

Executive Summary

Slater Environmental Consulting (SEC) reviewed the closure criteria for the Diavik Diamond Mine on behalf of the Environmental Monitoring Advisory Board (EMAB). The purpose of the review was to evaluate whether the closure criteria would be effective for measuring achievement of the closure objectives.

- Closure objectives describe what the proposed closure plan is supposed to achieve.
- Closure criteria are the standards and tools to measure and understand whether the closure plan has actually met the objectives.

Diavik Diamond Mines Incorporated (DDMI) provided closure criteria in its 2011 *Interim Closure and Reclamation Plan – Version 3.2*. It updated its closure criteria for the North Country Rock Pile (NCRP) as part of its 2016 *Final Closure Plan – North Country Rock Pile – Version 1.0*. SEC reviewed closure criteria from both of these plans.

For some closure objectives, DDMI has defined closure criteria that provide a solid framework for evaluating the performance of the closure plan, and whether closure objectives are being met.

For other closure objectives, the closure criteria do not provide a complete framework for understanding whether the closure plan achieves the objectives. Some key shortfalls include:

- For some objectives that require protection of aquatic life, DDMI has proposed water quality criteria that are not directly related to effects on aquatic life.
- Criteria related to contaminants appear to assume that increases in contaminants up to specified concentrations would be acceptable, even though this may not leave capacity for inputs from any other sources in the future.
- For some objectives related to the final landscape and vegetation, DDMI has not proposed any measurable criteria. Instead, DDMI has proposed that inspections by engineers will provide sufficient evidence about meeting closure objectives. While inspections by engineers are important monitoring methods, they do not define what conditions must be met.
- In some cases, DDMI has proposed criteria in the 2016 final closure and reclamation plan for the NCRP that are less defined than the ones provided in 2011.

The EMAB should consider providing detailed comments and recommendations to the WLWB about the proposed closure criteria for the NCRP and directly to DDMI about all of the closure criteria. The comments should include recommendations to develop criteria that include effective indicators and thresholds for which performance can be measured and verified.

Memorandum

To: John McCullum, Allison Rodvang – Environmental Monitoring Advisory Board

From: Bill Slater

Date: June 16, 2016

Re: **Review of Closure Criteria – Diavik Diamond Mine**

1.0 Introduction

This memorandum provides the results of Slater Environmental Consulting's (SEC's) review of closure criteria for the Diavik Diamond Mine on behalf of the Environmental Monitoring Advisory Board (EMAB). The review was conducted in accordance with the scope of work described in SEC's proposal to EMAB dated April 22, 2016, with the following purpose:

“To review the closure criteria for the Diavik Diamond Mine and evaluate their suitability and effectiveness as performance measures for determining achievement of the closure objectives.”

2.0 Background

The *“Guidelines for the Closure and Reclamation of Advanced Mineral Exploration and Mine Sites in the Northwest Territories”* (MVLWB and AANDC, November 2013.) describe an “objectives-based approach” for closure and reclamation planning in NWT. Achieving successful closure and reclamation outcomes relies on the establishment of closure objectives and associated closure criteria, where:

- Closure objectives describe what the selected closure activities are aiming to achieve, and
- Closure criteria are the performance indicators and thresholds that are used to determine whether the closure and reclamation activities have met the objectives.

Diavik Diamond Mines Incorporated (DDMI) has applied this objectives-based approach to closure planning for the Diavik Diamond Mine, with refinement of closure criteria as the closure planning process progresses. As the Diavik Diamond Mine moves towards final closure and reclamation, the suitability and effectiveness of closure criteria becomes increasingly important.

The current version of closure objectives and criteria for the Diavik Diamond Mine are compiled in several closure related documents:

- Appendix V of Diavik Diamond Mines Incorporated's (DDMI) *Interim Closure and Reclamation Plan – Version 3.2* (DDMI, 2011) lists a series of closure objectives and proposes related closure criteria.
- Appendices that are part of the *Annual Interim Closure and Reclamation Progress Report – 2015* (DDMI, 2016a) provide additional detail with respect to some closure criteria including:
 - Recommendations for numerical criteria for soil, water and other environmental components as described in *Site-specific Risk-based Closure Criteria Phase II Report* (ERM, 2016b)
 - Specific criteria for the North Country Rock Pile (NCRP) as described in the Appendix V of the *Final Closure Plan – North Country Rock Pile – Version 1.0 – Detailed Tabulation of Closure Objectives and Criteria – Waste Rock and Till Area* (DDMI, 2016b), and Appendix X – *Final Closure Plan – North Country Rock Pile – Version 1.0* (Golder Associates, 2016).
- The *Annual Interim Closure and Reclamation Progress Report – 2013*, (DDMI, 2013) includes, as Appendix IV-1, the “*Diavik Diamond Mine PKC Facility, Revised Closure Concept, FINAL*” (AMEC, 2013). However, the revised closure concept for the PKC Facility does not include any update or refinement of closure criteria. Instead, it appears to rely on the criteria established in the *Interim Closure and Reclamation Plan – Version 3.2* (DDMI, 2011).

3.0 Review Approach

In accordance with the purpose of the review, the approach for evaluating closure criteria considered the suitability and effectiveness of the criteria as performance measures for determining achievement of the closure objectives. The approach evaluated the criteria for each objective with respect to the following four key factors that help to define whether the criteria will work well as performance measures in the mine closure context.

1. **Effective Indicators**: For each objective, do the criteria rely on indicators that are relevant for evaluating the desired outcome, and are there indicators to address all important facets of the desired outcome?
2. **Measurable**: Is the performance of indicators measurable, and can results be verified independently?
3. **Thresholds**: Do the criteria for each objective establish thresholds that define acceptable performance conditions for the closure objective and its associated valued components?
4. **Timely Response**: Will monitoring of performance with respect to closure criteria allow for timely response to any failure to achieve closure objectives?

4.0 Review Findings

Tables 1 provides specific review findings for each of the criteria listed for the NCRP in Appendix V of the *Final Closure Plan – North Country Rock Pile – Version 1.0* (DDMI, 2016b), the *Detailed Tabulation of Closure Objectives and Criteria – Waste Rock and Till Area*. Table 2

provides specific review findings for each of the site wide and area specific criteria listed in the *Interim Closure and Reclamation Plan – Version 3.2* (DDMI, 2011). Comments are provided first on the NCRP because these criteria were refined more recently and are assumed to supersede earlier versions with respect to the NCRP. As a result, Table 2 does not address the older version of criteria for the Waste Rock and Till Area.

Several common themes and issues arose as part of the review. These are described further in the following sections.

4.1 Water Quality – Protection of Aquatic Life

Objective SW2 focuses on protection of aquatic life from effects of surface water and seepage quality. SEC assumes that the approach proposed for the NCRP represents DDMI's current approach for defining acceptable water quality criteria for protection of aquatic life. Despite the development of Site-Specific Risk Based Closure Criteria (SSRBCC), including identification of contaminants of potential concern (COPCs) and derivation of numerical criteria, DDMI has proposed criteria that are defined in the *Metal Mining Effluent Regulations* (MMER). The standards defined in the MMER are based on "Best Available Technology Economically Achievable" at metal mines, and therefore appear to have little relevance to achievement of the water quality objective for protection of aquatic life. DDMI does not provide any rationale for its decision to apply the MMER average monthly standards as criteria, or to only consider criteria for contaminants that have standards specified in the MMER.

4.2 Site-Specific Risk-Based Closure Criteria

Diavik Diamond Mine, Site-specific Risk-based Closure Criteria, Phase I Report (ERM, 2016a) and *Phase II Report* (ERM, 2016b) describe the development of SSRBCC for various environmental components. Numerical criteria like those defined in the SSRBCC Reports are good candidates for closure criteria that can be used to evaluate performance of objectives, for example objectives SW1 and SW2. These types of criteria can be good indicators and are often easily measurable. Appropriate thresholds can be developed, including stepped thresholds that allow early identification of problematic trends, in time to develop and implement responses.

SEC did not conduct a detailed review of the SSRBCC Reports to evaluate whether the specific numerical thresholds would be protective of valued components. Arcadis completed a review on behalf of EMAB. The Arcadis review identifies "*a number of concerns in the identification of the COPCs and approaches and assumptions used by ERM in the derivation of SSRBCC*" (Arcadis, 2016). Based on SEC's preliminary review of the SSRBCC Reports, SEC agrees with Arcadis' findings about methods used to identify COPCs, reliance on site-specific objectives from another site, reliance on operational conditions to define expected closure conditions, use of unsubstantiated dilution factors, consideration of off-site exposure for wildlife, and reliance on studies that evaluated non-protective endpoints.

Specifically with respect to criteria for water, the approach should rely on methods defined by the Canadian Council of Ministers of Environment (CCME) in its guidance on development of site-specific water quality objectives rather than a combination of a risk-based approach with guideline/objectives development methodology. Also, for contaminants that may be released by the mine but are unlikely to exceed generic guidelines, those guidelines should be established as criteria.

Based on the current status of the criteria defined in the SSRBCC Reports, SEC is supportive of the concept that these can be used as closure criteria, but the specific parameters and numbers will require further review and refinement.

4.3 Assimilative Capacity and Adaptive Management Plans

Applying SSRBCC directly as single numerical closure criteria assumes that: (1) all of the environmental capacity to absorb contaminants is available to DDMI, and (2) responses will be immediately effective if criteria are exceeded. Both assumptions warrant further consideration. Authorizing criteria that allow DDMI to consume all of the available assimilative capacity in the environment could have implications for future activities that may affect the same environmental components like Lac de Gras, Coppermine River or caribou populations. If there is interest in retaining some capacity for future activities, criteria may require adjustment. Whatever numerical criteria are established as an upper limit, they must be supported by an adaptive management plan that includes lower thresholds at which effective action can be taken to avoid exceedance of the upper limits.

4.4 Compliance with Designs

In some instances, DDMI proposes closure criteria that evaluate conformance of as-built reports with designs (and sometimes associated criteria related to final inspections by engineers). While construction of facilities in compliance with designs is important, it is only one aspect in a series of actions that will lead to achievement of objectives. Design of mine closure has many uncertainties and compliance with the design does not guarantee satisfactory performance. Criteria should be developed that address the specific types of performance that are desired. Based on these criteria, it will be possible to develop appropriate methods to evaluate whether they have been achieved immediately following construction and that they continue to be achieved throughout the closure and post-closure phases. A final inspection by an engineer is not a criterion, but part of a monitoring program. It offers a one-time characterization of performance, but should be recognized as one part of a monitoring program that will need to evaluate actual performance over time.

4.5 Criteria for Wildlife

There are several closure objectives related to wildlife use and effects on wildlife. Establishing relevant indicators that are measurable for specific wildlife objectives will be very challenging because it will be difficult to establish causality between specific mine

closure components, conditions or activities, and effects on wildlife. As such, evaluating performance of specific wildlife-related closure objectives is likely not to be effective. A holistic approach will be required, along with a well-defined adaptive management plan that will lead to timely implementation of effective mitigation actions in response to exceedance of agreed thresholds related to population, health and behaviour.

4.6 Refined Criteria for NCRP

For some objectives, Appendix V of the *Interim Closure and Reclamation Plan – Version 3.2* (DDMI, 2011) defines measurable criteria while the more recently developed Appendix V of the *Final Closure Plan – North Country Rock Pile – Version 1.0* (DDMI, 2016b), the *Detailed Tabulation of Closure Objectives and Criteria – Waste Rock and Till Area*, removes these criteria, leaving less certainty about achievement of closure objectives. The criteria for SW6, SW7, SW9 and W2 have been revised to remove specific indicators and thresholds. These criteria are primarily related to landform design, with the revised NCRP criteria all relying on conformance with designs rather than measurable indicators. The additional level of design completed for the NCRP should have provided an opportunity to define more specific criteria, rather than eliminate measurable results.

5.0 Conclusions and Recommendations

For some closure objectives, DDMI has defined closure criteria that include measurable thresholds for performance, based on relevant indicators. These provide a solid framework for evaluating the achievement of closure objectives once closure work commences.

For other closure objectives, the closure criteria do not provide a complete framework for evaluating performance of the objectives. In some cases, the criteria rely on indicators that are not specifically related to performance of the objective, or do not address all facets of the objective. In other cases, the criteria do not specify measurable thresholds that will support definitive conclusions about performance. Characterizing the achievement of closure objectives once closure work begins will require the development of more effective criteria for these objectives.

As DDMI moves towards development of final closure and reclamation plans, the establishment of clear, relevant and measurable criteria becomes more critical. Given the inadequacies of some proposed closure criteria, including the divergence away from effective criteria in the final closure and reclamation plan for the NCRP, the EMAB should consider the following opportunities for providing detailed input and recommendations about the closure criteria. These include providing input to the Wek'èezhìi Land and Water Board (WLWB), providing comments and recommendations directly to DDMI, and potentially undertaking further work to define and propose more effective closure criteria.

- The *Annual Interim Closure and Reclamation Progress Report – 2015 (Revised)* (DDMI, 2016a) is currently under review through the WLWB, with comments due

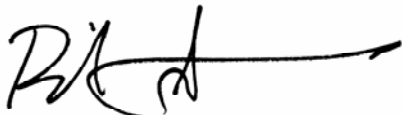
July 8, 2016. The Progress Report includes *Appendix IV-1 - North Country Rock Pile Final Closure Plan*, for which DDMI has requested approval from the WLWB. The EMAB should consider providing detailed comments to the WLWB about DDMI's proposed closure criteria for the NCRP. This should be accompanied by a recommendation that the WLWB request additional refinement of NCRP criteria from DDMI, and provide a further opportunity for review and input before granting approval of the final closure plan for the NCRP or its associated closure criteria. As part of its submission, EMAB could recommend that WLWB provide guidance to DDMI requiring development of criteria that include effective indicators and thresholds for which performance can be measured and verified.

- EMAB should continue to participate in WLWB review processes that relate to closure criteria, for example the review of the SSRBCC and any review processes related to interim or final closure plans. Review of closure criteria will continue to be important for each of these processes until closure criteria have been finalized.
- The EMAB should consider providing detailed comments and recommendations about all of the closure criteria directly to DDMI. Comments should be similar in nature to those provided to the WLWB in relation to the NCRP, with recommendations to develop criteria that include effective indicators and thresholds for which performance can be measured and verified.
- Depending on the response of DDMI to EMAB's comments, the Board may wish to initiate efforts to further develop its own recommendations for specific closure criteria. This would require a greater level of effort by the EMAB and would likely require engagement of a team that has expertise in specific technical areas where criteria need improvement. It would also likely include some engagement with other parties and groups to understand their perspectives about closure criteria. This would be particularly important since many of the criteria that lack effective indicators are related to final landform reclamation.

6.0 Closing

Thank you for the opportunity to complete this review of Diavik Diamond Mine closure criteria on behalf of the EMAB. If you have any questions about the findings or recommendations, I would be happy to discuss them with you.

Yours sincerely,



Bill Slater

Table 1: Closure Criteria – North Country Rock Pile

Closure Objective	Closure Criteria	Notes	Evaluation (1. Effective Indicators, 2. Measurable, 3. Thresholds, 4. Supports Timely Response)
Site Wide Objectives			
SW1. Surface runoff and seepage water quality that is safe for humans and wildlife.	Table V-3 (in Appendix V in DDMI, 2016b) or the result of a detailed Risk Assessment.	Table V-3 lists closure water quality criteria for wildlife and human health. Thresholds are based on SSRBCC (ERM, 2016a and 2016b).	<ol style="list-style-type: none"> 1. Contaminant concentrations in water are effective indicators. Criteria listed for all COPCs identified in SSRBCC Report¹. 2. Measurable. 3. In accordance with SSRBCC Report¹. 4. AMP required to define responses before thresholds are reached.
SW2 Surface runoff and seepage water quality that will not cause adverse effects on aquatic life or water uses in Lac de Gras or the Coppermine River.	Table V-3 (in Appendix V in DDMI, 2016b): No acute toxicity (96 hr Rainbow Trout, 48 hr <i>Daphnia Magna</i>).	Table V-3 lists closure water quality criteria for runoff/seepage entering Lac de Gras. Thresholds are established at MMER limits for only MMER listed parameters.	<ol style="list-style-type: none"> 1. Contaminant concentrations in water are effective primary indicators. Criteria not established for all identified COPC from SSRBC Report¹. Criteria for environmental effects on aquatic life (with supporting monitoring) should also be considered. 2. Measurable. 3. No information provided to demonstrate that meeting MMER standards in effluent discharge will achieve SSRBCC¹ in Lac de Gras. 4. AMP required to define responses before thresholds are reached.
SW3. Dust levels safe for people, vegetation, aquatic life, and wildlife.	Mean TSP concentrations less than 60 ug/m3 annual and 120 ug/m3 24 hr maximum acceptable (Canadian Ambient Air Quality Objectives and NWT Ambient Air Quality Standards).		<ol style="list-style-type: none"> 1. TSP concentrations in air are effective indicators. Criteria for PM_{2.5} should also be considered as PM_{2.5} is more relevant to human health. 2. Measurable. 3. Use of Canadian and NWT objectives/standards appropriate as thresholds. 4. Effective control measures could be implemented quickly.
SW4. Dust levels do not affect palatability of vegetation to wildlife.	Monitoring evidence of postclosure wildlife use of area.		<ol style="list-style-type: none"> 1. Criteria should specifically consider feeding activity, in addition to general wildlife use. 2. Will require comparison of wildlife activity to similar habitat in unaffected areas. Will be difficult to establish causality². 3. None listed. 4. Effective control measures could be implemented quickly.
SW6. Ground surface designed to drain naturally follow predevelopment drainage patterns.	NCRP As-Built Report conforms adequately with Golder (2016)	Objective as stated is about the design, rather than the actual performance. Actual objective is likely for "ground surface to	<ol style="list-style-type: none"> 1. Criteria should be based on performance of the final landform, rather than whether the landform was consistent with the design. Does water drain as intended? Are proportions of runoff, recharge and evapotranspiration similar to natural areas? For example, criteria may consider proportion of post-closure area that has pre-development drainage patterns and unit runoff as compared with natural areas.

¹ Detailed review of SSRBCC Report completed by Arcadis identifies concerns about the selection of COPCs and methodology for development of criteria. SEC agrees with the findings of the Arcadis review and recommends that these issues be addressed in finalizing the specific criteria and thresholds.

² Criteria for objectives related to wildlife use and effects generally present challenges with respect to causality, measurement and thresholds. In some cases, the objectives themselves may be suitable criteria. A holistic monitoring approach will be required to develop an understanding of effects and conditions, and support development of appropriate responses if needed. -

Table 1: Closure Criteria – North Country Rock Pile

Closure Objective	Closure Criteria	Notes	Evaluation (1. Effective Indicators, 2. Measurable, 3. Thresholds, 4. Supports Timely Response)
		drain naturally, following predevelopment drainage patterns.”	<ol style="list-style-type: none"> Evaluating performance requires understanding of predevelopment drainage patterns, and observation of drainage patterns on final landform – both initially and over time. Thresholds could be established for some types of criteria, and could be used as design criteria. Addressing failures arising from landform design will be difficult if they require further re-grading. This will be observable within the first few years during post-construction inspections. Addressing episodic failures that result in post-closure changes in drainage patterns will likely be possible but expensive. These are most likely to occur after flood events.
SW7. Areas in and around the site that are undisturbed during operation of the mine should remain undisturbed during and after closure.	NCRP As-Built Report conforms adequately with Golder (2016)	NCRP Closure Design (Golder Associates, 2016) includes criterion “the final NCRP footprint is to be minimized.”	<ol style="list-style-type: none"> Criteria should be based on amount of additional area disturbed by closure activities. How much is considered acceptable to meet the stated objective – 0% increase, 10%, 20%? Design addresses the objective, but with no threshold. Also, criterion’s measure of “conforms adequately” is not tied to performance against the specific objective. As-built will confirm final performance. Thresholds could specify the maximum extent of additional disturbance which could be used to limit design modification during implementation. Must be addressed in initial design and implementation. Failure to meet the objective cannot be addressed later.
SW8. No increased opportunities for predation of caribou compared to pre-development conditions.	No monitoring evidence of recurring predation directly associated with an aspect of the NCRP.	Wildlife monitoring program to include caribou road surveys, caribou PKC and NCRP use, caribou management/ observation, and wildlife monitoring.	<ol style="list-style-type: none"> Indicator of “recurring predation” may be ineffective if caribou avoid the area due to increased risk of predation². “Recurring predation” difficult to monitor and measure. Difficult to establish causality. Difficult to establish measurable thresholds. Need for responses should be considered in combination with other wildlife related objectives.
SW9. Landscape features (topography and vegetation) that match aesthetics and natural conditions of the surrounding natural area.	NCRP As-Built Report conforms adequately with Golder (2016)	<p>NCRP Closure Design (Golder, 2016) does not include criteria related to matching aesthetics and natural conditions of surrounding area.</p> <p>Post-closure effects assessment identifies local, long-term changes for vegetation and terrain.</p>	<ol style="list-style-type: none"> Criteria should be based on performance of final landform, not on conformance of as-built with a design that does not specifically include consideration of this objective. Criteria could consider specifying range of slopes, shapes of features, heights of features, types of visible vegetation from important views and other aesthetic features. Comparison of conditions may be difficult to measure objectively. Thresholds may be narrative. Some objective thresholds may be developed based on characteristics of surrounding topography and vegetation. Achievement of objective should be addressed in initial design as both topography and vegetation will be difficult to address later.
SW10. Safe passage and use for caribou and other wildlife.	No repeated harm to caribou as a direct result of passage through or use of the NCRP. (i.e. if a feature of NCRP is confirmed as being a hazard based on	Wildlife monitoring program to include caribou road surveys, caribou PKC and	<ol style="list-style-type: none"> Indicator of “repeated harm” may be ineffective if caribou avoid the area due to increased risk of harm². “Repeated harm” difficult to monitor and measure. Difficult to establish causality. Difficult to establish measurable thresholds.

Table 1: Closure Criteria – North Country Rock Pile

Closure Objective	Closure Criteria	Notes	Evaluation (1. Effective Indicators, 2. Measurable, 3. Thresholds, 4. Supports Timely Response)
	more than one incident then objective is not met for that feature)	NCRP use, caribou management/ observation, and wildlife monitoring.	4. Need for responses should be considered in combination with other wildlife related objectives.
Waste Rock and Till Area Objectives			
W1. Physically stable slopes to limit risk of failure that would impact the safety of people or wildlife	NCRP As-Built Report conforms adequately with Golder (2016). Final Geotechnical Inspection by Engineer of Record	NCRP Closure Design (Golder Associates, 2016) includes criterion “The final NCRP closure configuration is to meet or exceed minimum design criteria for Factors of Safety for rock pile stability (described in Table 2).”	<ol style="list-style-type: none"> Criteria should be based on performance of the final slopes, rather than whether the landform was consistent with the design. The design is intended to achieve stable slopes, but its effectiveness is only confirmed by actual performance. Physical stability design criteria (e.g., Factors of Safety, design seismic events) could be used as criteria. Post construction performance criteria should likely be defined, for example slope movement, settlement or erosion rates. Where slopes are expected to develop permafrost, thermal criteria may be warranted. Performance of slopes is observable, but may change over time. Instrumentation will likely be required for some slopes and facilities. A “final geotechnical inspection” following construction only provides a one-time observation. Confirmation of performance will require a geotechnical observation program, for which the frequency may diminish over time based on continued satisfactory performance. In most cases, significant changes or failures are likely to occur within the five years. Provided performance over the initial observational period is consistent with expectations, future failures would likely be a result of climatic or seismic events. Thresholds likely to be based on recommendations arising from inspections. Level of effort and time required to address failures will depend on the types of failures.
W2. Rock and till pile features (shape and appearance) that match aesthetics of the surrounding natural area	NCRP As-Built Report conforms adequately with Golder (2016)	See notes re: SW9.	See evaluation re: SW9.
W3. Contaminated soils and waste disposal areas that cannot contaminate land and water	NCRP As-Built Report conforms adequately with Golder (2016)	NCRP Closure Design (Golder Associates, 2016) does not appear to address contaminated soils and waste disposal areas.	<ol style="list-style-type: none"> Proposed criterion of “As-Built Report conforms adequately” to the NCRP Closure Design appears unrelated to the objective. The objective may not be relevant to the NCRP closure. If it is relevant, further development of appropriate criteria is required. If relevant, criteria should likely be based on numerical standards for contaminant concentrations. No further comments. No further comments. No further comments.

Table 2: Closure Criteria – Interim Closure and Reclamation Plan, Version 3.2

Closure Objective	Closure Criteria	Notes	Evaluation (1. Effective Indicators, 2. Measurable, 3. Thresholds, 4. Supports Timely Response)
Site Wide Objectives			
SW1. Surface runoff and seepage water quality that is safe for humans and wildlife.	Human- Table V-7 (in Appendix V in DDMI, 2011) drinking water criteria or site-specific risk-based criteria met. Wildlife – Site-specific risk-based criteria met.	Table V-7 lists closure water quality criteria for drinking water, but no information is provided about source or rationale for the numbers. Criteria are provided for more contaminants than those provided for the NCRP – based on the SSRBCC (ERM, 2016).	<ol style="list-style-type: none"> 1. Contaminant concentrations in water are effective indicators. Criteria listed for a range of metals and ions³. 2. Measurable. 3. Thresholds established³. 4. AMP required to define responses before thresholds are reached.
SW2 Surface runoff and seepage water quality that will not cause adverse effects on aquatic life or water uses in Lac de Gras or the Coppermine River.	Table V-7 (in Appendix V in DDMI, 2011) water entering LDG criteria or site-specific risk-based criteria met.	<p>Table V-7 lists closure water quality criteria for water entering LDG. Thresholds are based on:</p> <ul style="list-style-type: none"> • Effluent quality criteria defined through effects-based or BATT (Best Available Treatment Technologies)-based analysis completed in 2000⁴, or • Water licence standards. 	<ol style="list-style-type: none"> 1. Contaminant concentrations in water are effective primary indicators. Some criteria may be based on BATT rather than potential effects. All should be updated to address SSRBCC Report⁵. Criteria for environmental effects on aquatic life (with supporting monitoring) should also be considered. 2. Measurable. 3. No information provided to demonstrate that meeting MMER standards in effluent discharge will achieve SSRBCC⁵ in Lac de Gras. 4. AMP required to define responses before thresholds are reached.
SW3. Dust levels safe for people, vegetation, aquatic life, and wildlife.	Mean TSP concentrations less than 60 ug/m3 annual and 120 ug/m3 24 hr maximum acceptable (Canadian Ambient Air Quality Objectives and NWT Ambient Air Quality Standards).		<ol style="list-style-type: none"> 1. TSP concentrations in air are effective indicators. Criteria for PM_{2.5} should also be considered as PM_{2.5} is more relevant to human health. 2. Measurable. 3. Use of Canadian and NWT objectives/standards appropriate as thresholds. 4. Effective control measures could be implemented quickly.
SW4. Dust levels do not affect palatability of vegetation to wildlife.	Monitoring evidence of postclosure wildlife use of area.		<ol style="list-style-type: none"> 1. Criteria should specifically consider feeding activity, in addition to general wildlife use. 2. Will require comparison of wildlife activity to similar habitat in unaffected areas. Will be difficult to establish causality⁶. 3. No threshold listed. 4. Effective control measures could be implemented quickly.

³ Methodology for selection of COPCs not provided or reviewed. Adequacy of specific numerical thresholds not reviewed.

⁴ “Comparison of Effects-Based EQCs to BATT-Based EQCs” not reviewed.

⁵ Detailed review of SSRBCC Report completed by Arcadis identifies concerns about the selection of COPCs and methodology for development of criteria. SEC agrees with the findings of the Arcadis review and recommends that these issues be addressed in finalizing the specific criteria and thresholds.

⁶ Criteria for objectives related to wildlife use and effects generally present challenges with respect to causality, measurement and thresholds. In some cases, the objectives themselves may be suitable criteria. A holistic monitoring approach will be required to develop an understanding of effects and conditions, and support development of appropriate responses if needed.

Table 2: Closure Criteria – Interim Closure and Reclamation Plan, Version 3.2

Closure Objective	Closure Criteria	Notes	Evaluation (1. Effective Indicators, 2. Measurable, 3. Thresholds, 4. Supports Timely Response)
SW5. Re-vegetation targeted to priority areas.	<ul style="list-style-type: none"> Final re-vegetation procedures applied to priority areas as established with communities and approved by WLWB. Change in biodiversity (richness and diversity units) of Regional Study Area less than 1%. 	Stated objective appears to be a selected closure option where re-vegetation will be targeted to priority areas. Assume objective should likely be “effective re-vegetation” in those areas.	<ol style="list-style-type: none"> Indicators of biodiversity can be effective indicators. Indicators of vegetation density and productivity should also be considered. Indicators are measurable. Monitoring will be required for a lengthy period to evaluate performance. Threshold will be related to the actual areas subject to re-vegetation as compared to the size of the Regional Study Area. Change in biodiversity of 1% in RSA may not be achievable if large areas are not re-vegetated. Further re-vegetation can be completed if performance is not satisfactory.
SW6. Ground surface designed to drain naturally follow predevelopment drainage patterns.	<ul style="list-style-type: none"> Pre-development drainage channels re-established at Ponds 1,2, 3, 4, 5, 7, 10, 11, 12, and 13. Satisfactory final inspection of drainage construction by a professional engineer. 	Objective as stated is about the design, rather than the actual performance. Actual objective is likely for “ground surface to drain naturally, following predevelopment drainage patterns.”	<ol style="list-style-type: none"> First criterion defines locations where natural drainage is to be re-established – defining what needs to be incorporated into the design. SEC assumes that other areas are not included due to physical constraints arising from mining activities. Second criterion should be specifically based on performance of the final landform with respect to drainage patterns. Does water drain as intended in the areas that were listed in the first criterion? Are proportions of runoff, recharge and evapotranspiration similar to natural areas? Performance of drainage patterns is observable, but may change over time. A “final inspection” following construction only provides a one-time observation. Confirmation of performance will require a geotechnical observation program, for which the frequency may diminish over time based on continued satisfactory performance. In some cases, instrumentation may be required. Thresholds established as specific locations in first criterion, defining the level of expectations. Addressing failure arising from landform design will be difficult if they require further re-grading. This will be observable within the first few years during post-construction inspections. Addressing episodic failures that result in post-closure changes will likely be possible but expensive. These are most likely to occur after flood events.
SW7. Areas in and around the site that are undisturbed during operation of the mine should remain undisturbed during and after closure.	Mine footprint area less than 13 km ² post-closure. (Footprint is the directly disturbed area as used in the Wildlife Effects Monitoring Program for direct habitat/vegetation loss.)		<ol style="list-style-type: none"> Criterion is clear. Indicator is measurable. Threshold established. Must be addressed in initial design and implementation. Failure to meet the objective cannot be addressed later.
SW8. No increased opportunities for predation of caribou compared to pre-development conditions.	Caribou predation directly attributable to a landscape feature unique to this area does not result in increased overall predation on the herd.	Wildlife monitoring program to include caribou road surveys, caribou PKC and NCRP use, caribou management/ observation, and wildlife monitoring.	<ol style="list-style-type: none"> Indicator of “predation directly attributable to a landscape feature” may be ineffective if caribou avoid the area due to increased risk of predation⁶. “Predation directly attributable to a landscape feature” difficult to monitor and measure. Difficult to establish causality. Difficult to establish measurable thresholds. Need for responses should be considered in combination with other wildlife related objectives.

Table 2: Closure Criteria – Interim Closure and Reclamation Plan, Version 3.2

Closure Objective	Closure Criteria	Notes	Evaluation (1. Effective Indicators, 2. Measurable, 3. Thresholds, 4. Supports Timely Response)
SW9. Landscape features (topography and vegetation) that match aesthetics and natural conditions of the surrounding natural area.	<ul style="list-style-type: none"> • Surface of scarified native material (rock or till) • Mine footprint area less than 13 km² post-closure • Final re-vegetation procedures applied in priority areas • Change in biodiversity (richness and diversity units) of Regional Study Area less than 1% • No surface visible buildings, equipment or non-local materials 		<ol style="list-style-type: none"> 1. Additional criteria defined by characteristics of surrounding natural areas should be considered. Surface of scarified native materials is an appropriate criterion if this is typical of the surrounding area. Mine footprint size does not address the need for areas within the footprint to match the surrounding area. Re-vegetation in priority areas is only relevant if matching surrounding areas is the driver for setting priorities. Criterion re: change in biodiversity of RSA is likely relevant. Criterion re: visibility of non-local materials is relevant. 2. Comparison of conditions may be difficult to measure objectively for some relevant criteria. 3. Thresholds may be narrative. Some objective thresholds may be developed based on characteristics of surrounding topography and vegetation. 4. Achievement of objective should be addressed in initial design as both topography and vegetation will be difficult to address later.
SW10. Safe passage and use for caribou and other wildlife.	No repeated harm to caribou as a direct result of passage through or use of the area. (i.e. if a feature/area is confirmed as being a hazard based on more than one incident then objective is not met for that feature area)	Wildlife monitoring program to include caribou road surveys, caribou PKC and NCRP use, caribou management/ observation, and wildlife monitoring.	<ol style="list-style-type: none"> 1. Indicator of “repeated harm” may be ineffective if caribou avoid the area due to increased risk of harm⁶. 2. “Repeated harm” difficult to monitor and measure. Difficult to establish causality. 3. Difficult to establish measurable thresholds. 4. Need for responses should be considered in combination with other wildlife related objectives.
SW11. Mine areas are physically stable and safe for use by people and wildlife.	Satisfactory final inspection by a professional engineer		<ol style="list-style-type: none"> 1. Criteria should specifically reference the performance of physical stability attributes. The design is intended to achieve physical stability, but its effectiveness is only confirmed by actual performance. Physical stability design criteria (e.g., Factors of Safety, design seismic events) could be used as criteria. Post construction performance criteria should likely be defined, for example slope movement, settlement or erosion rates. Where slopes are expected to develop permafrost, thermal criteria may be warranted. 2. Performance of physical stability is observable, but may change over time. Instrumentation will likely be required for some slopes and facilities. A “final inspection” following construction only provides a one-time observation. Confirmation of performance will require a geotechnical observation program, for which the frequency may diminish over time based on continued satisfactory performance. In most cases, significant changes or failures are likely to occur within the five years. Provided performance over the initial observational period is consistent with expectations, future failures would likely be a result of climatic or seismic events. 3. Thresholds likely to be based on recommendations arising from inspections. 4. Level of effort and time required to address failures will depend on the types of failures.
Open Pit, Underground and Dike Areas Objectives			

Table 2: Closure Criteria – Interim Closure and Reclamation Plan, Version 3.2

Closure Objective	Closure Criteria	Notes	Evaluation (1. Effective Indicators, 2. Measurable, 3. Thresholds, 4. Supports Timely Response)
M1. Water quality in the flooded pit and dike area that is similar to Lac de Gras or at a minimum protective of aquatic life.	Table V-7 (in Appendix V in DDMI, 2011) aquatic life and drinking water criteria or site-specific risk-based criteria met.	Table V-7 lists closure water quality criteria for aquatic life and drinking water, but no information is provided about source or rationale for the numbers. Criteria are provided for more contaminants than those provided for the NCRP which are based on the SSRBCC (ERM, 2016).	<ol style="list-style-type: none"> 1. Contaminant concentrations in water are effective indicators. Criteria listed for a range of metals and ions⁷. Criteria for environmental effects on aquatic life (with supporting monitoring) should also be considered. 2. Measurable. 3. Thresholds established⁷. 4. AMP required to define responses before thresholds are reached.
M2. Pit and dike closure do not have adverse effects on aquatic life or water uses in Lac de Gras, the Coppermine River or on groundwater use.	Water license discharge criteria (EQC) or site-specific risk-based criteria met.	Basis for water licence discharge standards not reviewed.	<ol style="list-style-type: none"> 1. Contaminant concentrations in water are effective indicators. Criteria listed for a range of metals and ions⁷. Criteria for environmental effects on aquatic life (with supporting monitoring) should also be considered. 2. Measurable. 3. Thresholds established⁷. 4. AMP required to define responses before thresholds are reached.
M3. Enhanced lake-wide fish habitat to off-set fish habitat temporarily lost during operations.	Ratio of fish habitat units gained to fish habitat units lost of 1.2:1 or better as per Fisheries Authorization.		<ol style="list-style-type: none"> 1. Criterion is clear. 2. Indicator is measurable. 3. Threshold established. 4. Response possible based on monitoring results.
M4. Safe small craft navigation through dike and pit area.	Breaks in dikes to be a minimum of 30 m wide by 2 m deep as per Transport Canada approval.		<ol style="list-style-type: none"> 1. Criterion is clear. 2. Indicator is measurable. 3. Threshold established. 4. Response likely not required.
M5. Physically stable pit walls and shorelines to limit risk of a failure impacting people, aquatic life or wildlife.	Satisfactory final inspection by a professional engineer.		<ol style="list-style-type: none"> 1. Criteria should specifically reference physical stability attributes. The design is intended to achieve physical stability, but its effectiveness is only confirmed by actual performance. Physical stability design criteria (e.g., Factors of Safety, design seismic events) could be used as criteria. Post construction performance criteria should likely be defined, for example slope movement rates or pit wall ravelling rates. 2. Performance of physical stability is observable, but may change over time. Instrumentation will likely be required for to support observation of pit wall stability. A “final inspection” following construction only provides a one-time observation but pit walls will likely continue to change for many years. Confirmation of performance will require a geotechnical observation program, for which the frequency may diminish over time based on continued satisfactory performance. In most cases, significant

⁷ Methodology for selection of COPCs not provided or reviewed. Adequacy of specific numerical thresholds not reviewed.

Table 2: Closure Criteria – Interim Closure and Reclamation Plan, Version 3.2

Closure Objective	Closure Criteria	Notes	Evaluation (1. Effective Indicators, 2. Measurable, 3. Thresholds, 4. Supports Timely Response)
			<p>changes or failures are likely to occur within the five to ten years, but may occur later due to seismic events</p> <p>3. Thresholds likely to be based on recommendations arising from inspections.</p> <p>4. Level of effort and time required to address failures will depend on the types of failures.</p>
M6. Pit fill rate that will not cause adverse effects on water levels in Lac de Gras and Coppermine River.	Water levels in Lac de Gras remain above 415 m elevation to ensure Lac de Gras and Coppermine River remain within natural fluctuations.		<p>1. Criterion does not address seasonal variability under natural conditions. If seasonal water levels and flows are important, criterion should be revised to address seasonality, for example minimum water levels specified at specific times of the year.</p> <p>2. Measurable.</p> <p>3. Threshold established.</p> <p>4. Timely response possible by changing rate of pit filling.</p>
M7. Pit fill rate that will not cause adverse effects on fish or fish habitat in Lac de Gras and Coppermine River.	Water levels in Lac de Gras remain above 415 m elevation to ensure Lac de Gras and Coppermine River remain within natural fluctuations.		<p>1. Criterion does not directly address fish habitat or fish, inherently assuming that water levels are the only indicator for these values. Direct indicators for fish and fish habitat may warrant consideration.</p> <p>2. Measurable.</p> <p>3. Threshold established.</p> <p>4. Timely response possible by changing rate of pit filling.</p>
M8. Wildlife safe during filling of pits.	No mortalities of wildlife VEC caused by filling of pits.		<p>1. Relevant criterion.</p> <p>2. May be difficult to measure, depending on monitoring program and frequency of observations.</p> <p>3. Threshold established.</p> <p>4. Effectiveness and timeliness of responses will depend on causes of mortality.</p>
Processed Kimberlite Containment Area Objectives			
P1. No adverse effects on people, wildlife or vegetation.	<p>Human – Table V-8 criteria or site-specific risk-based criteria met.</p> <p>Wildlife – Site-specific risk-based criteria met.</p>	Table V-8 not included in Appendix V of the ICRP Version 3.2.	<p>1. Contaminant concentrations are effective indicators. Criteria listed for all COPCs identified in SSRBCC Report⁵.</p> <p>2. Measurable.</p> <p>3. In accordance with SSRBCC Report⁵.</p> <p>4. AMP required to define responses before thresholds are reached.</p>
P2. Physically stable processed kimberlite containment area to limit risk of a failure that would affect safety of people or wildlife.	Satisfactory final inspection by a professional engineer.		<p>1. Criteria should specifically reference physical stability attributes. The design is intended to achieve physical stability, but its effectiveness is only confirmed by actual performance. Physical stability design criteria (e.g., Factors of Safety, design seismic events) could be used as criteria. Post construction performance criteria should likely be defined, for example slope movement, settlement or erosion rates. Where slopes or facilities are expected to develop permafrost, thermal criteria may be warranted. For the PKC, criteria may be warranted in relation to phreatic surface or consolidation of PK.</p>

Table 2: Closure Criteria – Interim Closure and Reclamation Plan, Version 3.2

Closure Objective	Closure Criteria	Notes	Evaluation (1. Effective Indicators, 2. Measurable, 3. Thresholds, 4. Supports Timely Response)
			<ol style="list-style-type: none"> 2. Performance of physical stability is observable, but may change over time. Instrumentation will likely be required for the PKC to confirm performance of embankments for both physical stability and thermal behaviour. A “final inspection” following construction only provides a one-time observation. Confirmation of performance will require a geotechnical observation program, for which the frequency may diminish over time based on continued satisfactory performance. Some performance aspects of the PKC may be related to consolidation of PK, which could take many decades. Continued observation of performance will be required as long as consolidation continues to affect the facility. Once the facility has reached a stable, steady state, future failures would likely be a result of climatic or seismic events. 3. Thresholds likely to be based on recommendations arising from inspections. 4. Level of effort and time required to address failures will depend on the types of failures.
<p>P3. Prevent processed kimberlite from entering the surrounding terrestrial and aquatic environments</p>	<ul style="list-style-type: none"> • Erosion protection placed over PK material • Filter drain constructed. • Satisfactory final inspection of erosion protection and filter drain construction by a professional engineer. 		<ol style="list-style-type: none"> 1. Criteria for placement of erosion protection and filter drain are practical and can be confirmed by inspections conducted by engineer. Inspection by engineer is not a criterion. Criteria to evaluate actual performance of erosion protection and filter drain in preventing kimberlite migration should be developed. These may be criterion related to sediment transport, water quality or erosion rates. 2. Performance of design measures is observable, but may change over time. A “final inspection” following construction only provides a one-time observation. Confirmation of performance will require a geotechnical observation program, for which the frequency may diminish over time based on continued satisfactory performance. Effectiveness of PK containment measures should be observable within the first few years after construction. Once satisfactory, stable conditions are reached, exceedances of criteria would likely be related to climatic events. 3. Thresholds likely to be based on recommendations arising from inspections. 4. Level of effort and time required to address failures will depend on the types of failures.
North Inlet Area Objectives			
<p>NI1. Reconnect the North Inlet with Lac de Gras</p>	<p>North Inlet east dam deconstructed to leave a minimum 30 m wide by 2 m depth of water opening.</p>		<ol style="list-style-type: none"> 1. Criterion is clear. 2. Indicator is measurable. 3. Threshold established. 4. Response likely not required.
<p>NI2. Water quality and sediment quality in the North Inlet that is safe for aquatic life, wildlife and people.</p>	<p>Water and sediment quality that meets site-specific risk-based criteria for water and sediment.</p>		<ol style="list-style-type: none"> 1. Contaminant concentrations are effective indicators. Criteria listed for all COPCs identified in SSRBCC Report⁵. 2. Measurable. 3. In accordance with SSRBCC Report⁵. 4. AMP required to define responses before thresholds are reached.

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Closure Objective	Closure Criteria	Notes	Evaluation (1. Effective Indicators, 2. Measurable, 3. Thresholds, 4. Supports Timely Response)
NI3. Suitable fish habitat in the North Inlet.	Water and sediment quality that meets site-specific risk-based criteria for water and sediment.		<ol style="list-style-type: none"> 1. Water and sediment quality are effective indicators, but the criterion does not directly address fish habitat, inherently assuming that water and sediment quality are the only relevant indicators of fish habitat. Direct indicators for fish habitat may warrant consideration, for example criteria related to habitat suitability, or presence of healthy benthic communities. 2. Measurable. 3. In accordance with SSRBCC Report⁵. 4. AMP required to define responses before thresholds are reached.
NI4. Water quality in the North Inlet that is as similar to Lac de Gras as possible.	Monitoring results indicate that drawing more Lac de Gras water into the North Inlet and treating and releasing more North Inlet water will not significantly improve water quality.		<ol style="list-style-type: none"> 1. Criterion would benefit from clarification of “significantly improve water quality.” If not already decided, it may be useful to provide criteria related to the level of treatment effort (e.g., rates, type of treatment) that will be applied. 2. Measurable. 3. Threshold of “significantly improve water quality” does not provide clear guidance about acceptable conditions for ceasing treatment. Is it possible to define a rate of change, for example percent reduction in certain COPCs over a period of time? 4. Timely response is possible.
NI5. Water and sediment quality in the North Inlet that will not cause adverse effects on aquatic life or water uses in Lac de Gras or the Coppermine River.	Water and sediment quality that meets site-specific risk-based criteria for water and sediment.	Assume water and sediment criteria established in accordance with SSRBCC Reports.	<ol style="list-style-type: none"> 1. Contaminant concentrations in water and sediment are effective primary indicators. Criteria for environmental effects on aquatic life (with supporting monitoring) should also be considered, for example evaluation of contaminant concentrations in benthic invertebrates. 2. Measurable. 3. Thresholds can be established. 4. AMP required to define responses before thresholds are reached.
NI6. Physically stable banks of the North Inlet to limit risk of failure that would impact the safety of people or wildlife.	Satisfactory final inspection by a professional engineer.		<ol style="list-style-type: none"> 1. Criteria should specifically reference physical stability attributes. The design is intended to achieve physical stability, but its effectiveness is only confirmed by actual performance. Post construction performance criteria should likely be defined, for example slope movement, subsidence or erosion rates. 2. Performance of physical stability is observable, but may change over time. Instrumentation will likely be required for to help measure erosion or subsidence rates. A “final inspection” following construction only provides a one-time observation. Confirmation of performance will require a geotechnical observation program, for which the frequency may diminish over time based on continued satisfactory performance. In most cases, significant changes or failures are likely to occur within the five years. Provided performance over the initial observational period is consistent with expectations, future failures would likely be a result of climatic or seismic events. 3. Thresholds likely to be based on recommendations arising from inspections. 4. Level of effort and time required to address failures will depend on the types of failures.

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Closure Objective	Closure Criteria	Notes	Evaluation (1. Effective Indicators, 2. Measurable, 3. Thresholds, 4. Supports Timely Response)
Mine Infrastructure Areas			
I1. Opportunities for communities to re-use infrastructure, allowable under regulation, and where liability is not a significant concern.	Conditions of Socio-Economic Monitoring Agreement and Participation Agreements met.		No comments provided. SEC did not review conditions of Socio-Economic Monitoring Agreement and Participation Agreements.
I2. On-site disposal areas are safe for people, wildlife and vegetation.	CCME contaminated sites guidelines or site-specific risk-based criteria are met.	Assume criteria established in accordance with either CCME or SSRBCC Reports.	<ol style="list-style-type: none"> 1. Contaminant concentrations are effective indicators with respect to COPCs. Criteria should be considered to address other aspects of on-site disposal areas, e.g., physical stability and safety. 2. Measurable. 3. Thresholds can be established. 4. Level of effort and time required to address failures will depend on the types of failures.
I3. Prevent remaining infrastructure from contaminating land or water.	CCME contaminated sites guidelines or site-specific risk-based criteria are met.	Assume criteria established in accordance with either CCME or SSRBCC Reports.	<ol style="list-style-type: none"> 1. Contaminant concentrations are effective indicators with respect to COPCs. 2. Measurable. 3. Thresholds can be established. 4. Level of effort and time required to address failures will depend on the types of failures.

7.0 **References**

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