Minto Mine

Operations Adaptive Management Plan

2016-01

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Minto Mine
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Minto Mine Operations Adaptive Management Plan

First Issue: June 2014
Revision History

Revision Number	Issue Date	Description and Revisions Made
2014-01	June 2014	First Issue
2015-01	December 2015	Revisions made as per requirements of WUL QZ14-031 and QML-0001
2016-01	May 2016	Revisions made as per AMP comments from the Yukon Government, Selkirk First Nation and QML-0001 conditions

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1 Introduction

1.1 Overview

Minto Explorations Ltd. (Minto), a wholly owned subsidiary of Capstone Mining Corp. (Capstone), owns and operates the Minto copper mine. Minto Mine is located within Selkirk First Nation (SFN) Category-A Settlement Land (Parcel R-6A), and is approximately 240 km northwest of Whitehorse, Yukon Territory. The Minto mine commenced commercial operations in October 2007.

The Yukon Government's Decision Document (Yukon Government, 2014) following the YESAA review of Minto's Phase V/VI project proposal (file # 2013-0100, (Minto Explorations Ltd., 2013)) required an Adaptive Management Plan (AMP) for the mine operations. As an outcome of the Phase V/VI mine licensing processes, Minto is required to update the AMP with additional information outlined in its Quartz Mining License QML-0001 (QML) and Water Licence QZ14-031 (WL).

AMPs are tools used to address uncertainty or conditions beyond those anticipated in mining operations. AMPs outline a range of possible but unexpected outcomes and the responses that will be undertaken to curb possible negative impacts associated with these unexpected situations.

Mining activities are highly managed operations, with very prescriptive and detailed management plans required for both operational control and regulatory approval. More mature mines such as Minto have management plans which benefit from the operational experience at the site, and uncertainty in the range of conditions expected is reduced through this operational experience.

Minto has developed a number of operational management plans which describe the management and response actions for expected conditions at the site. These plans currently include:

- Solid Waste Management Plan;
- Environmental Monitoring, Surveillance, Reporting Plan;
- Wildlife Protection Plan;
- Spill Contingency Plan;
- Sediment and Erosion Control Plan;
- Mine Development and Operations Plan;
- Underground Mine Development and Operations Plan;
- Mill Operations Plan;
- Water Management Plan;
- Tailings Management Plan;
- Waste Rock and Overburden Management Plan;
- Emergency Response Plan;
- Heritage Resources Protection Plan; and

- Reclamation and Closure Plan

This AMP is intended to provide a framework for responses to conditions beyond those expected and identified in these decision-based management plans. Consequently, this AMP addresses a limited range of components.

1.2 Adaptive Management Planning

Adaptive management is an approach to environmental management that is appropriate when a mitigation measure may not function as intended or when broad-scale environmental change is possible. Adaptive management plans are precautionary in nature, and provide a level of security in long term environmental planning. Adaptive management plans also allow for the inclusion of improved science into mitigation measures as they are continually revised.

Adaptive management has been evolving since its emergence in the 1970s. Adaptive approaches include an ability to incorporate knowledge into the management plan as the knowledge is gleaned and circumstances change. Eberhard et al. (Eberhard, et al., 2009) described the categories of knowledge that may trigger changes to water quality management plans; system understanding, measuring progress and anticipating changes. These categories allow for the inclusion of knowledge and adaptation of management to changed conditions. Embedding adaptation into environmental plans involves thinking about how the results of monitoring will change management actions. Adaptive management plans are a way to accept uncertainties and build a structured framework to respond to changing conditions.

Adaptive management conducts a flexible path with actions to take when specific triggers occur. AMPs are a formalization of a plan for performance monitoring and project re-evaluation in the future. The general structure of adaptive management can be described by the following steps:

1. Identify risk triggers associated with vulnerabilities or uncertainties;
2. Quantify impacts and uncertainties;
3. Evaluate strategies and define implementation path that allows for multiple options at specific triggers;
4. Monitor the performance and critical variables in the system; and
5. Implement or re-evaluate strategies when triggers are reached.

Although there are no widely used AMP terms, the steps listed above are representative of typical AMP processes. Within AMPs, triggers provide decision points in a stepwise decision-making framework that identifies how and when management action should be taken. A key characteristic of adaptive management is monitoring, which is used to advance scientific understanding and to adjust management policies in an iterative process. Adaptive management is a rigorous method for addressing uncertainties in ecosystem management.

1.3 Adaptive Management Plan Objectives

An AMP is a management tool wherein a framework is provided to make quick and effective decisions to guide responses to unforeseen events. This document identifies areas of uncertainty within the operational phase of the Minto Mine life and provides an AMP framework for each. For each component the AMP describes monitoring commitments, thresholds, triggers and responses to underperforming elements or emerging risks within the

component. The steps laid out in the AMP framework are precautionary, and therefore they provide the confidence that action will be taken before adverse environmental impacts are observed.

Response planning, and results for anticipated events are contained within site management plans while AMPs guide responses to unforeseen or contingency events. This AMP provides a framework to guide responses to unanticipated monitoring results and to potential but low probability events where uncertainty exists.

It is difficult to predict the specific environmental condition that may arise which requires a response from management and, therefore, the AMP does not provide specific detailed descriptions of responses to a situation. The AMP provides a range of possible responses to use as a guide to respond to specific environmental conditions encountered. Management should use the information provided in the AMP and undertake the appropriate response.

1.3.1 Updated AMP Objectives

This 2016 version of the AMP has been updated to include the requirements of the QML and WL.

The QML was issued December 18, 2014 and was accompanied by a letter entitled outlining the components required in an Adaptive Management Plan (Yukon Government - Energy, Mines and Resources, 2014). The AMP includes the requirements outlined in the letter with the exception of Cover Systems, as they are more appropriately addressed in the Closure Adaptive Management Plan which forms part of the Reclamation and Closure Plan. Additionally, two conditions have been adopted into this plan as part of the March 2nd, 2016 EMR approval of the AMP.

The WL was issued August 5, 2015 and the requirements for the AMP are outlined in clause 109 (Yukon Water Board, 2015).

Clause 109 details and the sections in the AMP where these are addressed are summarized in Table 1-1.

Table 1-1: QZ14-031 Concordance table

109) The Licensee shall submit to the Board for Review and Approval an updated Operational Adaptive Management Plan. This plan shall be submitted by December 18, 2015, and shall be implemented once approved. The updated plan shall include, without limitation:	Section addressed
a) a surface water quality Adaptive Management Plan for McGinty Creek;	2.2
b) groundwater quality Adaptive Management Plans, including establishment of thresholds, for the Minto Creek and McGinty Creek watersheds;	2.3, 2.4
c) freeboard thresholds for each water storage facility;	2.5
d) WQOs, as stated in clause 8; (note: Clause 8 is presumed to be incorrect reference, and therefore W2 WQOs from licence have been included)	2.1
e) specifications for Monthly Reports that will include, but not be limited to the activities carried out under the Adaptive Management Plan, and	3.1
f) specifications for the Annual Report to include but not be limited to: i. activities undertaken in relation to the Adaptive Management Plan; ii. trend analysis and water levels in Minto and McGinty creeks; iii. proposed updates and revisions to the Adaptive Management Plan, and iv. any other revisions	3.1, 3.2

1.4 Adaptive Management Plan Approach

In addition to the conclusions drawn from research, the approach presented in this AMP follows the Environmental Code of Practice for Metal Mines, Section 4.1.17 on Adaptive Management:

"Mine owners/operators should use adaptive management methods to revise and refine the environmental management strategy. Adaptive management should consider a wide range of factors, including:

- The results of environmental audits or other evaluation activities;
- The results of environmental monitoring;
- The results of monitoring of the performance or condition of environmental infrastructure, such as containment structures, water management systems or treatment facilities;
- Technological developments; and
- Changing environmental conditions." (Environment Canada, 2009)

In addition to the guidance provided by the Environmental Code of Practice for Metal Mines, the AMP serves to meet the Yukon Government's Decision Document following the YESAA review of Minto's Phase V/VI project proposal which identifies some areas that an AMP for operations should be prepared to address including "*water quality, physical stability, covers, water treatment, and water management;".* Though some covers are anticipated to be placed as part of progressive reclamation, they are not an operational feature and therefore have not been included in this AMP.

1.4.1 AMP Components

The following AMP components have been identified as having the potential for unexpected conditions during the operational period for which the Operational Management Plans may not provide adequate mitigation against potential effects to the environment or human health and safety:

- Surface water quality;
- Groundwater quality;
- Water Management, and
- Physical Stability

The specific AMP framework for these components is described in subsequent sections.

1.4.2 AMP Framework

The AMPs for each component are laid out using a common element approach to create consistency in implementation of the AMP protocol for all components as illustrated in Figure 1-1. The common elements are:

1. Description of the component
   - *Description* - description and understanding of the component leads to risk narrative and specific performance thresholds.
   - *Risk Narrative* describe the possible environmental impacts and environmental conditions that implementation of the AMP will prevent.
2. Monitoring the component

- *Specific Indicators* are the environmental or physical parameters to be monitored and assessed. Specific indicators are measurable or observable, and are indicative of changes from the designed or expected condition.
- *Monitoring Requirements* describes the monitoring regime for the component including frequency, type of data required and interpretation of results.
- *Specific Performance Thresholds* define the conditions, in terms of specific indicators, when action is triggered. Performance thresholds are staged to accommodate levels of concern and a diversity of actions. To the extent possible, specific performance thresholds will include early warning thresholds.

3. Responding to unexpected conditions of the component

   Specific Responses are staged according to specific performance thresholds describes the actions to be implemented if specific performance thresholds are crossed. They are provided in the following categories:

   a) Notification

   b) Review

   c) Evaluation

   d) Action

4. Annual Reporting and Review

   Annual Reporting reflects annual changes made to the AMP as the site conditions change. The AMP should be modified whenever unexpected circumstances are encountered and the protocol is implemented or when additional proven science or technology becomes available. The annual review will include a review of the relevant monitored data and AMP elements. Updates, amendments, performance thresholds crossed, and trigger(s) activated will be provided to the appropriate governmental (including SFN) organizations as required and will be part of the annual report.

   Additional reporting is described further in section 3.

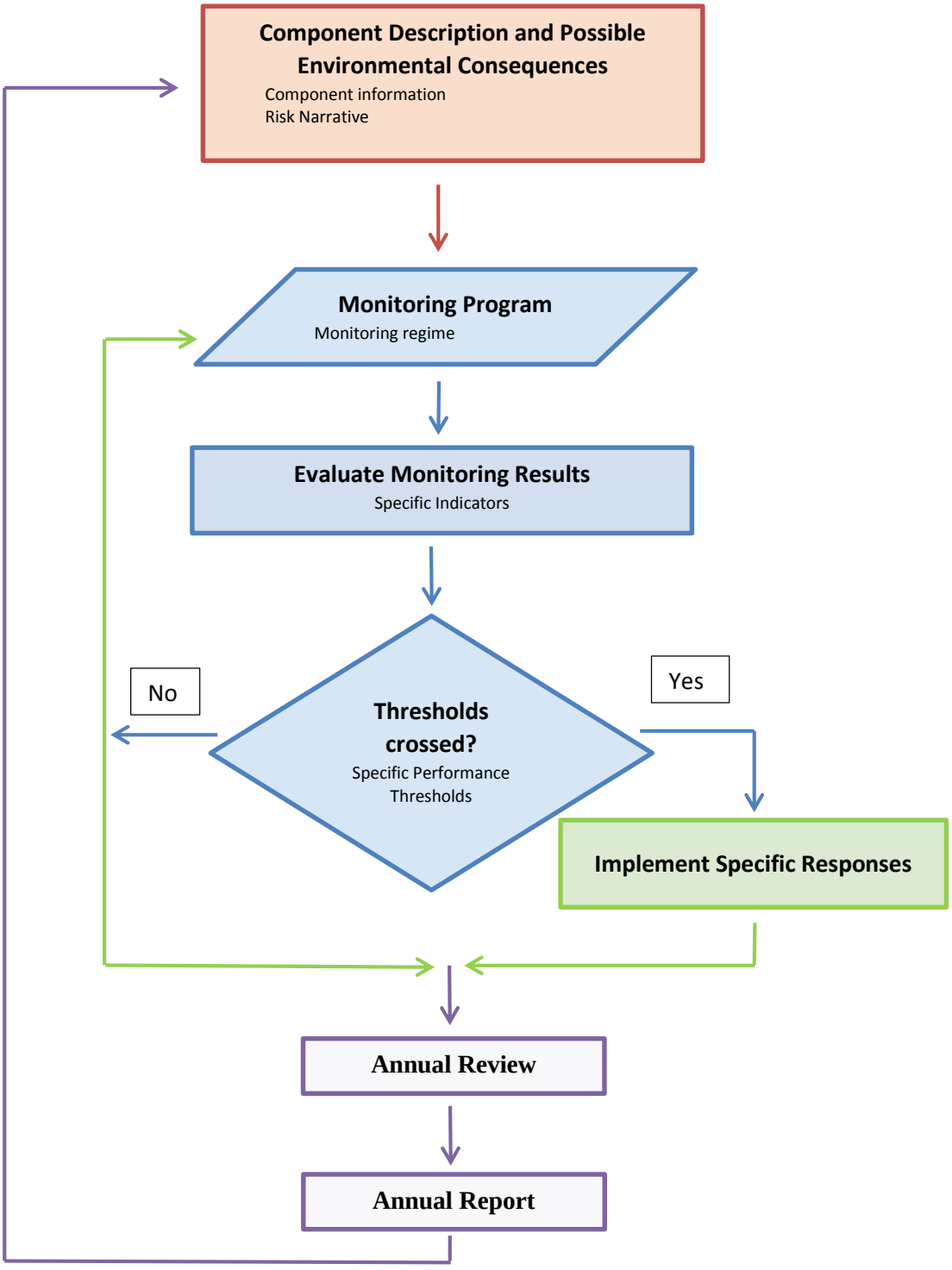

Figure 1-1: Sequential Components of the AMP (Adapted from AECOM 2010)

2 Adaptive Management Plans for Mine Components

2.1 Minto Creek Surface Water Quality

2.1.1 Description

Station W50 is considered the main control point on Minto Creek. It is also the last surface monitoring point on the mine site property and is considered a discharge compliance point under the current water licence. Additional key surface water monitoring locations upgradient of W50 and within the mine footprint are located at W16, W17, W15, W35, and W37.

As described in the Water Management Plan (Minto Explorations Ltd., 2015), Minto maintains substantial flexibility over the control and management of site runoff. The conveyance, storage and treatment systems are oriented to adequately manage site water to meet the current and proposed discharge standards at W50.

The W2 monitoring point near the Yukon River is beyond the final mine water discharge point controlled by Minto, and is subject to a broad range of influences from tributaries and catchment areas that are beyond Minto's control. However, Minto is committed to monitoring the water quality at W2 and responding to changing water quality in lower Minto Creek as appropriate. The AMP framework below compliments the operational water management plan at the mine site with a decision-based structure for ensuring that negative impacts to lower Minto Creek from mining activities are avoided.

2.1.2 Risk Narrative

Increase in contaminant concentrations from the mine causes adverse effects to aquatic resources in the receiving environment (lower Minto Creek) despite adherence to discharge standards.

2.1.3 Specific Indicators, Performance Thresholds and Responses

Indicators, performance thresholds and responses specific to water quality and the monitoring program are provided below in Table 2-1. Specific thresholds are identified in Tables 2-2. In some cases the AMP specific threshold has been refined to be based on observed conditions at the time of sampling, as opposed to a statistic from previous sampling data (i.e. dissolved cadmium WQO/threshold calculated using observed hardness). The monitoring results that will be evaluated and utilized in this component of the AMP are a requirement of the Surface Water Surveillance Program of the Environmental Monitoring, Surveillance and Reporting Plan (EMSRP) (Minto Explorations Ltd., 2016).

Table 2-1: Specific Indicators, Performance Thresholds and Responses for Surface Water Quality at Station W2 in lower Minto Creek.

Specific Indicators	Specific Performance Thresholds	Specific Responses

Aqueous Concentrations at Station W2 for the following parameters with water quality objectives
 	
Parameters:
• NH_4-N
• NO_2-N
• NO_3-N
• pH
• Quarterly Bioassay
 	
Dissolved
• Aluminum
• Arsenic
• Cadmium
• Chromium
• Copper
• Iron
• Lead
• Molybdenum
• Nickel
• Silver
• Selenium
• Zinc
 	
(See Table **2-2** below for specific threshold values)
	Specific Threshold 1
	
	• Exceedance of predicted expected case maximum for dissolved concentrations at W2.
	(Does not apply to pH, Bioassay, Arsenic, Iron, Lead, Molybdenum, Nickel, Silver, or Zinc)
		Notification
		• Minto Management
		• Include in scheduled Water Use Licence monthly reporting
		Review
		• Follow QA/QC investigative protocol:
		  ○ Review laboratory QA/QC report
		  ○ Validate original result, or re-run sample if a laboratory error is indicated
		Evaluation
		• Compare with W3 results
		Action
		• If comparison with W3 result indicates mine loadings are responsible for exceedance then:
		  ○ Re-sample both W2 and W3 within **24 hours** of original sample result review
		  ○ Actions will continue until performance thresholds are no longer exceeded.

	Specific Threshold 2
	
	• Exceedance of predicted expected case maximum for dissolved concentrations in **2 consecutive samples (scheduled or re-sample) at W2** where evaluation confirmed mine loading responsible for first exceedance
	
	(Does not apply to pH, Bioassay, Arsenic, Iron, Lead, Molybdenum, Nickel, Silver, or Zinc)
		Notification
		• Minto Management
		• Include in scheduled Water Use Licence reporting
		Review
		• Follow QA/QC investigative protocol:
		  ○ Review laboratory QA/QC report
		  ○ Validate original result, or re-run sample if a laboratory error is indicated
		Evaluation
		• Compare with W3 results. If comparison with W3 result indicates that mine loadings are responsible for exceedance; and validation confirms original result, then:
		  ○ Evaluate causes for load contributions and develop investigation plan; and
		  ○ A trend analysis will be conducted by a qualified person.
		Action
		• Implement investigation plan, including at a minimum:
		  ○ Re-sampling both W2 and W3 within **24 hours** of original sample result review; and
		  ○ Site investigation of candidate load contributions.
		• Review results of investigation and prepare recommendations if appropriate.
		• Implement recommendations
		• Actions will continue until performance thresholds are no longer exceeded.
		• If trend analysis suggests WQO exceedance within one year, then initiate actions for Specific Threshold 3.

	Specific Threshold 3
	
	• Exceedance of predicted **worst case** maximum for dissolved concentrations at W2
	
	OR
	
	• WQO exceeded at W2 in a single sample
		Notification
		• Minto Management, SFN, YG Inspector
		• Include in scheduled Water Use Licence reporting
		Review
		• Follow QA/QC investigative protocol
		  ○ Review laboratory QA/QC report
		  ○ Verify original result, or re-run sample if laboratory error indicated
		Evaluation
		• Compare with W3 results. If comparison with W3 result indicates mine loadings responsible for exceedance – and verification confirms original result – then:
		  ○ Evaluate candidate causes for load contributions and develop investigation plan (or review/revise as appropriate)
		Action
		• Maintain weekly monitoring at W2 and W3
		• Implement investigation plan, including any reviews/revisions, and at a minimum:

Specific Indicators	Specific Performance Thresholds	Specific Responses
		○ Re-sampling both W2 and W3 within **24 hours** of original sample result receipt; and ○ Site investigation of candidate load contributions; and ○ Engage a qualified individual for the evaluation of potential effects to aquatic resources (i.e. Compare to Predicted No Effect Concentration (PNEC) and apply Biotic Ligand Model (BLM) for D-Cu, invertebrate tissue for Se, compare with calculated acute guideline for D-Cd.) This may include but not be limited to the evaluation of existing data and results from effluent toxicity, surface water toxicity, sediment chemistry, sediment toxicity, benthic invertebrate community structure and fish health testing/programs. • Review results of investigation and prepare recommendations if appropriate • Implement recommendations • Actions will continue until performance thresholds are no longer exceeded.
	Specific Threshold 4 • Exceedance of predicted worst case maximum for dissolved concentrations in **2 consecutive samples (scheduled or re-sample) at W2** where evaluation confirmed mine loading responsible for first exceedance	**Notification** • Minto Management, SFN, YG Inspector • Include in scheduled Water Use Licence reporting **Review** • Compare with W3 results • Follow QA/QC investigative protocol **Evaluation** • Compare with W3 results. If comparison with W3 result indicates mine loadings responsible for exceedance; and verification confirms original result, then: ○ Evaluate candidate causes for load contributions and develop investigation plan (or review/revise as appropriate) ○ Provide investigation plan to SFN/YG Inspector • Evaluate potential for mine loadings to cause adverse effects to aquatic resources (i.e. redo BLM modeling) **Action** • Maintain weekly monitoring and collect samples at greater frequency as required • Develop investigation plan, including at a minimum: ○ Re-sampling both W2 and W3 within **24 hours** of original sample result review; and ○ Site investigation of load contributions ○ Evaluation of potential effects to aquatic resources • Review results of investigation and prepare recommendations • Implement recommendations arising from investigations. **If threshold consistently exceeded for 2 months**, then: • Develop revised forecast for near-term (12 months) water quality in Minto Creek. • Develop and implement any additional mitigation measures to reduce loading from mine site, if necessary, with appropriate regulatory approvals. • Actions will continue until performance thresholds are no longer exceeded.
	Specific Threshold 5 • WQO or PNEC exceeded in **2 consecutive samples (scheduled or re-sample) at W2** where evaluation confirmed mine loading responsible for first exceedance	**Notification** • Minto Management, SFN, YG Inspector • Include in Water Use Licence reporting **Review** • Compare with W3 results • Follow QA/QC investigative protocol **Evaluation** • All evaluation measures for ST4 and: ○ Consider ongoing WQ monitoring results in development of investigation plan • Evaluate potential for mine loadings to cause adverse effects to aquatic resources (i.e. redo BLM modeling) **Action** • Maintain weekly monitoring and collect samples at greater frequency as required. • Develop investigation plan, including at a minimum: ○ Re-sampling both W2 and W3 within **24 hours** of original sample result review; and ○ Site investigation of load contributions

Specific Indicators	Specific Performance Thresholds	Specific Responses
		○ Evaluation of potential effects to aquatic resources • Review results of investigation and prepare recommendations • Implement recommendations arising from investigations. • Implement necessary reasonable and practical measures to reduce contaminant loading from mine to Minto Creek. • Suspend discharge from the mine until water quality is appropriate for discharge. • Actions will continue until performance thresholds are no longer exceeded.

Table 2-2: Specific Performance Thresholds for Surface Water Quality in Lower Minto Creek (W2)

	W2 Water Quality Objective	Expected Case Water Quality Predictions at W2 – Operational Period	Worst Case Water Quality Predictions at W2 – Operational Period
	(mg/L)	(mg/L)	(mg/L)
Ammonia - N, mg/L	0.25	0.057	0.25
Nitrite - N, mg/L	0.06	0.015*	0.057*
Nitrate - N, mg/L	9.1	1.1	5.1
Aluminum (dissolved), mg/L	0.1	0.057	0.077
Arsenic (dissolved), mg/L	0.005	**	0.0007
Cadmium (dissolved), µg/L	$e^{(0.736(\ln(\text{hardness})-4.943)}$	0.000027	0.00004
Chromium (dissolved), mg/L	0.001	0.00062	0.00082
Copper (dissolved), mg/L (when [DOC] @ W2 >10 mg/L)	0.02	0.0092	0.014
Copper (dissolved), mg/L (when [DOC] @ W2 ≤10 mg/L)	0.013	0.0092	0.014
Iron (dissolved), mg/L	1.1	**	0.37
Lead (dissolved), mg/L	0.004	**	0.00044
Molybdenum (dissolved), mg/L	0.073	**	0.0015
Nickel (dissolved), mg/L	0.11	**	0.0021
Silver (dissolved), mg/L	0.0001	**	0.000042
Selenium (dissolved), mg/L	0.002	0.00055	0.00087
Zinc (dissolved), mg/L	0.03	**	0.0065
pH (pH units)	6.0 – 9.0	n/a	n/a
Bioassay (Quarterly Analysis) 30-day Early Life Stage Toxicity for rainbow trout (EPS 1/RM/28), 7-day for *Ceridaphnia dubia* (EPS 1/RM/21), and 72-hr for algae *(Pseudokirchnerialla subcaptiata*)(EPS 1RM/25)	Pass	n/a	n/a

*Prediction reduced by 75% to account for expected nitrification in Minto Creek.

** While predictions exist for these parameters, as no action will be taken on expected case predictions, they have not been included in this table.

Water Use Licence QZ14-031 identifies the WQO Station as:

- Station W2 during the period when flow is encountered at stations W15 and W35; or
- Station W50 during the period when flow is not encountered at stations W35 and W15.

Clause 11 of the licence identifies the water quality objectives (above in Table 2-2) for Minto Creek, and states that "any exceedances of these at the defined WQO Station shall trigger the Operations Adaptive Management Plan." The AMP framework in this section ensures that action under the Operational AMP is triggered in advance of exceedances of WQOs at station W2. In the event of the WQO station being W50 (no flow at stations W35 and W15), it is assumed that this would be under winter conditions, and that there will be no contributing flow from the rest of the Minto Creek catchment downstream of the mine. In this case, Minto would adhere to the simple AMP outline listed below:

Table 2-3: Specific Indicators, Performance Thresholds and Responses for Surface Water Quality at Station W50 in Minto Creek.

Specific Indicators	Specific Performance Thresholds	Specific Responses
Aqueous Concentrations at Station W50 for the following parameters with water quality objectives Parameters: • NH_4-N • NO_2-N • NO_3-N Dissolved • Aluminum • Arsenic • Cadmium • Chromium • Copper • Iron • Lead • Molybdenum • Nickel • Silver • Selenium • Zinc (See Table **2-2** above for specific threshold values)	**Specific Threshold** • Exceedance of WQO for in a single sample	**Notification** • Minto Management • Include in scheduled Water Use Licence reporting **Action** • Suspend discharge from the mine until water quality is appropriate for discharge.

2.2 McGinty Creek Surface Water Quality

2.2.1 Description

The Minto North deposit is an extension of the mineralization being mined within the Minto Creek catchment. It is within the McGinty Creek catchment area, to the north of Minto Creek. As described in the Water Management Plan (Minto Explorations Ltd., 2015), Minto actively manages water directly impacted by open pit mining and pumps or transports it to the Main or Area 2 Pits.

Minto has been monitoring surface water quality in the McGinty Creek catchment since 2009, and the results from monitoring program (until July 2012) were presented in Phase V/VI Mine Plan supporting information in *McGinty Creek Water Quality Characterization, June 2013 (Access/Minnow, 2013).* Additional data collected between August 2012 and July 2015 has been included in a re-characterization of the background water quality. The methodology for updating and employing these update data is described briefly in Section 2.2.3 below.

Station MN-4.5 is the monitoring station on the lower main stem of McGinty Creek near the confluence with the Yukon River. The YESAB Environmental Effects assessment supported Minto's conclusion of no anticipated significant adverse effects to aquatic resources, on the basis of the comparison of predicted surface water quality in lower McGinty Creek to water quality guidelines (or site-specific water quality objectives) for the protection of aquatic life, as evaluated at monitoring station MN-4.5. Surface water quality at the MN-4.5 monitoring point is subject to a broad range of influences from tributaries and catchment area that are beyond Minto's control (i.e. downgradient of the Minto North Pit). However, Minto is committed to monitoring the water quality at MN-4.5 and responding to changing water quality in lower McGinty Creek as appropriate. The AMP framework below complements the operational water management plan at the mine site with a decision-based structure for ensuring that negative impacts to lower McGinty Creek from mining activities are avoided.

2.2.2 Risk Narrative

Increase in contaminant concentrations from Minto North mining activities causes adverse effects to aquatic resources in the receiving environment (lower McGinty Creek).

2.2.3 Specific Indicators, Performance Thresholds and Responses

Indicators, performance thresholds and responses specific to water quality and the monitoring program are provided below in Table 2-4. The specific indicators are contaminant (pH, nitrogen species and metals/metalloids) concentrations for parameters identified in the Water Use Licence QZ14-031 Table 2 – Water Quality Objectives. Thresholds are all based on a proposed water quality objective (WQO). In its submission to the Yukon Water Board at the Public Hearing, Minto committed to updating WQOs for McGinty Creek. The approach to selecting WQOs for this AMP section is identical to the approach utilized in the YESAB evaluation for the Phase V/VI Project Proposal, and is consistent with the approach approved for Minto Creek – the protection of aquatic resources. That approach considered a background water quality dataset from monthly monitoring conducted from 2009 – 2012. Monthly monitoring has continued in the McGinty Creek catchment, and the background dataset has been updated to include all monitoring data until July 2015 (stripping of the Minto North Pit began in August 2015.) For indicators which do not exceed Canadian Water Quality Guidelines (CWQGs) at a frequency of greater than 10%

in background monitoring, the CWQG has been adopted as the WQO. Indicators which do exceed the CWQG at a frequency of >10% use the 95th percentile of the background dataset (at station MN-4.5) as the WQO. The information used in the selection of the WQO (and therefore the specific thresholds) is summarized in Table 2-5, and the actual threshold values are presented in Table 2-6. The monitoring results that are evaluated and utilized for this component of the AMP are a requirement of the Surface Water Surveillance Program of the EMSRP (Minto Explorations Ltd., 2016).

Table 2-4: Specific Indicators, Performance Thresholds and Responses for Surface Water Quality in McGinty Creek

Specific Indicators	Specific Performance Thresholds	Specific Responses

Aqueous Concentrations at Stations MN-4.5 for the following parameters:
• Ammonia-N
• Nitrate-N
• Nitrite-N
• Aluminum (total)
• Arsenic (total)
• Cadmium (total)
• Chromium (total)
• Copper (total)
• Iron (total)
• Lead (total)
• Molybdenum (total)
• Nickel (total)
• Silver (total)
• Selenium (total)
• Zinc (total)
• pH
 	
(See Table 2-5 below for Water Quality Objective values and calculations.)
	Specific Threshold 1
	
	• Exceedance of 80% of the WQO in two consecutive samples **(scheduled or re-sample)** at MN-4.5
		Notification
		• Minto Management
		• Include in scheduled Water Use Licence reporting
		Review
		• Follow QA/QC investigative protocol:
		  ○ Review laboratory QA/QC report
		  ○ Validate original result, or re-run sample if a laboratory error is indicated
		Evaluation
		• Compare with MN-1.5, MN-2.5 and MN-0.5 results
		• A trend analysis will be conducted by a qualified person
		Action
		• If comparison with other results suggests that Minto North operations may be responsible for exceedance then:
		  ○ Evaluate causes for load contributions, with particular focus on any sediment sources
		  ○ Re-sample both MN-4.5 and MN-1.5 within **48 hours** of original sample result review
		  ○ Actions will continue until performance thresholds are no longer exceeded.
		• If trend analysis suggests WQO exceedance within one year, and comparison of results above suggests that Minto North operations may be responsible for threshold exceedance, then initiate actions for threshold 2.

	Specific Threshold 2
	
	• Exceedance of the WQO at MN-4.5
		Notification
		• Minto Management
		• Include in scheduled Water Use Licence reporting
		Review
		• Follow QA/QC investigative protocol:
		  ○ Review laboratory QA/QC report
		  ○ Validate original result, or re-run sample if a laboratory error is indicated
		Evaluation
		• Compare with MN-1.5, MN-2.5 and MN-0.5 results
		• Evaluate potential effects to aquatic resources
		Action
		• If comparison with results suggests that Minto North loadings are responsible for exceedance and validation confirms original result, then:
		  ○ Evaluate causes for load contributions, with particular focus on any sediment sources
		  ○ Increase monitoring frequency to weekly.
		  ○ Re-sample both MN-4.5 and MN-1.5 within **48 hours** of original sample result review; and
		  ○ Where reasonable and practical, implement additional sediment and erosion control measures outlined in Minto's Erosion and Sediment Control Plan.
		  ○ If source of loading from Minto North is not sediment-related, develop a mitigation strategy with recommendations.
		• Actions will continue until performance thresholds are no longer exceeded.

	Specific Threshold 3 • Exceedance of the WQO at MN-4.5 in **2 consecutive samples (scheduled or re-sample)**	**Notification** • Notify management, SFN and YG • include in scheduled Water Use Licence reporting **Review**

Specific Indicators	Specific Performance Thresholds	Specific Responses

	where evaluation confirmed mine loading responsible for first exceedance	• Follow QA/QC investigative protocol:
		  ○ Review laboratory QA/QC report
		  ○ Validate original result, or re-run sample if a laboratory error is indicated
		Evaluation
		• Compare with MN-1.5, MN-2.5 and MN-0.5 results.
		• Engage a qualified individual to evaluate potential effects to aquatic resources
		Action
		• If comparison with results (evaluation, above) suggests that Minto North loadings are STILL responsible for exceedance; and validation confirms original result, then:
		  ○ If not already implemented, increase monitoring frequency to weekly.
		• If evaluation above also suggests that Minto North loadings are contributing to a potential for significant adverse effects to aquatic resources, then:
		  ○ Implement recommendations from mitigation strategy (threshold 2 response)
		• Actions will continue until performance thresholds are no longer exceeded.

Table 2-5: Information utilized in the selection of Water Quality Objectives for use at Station MN-4.5.

Water Quality Parameter	Units	95th Percentile at MN-4.5 (2009 – 2015)	Canadian Water Quality Guideline
N-NH3	mg/L	0.114	**0.197**
N-NO2	mg/L	0.025	**0.06**
N-NO3	mg/L	0.222	**3**
Al-T	µg/L	**2834**	5 µg/L if pH < 6.5 100 µg/L if pH ≥ 6.5
As-T	µg/L	1.95	**5**
Cd-T	µg/L	0.101	**0.04 µg/L if hardness (as $CaCO_3$) < 17 mg/L** **$10^{\{0.83(\log[\text{hardness}]) - 2.46\}}$ if hardness ≥ 17 mg/L and ≤ 280 mg/L** **0.37 µg/L if hardness > 280 mg/L**
Cr-T	µg/L	**5.5**	1
Cu-T	µg/L	**12.67**	2 µg/L if hardness (as $CaCO_3$) ≤ 82 mg/L or unknown $0.2 * e^{\{0.8545[\ln(\text{hardness})]-1.465\}}$ if hardness ≥ 82 mg/L and ≤ 180 mg/L 4 µg/L if hardness > 180 mg/L
Fe-T	µg/L	**4937**	300
Pb-T	µg/L	2.12	**1 µg/L if hardness (as $CaCO_3$) ≤ 60 mg/L or unknown** **$e^{\{1.273[\ln(\text{hardness})]-4.705\}}$ if hardness > 60 mg/L and ≤ 180 mg/L** **7 µg/L if hardness > 180 mg/L**
Mo-T	µg/L	1.1	**73**
Ni-T	µg/L	8.0	**25 µg/L if hardness (as CaCO3) ≤ 60 mg/L or unknown** **$e^{\{0.76[\ln(\text{hardness})]+1.06\}}$ if hardness > 60 mg/L and ≤ 180 mg/L** **150 µg/L if hardness > 180 mg/L**
Se-T	µg/L	0.22	**1**
Ag-T	µg/L	0.04	**0.25**
Zn-T	µg/L	29.5	**30**
pH	pH units	n/a	**6.0 – 9.0 (from WUL Table 2, Clause 11)**

** Cd-T CCME guideline is the long term guideline*

***Shaded and bolded cells indicate values used as WQOs*

Table 2-6: Threshold values for AMP use at Station MN-4.5.

Water Quality Parameter	Units	80% of Water Quality Objective	Water Quality Objective
N-NH3	mg/L	0.158	0.197
N-NO2	mg/L	0.025	0.06
N-NO3	mg/L	0.222	3
Al-T	mg/L	2.26	2.83
As-T	mg/L	0.004	0.005
Cd-T	µg/L	0.8*(CWQG @ observed hardness)	0.04 µg/L if hardness (as $CaCO_3$) < 17 mg/L $10^{\{0.83(\log[\text{hardness}]) - 2.46\}}$ if hardness ≥ 17 mg/L and ≤ 280 mg/L 0.37 µg/L if hardness > 280 mg/L
Cr-T	mg/L	0.0044	0.0055
Cu-T	mg/L	0.0102	0.0127
Fe-T	mg/L	3.95	4.94
Pb-T	µg/L	0.8*(CWQG @ observed hardness)	1 µg/L if hardness (as $CaCO_3$) ≤ 60 mg/L or unknown $e^{\{1.273[\ln(\text{hardness})]-4.705\}}$ if hardness > 60 mg/L and ≤ 180 mg/L 7 µg/L if hardness > 180 mg/L
Mo-T	mg/L	0.058	0.073
Ni-T	µg/L	0.8*(CWQG @ observed hardness)	25 µg/L if hardness (as CaCO3) ≤ 60 mg/L or unknown $e^{\{0.76[\ln(\text{hardness})]+1.06\}}$ if hardness > 60 mg/L and ≤ 180 mg/L 150 µg/L if hardness > 180 mg/L
Se-T	mg/L	0.0008	0.001
Ag-T	mg/L	0.0020	0.0025
Zn-T	mg/L	0.024	0.030
pH	pH units	n/a	6.0 – 9.0

2.3 Groundwater Quality in Minto Creek Watershed

2.3.1 Description

Groundwater quality has the potential to be important in terms of contributions to surface water quality. Groundwater contributes to streamflow as baseflow, which is typically most important during the autumn/winter low flow season when surface water flows are minimal.

All mine workings and waste facilities within in the Minto Creek catchment are located upgradient (and west) of the Water Storage Pond (WSP). The monitoring supporting the AMP framework is defined and described in the Groundwater Monitoring Plan (GMP) (Minto Explorations Ltd., 2016). Groundwater is monitored both upgradient (west) and downgradient (east) of the WSP; upgradient monitoring is carried out via a multi-level monitoring well at MW12-06, and downgradient monitoring is carried out via a multi-level monitoring well at MW12-05. Surface water downgradient of the WSP is monitored at several stations including station W3, which is located immediately adjacent to MW12-05.

As described in the 2015 Groundwater Model Update (SRK 2015a), groundwater coming from the mine area (the western and highest elevation portion of the Minto Creek catchment) is expected to discharge to surface water in the vicinity of the Water Storage Pond (i.e. upgradient of monitoring well MW12-05). Minimal groundwater from the mine area is expected to discharge to Minto Creek down gradient of the Water Storage Pond. MW12-05 and MW12-06 are optimally located to monitor expected groundwater flow paths.

The W2 surface water monitoring station is located at approximately 600 m from the Yukon River and is 6 km downstream of the Minto lease boundary. Water reporting to W2 is subject to influences from groundwater and surface water outside the mine area. Minto is committed to monitoring groundwater quality at MW12-05 and MW12-06 and surface water quality at W2 as required by Water Use Licence QZ14-031, and responding to changing water quality in groundwater and lower Minto Creek as appropriate.

The operational AMP framework below complements the operational water management plan at the mine site with a decision-based structure for ensuring that negative impacts to lower Minto Creek from mining activities are avoided.

2.3.2 Risk Narrative

Flux of geochemical load from the mine via groundwater pathways causes surface water quality objectives to be in exceeded in Minto Creek at station W2.

2.3.3 Specific Indicators, Performance Thresholds and Responses

Indicators, performance thresholds and responses specific to groundwater quality in Minto Creek watershed are provided in Table 2-6. Specific Performance Thresholds (SPTs) are defined for each of the Effluent Standards (ES) parameters identified in Clause 9 (a), Table 1 of Water Use Licence QZ14-031, with the exception of pH, oil and grease, iron and nitrite (as discussed later in this section). Additionally, although it is not specified in Clause 9(a), sulphate has been included in the SPTs. Table 2-7 compiles the concentration of background groundwater for each Specific Indicator and the Specific Performance Threshold values.

At present, MW09-03 is considered to be the most representative of the baseline groundwater conditions for the entire project site. MW09-03 was installed in 2009 and monitored to collect baseline data downgradient of the Minto North ore body- this well is located near the southern limit of the McGinty Creek catchment close to the

surface water divide with Minto Creek. Pre-mining groundwater concentrations for certain parameters such as cadmium and iron have been relatively high, likely due to the adjacent highly mineralized zone. Mining of this ore body began in Q3 2015 and as such the monitoring record prior for the 2009-2015 period reflects baseline conditions.

The concentrations of the background groundwater are based on the respective median parameter concentrations at monitoring well MW09-03 (including all monitoring ports). At present (April 2016), the MW09-03 monitoring record is considered to be the most representative indicator of the baseline groundwater conditions for the entire project site. MW09-03 was installed in 2009 and monitored to collect baseline data downgradient of the Minto North ore body- this well is located near the southern limit of the McGinty Creek catchment close to the surface water divide with Minto Creek. Pre-mining groundwater concentrations for certain parameters such as cadmium and iron have been relatively high, likely due to the adjacent highly mineralized zone. Mining of this ore body began in Q3 2015 and as such the monitoring record prior for the 2009-2015 period reflects baseline conditions. Another groundwater well (MW16-08) will be installed in 2016 to allow groundwater quality monitoring within the Minto Creek catchment upgradient of any mine disturbances. Once the groundwater quality from MW16-08 becomes available, the groundwater quality at MW09-03 and MW16-08 will be compared by a qualified professional to verify and assess if background groundwater concentrations used in the current operational AMP remain appropriate.

Iron and nitrite have been excluded from the Specific Indicators for groundwater quality because of the magnitude of the natural variability observed in groundwater at Minto. In addition, pH as also been excluded as a Specific Indicator for groundwater quality because it is not as useful an early warning indicator as sulphate and metal/ metalloid concentrations, and Oil & Grease has been excluded because it is not relevant as a specific indicator for groundwater. Although iron, nitrite and pH are excluded from the Specific Indicator list, these three constituents are monitored and would be included in the review of groundwater quality if an SPT was exceeded.

Three SPTs have been defined for the Minto Creek watershed. Rationale for development of the SPTs is as follows:

- SPT-1 corresponds to the Effluent Standards concentrations defined in Clause 9 (a), Table 1 of Water Use License QZ14-031 (with three exceptions (Cr-D, Cu-D and sulphate) as indicated in the notes to Table 2-6). The Effluent Standards are defined for surface water discharge, and the mine is not permitted to discharge surface water that exceeds any ES guidelines to surface water. However, if groundwater concentration of one Specific Indicator reached the SPT-1 in an individual port, the quality of the lower Minto Creek at W2 would still remain below the Water Quality Objectives due to: the contribution of groundwater from un-impacted areas of the Minto Creek watershed (i.e. groundwater concentrations at background levels, , which will make up roughly 80% of the groundwater discharge to the stream); the long travel time required for groundwater monitored at the mine to discharge to Minto Creek; and the small proportion of total mine groundwater flow represented by water monitored in a single monitoring zone (the groundwater concentrations at a specific monitoring well port represent only a portion of the total flow and not the whole groundwater flow field originating from the mine area). The SPT-1 provides a conservative threshold for action before any significant effect would be observed in surface water.
- SPT-2 corresponds to the estimated concentrations in groundwater that would be necessary to cause exceedance of the Water Quality Objectives in lower Minto Creek, at W2, under long term steady state conditions. These concentrations were determined by conducting a mass loading calculation to determine the groundwater concentrations that would be necessary to cause exceedance of WQOs in lower Minto Creek during low flow periods where all streamflow is derived from groundwater discharge. The mass

loading calculation was structured to represent a low-flow period when all surface flows in lower Minto Creek originate from groundwater discharge to the creek. The calculation was done using the following formula:

$$C_{gw\text{-}mine\_max} = ((Q_{W2} \times C_{W2\text{-}WQO})-(Q_{gw\text{-}bgrnd} \times C_{gw\text{-}bgrnd}))/Q_{gw\text{-}mine}$$

Where:

- $C_{gw\text{-}mine\_max}$ = the indicator parameter concentration of all groundwater upgradient of MW12-05 that reports to Minto Creek that would be required to cause surface water to exceed the WQO at station W2.
- Q_{W2} = the combined groundwater flow discharging to Minto Creek (total groundwater discharge to Minto Creek from the 2015 groundwater model update) during low flow periods
- $C_{W2\text{-}WQO}$ = the WQO parameter concentration for surface water at W2
- $Q_{gw\text{-}bgrnd}$ = background groundwater flow discharging to Minto Creek (groundwater discharge down gradient of the Water Storage Pond from the 2015 groundwater model update) during low flow periods
- $C_{gw\text{-}bgrnd}$ = background groundwater concentration (based on average values from MW12-05 and MW12-06)
- $Q_{gw\text{-}mine}$ = the estimated groundwater flow from the mine at the Water Storage Pond (from the 2015 groundwater model update)

If groundwater concentration of one indicator reached the SPT-2 in an individual port, the quality of the lower Minto Creek at W2 would not yet exceed the Water Quality Objective due to the contribution of groundwater from un-impacted areas of the Minto Creek watershed and the fact that groundwater concentrations at a specific monitoring well port represents only a portion of the flow and not the whole groundwater flow field. The SPT-2 provides therefore a conservative threshold for action before any significant effect would be observed in surface water.

- SPT-3 corresponds to a trend based assessment designed to flag a potential rapid increase in groundwater loadings. The assessment is structured to determine if an indicator has increased significantly compared to the last sampling event. The assessment will be performed as followed:

  $$((C_n - C_{n-1})/(C_{SPT\text{-}1} – C_n) > 0.2$$

  Where:

  - C_n = the parameter concentration of groundwater from the latest sampling event;
  - C_{n-1} = the parameter concentration of groundwater from the last sampling event ;
  - $C_{SPT\text{-}1}$ = the parameter concentration for the SPT-1;

The SPT-3 provides a conservative threshold considering that it is weighted against the concentration for the SPT-1. The SPT-3 will be increasingly sensitive to change in concentrations between two sampling events as groundwater approaches the SPT-1, since the size of the denominator decreases as the SPT-1 value is approached.

The monitoring results that are evaluated and utilized for this component of the AMP are a requirement of the Groundwater Monitoring Program of the EMSRP (Minto Explorations Ltd., 2016).

Table 2-6: Specific Indicators, Performance Thresholds and Responses for Groundwater Quality in Minto Creek

Specific Indicators	Specific Performance Thresholds	Specific Responses

Aqueous concentrations in samples collected from multi-level groundwater monitoring wells MW12-05 or MW12-06 for the following parameters with water quality objectives:
 	
• Dissolved Aluminum
• Dissolved Arsenic
• Dissolved Cadmium
• Dissolved Chromium
• Dissolved Copper
• Dissolved Iron
• Dissolved Lead
• Dissolved Molybdenum
• Dissolved Nickel
• Dissolved Silver
• Dissolved Selenium
• Dissolved Zinc
• NH_4-N
• NO_3-N
• Sulphate
	SPT-1
	• Exceedance of SPT-1 concentrations in 2 consecutive samples (scheduled or re-sampled) collected during routine monitoring from multilevel groundwater monitoring wells MW12-05 or MW12-06.
		Notification
		• Minto Management
		• Include in scheduled Water Use Licence reporting
		Review
		• Follow QA/QC investigative protocol:
		  ○ Review laboratory QA/QC report
		  ○ Validate original result, or re-run sample if a laboratory error is indicated
		Evaluation
		• Review of groundwater monitoring data to be undertaken by qualified professional, and appropriate recommendations to be developed
		  ○ Review must consider the risk narrative (i.e. exceedance of surface water quality objectives as a result of groundwater flux)
		Action
		• Follow recommendations arising from review undertaken by qualified professional.

	SPT-2
	• Exceedance of SPT-2 in 2 consecutive samples (Scheduled or re-sampled) collected during routine monitoring from multilevel groundwater monitoring wells MW12-05 or MW12-06.
		Notification
		• Minto Management
		• Include in scheduled Water Use Licence reporting
		Review
		• Follow QA/QC investigative protocol:
		  ○ Review laboratory QA/QC report
		  ○ Validate original result, or re-run sample if a laboratory error is indicated
		Evaluation
		• Review of groundwater monitoring data to be undertaken by qualified professional, and appropriate recommendations to be developed
		  ○ Review must consider the risk narrative (i.e. exceedance of surface water quality objectives as a result of groundwater flux)
		Action
		• Follow recommendations arising from review undertaken by qualified professional.
		• Increase monitoring frequency to monthly sampling of all monitored zones in the affected multi-level well for a period to be defined by qualified professional.

Specific Indicators	Specific Performance Thresholds	Specific Responses
	SPT-3 • Exceedance of SPT-3 for any sample collected during routine monitoring from multilevel groundwater monitoring wells MW12-05 or MW12-06.	**Notification** • Minto Management • Include in scheduled Water Use Licence reporting **Review** • Follow QA/QC investigative protocol: ○ Review laboratory QA/QC report ○ Validate original result, or re-run sample if a laboratory error is indicated **Evaluation** • Review of groundwater monitoring data to be undertaken by qualified professional, and appropriate recommendations to be developed ○ Review must consider the risk narrative (i.e. exceedance of surface water quality objectives as a result of groundwater flux) **Action** • Follow recommendations arising from review undertaken by qualified professional.

Table 2-7: Background concentrations and SPTs for the groundwater monitoring in the Minto Creek watershed

Minto Creek	***Concentrations (mg/L)***													
	Ag-D	Al-D	As-D	Cd-D	Cr-D	Cu-D	Pb-D	Mo-D	Ni-D	Se-D	Zn-D	N-NO3	Ammonia	Sulphate[2]
SPT-2 [1]	0.00046	0.48	0.025	0.0060	0.0030	0.060	0.020	0.34	0.55	0.0093	0.13	45	1.0	4951
SPT-1	0.00030	0.30	0.015	0.0030	0.0015	0.030 [4]	0.012	0.22	0.33	0.0060	0.090	27	0.75	1000
Background Groundwater[3]	0.00001	0.0045	0.0001	0.00002	0.00050	0.0014	0.0001	0.006	0.001	0.0002	0.006	0.07	0.051	12

Notes:

1: SPT-2 is the calculated concentration that all groundwater from the mine must attain to reach the Effluent Standards at W2. Model flows were based on 2015 Groundwater Model Update. 15 L/s is the total groundwater discharging to Minto Creek. 3 L/s is the estimated groundwater flow from the Minto Creek catchment up gradient of the Water Storage Pond.

2: There is no Effluent Standard for sulphate. For the SPT-1, the guideline for Aquatic Life from the Contaminated Site Regulation Schedule 3 was used as a replacement.

3: The background concentration in groundwater is calculated as the median of concentrations observed at groundwater monitoring well MW09-03

4: SPT-1 for dissolved copper and dissolved chromium set at one-half (50%) of Effluent Standard (SPT-1 for all remaining parameters (other than sulphate) is equal to (100% of) the Effluent Standard).

2.4 Groundwater Quality in McGinty Creek Watershed

2.4.1 Description

The mine workings in the McGinty Creek catchment are limited to the Minto North Pit- the pit and the overall catchment are described in Section 2.2.1. The catchment area of the Minto North Pit is roughly 15 ha and the catchment area of the McGinty Creek watershed is roughly 3400 ha (SRK 2013); in other words, the Minto North Pit catchment is roughly 0.4% of the total McGinty Creek catchment area. While a groundwater model encompassing the full extent of the McGinty Creek catchment has not been developed, it is clear that only a very small proportion of the groundwater in the McGinty Creek watershed can be affected by the Minto North Pit.

The monitoring supporting the AMP framework is defined and described in the Groundwater Monitoring Plan (part of the EMSRP ((Minto Explorations Ltd., 2016)). Groundwater in the McGinty Creek catchment downgradient of the Minto North Pit is monitored at multi-level monitoring well MW09-03.

2.4.2 Risk Narrative

Flux of geochemical load from the Minto North Pit via groundwater pathways causes surface water quality objectives to be in exceeded in McGinty Creek at station MN4.5.

2.4.3 Specific Indicators, Performance Thresholds and Responses

Indicators, performance thresholds and responses specific to groundwater quality in McGinty Creek watershed are provided below in Table 2-8. SPTs are defined for each of the Effluent Standards (ES) parameters identified in Clause 9 (a), Table 1 of Water Use License QZ14-031, with the exception of pH, Oil & Grease, iron and nitrite (for reasons described in the Minto Creek groundwater section (Section 2.3). Additionally, although it is not specified in Clause 9(a), sulphate has been included in the SPTs. The concentration of background groundwater and the Specific Performance Threshold values for each Specific Indicator and each zone (i.e. individual well port) of MW09-03 are compiled in Table 2-10.

At present, MW09-03 is considered to be the most representative of the baseline groundwater conditions for the entire project site. MW09-03 was installed in 2009 and monitored to collect baseline data downgradient of the Minto North ore body- this well is located near the southern limit of the McGinty Creek catchment close to the surface water divide with Minto Creek. Pre-mining groundwater concentrations for certain parameters such as cadmium and iron have been relatively high, likely due to the adjacent highly mineralized zone. Mining of this ore body began in Q3 2015 and as such the monitoring record prior for the 2009-2015 period reflects baseline conditions.

Two Specific Performance Thresholds have been defined for McGinty Creek watershed groundwater- both are conservative given the application of the thresholds at individual ports, the small proportion of catchment groundwater that will be influenced by the mine workings and the expected slow rates of groundwater movement. Rationale for development of the two specific performance thresholds is as follows:

- SPT-1: Three consecutive exceedances of the 75th percentile background level in a single monitoring port.
    - The specification of three consecutive exceedances is intended to avoid triggering the AMP unnecessarily, but to ensure that any sustained increase from baseline conditions receives appropriate scrutiny.
- SPT-2: Three consecutive exceedances of the 95th percentile background level in a single monitoring port.

- The specification of three consecutive exceedances is intended to avoid triggering the AMP unnecessarily, but to ensure that any sustained increase from baseline conditions receives appropriate scrutiny.

The monitoring results that are evaluated for this component of the AMP are an obligation of the Groundwater Monitoring Program of the EMSRP.

Table 2-8: Specific Indicators, Performance Thresholds and Responses for Groundwater Quality in McGinty Creek

Specific Indicators	Specific Performance Thresholds	Specific Responses
Aqueous concentrations in samples collected from multi-level groundwater monitoring well MW09-03 for the following parameters: • Dissolved Aluminum • Dissolved Arsenic • Dissolved Cadmium • Dissolved Chromium • Dissolved Copper • Dissolved Lead • Dissolved Molybdenum • Dissolved Nickel • Dissolved Silver • Dissolved Selenium • Dissolved Zinc • NH_4-N • NO_3-N • Sulphate	**Specific Threshold 1** • Three consecutive exceedances of the 75th percentile value* from the baseline period (2009-2015) in routine monitoring results from a single monitoring port in MW09-03. *values provided in Table 2-10	**Notification** • Minto Management • Include in scheduled Water Use Licence reporting **Review** • Follow QA/QC investigative protocol: ○ Review laboratory QA/QC report ○ Validate original results, or re-run samples if a laboratory error is indicated **Evaluation** • Review of groundwater monitoring data to be undertaken by qualified professional, and appropriate recommendations to be developed ○ Review must consider the risk narrative (i.e. exceedance of surface water quality objectives as a result of groundwater flux) **Action** • Follow recommendations arising from review undertaken by qualified professional.
	Specific Threshold 2 • Three consecutive exceedances of the 95th percentile value* from the baseline period (2009-2015) in routine monitoring results from a single monitoring port in MW09-03. *values provided in Table 2-10	**Notification** • Minto Management • Include in scheduled Water Use Licence reporting **Review** • Follow QA/QC investigative protocol: ○ Review laboratory QA/QC report ○ Validate original results, or re-run samples if a laboratory error is indicated **Evaluation** • Review of groundwater monitoring data to be undertaken by a qualified professional, and appropriate recommendations to be developed ○ Review must consider the risk narrative (i.e. exceedance of surface water quality objectives as a result of groundwater flux) **Action** • Follow recommendations arising from review undertaken by qualified professional. • Increase monitoring frequency to monthly sampling of all monitored zones in the affected multi-level well for a period to be defined by qualified professional.

Table 2-9: Background concentrations and SPTs for the groundwater monitoring in the McGinty Creek watershed

Minto Creek		*Concentrations (mg/L)*[1]													
		Ag-D[3]	Al-D	As-D	Cd-D	Cr-D[3]	Cu-D	Pb-D[3]	Mo-D	Ni-D	Se-D	Zn-D	N-NO3	NH_4-N	Sulphate
MW09-03-01	95th Percentile	0.000016	0.0101	0.00081	0.000272	0.000575	0.00625	0.0003	0.026	0.0060	0.0015	0.022	0.28	0.133	38
	75th Percentile	0.000010	0.0065	0.00011	0.000075	0.000500	0.00155	0.0001	0.005	0.0021	0.0001	0.013	0.13	0.067	24
	Median[2]	0.000010	0.0045	0.00005	0.000022	0.000500	0.00031	0.0001	0.004	0.0015	0.0001	0.006	0.07	0.045	22
MW09-03-02	95th Percentile	0.000034	0.0095	0.00092	0.000272	0.000796	0.01080	0.0002	0.062	0.0026	0.0040	0.015	0.07	0.282	67
	75th Percentile	0.000018	0.0073	0.00074	0.000031	0.000500	0.00263	0.0001	0.018	0.0009	0.0005	0.010	0.03	0.230	7
	Median[2]	0.000010	0.0062	0.00067	0.000026	0.000500	0.00122	0.0001	0.017	0.0005	0.0002	0.008	0.01	0.210	1
MW09-03-03	95th Percentile	0.000010	0.0075	0.00014	0.000069	0.000500	0.00500	0.0003	0.018	0.0011	0.0004	0.011	0.54	0.058	13
	75th Percentile	0.000010	0.0047	0.00005	0.000023	0.000500	0.00247	0.0001	0.006	0.0005	0.0004	0.008	0.50	0.020	12
	Median[2]	0.000010	0.0025	0.00005	0.000015	0.000500	0.00174	0.0001	0.005	0.0005	0.0003	0.003	0.48	0.012	11

Notes:

1: For monitoring results where concentrations were below the analytical detection limits, a concentration of half the detection limit was adopted for calculation purposes.

2: For AMP purposes, the background concentration in groundwater at MW09-03 is defined as the median concentration observed in each port over the 2009-2015 baseline monitoring period.

3: For Ag-D, Cr-D and Pb-D, most 2009-2015 concentrations were at the limit of analytical detection, and as such the calculated 75th and 95th percentile values are skewed low.

2.5 Water Management

2.5.1 Description

The Minto Mine site has a positive water balance. Therefore, it is necessary to release water from site from time to time to prevent accumulation of excess water. The primary objective of Minto's water management strategy is to ensure that water can be released from site in a way that protects the water quality in Minto Creek. Details concerning water management for Phase V/VI are provided in the Minto Mine Phase V/VI Water Management Plan as amended from time to time (Minto Explorations Ltd., 2015).

The strategy can be summarized as follows:

- Runoff from developed mine areas (mine water) will be collected and stored in the Main Pit Tailings Management Facility (MPTMF) and the Area 2 Pit Tailings Management Facility (A2PTMF). Mine water will be used for ore processing.
- The site water balance will be used to define mine water inventory targets and targets for volumes to be released to Minto Creek. Inventory targets will be defined on an annual basis and reported in the annual water balance update.
- To the extent possible, water will be released from site by collecting and diverting discharge-compliant (clean) runoff to the water storage pond (WSP) and from there to Minto Creek.
- If collection, diversion and release of clean water does not move enough water off site then Minto has the option of treating and releasing mine water.

The water management strategy is able to deal with most foreseeable conditions that may be encountered though the mine development. However, certain unforeseen conditions may require an adaptive response as described below.

2.5.2 Risk Narrative

The existing water treatment plant is not able to treat and discharge enough mine water, and as a result the mine water inventory exceeds the target.

2.5.3 Specific Indicators, Performance Thresholds and Responses

Indicators, performance thresholds and responses specific to water management are provided below in Table 2-10. The monitoring results that are evaluated and utilized for this component of the AMP are a requirement of the Water Inventory Tracking of the Water Management Plan (Minto Explorations Ltd., 2015).

Table 2-10: Specific Indicators, Performance Thresholds and Responses for Water Management

Specific Indicators	Specific Performance Thresholds	Specific Responses

Water inventory in the Main Pit Tailings Management Facility or the Area 2 Pit Management Facility exceeds target inventory	**Specific Threshold 1**
	• Water inventory target is exceeded for a period of three months. The water storage capacity still exceeds 1,000,000 m^3.
		Notification
		• Minto Management
		• Include in monthly report
		Review
		• Review site water balance
		• Review recent water management and water treatment practices
		Evaluation
		• Evaluate the water inventory targets. For example, how much water can be stored in the pits for how long? Can the inventory target safely be changed to accommodate the excess volume of water?
		Action
		• Develop plan to address the water excess inventory such that the target can be met within 6 months. The plan may include:
		  ○ An adjustment of the target inventory,
		  ○ Diverting more clean water to the WSP,
		  ○ Modifying or expanding water treatment.

	Specific Threshold 2
	• The water storage capacity is less than 1,000,000 m^3.
		Notification
		• Minto Management, SFN and YG Inspector.
		• Include in scheduled Water Use Licence reporting.
		Review
		• Review site water balance.
		• Review recent water management and water treatment practices.
		Evaluation
		• Evaluate the water inventory targets. For example, how much water can be stored in the pits for how long? Can the inventory target safely be changed to accommodate the excess volume of water?
		• Evaluate treatment requirements and determine if the exiting water treatment plant has sufficient capacity to meet the requirements.
		Action
		• Immediately develop and implement a plan to address the lack of storage capacity such that the capacity can be restored prior to subsequent freshet.
		  ○ The plan may include, modifying or expanding the water treatment plant.
		  ○ Plans to bring mobile treatment equipment to site may be considered.

	Specific Threshold 3 • The water storage capacity is less than 500,000 m^3.	**Notification** • Minto Management, SFN, YG Inspector and Regulators. • Include in Water Use Licence reporting. **Review** • Review site water balance. • Review recent water management and water treatment practices. **Evaluation** • Evaluate treatment requirements and determine if the existing water treatment plant has sufficient capacity to meet the requirements. **Action**

Specific Indicators	Specific Performance Thresholds	Specific Responses
		• Immediately make plans to bring mobile treatment equipment to site, if existing plant does not have sufficient capacity.

2.5.4 Freeboard Thresholds for Water Storage Facilities

The water storage facilities authorized under the WL include the Water Storage Pond, the Mill Water Pond, the Ridgetop North Pit, the Main Pit and the Area 2 Pit. With the exception of the Ridgetop North Pit, all of these facilities have documents associated with their design.

Storage Facility	Freeboard limit (m) from spill elevation
Water Storage Pond	1
Main Pit Tailings Management Facility	2
Area 2 Pit Tailings Management Facility	5

All of the water storage facilities water levels and volumes are managed through permanent pumping and piping systems.

The mill water pond contains an overflow culvert and does not require a freeboard limit.

2.6 Physical Stability

2.6.1 Description

The physical stability of the waste rock, tailings and water storage facilities are monitored according to the Physical Monitoring Plan, which forms part of the Environmental Monitoring, Surveillance and Reporting Plan (Minto Explorations Ltd., 2016). The document describes the inspection and instrumentation data collection frequencies, instrument locations, installation details, as well as the data collection procedures.

The purpose of the monitoring program is to identify physical changes to the conditions of the facilities which may lead to future instability and to allow the mine mitigate these conditions prior to any occurrence of instability. The facilities have been separated into two sets of geotechnical thresholds and response criteria (Table 2-11). The Water Storage Dam has been excluded from the operational AMP as the facility is to be managed according to its Operation, Maintenance and Surveillance (OMS) Manual (Tetra Tech EBA, 2014).

Table 2-11: Physical Stability Categories

Category	Facility
1	• Dry Stack Tailings Storage Facility and Mill Valley Fill Extension (Stage 1 and 2) • Southwest Waste Dump • South Wall Buttress / Main Pit Dump
2	• Main Waste Dump and Main Waste Dump Extension • Reclamation Overburden Dump • Ice-Rich Overburden Dump • Main Pit Dump

Category 1 facilities are founded in areas of ice-rich periglacial foundations that have previously experienced deep seated foundation movement. The Mill Valley Fill Extension (MVFE) and South Wall Buttress (SWB) are designed to mitigate movements in the Dry Stack Tailings Storage Facility (DSTSF) and Main Pit South Wall areas, respectively, and the Main Pit Dump provides further stabilization to the Main Pit South Wall area. Additional monitoring inspection and response requirements for the DSTSF are detailed in the Operations, Maintenance, and Surveillance Manual (OMS) for the facility (Minto Explorations Ltd., 2014).

Category 2 facilities consist of all the remaining waste rock dumps. These waste dumps are located in areas with good foundation conditions that avoid areas underlain by ice-rich overburden.

2.6.2 Risk Narrative

A mass failure of one of the waste facilities has the potential to endanger the health and safety of site employees or visitors, or lead to an increase in contaminant loadings from the mine and subsequent adverse effects to aquatic resources in the receiving environment (lower Minto Creek).

2.6.3 Specific Indicators, Performance Thresholds and Responses

Indicators, performance thresholds and responses specific to Category 1 and Category 2 Facilities are provided in Table 2-12 and Table 2-13, respectively. The monitoring results that are evaluated and utilized for this component of the AMP are a requirement of the Physical Monitoring Program of the EMSRP (Minto Explorations Ltd., 2016).

Table 2-12: Specific Indicators, Performance Thresholds and Responses for Category 1 Facilities

Specific Indicators	Specific Performance Thresholds	Specific Responses

• Mass movement indicated by monitoring of geotechnical instrumentation
• Visual observations of physical damage
• Visual observations of evidence that could suggest mass movement
• Occurrence of seismic events
	Specific Threshold 1
	
	• Observation of unusual occurrence including:
	  • tension cracks, settlement, or sloughing;
	  • a seismic event that exceeds the 1:475 return period event[1];
	  • abnormal seepage from any area of the slopes;
	  • increased turbidity from seepage;
	  • physical damage.
		Notification
		• Mine Manager
		• Geotechnical Engineer
		• Include in annual report
		
		Review
		• Review previous inspection reports, existing instrumentation including piezometer, temperature, inclinometer, and survey data.
		
		Evaluation
		• Geotechnical Engineer to compare recent monitoring results against older results for additional evidence of instability.
		
		Action
		• Inspect the area for any other signs of instability.
		• Follow any recommendations of the Geotechnical Engineer. At a minimum, the Engineer will consider the need for:
		  ○ An increase in the frequency of routine inspections and monitoring.
		  ○ Additional inspection, instrumentation, monitoring, or analyses
		
		• If the results of the analysis indicates there is a stability concern, the mine inspector and Selkirk First Nation will be notified immediately.

	Specific Threshold 2 • One survey hub or inclinometer reading indicating acceleration of movement greater than the long-term trend and outside range of instrumentation error	**Notification** • Geotechnical Engineer **Review** • Review existing instrumentation data. **Evaluation** • Geotechnical Engineer to compare recent monitoring results against older results. **Action** • Retake reading. • If the reading was accurate, increase the survey hub or inclinometer frequency. • If the results of the analysis indicates there is a stability concern, the mine inspector and Selkirk First Nation will be notified immediately.

[1] This size of a seismic event would be felt by most people on site. It would shake buildings, and rattle or break dishes, hanging objects, etc. Earthquake information may also be found online at: http://www.earthquakescanada.nrcan.gc.ca/index-eng.php

Specific Indicators	Specific Performance Thresholds	Specific Responses
	Specific Threshold 3 • For DSTSF and MVFE piezometers 13-DSP-05a, 13-DSP-06, 15-DSP-07, and 15-DSP-08, an increase in pore water pressures such that Ru[2] exceeds 0.4[3]. • For MVFE2 piezometer 15-DSP-10, an increase in pore water pressures such that the water elevation is 1 m above the original ground surface. Or • Temperature greater than zero at a depth of 2 m below original ground *(all SWD ground temperature cables, and DSTSF ground temperature cables DST-10, DST-11, and DST-14 only)*	**Notification** • Mine Manager • Geotechnical Engineer • Include in annual report **Review** • Review previous inspection reports, existing instrumentation including piezometer, temperature, inclinometer, and survey data. **Evaluation** • Geotechnical Engineer to compare recent monitoring results against older results for additional evidence of instability. **Action** • Inspect the area for any other signs of instability. • If pore water pressure threshold exceeded: immediately increase frequency to **twice-weekly** or as directed by the Engineer until determined unnecessary. • Follow any additional recommendations of the Geotechnical Engineer. • If the results of the analysis indicates there is a stability concern, the mine inspector and Selkirk First Nation will be notified immediately.
	Specific Threshold 4 • For DSTSF and MVFE piezometers 13-DSP-05, 13-DSP-06, 15-DSP-07, and 15-DSP-08, an increase in pore water pressures such that Ru exceeds 0.6. • For MVFE2 piezometer 15-DSP-10, an increase in pore water pressures such that the water elevation is 3 m above the original ground surface.	**Notification** • Mine Manager • Geotechnical Engineer • Include in annual report **Review** • Review previous inspection reports, existing instrumentation including piezometer, temperature, inclinometer, and survey data. **Evaluation** • Geotechnical Engineer to compare recent monitoring results against older results for additional evidence of instability. **Action** • Inspect the area for any other signs of instability. • Immediately increase pore water pressure monitoring and data review frequency to **daily** or as directed by the Engineer until determined unnecessary. • Follow any additional recommendations of the Geotechnical Engineer. At a minimum, the Engineer will consider the need for:

[2] Ru is the pore water pressure coefficient which is the ratio of pore water pressure to the overburden pressure. A pore water pressure ratio of 0.5 would be similar to the effect of a groundwater table at surface.
[3] Piezometer 13-DSP-5b exceeded this trigger on April 2015. A review of the data and stability analysis was completed and documented in the 2015 annual geotechnical inspection report (SRK 2015a) and found no stability issue and recommended continued monthly monitoring.

Specific Indicators	Specific Performance Thresholds	Specific Responses
		○ An increase in the frequency of routine inspections and monitoring. ○ Additional inspection, instrumentation, monitoring, or analyses. ○ Modifications to the waste placement/construction practices. • If the results of the analysis indicates there is a stability concern, the mine inspector and Selkirk First Nation will be notified immediately.
	Specific Threshold 5 • Three consecutive survey hub or inclinometer readings indicating acceleration of movement greater than the long-term trend. Or • Three consecutive survey hub readings indicating a change in horizontal direction of movement greater than 15 degrees from the long term trend.	**Notification** • Mine Manager • Geotechnical Engineer • Include in annual report **Review** • Review previous inspection reports, existing instrumentation including piezometer, temperature, inclinometer, and survey data. **Evaluation** • Geotechnical Engineer to compare recent monitoring results against older results for additional evidence of instability. **Action** • Inspect the area for any other signs of instability. • Complete a ground survey of the area of interest to monitor any future displacement. • Immediately increase monitoring and data review frequency to **twice-weekly** or as directed by the Engineer until determined unnecessary. • Follow any additional recommendations of the Geotechnical Engineer. At a minimum, the Engineer will consider the need for: ○ An increase in the frequency of routine inspections and monitoring. ○ Additional inspection, instrumentation, monitoring, or analyses ○ Modifications to the waste placement/construction practices, including discontinuation of loading. • If the results of the analysis indicates there is a stability concern, the mine inspector and Selkirk First Nation will be notified immediately.

Table 2-13: Specific Indicators, Performance Thresholds and Responses for Category 2 Facilities

Specific Indicators	Specific Performance Thresholds	Specific Responses

• Mass movement indicated by monitoring of geotechnical instrumentation
• Visual observations of physical damage
• Visual observations of evidence that could suggest mass movement
• Occurrence of seismic events
	Specific Threshold 1
	
	• Observation of unusual occurrence including:
	  • tension cracks, settlement, or sloughing;
	  • a seismic event that exceeds the 1:475 return period event;
	  • abnormal seepage from any area of the slopes;
	  • increased turbidity from seepage;
	  • physical damage.
		Notification
		• Mine Manager
		• Geotechnical Engineer
		• Include in annual report
		
		Review
		• Review previous inspection reports, existing instrumentation including piezometer, temperature, inclinometer, and survey data.
		
		Evaluation
		• Geotechnical Engineer to compare recent monitoring results against older results for additional evidence of instability.
		
		Action
		• Inspect the area for any other signs of instability.
		• Follow any recommendations of the Geotechnical Engineer. At a minimum, the Engineer will consider the need for:
		  ○ An increase in the frequency of routine inspections and monitoring.
		  ○ Additional inspection, instrumentation, monitoring, or analyses.
		• If the results of the analysis indicates there is a stability concern, the mine inspector and Selkirk First Nation will be notified immediately.

	Specific Threshold 2
	
	• Survey hub cumulative displacements between 150 mm and 500 mm;
	
	Or
	
	• Increase in pore water pressures such that Ru exceeds 0.2.
		Notification
		• Mine Manager
		• Geotechnical Engineer
		• Include in annual report
		
		Review
		• Review previous inspection reports, existing instrumentation including piezometer, temperature, inclinometer, and survey data.
		
		Evaluation
		• Geotechnical Engineer to compare recent monitoring results against older results for additional evidence of instability.
		
		Action
		• Inspect the area for any signs of instability.
		• Immediately Increase monitoring and data review frequency until determined unnecessary:
		  ○ If survey hub threshold exceeded: increase frequency to **twice-monthly** or as directed by the Engineer.
		  ○ If pore water pressure threshold exceeded: increase frequency to **twice-weekly** or as directed by the Engineer.
		• Follow any additional recommendations of the Geotechnical Engineer.

Specific Indicators	Specific Performance Thresholds	Specific Responses
		• If the results of the analysis indicates there is a stability concern, the mine inspector and Selkirk First Nation will be notified immediately.

	Specific Threshold 3
	
	• Survey hub cumulative displacements greater than 500 mm.
	
	Or
	
	• Increase in pore water pressures such that Ru exceeds 0.4.
		Notification
		• Mine Manager
		• Geotechnical Engineer
		• Include in annual report
		
		Review
		• Review previous inspection reports, existing instrumentation including piezometer, temperature, inclinometer, and survey data.
		
		Evaluation
		• Geotechnical Engineer to compare recent monitoring results against older results for additional evidence of instability.
		
		Action
		• Inspect the area for any other signs of instability.
		• Complete a ground survey of the area of interest to allow for a stability assessment to be completed (if required by the Engineer), and to monitor any future displacement.
		• Immediately increase monitoring and data review frequency until determined unnecessary:
		  ○ If survey hub threshold exceeded: increase frequency to **twice-weekly** or as directed by the Engineer.
		  ○ If pore water pressure threshold exceeded: increase frequency to **daily** or as directed by the Engineer.
		• Follow any additional recommendations of the Geotechnical Engineer. At a minimum, the Engineer will consider the need for:
		  ○ An increase in the frequency of routine inspections and monitoring.
		  ○ Additional inspection, instrumentation, monitoring, or analyses
		  ○ Modifications to the waste placement/construction practices, including discontinuation of loading.
		• If the results of the analysis indicates there is a stability concern, the mine inspector and Selkirk First Nation will be notified immediately.

3 Reporting and Review

Reporting and review represent an essential part of the Adaptive Management Framework, as described in section 1.4.2, and reporting on adaptive management is included in the notification component of all specific responses described in section 2.

3.1 Monthly and Annual Reporting

Monthly reports are required to be submitted to the Yukon Water Board under Water Licence QZ14-031, and annual reports are required for submission under both the Water Licence and the Quartz Mining License. Both licenses require reporting on adaptive management.

Monthly reporting includes all activities carried out under the Adaptive Management Plan.

Annual reporting will include summaries of all activities carried out under the Adaptive Management Plan, including monitoring results compared to thresholds and any actions taken. The annual report will also include water levels and a trend analysis of observed water quality in Minto and McGinty Creeks.

3.2 Annual Review

The AMP may be modified when unexpected circumstances are encountered and the protocol is implemented or when additional understanding becomes available. An annual review of the AMP will take place prior to annual reporting, and Annual Reports will include a summary of proposed updates and revisions to the Adaptive Management Plan and include a revised Adaptive Management Plan, if warranted.

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