*." Table 7 of Attachment 2 in the Monitoring Plan clarifies that the final sampling event will entail "*at least three stations located evenly spaced around the Collection Pond shoreline*." Because the proposed decommissioning of ponds will entail breaching the ponds leading to uncontrolled flow whenever water is present, it will be important to ensure that water quality is expected to remain suitable for discharge in a variety of flow conditions and throughout the year. As a result, the decision to decommission ponds needs to consider data collected over a range of conditions.

Recommendation 3: Decommissioning should be prohibited until monitoring demonstrates that water quality has remained suitable in various flow conditions and throughout the year.

FCRP Section 5.2.18 proposes that "*Sediment remaining in the ponds will be tested for contamination and covered, if required*." Section 5.2.8.3.2 makes a similar statement. The FCRP Monitoring Plan does not include any information about monitoring of sediment in Collection Ponds.

Recommendation 4: DDMI should describe planned sediment sampling for Collection Ponds, and the decision-making framework for making decisions about whether mitigation (e.g., covering) is required.

3.0 Surface Water Action Level Framework

One of the mitigation responses in the SWALF is to re-establish temporary water collection. This is a reasonable response to address concerns about effects of runoff discharge and should be an early consideration when the SWALF is triggered. However, it is not clear whether the temporary water collection also includes some form of treatment. Without some form of treatment, the re-establishment of collection would only provide control over timing of discharges, but may not limit the effects.

Recommendation 5: Revise the SWALF to clarify that temporary water collection would be accompanied by whatever other measures are necessary (e.g., settlement or treatment) to ensure that discharge meets the licence limits, closure criteria and thresholds in the SWALF.

As noted in the introduction to this memo, progressive reclamation of surface water management ponds prior to completion of reclamation activities – possibly including earth moving and land disturbing activities – is unconventional for mine reclamation projects. Given that future land disturbance is possible in some of the Collection Pond catchments, water quality conditions could change quickly, leading to a need to re-establish Collection Pond functionality. If the ponds are breached, this will be difficult, especially at times when water quality conditions are most likely to deteriorate, due to high flow events. Retaining ponds while allowing controlled discharge of water (e.g., siphon, pump or overflow) that meets licence limits for discharge from Collection Ponds, numerical closure criteria in Decommissioning Plans and thresholds in the SWALF should be considered further. This would provide authorization to proceed with discharge of clean runoff, while maintaining effective and proactive contingency capacity.

Recommendation 6: In any Collection Pond catchments where future mine operations or reclamation measures may include land disturbance or earth moving activities, retain functionality of Collection Ponds while allowing controlled discharge of surface runoff that meets licence limits (for discharge from Collection Ponds), numerical closure criteria and thresholds in the SWALF.

The Surface Water Action Level Framework (SWALF) proposes that the first action to take if water quality exceeds Closure Criteria SW1-1 or SW1-2 is to "*conduct a risk assessment and revise criteria as appropriate*." The concept of risk-based criteria has been discussed and proposed in the past, and provides a mechanism to evaluate site-specific conditions and risks. However, it should not be the first step taken when confronted with an exceedance of a numerical closure criterion. Instead, there should be some investigation of causes, and consideration of maintenance or practical mitigations to address exceedance of criteria. Only if these measures cannot address the exceedance should revision of criteria be considered.

Recommendation 7: Revise the SWALF to provide for investigation of causes of SW1-1 or SW1-2 exceedance, and consideration of maintenance/mitigation before revising closure criteria.

4.0 Closure Objective SW1

Table 5 in Appendix V specifies the numerical water quality criteria for Closure Criteria SW1-1 (Human Health) and SW1-2 (Wildlife). For human health, the criteria are aimed at protecting recreational use of water and are based on human health drinking water guidelines "*multiplied by a factor of twenty to account for the potential for incidental consumption during recreation.*" This approach assumes that the runoff water will not be used as a source for drinking water but only ingested incidentally for example while swimming.

DDMI's modelling predicts that concentrations at the mixing zone boundaries will be lower than the consumption criteria for both wildlife and humans, indicating that use of water for drinking at these locations is not expected to be adversely affected by mine discharges. The modelling also predicts that runoff water itself will have concentrations that are lower than the criteria for consumption by

wildlife, indicating that all of the water should be safe for consumption by wildlife. It is important to recognize that runoff and mixing zones will have long-term constraints on their suitability for human consumption as drinking water.

Recommendation 8: DDMI should identify how it plans to manage long-term constraints on use of runoff water and mixing zone water for human drinking water purposes.

5.0 Closure Objective SW2

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 address sublethal toxicity (SW2-1) and acute toxicity (SW2-2). Schedule 8 of the Draft Water Licence indicates that additional Closure Criteria could be added to this objective, including possible numerical criteria (also see comments above re: Regulatory Concept).

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 before reaching 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 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 9: Closure Criterion SW2-1 should be revised to refer more generally to avoiding chronic toxicity. It should also identify that further criteria will be developed as part of Decommissioning Plans. The monitoring approach for evaluating chronic toxicity should be revised to identify additional species that will be used for evaluating achievement of Closure Criterion SW2-1. Typically testing would be completed on relevant sensitive fish, invertebrate and algae/aquatic plant species.

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*. While not specifically stated in the documents, it is likely that DDMI 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, it does not mean that there is no acute toxicity.

Recommendation 10: DDMI should clarify how it intends to interpret testing for acute toxicity when evaluating Closure Criterion SW2-2.

6.0 Closure Objective SW6

Closure Objective SW6 is stated as "*ground surface designed to drain naturally following pre-development drainage patterns*." The associated Closure Criteria address satisfactory completion of the design (SW6-1) and satisfactory performance of drainage networks (SW6-2). DDMI proposes annual monitoring at freshet for a period of five years to evaluate the performance and condition of

the drainage network, and identify any need for maintenance or repair. This is a reasonable approach to evaluate initial performance and confirm initial achievement of the Closure Objective. However, the stability and performance of drainage networks is related to the size of hydrologic events that occur more than to the passage of time.

The proposed initial monitoring program makes sense because it includes monitoring at freshet when major flows are likely to occur. But, additional monitoring is needed to confirm performance after the initial period, and after any high flow events whether in the initial five years or in the long-term.

Recommendation 11: The monitoring program should include inspections during the initial five-year period after any major storm events that may cause erosion or damage to conveyance channels or pond breaches. Once the initial five-year period has passed, periodic monitoring should likely continue at lower frequency, and event specific monitoring should be conducted after large events.

7.0 Design Criteria

Appendix X-12, a Golder report on Surface Water Management, provides designs for the breaches of most Collection Ponds – all except Pond 3 which is to be addressed through design for the PKC Facility. 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.

Recommendation 12: 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.

For the small catchments on East Island, the choice to design on the basis of 24-hour storm events results in an increased risk that failures may occur in shorter duration events with return periods much less than the 1:200-year design criterion. Table 3 of Appendix X-12 identifies longest flow paths for pond catchments that range from 240 m to 1980 m. Many of these catchments likely have times-of-concentration much less than 24 hours. As a result, rainfall events of shorter duration with higher intensity may have peak flows higher than those associated with a 1:200-year 24-hour event. These shorter duration, higher intensity events could also have much lower return periods.

In this case, the breach designs would not provide protection for peak flows from some 1:200-year events.

Recommendation 13: DDMI should evaluate peak flows for 1:200-year events of shorter duration to confirm that breach designs can withstand higher intensity, lower return-period events.

8.0 Water Quality Model – Source Term for PKC

The water quality model, described in Appendix X-20 assumes that, in the long-term, there is no seepage from processed kimberlite (PK) stored in the Processed Kimberlite Containment (PKC) Facility and that loading 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 PKC Facility. 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 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.

Recommendation 14: A model sensitivity run should be undertaken to evaluate the potential impacts of long-term seepage from the PKC Facility. It would be reasonable to conduct a sensitivity analysis that assumes continued seepage at current rates.

9.0 Hydrodynamic Model – Mixing Zones

Section 7.3.2 of Appendix X-20 describes the methodology for predicting concentrations at the edge of mixing zones. Additional clarity is provided in Figure 36 of the same Appendix. There are two mixing zone sizes identified, one at approximately 100 to 200 m from the discharge points (with some exceptions) and another at approximately 500 m from the discharge point. The results presented for the first (100 to 200 m) mixing zone are the average of predicted values for model cells that fall between 100 and 200 m. Because the analysis is based on average values, it is possible that the actual conditions may lead to higher concentrations in some specific locations, depending on mixing characteristics. Generally, we can expect that concentrations at 100 m from discharge points will be higher than the predicted results because the area for mixing is smaller at this location than the area represented by the values used in the predictions. Nonetheless, the Rationale for Assessed Runoff Mixing Zones (Appendix X-22) asserts that "*assessed runoff mixing zones for post-closure are either at a minimum distance of 100 m from the discharge … or at the shortest distance where modelling demonstrates that Effects Benchmarks … will be met*." Based on the modelling, it is not clear that benchmarks will be met at 100 m. The approach to model predictions will be important when making decisions about the size of mixing zones and the location of monitoring locations for mixing zone boundaries.

Recommendation 15: DDMI should provide additional clarity about how it will determine the monitoring locations for mixing zone boundaries for site runoff locations.

10.0 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. For example, materials are not necessarily well mixed with other neutralizing materials, and flow paths of runoff/seepage may not contact neutralizing materials. 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 all of 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.

Recommendation 16: 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.

11.0 Monitoring

11.1 Water Quality Sampling for Runoff Locations

Part E of the Draft Licence describes sampling requirements. For Collection Pond locations, the sampling includes total metals, but not dissolved metals. For site runoff, it will be important to sample for both total and dissolved metals. TSS is an important contaminant of concern for mine site runoff and it will influence the concentrations of total metal contaminants. However, dissolved concentrations are also important for understanding potential effects in the aquatic environment. Table 7 in Attachment 2 of the FCRP Closure and Post-Closure Monitoring Plan includes dissolved metals as part of the proposed monitoring. This should be reflected in the licence.

Recommendation 17: Water quality sampling for site runoff should include sampling and analysis for both total and dissolved metals.

11.2 Post-Closure Frequency of Monitoring

DDMI proposes that frequency of monitoring of site runoff will be reduced to twice annually after completion of closure activities on the site. The desire to reduce monitoring frequency once all closure activities are complete is understandable. Nonetheless, monitoring of site runoff is an important mechanism for understanding performance of the closure landscape. At the very least,

the post-closure monitoring program should be designed to understand the water quality conditions including seasonal variability, and conditions in various flow conditions. Twice annual monitoring is likely not sufficient to achieve this purpose. Understanding the variability will require monitoring at least during freshet (when flows and TSS are both likely to be high) after freshet (when modelling indicates that maximum effects are likely to occur – FCRP Closure and Post-Closure Monitoring Plan Section 3.1.4.3) during summer, and during fall (once open water flows have declined). For intermittent discharges, monitoring will need to focus on times when flows are likely to be present (e.g, storm events). This frequency of monitoring should be continued until results demonstrate that lower frequency can provide adequate understanding of variability.

Recommendation 18: Increase post-closure monitoring frequency for surface runoff, with sampling of sufficient frequency to capture major hydrological periods and water quality variability. For intermittent flows, monitoring should focus on time periods when flow is likely to be present.

DDMI proposes once annual monitoring of water quality at the mixing zone boundary for a period of two years following completion of decommissioning of each Collection Pond. It proposes that sampling would continue if source water samples do not meet closure criteria, or if concentrations at the edge of the mixing zone exceed AEMP effects benchmarks. The modelling predicts that concentrations at mixing zone boundaries for many parameters and locations will be well below AEMP benchmarks. As a result, exceedance of AEMP benchmarks at the mixing zone boundary would, in most cases, be unlikely, and therefore the AEMP benchmarks at this location are not an effective threshold for making decisions about future monitoring. Instead, it makes sense to rely on comparison with predicted conditions to evaluate the need for continued monitoring.

Recommendation 19: Sampling conducted in the first two years at mixing zone boundaries should be compared with predicted concentrations from modelling, to evaluate whether the runoff and mixing conditions are consistent with expectations. If concentrations of any parameters are higher than predictions, monitoring should continue.

Appendix VI-2, the FCRP Closure and Post-Closure Aquatic Effects Monitoring Program Design Plan describes proposed AEMP monitoring for the closure and post-closure period. It "*incorporates updates that account for changes to site drainage conditions on the East Island that will occur during closure and post-closure*" (AEMP Design Plan, Section 4.4.1). Until then, DDMI proposes to continue with the operational AEMP Program. The operational AEMP Program is premised on a single discharge of water from the site, the North Inlet Water Treatment Plan (NIWTP) discharge. The Closure and Post-Closure Plan on the other hand, is premised on discharges from various catchments around East Island. DDMI plans to decommission some of the Collection Ponds as early as 2023, before the mine enters the closure and post-closure stage. FCRP Section 6.3.1.4 indicates that breaching of Collection Ponds 1,2,4,7,10,11,12, and 13 and Sump 21 may potentially occur as progressive reclamation. The AEMP for the operational period is not designed to monitor potential effects of the additional discharge locations.

Recommendation 20: DDMI should be required to implement relevant parts of the Closure and Post-Closure AEMP Design Plan, including monitoring potential effects of the additional discharge

locations, in association with any Collection Ponds that are decommissioned during the operational period.

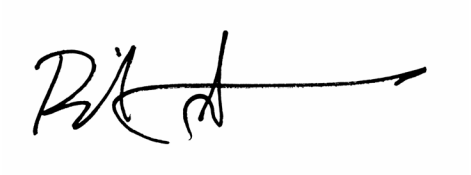
12.0 Specific Comment on Draft Licence

1. Part G, Clause 33 should be revised to clarify that authorization to discharge from components of the Collection Pond System is subject to other conditions of the licence, e.g., Part G, Clauses 36 and 37.
2. Part J, Clause 10 should be revised to clarify that authorization to discharge from components of the Collection Pond System is subject to other conditions of the licence.
3. Schedule 8, Clause 3(d)(ii): rationale should be provided for why controlled discharge as an initial step in Collection Pond decommissioning is not appropriate. The need to provide rationale should not be restricted to consideration of research. In all cases there may be benefit to initially discharging with controlled means (e.g., siphon, pump, overflow) but without actually breaching ponds, as this will provide an opportunity to easily revise plans if water quality changes when settling in ponds is eliminated.
4. Schedule 8, Clause 3(g)(ii) should direct that the Decommissioning Plan must include the listed monitoring, not that it just be considered.

13.0 Closing

Thank you for the opportunity to support EMAB in its review of the water licence amendment application. Please contact me if you have any questions about the comments provided or further questions about the application.

Sincerely,



Bill Slater.