



**Scope 4—Reclamation
Monitoring Program**

Myra Falls Mine Reclamation Research
Program

December 13, 2019

Prepared for:

Integral Ecology Group and Nyrstar
Myra Falls Ltd.

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SCOPE 4—RECLAMATION MONITORING PROGRAM

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Executive Summary

Myra Falls Mine (the site) is located in Strathcona-Westmin Provincial Park, approximately 90 kilometres (km) southwest of Campbell River, on central Vancouver Island, British Columbia (BC). The mine is a polymetallic zinc, copper, silver and gold mine operated by Nyrstar Myra Falls Ltd. (Nyrstar). Progressive reclamation during mining operations has been ongoing at the mine site for many years.

The Reclamation Monitoring Program (RMP) presented herein is part of a larger Reclamation Program to be provided to the British Columbia Ministry of Energy, Mines, and Petroleum Resources (EMPR). Reclamation research design, planning, implementation and monitoring are based on the approved closure and reclamation plan. The results of reclamation research are reported in the annual reclamation report, and re-evaluated and adjusted during the rolling five-year reclamation and closure report update.

Reclamation research and monitoring of reclamation activities at the site is based on the objectives of closure and reclamation in the mine permit approval, Park permit approval as well as stakeholder input and First Nation engagement. To support operational scale reclamation, a series of research trials and field-based knowledge gathering surveys are put in place to test and verify that specific reclamation prescriptions will work towards meeting end land use objectives prior to being applied at an operational scale. The key reclamation research themes identified for the site are:

- **Long-term Watercourse Reclamation Plan**, including a Water Infrastructure Decommissioning and Reclamation Monitoring Program as well as associated studies, and an Aquatic Habitat Reclamation Plan. This plan addresses and describes the reclamation details of each watercourse at the site, and the methods proposed to determine the effectiveness of instream reclamation and habitat restoration.
- **Terrestrial Reclamation Plan**, including an Erosion and Sediment Assessment Program, Soil Compaction and Decompaction Plan, Revegetation Prescription Plan, research for old-growth attributes and a Soil Cover Plan. The focus of this plan is designing studies to assess, monitor and evaluate the reclamation efforts on soil, vegetation and wildlife at the site.
- **Metal Uptake Monitoring Plan**, addressing proposed study designs and methodologies to develop a monitoring program to evaluate metal uptake in exposed terrestrial and aquatic ecosystems. Additionally, a study is designed to assess and monitor the effects of metal uptake in aquatic organisms, as well as to identify what the potential constituents of potential concern (CoPC), exposure risk and exposure pathways to wildlife are on site.

The RMP presented herein builds on the results and research themes identified under previous scopes with the objective to develop a progressive reclamation monitoring program that evaluates the effectiveness of completed and ongoing progressive reclamation. The proposed monitoring program includes quantifiable performance objectives (QPO's) for the reclamation monitoring activities and specifies sampling requirements and frequencies. The RMP further includes possible mitigation techniques to be considered in the event the QPO's are not met. Roles and responsibilities, reporting requirements, and a Trigger, Action, Response Plan are included in the RMP. Overall, the RMP will support to demonstrate that reclamation is meeting permit and internal requirements.



Abbreviations

BC	British Columbia
CCME	Canadian Council of Ministers of the Environment
CHaMP	Columbia Habitat Monitoring Program CHaMP
CoPC	Constituents of Potential Concern
CPUE	catch-per-unit-effort
DO	dissolved oxygen
EMPR	Ministry of Energy, Mines, and Petroleum Resources
ha	hectare
IEG	Integral Ecology Group
km	kilometre
LWRP	Long-Term Watercourse Reclamation Plan
Nyrstar	Nyrstar Myra Falls Ltd.
QPO	Quantifiable Performance Objective
RISC	Resources Information Standards Committee
RMERP	Reclamation Methodology Evaluation Research Program
RMP	Reclamation Monitoring Program



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RRP	Reclamation Research Program
Stantec	Stantec Consulting Ltd.
TDF	Tailings Disposal Facility
TLU	traditional land use
Wood	Wood Environment & Infrastructure Solutions
WQG	Water Quality Guideline



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1.0 INTRODUCTION

Stantec Consulting Ltd. (Stantec) was retained by Integral Ecology Group (IEG) to develop a Reclamation Monitoring Program (RMP) for the Myra Falls Mine (the site). The site is located in Strathcona-Westmin Provincial Park, approximately 90 kilometres (km) from Campbell River, on central Vancouver Island, British Columbia (BC). The mine is a polymetallic zinc, copper, silver and gold mine operated by Nyrstar Myra Falls Ltd. (Nyrstar).

The RMP (Scope 4) is part of a larger Reclamation Program to be submitted to the British Columbia Ministry of Energy, Mines, and Petroleum Resources (EMPR). The RMP is part of several scopes that are contributing to the Reclamation Program as follows:

- **Scope 1:** Reclamation Research Program (RRP) that summarized reclamation research undertaken at the site and identified reclamation themes along with implementation plans to close knowledge gaps identified; the RRP also provided the framework for scopes 2, 3, and 4 (Stantec 2019a).
- **Scope 2:** Site-wide End Land Use and Post-closure Ecosystem Development Plan (the Development Plan) that developed site-specific reclamation prescriptions (Stantec 2019b and IEG 2019).
- **Scope 3:** Reclamation Methodology Evaluation Research Program (RMERP) that proposed study designs for the development of a five-year research program and evaluated reclamation methodologies recommended by current and future reclamation plans (Stantec 2019c).
- **Scope 4:** RMP, presented herein, to demonstrate that reclamation is meeting permit and internal requirements, using comparison to Quantifiable Performance Objectives (QPOs) and including trigger, action and response plans.

The RMP has been informed by the assessments completed in Phase 1 of Nyrstar's reclamation studies, including Topsoil Management Plan (Wood 2018), Pre-mining Habitat Assessment (Wood 2019a), and Habitat Loss Mitigation Plan (Wood, 2019b). The following sections describe the RMP and its components in further detail.

1.1 REGULATORY CONTEXT

Reclamation research design, planning, implementation and monitoring are based on the approved closure and reclamation plan. The results of reclamation research are reported in the annual reclamation report, and re-evaluated and adjusted during the rolling five-year reclamation and closure report update.

The objectives of closure and reclamation are based on *Mines Act* Permit M-26 and *Parks Act* Permit approvals, stakeholder input and First Nation engagement. To support operational scale reclamation, a series of research trials and field-based knowledge gathering surveys are proposed to test and verify that specific reclamation prescriptions will work towards meeting end land use objectives prior to being applied at an operational scale.



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The following key regulations and permits have been considered in the development of the RMP:

- Section 10 of the Health, Safety, and Reclamation Code for Mines
- *Mines Act* Permit M-26 administered by EMPR
- *Environmental Management Act* Effluent Permit PE-6858 administered by the BC Ministry of Environmental and Climate Change Strategy
- *Drinking Water Protection Act* and Drinking Water Protection Regulation Permit AMID-927USG administered by the Vancouver Island Health Authority
- *Fisheries Act* Metal and Diamond Mine Effluent Regulations administered by Environmental Canada
- Master Plan for Strathcona-Westmin Provincial Park (Ministry of Environment Lands and Parks)
- *Parks Act* Park Use Permits 102633 and 102201

1.2 INDIGENOUS CONTEXT

The site is located within the Strathcona-Westmin Provincial Park on Vancouver Island, BC. Four First Nations Groups occupy this region: Wei Wai Kum, We Wai Kai, K'ómoks, and Mowachaht/Muchalaht First Nations. A Pre-Mining Habitat Assessment (Wood 2019a) was completed to assess land capability for potential traditional use focused on the four First Nations Groups and their respective associated tribal regions (Kwakwaka'wakw, Kwakwaka'wakw, Coast Salish, Nuuchah-nulth).

Understanding the end land use objectives for the post-mine landscape is key to meeting traditional land use (TLU) objectives. Some assessments have been completed to date which help guide site specific prescriptions. To support reclamation of the terrestrial habitats, six tree species, nine shrub species and seven herb species were identified in Wood's pre-mine habitat assessment report as potential TLU species, and the assessment focused on plant species for food and medicinal purposes (Wood 2019a). Traditional use plants are considered when developing reclamation prescriptions. However, these species are not always commercially available or the related propagation methods are not well understood. For aquatic habitats that require restoration, understanding how waterways were used prior to mining provides guidance on the prescriptions that need to be designed and tested.

The *Mines Act* Permit M-26 and the *Parks Act* Park Use Permits 102633 and 102201 have outlined requirements for engagement with First Nations as presented in Table 1.

Nyrstar is leading the engagement process with First Nations as part of their reclamation program. Inputs from First Nations provided through engagement activities will be incorporated into the RRP, RMERP and RMP.



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Table 1 Permit Requirements regarding Engagement with First Nations

Permit Name	Permit Section	Permit Condition
<i>Mines Act</i> Permit M-26	Section A: General	Unless otherwise requested, the Permittee shall provide to the Wei Wai Kum, We Wai Kai, K'ómoks, and Mowachaht/Muchalaht First Nations all material reports and plans relevant to this permit, including annual monitoring reports and material changes to the approved Reclamation and Closure Plan.
	Section E: Reclamation and Closure Program	The land surface shall be reclaimed with the intent of re-establishing average pre-mining capability to the following end land use objectives: wildlife habitat, particularly for Columbian black-tailed deer, Roosevelt Elk, black bears, wolves, cougars, American marten, red squirrel, deer mice, and bats, provincial park wilderness and recreational values, and opportunities for traditional use of the land by the Wei Wai Kum, We Wai Kai, K'ómoks, and Mowachaht/Muchalaht First Nations.
<i>Parks Act</i> Park Use Permit No. 102201 and 102633	Article 6: Covenants of the Permittee	The Permittee must: Once each calendar year, meet with the Minister, the area First Nations and the Strathcona-Westmin Park Public Advisory Committee, to discuss any management concerns that arose in the previous calendar year and to brief the Minister, the area First Nations and the Strathcona-Westmin Park Public Advisory Committee on the Permittee's planned activities under this Permit for the current calendar year.

1.3 END LAND USE OBJECTIVES

The land end use objectives for the Myra Falls Mine are included in *Mines Act* Permit M-26 Approving Price Plan and Security (2018)—E. Reclamation and Closure Program, 2 Land Use, which states:

- (a) The land surface shall be reclaimed with the intent of re-establishing average pre-mining capability to the following end land use objectives: wildlife habitat, particularly for Columbian black-tailed deer, Roosevelt Elk, black bears, wolves, cougars, American marten, red squirrel, deer mice, and bats, provincial park wilderness and recreational values, and opportunities for traditional use of the land by the Wei Wai Kum, We Wai Kai, K'ómoks, and Mowachaht/Muchalaht First Nations.
- (b) Ecosystem type old growth forest that is predicted to be lost as a direct result of mining activities shall be mitigated in a manner acceptable to the Chief Inspector. A plan for mitigating losses to old growth forest capability incurred within the mine disturbance shall be submitted by June 30, 2019.
- (c) Borrow pits and quarries belonging to the mine development and operations, shall be reclaimed to the approved end land use once no longer required.



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Further, Permit M-26 Approving Work System and Reclamation Program (1998)—Section 3 Land Use (page 5), states:

“The surface of the land and watercourses shall be reclaimed to end uses to enhance Park values for recreation and conservation including:

- a) reintegration of disturbed land into the surrounding landscape and park,
- b) re-establishment of native forest
- c) reduction of erosion through development of maintenance-free indigenous vegetation covers, and the development of self-sustaining, erosion-resistant watercourses.”

1.4 RECLAMATION MONITORING OBJECTIVES

Reclamation monitoring objectives are developed to support achievement of permit objectives and implementation of proposed reclamation research activities and studies. Each objective has criteria that demonstrates fulfillment of that objective, and each criterion has one or more indicators that will be measured to demonstrate that the criterion has been met. The proposed indicators will provide information on a broader suite of characteristics and processes and will be testable against established and defensible thresholds. The following sections describe the reclamation monitoring objectives in greater detail for each reclamation theme.

2.0 RECLAMATION MONITORING PROGRAM

The following sections provide the approach and details of the proposed RMP. Summary tables of the proposed monitoring activities, and Trigger, Action and Response Plan are presented in Section 2.5.

2.1 APPROACH

The RMP builds on the results and research themes identified under previous scopes with the objective to develop a reclamation monitoring program that evaluates the effectiveness of completed and ongoing progressive reclamation activities. The RMP includes QPO's for the reclamation monitoring activities and specifies sampling requirements and frequencies. The RMP includes possible mitigation techniques to be considered in the event the QPO's are not being met. Roles and responsibilities, reporting requirements, and a Trigger, Action, Response Plan are included in the RMP. Overall, the RMP will determine that reclamation is meeting permit and internal requirements.

Detailed monitoring activities presented herein are based on the following reclamation research themes:

1. **Long-Term Watercourse Reclamation Plan** including a Water Infrastructure Decommissioning and Reclamation Monitoring Program, associated studies, and an Aquatic Habitat Reclamation Monitoring Plan;
2. **Terrestrial Reclamation Plan** including an Erosion and Sediment Assessment Program, Soil Compaction and Decompaction Plan, Revegetation Prescription Plan, Research for Old-Growth Attributes and Soil Cover Plan; and
3. **Metal Uptake Monitoring Plan** including a Soils and Vegetation Baseline and Uptake Program, a Wildlife Exposure Risk Study, a Water Quality Sampling Program and a Metal Uptake in Aquatic Organisms Program.

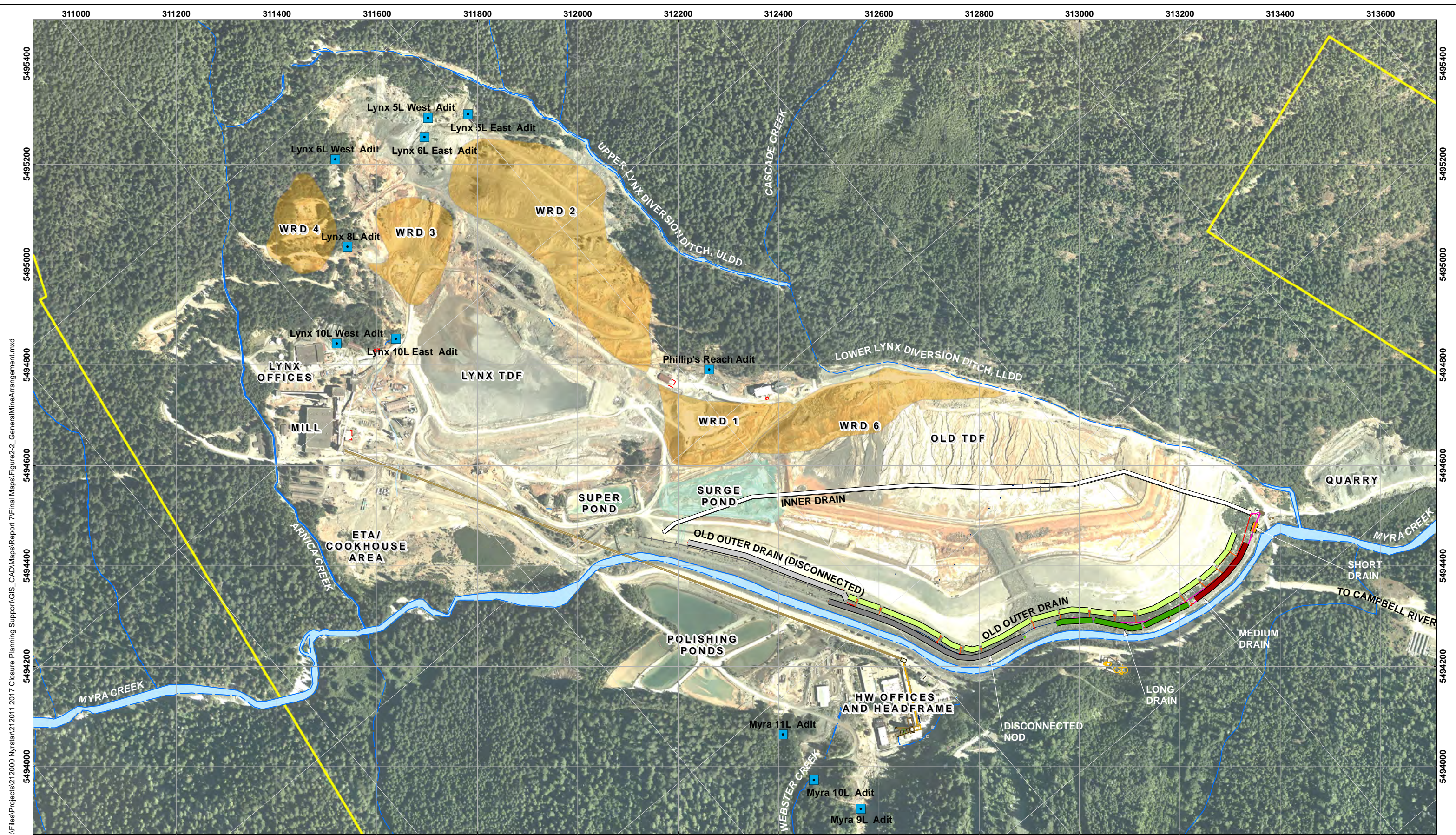


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The following sections provide details on the proposed monitoring activities including QPOs, frequencies and roles for each of these main themes. In the RMERP presented in Scope 3 it was discussed that rather than focusing on single sites, the approximately 30 ha area old TDF could provide an area for larger scale reclamation that can also include selected monitoring sites presented in Scope 4.

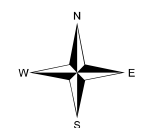




S:\Files\Projects\212000 Nyrstar\212011 2017 Closure Planning Support\GIS_CAD\Maps\Report 7\Final Maps\Figure2-2_GeneralMineArrangement.mxd

Legend

— Class B Park Boundary



Scale 1:7,000

0 50 100 200 300 400 500 Meters

NAD83 UTM Zone 10N

Robertson GeoConsultants Inc.
 Consulting Engineers and Scientists for the Mining Industry
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General Mine Arrangement 2018, Nyrstar Myra Falls

Client:	Figure: 1
Project: 2018 Load Balance Update	Last Update: Nov 16, 2018
Report: RGC 212011/7	Drawn: L.R.
Original File: Figure2-2_GeneralMineArrangement.mxd	

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2.2 LONG-TERM WATERCOURSE RECLAMATION PLAN

The objective of the Long-Term Watercourse Reclamation Plan (LWRP) is to return watercourses to their pre-disturbance hydrology and geomorphology to support biodiversity, recreation, and flood management criteria. The LWRP will be developed in a phased approach. The first phase will involve monitoring of watercourses that could be reclaimed post-closure during water treatment. The second phase will involve monitoring watercourses that could only be reclaimed post-closure after water treatment is no longer required. As the timing water treatment completion is unknown, this plan describes only the first phase of the LWRP which includes a monitoring program associated with the water infrastructure decommissioning and reclamation monitoring program and an Aquatic Habitat Reclamation Monitoring Plan.

2.2.1 Water Infrastructure Decommissioning and Reclamation Monitoring Program

Nyrstar is developing the final design for watercourse reclamation and these designs will be informed by the studies described in the RMERP (Scope 3). This Water Infrastructure Decommissioning and Reclamation Monitoring Program describes the monitoring required to evaluate whether reclamation objectives are being met based on preliminary watercourse reclamation plans. Reference site data collection must be completed before Nyrstar can develop a Trigger, Action, and Response Plan as these data will act as a benchmark for monitoring reclamation success.

2.2.1.1 Requirements

The Water Infrastructure Decommissioning and Reclamation Monitoring Program includes the monitoring components of three studies: Performance Assessment of Diversion Ditches, Surface Water Flow Monitoring Study, and a Myra Creek Geomorphology Monitoring Study. The Power Supply Options Analysis mentioned in RMERP (Scope 3) is not included in this report, as monitoring requirements (if any) are not yet determined.

The following sections describe the proposed monitoring and evaluation activities based on preliminary watercourse reclamation plans and in accordance with the Water Infrastructure Decommissioning and Reclamation Monitoring Program that is designed to comply with the *Mines Act* Permit M-26, which states that *“all surface water management ponds and water diversions shall be reclaimed to satisfy stability and erosion control requirements and the approved end land use once no longer required.”* As per the *Mines Act*, watercourses shall be restored for long-term physical and geochemical stability, drainage should be restored to original state or a new watercourse that is self-sustaining without maintenance and that supports a level of productive capacity that is not less than what was existing prior to mining, unless it is impractical to do so. While noting that streambank instability and streambed erosion are part of the lifecycle of natural watercourses, this goal is generally interpreted as restoring the watercourse to a state that reflects its natural behavior, follows a pathway that is reflective of underlying topography, and has opportunity for lateral migration. More specifically, the goal for watercourse reclamation is defined as returning watercourses to their pre-disturbance hydrology and geomorphology to support biodiversity (e.g., fish and fish habitat), recreation, and flood management with restoring lateral and/or longitudinal connectivity of water and sediment.



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2.2.1.2 Quantifiable Performance Objectives, Frequencies, and Roles and Responsibilities

QPOs are described in this section while criteria, indicators, sampling frequencies, and roles and responsibilities are presented in Table 2. As discussed in Section 2.2.1, the Trigger, Action, and Response Plan will be finalized after reference site data is collected and analyzed by a qualified professional. A preliminary plan is shown in Table 3.

To address Permit M-26 requirements, Nyrstar will be required to demonstrate that water use and capacity objectives are achieved to a level not less than existed prior to mining activities. This level of reclamation may not be achievable as some of the existing water infrastructure (e.g., water settling ponds, lime agitators) must remain in-place due to water treatment as well as water infrastructure (i.e., the Tailings Disposal Facility [TDF]) are blocking pre-mining watercourse pathways.

Pre-mining conditions of the diverted Arnica Creek, Cascade Creek, Myra Creek, and other small diverted creeks are unknown. To account for lack of pre-mining hydrology and geomorphology data for these creeks, sites unaffected by mining operations will be evaluated using QPOs.

Performance Assessment of Diversion Ditches

Non-contact surface water from the Arnica Creek and Cascade Creek watersheds is diverted around the mine material; specifically, the waste rock piles, Lynx TDF, and the Old TDF (see Figure 1). These diversions, the Arnica Diversion Ditch, the Upper Lynx Diversion Ditch, and Lower Lynx Diversion Ditch will be monitored to assess their functionality with respect to flow and sediment transport in the watershed. It is assumed as-built surveys will be used to ensure the ditches were built as designed. The monitoring program is to be implemented to assess whether the diversions do not prevent the downstream movement of flow and sediment. This data will be used to develop the Trigger, Action, and Response Plan for diversion ditch performance.

This performance assessment will include desktop and field components and be completed by a qualified professional with appropriate qualifications in fluvial geomorphology and hydrology as described in the RMERP (Scope 3). Once this assessment is complete and any upgrades to current diversion ditches are completed, performance monitoring of the assessment ditches will occur.

Monitoring of the diversion ditches will be quantifiably measured by:

- Monitoring flows into and out of the ditches:
 - Field flow measurements during all seasonal conditions (i.e., peak and low flow)
 - Height of bank freeboard during peak flows
- Sediment source inventory—regular monitoring of sediment sources upstream of diversion ditch
- Sediment mobility/continuity—annual visual assessments of diversion ditch to identify any sediment accumulation occurring within the ditch.
- Cross-section monitoring location will be established to ensure that the hydraulic conveyance capacity of the ditch does not change overtime as a result of erosion or deposition.
- Presence of spillover, erosion, and damage will be noted during monitoring events



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It is recommended that performance monitoring be conducted annually by onsite Nyrstar staff, trained by a qualified and experienced third-party consultant, for Years 1 to 5. Frequency of monitoring will be evaluated after Year 1 and may be reduced to quarterly if performance objectives are met. Frequency of monitoring will be evaluated again in Year 5 to assess monitoring frequency based on performance objective success. Flow monitoring should coincide with the Surface Water Flow Monitoring Study, occurring 5 to 10 times per year, starting in 2020 and continue into Years 1 through 5. Long-term monitoring (i.e., Years 10, 15, 20) is recommended to provide evaluation of the continued success of the diversion ditches.

Surface Water Flow Monitoring Study

Flow data will be collected by installing hydrometric stations on the mine site and conducting flow measurements. In addition to the existing hydrometric station (on Myra Creek), stations will need to be installed at lower Arnica Creek, Lower Lynx Diversion Ditch, and Webster Creek. It is likely that a new station in Myra Creek is required upstream of the existing station and outside of the mine footprint. A more detailed assessment of the total number of stations to be installed will be undertaken by a qualified professional prior to field work as described in the RMERP (Scope 3). The aim of the flow program is to ensure that the design assumptions are being met and the diversions and/or reclaimed channels are conveying the volume of water introduced at the upstream end.

Monitoring of the channels will be quantifiably measured by:

- Flow measurements relative to local waterbodies
- Continuous hydrometric data collection to understand seasonal variability and effectiveness of the reclamation plans throughout the year

Flow monitoring should be conducted by collecting continuous hydrometric data from hydrometric stations and manual flow measurements, at least 5 to 10 per year, commencing in 2020 to establish background data/reference sites and continuing post closure for Years 1 to 5. This monitoring study will follow the Manual of British Columbia Hydrometric Standards (2018) protocols. Continuous collection of hydrometric data and flow monitoring of Myra Creek is recommended during closure to inform water management during the water treatment phase of mine closure (Year 5+) and will be developed as part of the adaptive management component of Nyrstar's Closure and Reclamation Plan.

Myra Creek Geomorphology Monitoring Study

This study will select reference sites on Myra Creek to establish the creek's natural geomorphology that would have existed prior to mining activities. The reference site locations will be located on Myra Creek upstream and/or downstream of the mine. The final locations of this study will be determined onsite by a geomorphologist, incorporating the understanding of the long-term objectives of the channel and reaches in Myra Creek that appear to be in a state of quasi-equilibrium. Selected sites should reflect the stream geomorphology of Myra Creek that is unaffected by mining operations and are to be used as reference sites. The methods of this study are described in the RMERP (Scope 3).



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The results of this study will be used as a baseline for Myra Creek's natural behavior regarding erosion and sedimentation processes as well as channel stability and will be used to develop the Trigger, Action, and Response Plan. This data will inform the reclamation plan (under development) and therefore activities for the re-routed portion of Myra Creek. Once reclamation activities have been complete, performance of the restored Myra Creek will be quantifiably measured by the following methods

- Longitudinal profile (thalweg profiles) surveys of the creek bed elevation along the deepest portion of the channel to identify deep habitat (i.e., pools) and shallow habitats (i.e., riffles) based on methods from the Columbia Habitat Monitoring Program (CHaMP) Pess et. al 2014). Longitudinal profile surveys should be conducted prior to reclamation activities, immediately after, and at least every 3-5 years. These profiles provide quantitative measures of channel morphology and fish habitat independent of flow conditions. The information will also be used to monitor the how the reclaimed section of Myra Creek changes overtime relative to the creek upstream of the activities. The information will also be used to assess whether the reclaimed section has affected the section of Myra Creek downstream of reclamation activities.
- Channel cross-sections (line transects) will be established at various locations upstream, within, and downstream of watercourse reclamation activities. These surveys typically happen on an annual basis, or sometimes an event basis (depending on magnitude of the event and if channel change is observed). The main objectives of these surveys are to:
 - To monitor local 1D channel changes, cross-sectional scour and fill.
 - Bed sediment in within the cross-section can be visually monitored overtime to assess any potential changes in surface sediment composition.

Additional details to the monitoring program will be added once reclamation plans are finalized.

As indicated above it is recommended that channel cross-sectional surveys be conducted every year, for at least during Years 1 to 5 following channel restoration by a qualified and experienced third-party consultant. The frequency of long-profile surveys will be less frequent and conducted at least every 3 years. Frequency of monitoring after Year 5 will be based on performance as part of the adaptive management component of Nyrstar's Closure and Reclamation Plan. It should be noted that both surveys should be conducted following a large peak flow event when visual assessments conclude channel changes have occurred. Long-term monitoring (i.e., Years 10, 15, 20) is recommended to provide evaluation of the continued success of the Myra Creek restoration.

2.2.1.3 Considerations

Consideration of mitigations or remedial actions for sites that do not meet applicable criteria for the Water Infrastructure Decommissioning and Reclamation Monitoring Program are listed below for each monitoring study:



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Performance Assessment of Diversion Ditches:

- If the diversion ditch design does not meet the conveyance objectives of limiting overflow, flooding, or erosion, additional engineering will be required, as well as re-analysis of the initial hydrologic criteria used in designing the diversion.
- If sediment delivered from upstream sources is not being transported downstream, modification of the diversion can be undertaken to improve sediment throughput. Additionally, sediment that has accumulated within the ditch can be excavated and re-introduced into Myra Creek via a gravel supplementation program.

Surface Water Flow Monitoring Study

- This study is a collection of baseline data to understand seasonal variability and effectiveness of the reclamation plans throughout the year; therefore, QPOs, indicators, and considerations do not apply at this time.

Myra Creek Geomorphology Monitoring Study

- The relative geomorphic change within the reclaimed portion Myra Creek exceeds that of the upstream control sites. Additional instream works may be required to rectify the discrepancy.
- The relative geomorphic change of the downstream portion of Myra Creek relative to the upstream control sites. Assess whether change is related to inputs from upstream or is a result of localized instability. If related to project work, additional instream works may be required within the reclaimed portion to rectify the discrepancy.

Once any potential instream works have been corrected, monitoring programs will need to be adjusted accordingly.

2.2.1.4 Data Evaluation and Reporting

Data Analysis

The data collected during these three monitoring studies will be reported as follows:

- Performance Assessment of Diversion Ditches: Flow data will be evaluated following British Columbia Hydrometric Standards (RISC 2018) best practices and will be presented as tabulated data and figures. Diversion ditch capacity and conveyance will be evaluated overtime with reference to the original designs and monitoring of cross-sections.
- Surface Water Flow Monitoring Study: Data will be evaluated following the Manual of British Columbia Hydrometric Standards (2018) best practices and will be presented as tabulated data and figures. This will include rating-curve development and annual maintenance, as well as grading the data collected on an annual basis based on the guidelines.
- Myra Creek Geomorphology Study: Data from longitudinal and cross-section surveys will be evaluated using applicable graphing techniques following CHaMP guidelines (Pess et. al 2014 and Crawford 2011) and presented as tabulated data and figures.



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Feedback Loop

The results of the monitoring program will assess the applicability and relevance of the monitoring methods and inform the feedback loop step to help refine the Reclamation Research Program activities (e.g., focused monitoring activities, QPOs, and Trigger, Action, and Response Plan) and will be developed following collection and analysis of background site data.

Reporting

A comprehensive report covering the results of the Water Infrastructure Decommissioning and Reclamation Monitoring Program will be produced annually. This annual report will discuss the results from the three monitoring studies outlined above and how results from study at the exposure site compare to reference site and success criteria. The frequency of reporting will be assessed as part of adaptive management.

2.2.2 Aquatic Habitat Reclamation Monitoring Plan

2.2.2.1 Requirements

The Aquatic Habitat Reclamation Monitoring Plan has been designed to determine if reclamation activities are working towards the end land-use objective for watercourses identified in *Mines Act*, Permit M-26. This objective states: *“Watercourses shall be reclaimed to a conditions that ensures (a) drainage is restored either to original watercourses or to new watercourses that will sustain themselves without maintenance, and (b) the level of productive capacity shall not be less than existed prior to mining [...]”*.

The Aquatic Habitat Reclamation Monitoring Plan includes a Habitat Monitoring Study, a Bed Sediment Monitoring Study, and a Fish Habitat Utilization Monitoring Study. The following sections discuss the QPOs identified for each monitoring study to evaluate throughout the 5-year reclamation program whether the reclamation efforts comply with, or are working towards, the Permit guidelines.

2.2.2.2 Quantifiable Performance Objectives, Frequencies, and Roles and Responsibilities

QPOs, criteria and indicators are presented in Table 2 along with sampling frequencies and roles and responsibilities. To address the Permit M-26 requirements, Nyrstar will be required to demonstrate that reclaimed watercourses are stable and have similar productive capacity to what existed prior to mining. Cutthroat trout (*Oncorhynchus clarkii*) has been identified as the single resident fish population in Myra Creek (Nautilus Environmental, 2017). Depending on whether pre-mine fish and aquatic habitat information for Myra and Arnica Creeks is available it might not be possible to know what the productive capacity of the affected watercourses was prior to mining. Based on site constraints (e.g., channel gradient, sinuosity, size, etc.), it is possible that affected watercourses were not suitable for all fish life stages prior to mining and, therefore, it may not be possible to provide habitat, or restore productivity capacity, for all fish life stages following reclamation. If the productive capacity of the habitat prior to mining operations is unknown, it is recommended that, once restored, the previously affected area should



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aim to reflect habitat productive capacity from areas unaffected by the mining operations (i.e., reference sites).

The success of reclamation to re-establish aquatic habitat and its productive capacity will be evaluated using QPOs. These QPOs, listed below by monitoring study, will have indicators that will be measured over time so that trends observed through monitoring can be evaluated against criteria, and the influence of seasonal variability (where applicable) can be determined. Accurate monitoring and data collection over time will show when and if indicators deviate from desired outcomes, objectives or permit guidelines and identify if trigger thresholds are exceeded such that additional reclamation actions are required. The goal of this monitoring approach is to establish a trajectory of aquatic habitat that provides functional habitat for target fish species (cutthroat trout).

Habitat Monitoring Study

To assess whether the Habitat Monitoring Study is meeting the end land-use objectives and Permit requirements, the following QPO has been identified for this study: *Habitat in reclaimed watercourses is stable and provides similar productive capacity for cutthroat trout as reference sites.*

A feasibility study will need to be developed to evaluate whether re-establishment of habitat requirements for specific life-stages of cutthroat trout are feasible within the area affected by reclamation efforts, based on channel hydraulics, flow regime, barriers to fish passage, and other potential habitat constraints.

Habitat conditions in reference sites (i.e., unaffected by mining operations) are recommended to be compared to habitat conditions in affected watercourses to assess productive capacity following reclamation efforts. The indicators that should be monitored to determine the success of the Habitat Monitoring Study are:

- Riparian vegetation cover
- Riparian vegetation survival
- Instream habitat characteristics important to cutthroat trout (e.g., average thalweg depth, % total cover, % pools, and pool/riffle ratio in late summer/low flow period)
- Substrate composition (e.g., % cobble in riffle-run areas; % gravel in riffles and pool tail-outs; % fines in riffle-run areas and pool tail-outs used for spawning)

Monitoring of riparian vegetation and instream habitat and comparing it to reference sites will facilitate an improved understanding of trends and a determination of the degree to which habitat productive capacity for cutthroat trout is approaching or meeting reclamation success criteria. Collected data on riparian vegetation composition and stream cover will be used to demonstrate how the aquatic habitat and riparian vegetation evolves over time and the response to channel modifications and restoration efforts.



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Frequency

It is recommended that monitoring be conducted in Year 1 to collect baseline data and again in Year 5. Annual monitoring can be conducted to assess the survival of riparian vegetation. Long-term monitoring (i.e., Year 10, 15, and 20) should be conducted to evaluate the success of restoration on riparian vegetation, stream cover and instream habitat characteristics.

Roles and responsibilities

It is recommended that monitoring activities for the Habitat Monitoring Study be conducted by a qualified third-party professional consultant.

Bed Sediment Monitoring Study

To assess whether the Bed Sediment Monitoring Study is meeting the end land-use objectives and Permit requirements, the following QPO has been identified for this study: *Channel bed and banks are stable and provide suitable habitat for different cutthroat trout life stages*. The criterion for meeting this objective is: *Channel substrates that are favorable for various cutthroat trout life stages*.

Size distribution of bank sediments and channel substrates should be the indicators to be measured to assess the success of reclamation activities for this study. Depending on whether pre-mine data on bank sediment and channel substrate size distribution at the reclaimed watercourses are available, data collected at reference sites upstream and downstream of site will need to be used to provide a frame of reference to compare to reclaimed watercourses so that the success of the reclamation efforts can be assessed.

Different life stages of cutthroat trout have different habitat and substrate requirements (e.g., clean gravels in riffle and pool tail-outs for spawning, cobble/gravel/boulder in riffles and runs for benthic invertebrate production, large cobble/boulders in pools and runs for overwintering). Therefore, transects should be placed in different habitat types in the affected and reference streams to document how substrate composition in these habitats compare over time as the reclaimed channels stabilize. This will also indicate whether remedial reclamation activities need to be conducted to improve bank sediment and channel substrate conditions for fish and benthic invertebrate production. Collecting data on associated environmental variables, such as water depth and water velocity will allow sediment size and distribution to be put into context of the various habitat types.

Throughout the reclamation monitoring period, the size distribution of sediment will need to be monitored and compared to baseline data collected in Year 1 and at reference sites upstream and downstream of the site. To do this, transects should be placed in a random selection of riffle, run, and pool habitats and revisited annually to document any change in substrate composition over time and to compare substrates in reclaimed watercourses to substrates in reference sites. Substrates at these transects should be measured using standardized techniques such as Wolman pebble counts, quadrants, and/or particle size distribution sampling for lab analysis. Methods described in the “Guidelines for Monitoring Fine Sediment Deposition in Streams” (BC Ministry of Water, Land, and Air Protection 2002) should be considered.



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Frequency

Bank sediments and channel substrates should be monitored annually at affected and reference sites. Sampling frequency and intensity may be re-evaluated after Year 5.

Roles and responsibilities

It is recommended that monitoring activities for the Bed Sediment Monitoring Study be conducted by a third-party consultant (qualified professional).

Fish Habitat Utilization Monitoring Study

To assess whether the Fish Habitat Utilization Monitoring Study is meeting the end land-use objectives and Permit requirements, the following QPO has been identified for this study: *Reclaimed watercourses have the same fish abundance and age structure as reference streams.*

Increasing numbers of cutthroat trout are expected in Myra Creek following stream channel and habitat restoration (Scope 3). Depending on whether pre-mine aquatic habitat and fish productivity are available, upstream or downstream sites unaffected by mining operations will be used as reference sites. Similar fishing locations as described in Nautilus Environmental (2017) are recommended, to expand on existing datasets and allow for comparison to previous years.

The relative abundance of different life stages of cutthroat trout, as determined by catch-per-unit-effort (CPUE) of backpack electrofishing and/or minnow trapping, should be used as the indicator to determine whether the QPO for this study is being met. This should be done by sampling sufficiently long sections of the reclaimed watercourses and reference sites to include pools, riffles, and run habitats in similar proportion to those present in the different watercourses. Typically, this is 100 m or 12 times the bankfull width of the stream. Backpack electrofishing and minnow trapping should be conducted as described in BC Field Sampling Manual (BC Ministry of Water, Land, and Air Protection 2003), Fish Collection Methods and Standards (BC Ministry of Environment, Lands, and Parks 1997) and Reconnaissance 1:20,000 Fish and Fish Habitat Inventory: Standards and Procedures (BC Resource Inventory Committee 2001). Single-pass electrofishing in open sites or three-pass depletion sampling in closed sites can be used depending on site conditions; three-pass depletion methods are preferred as they are more accurate, repeatable and allow calculation of fish density.

Relative abundance determined at affected and reference sites over time should be plotted to determine seasonal and annual trends within the affected site and compare to the reference sites. Comparison of the slopes of these lines will provide insight into whether the cutthroat trout population in the reclaimed watercourses is increasing over time, whether it will converge with fish numbers observed at reference sites, and whether the population trends in reclaimed and reference streams are similar. Additionally, the seasonal data will allow determination of the likely seasonal variability and habitat use by different life-stages of cutthroat trout.



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Frequency

Fish utilization should be conducted seasonally in the first 5 years of monitoring to document the likely change in seasonal distribution and density of cutthroat in response to spawning migrations, distribution of various cutthroat trout life stages in different habitat types in summer, and concentration of all cutthroat trout life stages in similar habitats in winter. Sampling frequency can be re-evaluated after the Year 5 assessment (Table 2).

Roles and responsibilities

It is recommended that sampling for the Fish Habitat Utilization Monitoring Study be conducted by a third-party consultant (qualified professional).

2.2.2.3 Considerations

Potential remedial actions for sites that do not meet their success criteria for the Aquatic Habitat Reclamation Monitoring Plan are listed below for each study.

Habitat Monitoring Study

- If riparian vegetation survival, composition, or cover along the reclaimed watercourses is found to be deficient in comparison to reference sites, a revised revegetation strategy may be required
- If instream habitat characteristics in the reclaimed watercourses do not appear to be developing toward the characteristics present in reference sites or do not appear to be providing the characteristics preferred by cutthroat trout, channel re-designs may be necessary
- If substrate composition in the reclaimed watercourses is not approaching those found in reference sites or are not providing the substrates required by cutthroat trout in different habitat types for their different life stages, channel re-designs or substrate additions/manipulations may be required

Bed Sediment Monitoring Study

- An assessment may need to be conducted to understand what factors are affecting the size distribution of bank sediment and channel substrates in reclaimed watercourses and in reference sites (i.e., hydraulic assessment of shear stresses during peak flood events)

Fish Habitat Utilization Monitoring Study

- If the relative abundance of various cutthroat trout life stages does not increase or trend towards the relative abundance in reference sites or show signs of parallelism (similar interannual variation in relative abundance) between the affected sites and reference sites, an assessment of habitat constraints (including fish barriers, flow regime, temperature regime, dissolved oxygen concentration regime, water quality, and habitat quality using standardized methods) and/or re-evaluation of the objective of re-colonizing reclaimed watercourses with cutthroat trout may be warranted

These considerations form the foundation of the Trigger, Actions, and Response plan as described in Section 2.5.3 and Table 3.



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2.2.2.4 Data Evaluation and Reporting

Data Analysis

Data collected during these monitoring studies will be analyzed and reported as follows:

- *Habitat Monitoring Study*: The composition and percentage cover of riparian vegetation along the impact site will be presented visually, using relevant graphing and mapping techniques. Summary statistics of instream habitat characteristics and riparian vegetation survival rate will be provided
- *Bed Sediment Monitoring Study*: Sediment and substrate size distribution at reclaimed watercourses and at reference sites will be plotted over time, using graphing techniques and descriptive statistics
- *Fish Habitat Utilization Monitoring Study*: CPUE data will be presented visually (using relevant graphing techniques) and plotted by season. Additionally, the data will be plotted by age-class (following Nautilus Environmental, 2017) and, if possible, by habitat type. Summary statistics and graphs showing annual and seasonal trends will be provided to demonstrate fish habitat use over time. These parameters will be presented for reclaimed watercourses and reference sites for comparative purposes

Feedback Loop

Results of the monitoring studies will be used to assess the relevance of the monitoring methods and to inform the evaluation of the effectiveness of reclamation activities. The Trigger, Action, and Response Plan for the Aquatic Habitat Reclamation Monitoring Plan monitoring activities are presented in Table 3.

Reporting

A comprehensive report that describes the methods and results of the Aquatic Habitat Reclamation Monitoring Plan will be produced annually. This annual report will discuss results of the three monitoring studies outlined above and how results from reclaimed watercourses compare to reference sites and associated success criteria. It is assumed the evaluation program will be completed with enough information to initiate the RRP within two to three years. However, this time frame is contingent on how effective the monitoring methods are at detecting a response to stream restoration.

2.3 TERRESTRIAL RECLAMATION PLAN

The Terrestrial Reclamation Plan includes an Erosion and Sediment Assessment Program, Soil Compaction and Decompaction Plan, Revegetation Prescription Plan, Soil Cover Plan, and Research for Old-Growth Attributes. The following sections describe the proposed monitoring activities for this plan.



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2.3.1 Soil Erosion and Sediment Delivery Assessment Program

2.3.1.1 Requirements

Section D, Part 12(k) of Permit M-26 states that Nyrstar needs to *develop “a monitoring program designed to evaluate the success of revegetation, soil development and erosion control. This program shall include specific sampling parameters and performance criteria”*.

2.3.1.2 Quantifiable Performance Objectives, Frequencies, and Roles and Responsibilities

QPOs, criteria and indicators for the Soil Erosion and Sediment Delivery Program are presented in Table 2. The purpose of the soil erosion and sediment delivery monitoring program is to provide information on the occurrence and extent of rill and gully erosion and the casual factors of erosion on the reclaimed mine. A rill and gully erosion survey will occur in 1-year intervals. This will provide an annual reconnaissance estimate of the occurrence, extent and volumes of rill and gully erosion loss and the causes of erosion (e.g., lack of surface plant cover or concentrated surface water runoff). Areas where specific temporary erosion control measures need to be implemented (e.g., installation of silt fences, check dams, bioengineering) in conjunction with longer term erosion control (e.g., establishment of a vigorous plant cover) will be monitored on a more frequent basis to determine their effectiveness. The monitoring program will identify triggers on the causal reasons of erosion, effectiveness of erosion control mitigation and allow for an evaluation of reclamation strategies that can limit future soil erosion.

2.3.1.3 Considerations

The following considerations should be accounted for:

- The methods employed in the soil erosion and sediment delivery program will provide a reconnaissance estimate of the erosion occurrence and soil loss that can be used to inform mitigating soil erosion loss and for future planning. The estimates do not account for sheet erosion and cannot be used to provide an accurate sediment budget for reclaimed areas on the site.
- Implementation and monitoring of temporary erosion and sediment control measures are, as the name implies, temporary and require a high level of maintenance and monitoring that needs to be the responsibility of on-site operational staff rather than a third-party consultant. In addition, most temporary sediment erosion control methods are not planned for an unforeseen 1 in 10-year or even 1 in 5-year storm event.
- The soil erosion and sediment delivery program requires the full involvement of Nyrstar staff and full access to the site by a third-party consultant.
- The level of effort required as part of the annual survey of rill and gully erosion will depend on the extent and severity of soil erosion on the reclaimed landscape.



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2.3.1.4 Data Evaluation and Reporting

Data Analysis

Temporary Erosion and Sediment Control effectiveness will be analyzed frequently (e.g., after a major storm event) and warranted adjustments will need to be made as required. Data collected as part of the yearly overview of rill and gully erosion will be summarized and presented so that it provides pertinent information on erosion type, volumetric loss and causal factors. Summary statistics may be carried out to provide information on differences in rill and gully erosion by slope gradient, slope length, material type or facility type.

Feedback Loop

The results of the erosion program will assess the erosion occurrence and extent on reclaimed mine sites, provide evidence-based information to track the effectiveness and/or to trigger a review of the soil erosion and sediment delivery program if soil erosion losses are at an unacceptable level or mitigation for soil erosion is not effective. The Trigger, Action, and Response Plan for the Soil Erosion and Sediment Delivery program monitoring activities is presented in Table 3.

Reporting

A comprehensive report covering erosion and sediment delivery program will be produced annually.

2.3.2 Soil Compaction and Decompaction Program

2.3.2.1 Requirements

Section D, Part 12(i) of Permit M-26 states that Nyrstar shall “*conduct research to assess decompaction methodologies to ensure that the severity of compaction that exists prior to commencing reclamation activities is effectively addressed in a manner intended to achieve end land use objectives and erosion control.*” In addition, Section E, Part 5(b) of the Permit M-26 states all reclaimed areas shall be “*decompacted to the minimum depth required to adequately address the severity of compaction prior to placement of soil and or vegetation, in a manner intended to achieve end land use objectives and erosion control.*”

2.3.2.2 Quantifiable Performance Objectives, Frequencies, and Roles and Responsibilities

QPOs, criteria and indicators for the Soil Compaction and Decompaction are presented in Table 2.

The purpose of the soil compaction and decompaction monitoring program is to:

- Provide information on areas in the reclaimed landscape where soil compaction may hinder the vegetative community establishment and development.
- Monitor the effectiveness of decompaction treatments on areas with identified soil compaction



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A soil compaction survey will be carried out on areas available for reclamation (e.g., the 30 ha TDF area) in Year 1 of the program. Soil compaction surveys will be carried out in Years 2 to 5 of the program on lands that become available for reclamation during that time period.

Decompaction activities will be carried out on areas with identified compaction issues identified in the soil compaction survey or by Nyrstar staff. Soil bulk density will be measured prior to decompaction treatments. Soil bulk density and plant vigour parameters (e.g., shoot leader growth or plant biomass) will be measured annually in both treated areas where soil decompaction activities were carried out and on adjacent untreated areas. The goal of this decompaction monitoring program will be to determine the effectiveness of decompaction strategies/methods and the associated vegetative response to decompaction efforts.

2.3.2.3 Considerations

The following considerations should be accounted for:

- Level of effort required to monitor the decompaction trials will depend on the total treated area of decompaction and the number of types of decompaction techniques employed on the reclaimed landscape.
- There is a general understanding that soil bulk density has a direct effect on a site's ability to support plant communities, however, the exact threshold at which this occurs can vary. It is therefore important to assess both soil bulk density and plant cover during the initial survey (if sites are vegetated) and when assessing the effectiveness of decompaction techniques.
- Strategies and techniques employed in decompaction trials will require the full involvement of Nyrstar staff and full access to the site by a third-party consultant.

2.3.2.4 Data Evaluation and Reporting

Data Analysis

Soil bulk density mean and range will be summarized by facility and reclamation site preparation type. Soil bulk density and measured vegetative parameters such as shoot growth or plant biomass will be summarized in areas where decompaction trials are carried out.

Feedback Loop

The results of the soil compaction survey carried out in Year 1 and on newly reclaimed areas in subsequent years will provide a feedback loop to managers and operational reclamation staff on where soil decompaction has been identified as an issue and decompaction is recommended. Decompaction trials will provide information the effectiveness and utility of decompaction techniques that can be employed reclaimed landscape. The Trigger, Action, and Response Plan for the Soil Compaction and Decompaction Program monitoring activities is presented in Table 3.



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Reporting

A comprehensive report summarizing soil compaction and decompaction program will be produced annually.

2.3.3 Revegetation Prescriptions Program

2.3.3.1 Requirements

Section D, Part 12 (f) (g) and (k) of Permit M-26 states that Nyrstar shall *"establish test plots that will be used to evaluate the reclamation approaches and prescriptions applied to confirm that ecological trajectories consistent with the land use and capability targets are being achieved; shall conduct research to determine the viability of revegetation with native plant species, including culturally important species; and shall develop a monitoring program designed to evaluate the success of revegetation, soil development and erosion control and that this program shall include specific sampling parameters and performance criteria."*

In addition, Section E, Part 4 of the Permit M-26 states that Nyrstar shall *"ensure the land is revegetated to a self-sustaining state using appropriate and or native plant species including culturally important native species."*

2.3.3.2 Quantifiable Performance Objectives, Frequencies, and Roles and Responsibilities

QPOs, criteria and indicators for the revegetation prescription program are presented in Table 2. Revegetation efforts to establish terrestrial ecosystems that will begin the successional process needed to achieve the desired end land uses will employ and investigate a number of different strategies including seeding for erosion control and tree and shrub establishment, cover soil replacement from stockpiles and direct salvage replacement, seedling/vegetation transplant and seedling and propagule planting. Revegetation success will be assessed using several quantifiable parameters including planting seedling/propagules survivability, plant vigour and growth, species diversity and ability to compete with surrounding vegetation. These quantifiable parameters will be measured 6 months after initial revegetation efforts and then at 1-year intervals as per applicable BC protocols (e.g. seedling planting establishment surveys). The goal of this monitoring approach is to determine both the initial success of revegetation efforts and if the desired trajectory of ecological succession needed to achieve the desired end land use goals is in progress. In addition, parameters will be evaluated after each measurement interval to identify triggers, such as high seedling mortality, that may require a re-evaluation of revegetation prescriptions and strategies or additional operational revegetation activities (e.g., replanting or fill-in planting).



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2.3.3.3 Considerations

Monitoring of revegetation prescription will need to be adaptive and consider a number of different factors when assessing revegetation prescription success and suitability.

- *Seeding for Erosion Control*—The rapid establishment of plant cover is crucial component of erosion and sediment control
- *Seeding for Tree and Shrub Establishment*—Monitoring of seeding for tree and shrub establishment needs to consider factors such as availability and viability of seeds, rodent predation and soil moisture conditions immediately after seeding operations when assessing the suitability of this revegetation prescription. In addition, seeding for tree and shrub establishment and seeding for erosion control, although related, should be carried out and monitored in different areas.
- *Seedling transplants*—Monitoring transplanting of seedling/vegetation pads needs to consider factors such as the transplant method, soil moisture conditions during and after transplanting, animal browsing and the effect of competition when assessing the suitability of this revegetation prescription.
- *Natural Vegetation Establishment on Soil Covers*—Monitoring the effectiveness of soil cover in establishing natural vegetation needs to consider if the soil replacement is from stockpiles or from recently salvaged soil.
- *Planted Seedlings and Propagules*—Monitoring of planted seedlings needs to consider factors such as stock type, species, animal browsing, vegetative competition and soil texture and moisture content. Likewise, monitoring of planting propagules (e.g., live staking) needs to consider species, animal browsing, effectiveness of rooting hormone (if used) and soil texture and moisture.
- *Number of Plots and Level of Effort*—The level of effort and number of plots required to monitor the revegetation prescription will depend on the area revegetated and the number trial established on the reclaimed landscape.

Nyrstar's collaboration will be required to implement and monitor the revegetation prescriptions as follows:

- *Equipment and personnel*—Establishing revegetation prescriptions will require a commitment from Nyrstar for equipment (e.g., cover soil replacement) and personnel (e.g., planting the TDF)
- *Planting stock, propagules and seeds*. Establishing the planned revegetation prescriptions will depend on the seedlings, propagules and seed ordering and availability.
- *Site Access*—Access to the revegetation prescriptions will have to be coordinated with Nyrstar in a timely manner as this will be crucial to monitoring efforts.



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2.3.3.4 Data Evaluation and Reporting

Data Analysis

Soil plant cover, plant growth and vigour and observed incidents of erosion will be summarized for areas seeded for erosion control. Seedling growth and vigour, seedling ability to compete with surrounding vegetation and plant species diversity will be measured in areas seeded for shrub and tree establishment or areas where seedlings/vegetative pads have been transplanted onto the reclaimed landscape. Discernable differences in vegetative cover and vigour and plant species diversity between areas of both direct and stockpile cover soil replacement verses areas of no cover soil replacement will be summarized. Planted survival rates, growth and vigour and ability to compete with surrounding vegetation will be summarized in areas of seedling/propagule planting prescriptions.

Feedback Loop

Data will be summarized at 6 months and then annually after revegetation prescription establishment. The results of the analysis will be used to track progress and/or to trigger a review of the revegetation prescription strategy and/or methods if the outlined criteria or indicators are not being met (e.g., out-planted seedlings have a 90% mortality rate after 6 months or transplanted vegetation pads all desiccate and die after 1 year). The Trigger, Action, and Response Plan for the Revegetation Prescription Program monitoring activities is presented in Table 3.

Reporting

A comprehensive report summarizing soil compaction and decompaction program will be produced annually.

2.3.4 Wildlife Habitat Restoration Plan

2.3.4.1 Requirements

Nyrstar must re-establish pre-mining capability wildlife habitat as per Section D, Part 2(a) of Permit M-26. Monitoring wildlife habitat restoration is required to determine the success of restoration treatments in providing suitable habitat for wildlife that can support the life requisites (e.g., food, thermal and security cover) of a diversity of wildlife species, including the target species and species groups listed under Permit M-26¹.

¹ Columbian black-tailed deer, Roosevelt elk, black bear, wolf, cougar, American marten, red squirrel, deer mouse, and bats.



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2.3.4.2 Quantifiable Performance Objectives, Frequencies, and Roles and Responsibilities

QPOs, criteria, and indicators for the wildlife habitat restoration plan are presented in Table 2.

The success of reclamation in re-establishing wildlife habitat will be evaluated by monitoring wildlife use and the condition of wildlife habitat over time. A preliminary wildlife field survey at Myra Falls will be undertaken in Year 1 prior to the initiation of reclamation activities to assess current wildlife use, habitat suitability, and location of wildlife features (Scope 3). Subsequent wildlife monitoring will be undertaken in Year 3 and Year 5 following revegetation prescriptions and the installation of habitat elements.

Results from the preliminary wildlife field survey will be used to assist in the development of wildlife performance objectives, criteria, and indicators for the Wildlife Habitat Restoration, Research for Old-Growth Attributes Program (Section 2.3.5) and the Wildlife Exposure Risk Study (Section 2.4.2).

QPO's for wildlife habitat could include wildlife use of reclaimed areas and the availability of wildlife forage, thermal/security cover, landscape connectivity, and habitat elements (Table 2).

Wildlife Use Surveys

Wildlife use of reclaimed habitats can be monitored by recording direct (i.e., visual or auditory) or indirect (e.g., tracks, scat, wildlife movement corridors) observations. Field methods to monitor wildlife use of reclaimed areas may include:

- Wildlife cameras studies
- Breeding bird surveys
- Bat detection surveys
- Small mammal trapping
- Winter track surveys
- Amphibian surveys

As identified in the Site-wide End Land Use and Post-Closure Ecosystem Development Plan 'Crosswalk Table' (Stantec 2019b), the site will progress through successive structural stages over time, each of which is expected to support different wildlife communities. Data collected on wildlife species occurrence, composition, and relative abundance will be evaluated against criteria from undisturbed habitats with similar habitat conditions and structural stages.

Wildlife Habitat Assessment

The presence of key life requisites and habitat features will be monitored through targeted field surveys in reclaimed areas. Monitoring will provide an indication of habitat suitability and an evaluation of reclamation treatments. Habitat requirements will vary seasonally and between different habitat types and successional stages. Details on the life requisites and habitat attributes for target species will be identified prior to monitoring.



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2.3.4.3 Considerations

Monitoring of wildlife habitat restoration will need to be adaptive and account for the following considerations:

- Specific criteria (e.g., relative species abundance, % forage species, woody debris density/volume) for each QPO will be determined following the preliminary wildlife field survey and after receiving input from First Nations.
- Monitoring will occur across combinations of age and reclamation prescription to be able correlate wildlife use to reclamation prescriptions.
- The level of effort and number of survey sites required will depend on the reclaimed areas and number of revegetation trials established on the reclaimed landscape.
- Logistical constraints should be evaluated at the beginning and throughout the wildlife program to identify feasible monitoring techniques for wildlife use. Wildlife use surveys will require appropriate sampling protocols to account collect meaningful data on wildlife (e.g., sampling at the appropriate time of year).

2.3.4.4 Data Evaluation and Reporting

Data Analysis

Data on wildlife use, life requisites, and habitat features collected Year 1, 3 and 5 will be summarized. Wildlife monitoring data collected in Year 3 and 5 will be compared to criteria from reference habitats with similar habitat conditions, structural stages, and stressors.

Trigger/Feedback Loop

The results of the analysis will be used to evaluate the trajectory of wildlife habitat recovery over time and identify if the outlined criteria and indicators are being met. If the wildlife indicators do not meet the desired criteria, a response and series of actions and/or mitigation techniques will be triggered (e.g., wildlife browsing in reclaimed areas limits plant survivability and growth resulting in low habitat value. The Trigger, Action, and Response Plan for the Wildlife Habitat Restoration Program monitoring activities is presented in Table 3.

Reporting

Wildlife monitoring activities initiated or completed will be summarized in the annual reclamation report. If applicable, the summary will describe how findings of the wildlife monitoring activities will be incorporated into the RRP, if and how adaptive management was applied, and recommendations for future monitoring.



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2.3.5 Research for Old-Growth Attributes Program

2.3.5.1 Requirements

Nyrstar must implement methods to mitigate old-growth forest that is lost as a result of mining activities as per section E, Part 2 (b) of Permit M-26. The Research for Old-Growth Attributes Monitoring Program will establish and monitor research trials to evaluate techniques for restoring old-growth forest attributes to comply with Section D, Part 12(f) of the Permit. Restoring old-growth attributes is an integral part of re-establishing average pre-mining capability for wildlife habitat to comply with Section E, Part 2 (b) of the Permit.

2.3.5.2 Quantifiable Performance Objectives, Frequencies, and Roles and Responsibilities

QPOs, criteria and indicators for the Old-Growth Attributes Program are presented in Table 2. The monitoring program will evaluate the effectiveness of the research trials for old-growth attributes that can be created artificially through reclamation treatments (e.g., installing snags, coarse woody debris) within a 5-year time frame. Research trials will be evaluated based on wildlife use and ability to support the life requisites of target species.

2.3.5.3 Considerations

There is degree of uncertainty regarding the effectiveness of artificial habitat structures or reclamation treatments used to replicate old-growth conditions. Implementation of research trials will depend on several factors including the availability of material (e.g., woody debris, sourcing snags of appropriate decay class) and the feasibility of installation. Even if habitat enhancement research trials achieve the desired objective and criteria (e.g., number of snags per hectare) several factors may prevent wildlife from utilizing these areas, including the availability and condition of adjacent habitat, human activity levels, or competition from other wildlife species. Due to the uncertainty surrounding methods for re-establishing old-growth forests on mine sites and the long timeframe involved, offsetting, as described by Wood (2019b) will also be required to meet *Mines Act* Permit M-26 conditions.

2.3.5.4 Data Evaluation and Reporting

Data Analysis

Data on wildlife use and habitat conditions within research trials will be summarized and compared to criteria from undisturbed old-growth habitats. Criteria to evaluate if reclaimed areas are on a trajectory towards establishing old-growth attributes that take time to develop (e.g., spatial heterogeneity, tree size) will be developed after the initial 5-year monitoring period.



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Feedback Loop

Monitoring from the research trials will provide results to help assess whether reclamation methods can re-establish old-growth attributes and whether design modifications, if feasible to implement, are necessary. The Trigger, Action, and Response Plan for the Research for Old-Growth Attributes Program monitoring activities is presented in Table 3.

Reporting

Old-growth research, trials, and monitoring activities completed will be summarized and included in an annual reclamation report.

2.3.6 Soil Cover Plan

2.3.6.1 Requirements

Section D, Part 8(a) (e) states that Nyrstar shall “*establish a Soil Management and maintain an inventory of stockpiles of salvaged soil, overburden and organic matter including large woody debris specifying the locations, origins, and quantities of material.*”

Part 12(h) of the Permit M-26 states that Nyrstar shall “*conduct research to inform that: development of a soil replacement plan that is designed to achieve land capability and end land use objectives.* If a shortfall of soil volumes is anticipated, contingency plans shall be developed.”

2.3.6.2 Quantifiable Performance Objectives, Frequencies, and Roles and Responsibilities

QPOs, criteria and indicators for the soil cover plan are presented in Table 2. The purpose of the soil cover plan monitoring program is to determine if the information collected is sufficient to describe the volumes, types and quality of cover soil available for reclamation. The cover soil plan will be conducted and in completed in Year 1 of the program.

2.3.6.3 Considerations

The sampling intensity required to adequately describe volumes and physical and chemical characteristics of the growth medium depends on the variability of materials. Depending on chemical variability, it is possible that a second round of samples may need to be collected and analyzed to adequately describe cover soil variability.



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2.3.6.4 Data Evaluation and Reporting

Data Analysis

Field and laboratory data will be collated used to determine soil suitability for reclamation by comparing them to undisturbed soils in the area and the Soil Quality Criteria Relative to Disturbance and Reclamation developed by Alberta Agriculture (AAFRD 1987). Total element concentrations will be assessed against the Soil Quality Guidelines for the Protection of Environmental and Human Health developed by the Canadian Council of Ministers of the Environment (CCME 2003).

Feedback Loop

The results of the reclamation suitability assessment will provide a feedback loop to the environmental manager and operational reclamation staff on suitable growth medium and alternative materials available for use in future reclamation activities. The Trigger, Action, and Response Plan for the Soil Cover Plan monitoring activities is presented in Table 3.

Reporting

A comprehensive report detailing the characterization and reclamation suitability of growth medium and alternative materials on site will be completed in Year 1. The results of the assessment will be included in the annual reclamation report.

2.4 METAL UPTAKE MONITORING PLAN

The Metal Uptake Monitoring Plan includes a Soils and Vegetation Baseline and Uptake Program, a Wildlife Exposure Risk Study, a Water Quality Sampling Program and a Metal Uptake in Aquatic Organisms Program. The following sections describe the proposed monitoring program for this Plan.

2.4.1 Soils and Vegetation Metal Baseline and Uptake Program

2.4.1.1 Requirements

Section D, Part 12(l) states that Nyrstar *shall develop a monitoring program for evaluating metal uptake in exposed terrestrial and aquatic ecosystems, which specifies sampling requirements and performance criteria*. Where harmful levels are found, Nyrstar shall *take any corrective action necessary to mitigate to ensure levels are safe for plant and animal life*.



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2.4.1.2 Quantifiable Performance Objectives, Frequencies, and Roles and Responsibilities

QPOs, criteria and indicators for the soils and vegetation metal baseline and uptake program are presented in Table 2. The purpose of the soils and vegetation metal baseline and uptake program is to:

- Provide information on soils and vegetation Constituents of Potential Concern (CoPC) baseline number and determine if they are below the applicable soil CCME guidelines (CCME 2003).
- Provide information on vegetation CoPC and how they compare to levels reported by Kabata-Pendias (2010) and the US National Research Council (2005)
- Provide comparison of soil and vegetation samples CoPC concentrations collected on the reclaimed landscape with off-site reference concentrations.
- Provide information on trends in soil and vegetation CoPC concentrations over time
- Provide information to other disciplines if a pathway analysis needs to be conducted.

Soils samples will be collected and then analyzed at established plots on areas available for reclamation (e.g., the 30 ha TDF area) in Year 1 of the program and at “off- site” established plots. Additional soil samples will be collected at established plots in Years 2 to 5 of the program on lands that become available for reclamation during that time period. Soil will again be sampled at the same established plots five years after the baseline sampling.

Vegetation samples will be collected and then analyzed, at the same off-site reference and reclaimed site plots where soil samples have been collected, once these sites are revegetated. Vegetation samples will be collected annually. Soil and vegetation sampling and analysis will be conducted over a 5-year period and this will provide baseline reclaimed and off-site reference CoPC concentrations and should provide some insight into soil and vegetation CoPC trends.

2.4.1.3 Considerations

Monitoring will need to be adaptive in order to adequately describe baseline soil and vegetation CoPC levels and provide a basis for discerning any trends:

- Sufficient samples will need to be collected and analyzed on both the reclaimed landscape and off-site reference sites in order to accurately describe baseline conditions.
- If CoPC concentrations are above CCME guidelines or below CCME guidelines but elevated above off-site reference site levels and there is not a discernable decrease over time, then perhaps an exposure pathway analysis will be required that includes aquatic and wildlife components.



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2.4.1.4 Data Evaluation and Reporting

Data Analysis:

Soil CoPC concentrations data will be compared to CCME guidelines and to the off-site reference plots. Analysis will be carried out to determine if there is a statistical difference between off-site reference soil/vegetation CoPC concentrations and the concentrations from plots established on the mine site reclaimed areas. Analysis and comparison will also be carried out on soil CoPC concentrations collected at Year 1 and Year 5 of the program and on vegetation CoPC concentrations collected annually. Data will be presented visually using relevant graphic techniques, and site-specific summary statistics will be provided.

Feedback Loop

The results of the soil and vegetation CoPC program will assess the suitability of salvaged soil stockpiles for reclamation, the long terms trends in soil CoPC concentrations and the uptake and CoPC concentrations by vegetation. This information will provide managers with evidence-based information for deciding on future actions including mitigation, initiation of a pathway analysis or revision in the monitoring program. The Trigger, Action, and Response Plan for the Soil and Vegetation Metal Baseline and Uptake Program monitoring activities is presented in Table 3.

Reporting

A comprehensive report covering the results of the soil/vegetation metal uptake will be produced annually.

2.4.2 Wildlife Exposure Risk Study

2.4.2.1 Requirements

To comply with the requirements under Section D, Part 12(i) of *Mines Act* Permit M-26, the Wildlife Exposure Risk Study will investigate and monitor wildlife exposure risk and exposure pathways to CoPC. If CoPC's are found to exceed specified performance criteria in terrestrial and/or aquatic systems, corrective mitigation actions will be implemented.

2.4.2.2 Quantifiable Performance Objectives, Frequencies, and Roles and Responsibilities

QPOs, criteria, and indicators for the Wildlife Exposure Risk Study are presented in Table 2. The QPOs are as follows: Wildlife are not exposed to CoPCs that exceed the CCME Water Quality Guidelines (WQGs), the Approved Water Quality Guidelines for Aquatic Life, Wildlife and Agriculture (Gov of B.C., 2019), or permit guidelines (Science Based Environmental Benchmarks) for water, soils or vegetation.



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The concentration of CoPC in terrestrial and aquatic systems will be informed by soil, vegetation, and water quality monitoring components of the Metal Uptake Monitoring Plan in Year 1. In areas where CoPC concentrations exceed the guidelines safe for aquatic life, an exposure pathway analysis will be completed to determine how wildlife may be affected. Potential exposure pathways for wildlife on site include the following:

- Consumption or exposure to CoPCs in soil
- Inhalation or exposure to CoPCs in dust
- Consumption or exposure to CoPCs in water
- Consumption of CoPCs in plants or soil
- Consumption of CoPCs in animals

Exposure pathways will be evaluated and monitored through wildlife use surveys (e.g., remote camera monitoring, field surveys) targeted in areas with CoPC concentrations that exceed the CCME WQGs, the Approved Water Quality Guidelines for Aquatic Life, Wildlife and Agriculture, or permit guidelines for water, soils or vegetation. The number and location of areas monitored for wildlife use will be determined in Year 2 following acquisition of results from the soil, water, and vegetation sampling and the wildlife use survey (Section 2.3.4). Additional areas may be included for monitoring in Years 3-5. Monitoring is recommended to be undertaken by a third-party consultant and done seasonally to capture differences in wildlife use of areas on the mine site.

If exposure pathways exist, the level of metal accumulation in mammals and birds will be determined by collecting biological samples in Year 3. Biological samples may include collecting hair, feather, or eggshell samples that will be sent to a laboratory for metal analysis. Specific criteria for acceptable CoPC concentrations will be discussed in consultation with First Nations, particularly for species that may be used for subsistence hunting and harvesting. If biological samples exceed the specified criteria, corrective mitigation actions will be developed and implemented. Mitigation actions may include additional reclamation treatments or erecting wildlife exclosures to prevent exposure pathways until CoPC concentrations in an area are reduced to concentrations that meet the specified targets. Wildlife exposure pathways and biological sampling will be re-evaluated in Year 5.

Considerations

Considerations for monitoring metal uptake in wildlife are listed below:

- Criteria for acceptable CoPC uptake concentrations in biological samples wildlife will be determined following a literature review (see Stantec. 2019c), off-site metal uptake sampling in wildlife species of interest, and consultation with First Nations.
- Sufficient samples will need to be collected and analyzed on both the reclaimed landscape and off-site reference sites in order to accurately describe baseline metal uptake concentrations for target wildlife species.
- If CoPC uptake concentrations are above the determined criteria on reclaimed land for wildlife, then a mitigation strategy will need to be developed for each affected species.



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2.4.2.3 Data Evaluation and Reporting

Data Analysis:

To evaluate exposure pathways, wildlife use data will be compared to CoPC concentrations in soil, vegetation and surface water quality data and summarized. CoPC uptake concentrations in biological samples will be compared to regional baseline data for each species of interest. A robust sampling design will be developed by a qualified professional to account for natural variation in metal uptake among different age classes and individuals.

Feedback Loop:

Wildlife exposure risk will be evaluated and compared to the desired performance objectives (Table 2). If wildlife indicators reflect the desired QPO for CoPC uptake, then reclamation activities will proceed as scheduled. If indicators do not meet the desired criteria, a response and series of actions and/or mitigation techniques will be triggered (Table 3). This feedback loop will provide information to develop and revise reclamation activities that will facilitate reducing CoPCs to concentrations that are safe for wildlife.

The Trigger, Action, and Response Plan for the Wildlife Exposure Risk Study monitoring activities is presented in Table 3.

Reporting

Activities related to wildlife use monitoring, exposure pathway analysis, and biological sampling, including associated results, will be reported annually as part of a wildlife monitoring report.

2.4.3 Water Quality Monitoring Study

2.4.3.1 Requirements

The Water Quality Monitoring Study has been designed to determine if reclamation activities comply with the end land-use objective for watercourses identified in *Mines Act*, Permit M-26 Approving Work System and Reclamation Program (1998), Section 10 Watercourses, which states “*Long-term water quality is maintained to a standard acceptable to the Regional Waste Manager (MELP)*”.

Metal concentrations in water will have to comply with regulatory guideline limits including the CCME Water Quality Guidelines (WQG), the BC Approved Water Quality Guidelines for Aquatic Life, Wildlife and Agriculture, and adhere to guidelines of Drinking Water Protection Regulation Permit AMID-927USG.



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2.4.3.2 Quantifiable Performance Objectives, Frequencies, and Roles and Responsibilities

QPOs, criteria and indicators for the Water Quality Monitoring Study are presented in Table 2 along with sampling frequencies and responsibility roles. The concentration of metals will be used as indicators and compared to the federal and provincial water quality guidelines (WQGs) which will be the criteria for this study. Of interest are the CoPCs mentioned in Scope 3: zinc, copper and cadmium.

The QPOs of the Water Quality Monitoring Study are:

- I. CoPC concentrations in water in the reclaimed watercourses do not exceed permit guidelines and there are no statistically significant differences between CoPC concentrations in reclaimed watercourses and reference sites
- II. There are no statistically significant differences in the other water quality parameters important to cutthroat trout and other aquatic biota (i.e., hardness, temperature, dissolved oxygen (DO) concentrations, pH and conductivity) between the reclamation watercourses and reference sites

It is important to characterize the natural variability in metal concentrations. Therefore, samples need to be collected in the reclaimed watercourses and in reference sites upstream and downstream to assess the impact of reclamation efforts on water quality.

Frequency

The extent of sampling will be over a long enough period to establish a trend in water quality parameters related to reclamation activities (i.e., before and after the installation and operation of the Lynx SIS and long enough to determine a response). The sampling frequency in Myra Creek will be monthly to:

- Understand how metal concentrations and water quality parameters vary with season and hydrologic conditions
- Account for spatial and temporal variability for statistical analysis to be valid (i.e., variable data will require higher sampling frequency to obtain adequate statistical power, and to adequately detect an environmental response)
- Characterize how reclamation is affecting or not affecting CoPCs

Frequency of water quality sampling is recommended to increase to 5 days in every 30 days during freshet conditions, provided that the conditions are safe. Currently, water quality sampling is conducted daily by Nyrstar downstream of the Lynx SIS but it is unclear whether these samples also include measurements of *i.e.*, metal concentrations.

Roles and responsibilities

Water quality sampling is recommended to be conducted internally by Nyrstar, and the results reviewed and interpreted by a qualified third-party consultant throughout the operations.



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2.4.3.3 Considerations

The triggers, feedback loop and mitigation measures for the Water Quality Monitoring Study are presented in Table 3. If metal concentrations, particularly those of the CoPCs, are not trending towards concentrations found at reference sites, or alternatively, are increasing or exceeding guidelines, a revised reclamation strategy to decrease metal concentrations in Myra Creek will need to be developed. This may include, but not be limited to:

- Increased capping of waste rock
- Improved contact and non-contact water separation
- Improved contact water collection and conveyance
- Improved in-situ passive water treatment (i.e., polishing ponds, wetlands)
- Alternative re-vegetation planning
- Active water treatment

2.4.3.4 Data Evaluation and Reporting

Data Analysis

Metal concentrations in water will be compared to permit limits and to water quality at reference sites. Analysis will be carried out to determine if there is a statistical difference between the metal concentrations at reference sites and in the reclaimed watercourses. Analyses will include, but not be limited to, calculation of the frequency and magnitude of guideline exceedances, calculation of the frequency and magnitude of exceedances above baseline and reference site concentrations, and graphical representation of water quality data over time compared to appropriate guidelines for each CoPC.

Analysis will be conducted at the end of each year and will use monthly data to show monthly and annual variability in water quality parameters with flow, throughout the 5-year monitoring program. Data will be presented visually using relevant graphic techniques, and site-specific summary statistics will be provided.

Feedback Loop

Results of the Water Quality Monitoring Program will be used to assess the effect of reclamation efforts on water quality in the reclaimed watercourses. This information will provide managers with evidence-based information for any additional reclamation measures that may be necessary to improve water quality for fish and aquatic biota in reclaimed watercourses and will provide a feedback loop for revising or refining the Reclamation Research Program activities. The Trigger, Action, and Response Plan for the Water Quality Sampling Program monitoring activities is presented in Table 3.

Reporting

A comprehensive report summarizing the methods and results of the water quality monitoring study will be produced annually.



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2.4.4 Metals Uptake in Aquatic Organisms Monitoring Program

2.4.4.1 Requirements

The Metals Uptake in Aquatic Organisms Monitoring Program has been designed to determine if reclamation activities comply with the end land-use objective for watercourses identified in *Mines Act*, Permit M-26, Section D, Part 12 (i) which states: *“(I) The Permittee shall develop a monitoring program for evaluating metal uptake in exposed terrestrial and aquatic ecosystems, which specifies sampling requirements and performance criteria. Where harmful levels are found, the Permittee shall take any corrective action necessary to mitigate to ensure levels are safe for plant and animal life.”*

This program will evaluate the exposure risk of aquatic organisms, including fish, throughout the RRP. Results from this program will inform whether additional restoration measures are required.

2.4.4.2 Quantifiable Performance Objectives, Frequencies, and Roles and Responsibilities

QPOs, criteria and indicators for the revegetation prescription program are presented in Table 2 along with sampling frequencies and responsibility roles. The QPO for this program is *“No statistically significant differences in cutthroat trout early life stage survival, growth, or condition between reclaimed watercourses and reference sites”*. This objective will be determined by comparing larval cutthroat trout survival, length and weight, and body condition between reclaimed watercourses and reference sites (success criterion).

The indicators for this program will be the survival, growth, and condition of larval cutthroat trout in *in situ* hatch-boxes placed in the reclaimed watercourses and in reference sites. Results from hatch-boxes in each stream will be statistically compared to determine if there are significant differences in trout survival, growth, and conditions between reclaimed watercourses and reference sites over time. Results can build on, and be compared to, results of the *in-situ* hatch-box studies conducted in previous years and monitoring cycles (Nautilus Environmental, 2017). This will allow for the identification of any potential trends in fish survival, growth, and condition to be identified which may indicate possible cause and effect between metal loads in the water and fish survival, growth, and condition.

Frequency

It is recommended that the Metals Uptake in Aquatic Organisms Monitoring Program be conducted on a similar frequency as the previous hatch-box studies (i.e., every 3 years).

Roles and Responsibilities

It is recommended that the Metals Uptake in Aquatic Organisms Monitoring Program be conducted by a third-party consultant (qualified professional).



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2.4.4.3 Considerations

The Trigger, Action, and Response Plan for the Metals Uptake in Aquatic Organisms Monitoring Program are presented in Table 3. If monitoring and statistical analyses indicate that there is a significant difference in the survival rate, development or body condition of larval cutthroat trout in hatch-boxes deployed in reclaimed watercourses and reference sites, this will indicate differences in potential acute or chronic toxicological effects on fish in the different streams. Evaluation of potential cause-and-effect pathways should then be explored including, but not limited to: CoPC concentrations; sediment quality parameters, in-situ water quality parameters (e.g., temperatures, DO, conductivity), periphyton density and/or benthic invertebrate drift (i.e., food supply). Depending on results of the cause-and-effect evaluation, plans to reduce metal concentrations in the water, increase the suitability of stream temperatures, dissolved oxygen concentrations, conductivity or pH for cutthroat trout, or increase the production of periphyton and benthic invertebrate production should be developed. Following this, it is advised that sampling frequency be increased to annually to monitor and evaluate the success of the mitigation measures.

2.4.4.4 Data Evaluation and Reporting

Data Analysis

Data will be collected from the hatch-box treatments to assess survival, growth, and condition of larval cutthroat trout. Analysis will be carried out to determine if there is a statistical difference between larval cutthroat trout survival, growth and condition at the affected site and individuals at unaffected reference sites upstream of the site. The results will be presented visually (using relevant graphing techniques) and statistically to demonstrate changes in fish endpoints.

Feedback Loop

Results of the Metals Uptake in Aquatic Organisms Monitoring Study will be used to assess the relevance of the monitoring methods and study design and will provide feedback to help refine the Reclamation Research Program activities (e.g., focused monitoring activities and QPOs), as needed. The Trigger, Action, and Response Plan for the Metal Uptake in Aquatics Organism Program monitoring activities is presented in Table 3.

Reporting

A comprehensive report summarizing the methods and results of the Metals Uptake in Aquatic Organisms Monitoring Study will be produced every 3 years. It is unclear how responsive cutthroat trout early life stages will be to changes related to reclamation activities. Therefore, it is difficult to estimate the temporal extent needed to effectively inform the RMP.



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2.5 SUMMARY

The following sections provide summary tables that present the criteria, indicators, frequencies, and roles and responsibilities as well as the Trigger, Action and Response Plan for each monitoring activity and reclamation theme.

2.5.1 Monitoring Activities—Criteria, Indicators, Frequencies, and Roles and Responsibilities

Table 2 presents a summary of criteria, indicators, frequencies, and roles for each monitoring activity and reclamation theme.



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Table 2 Monitoring Activities - Criteria, Indicators, Frequencies, and Roles and Responsibilities

Reclamation Research Theme	Research Design Program Activities	Quantifiable Performance Objective	Criteria	Indicators	Frequency	Roles and Responsibilities
Long-term Watercourse Reclamation Plan	Water Infrastructure De-commissioning and Reclamation Monitoring Program	<u>Performance Assessment of Diversion Ditches.</u> Diversion ditches should convey non-contact surface water around mine waste, deliver sediment to Myra Creek, and are designed to limit erosion and to support seasonal flows without occurrences of overflow.	• Flow capacity	• Visual assessment of presence of spillover, hydraulic conveyance capacity monitoring, and flow monitoring.	Annual, Year 1 to 5. Frequency will be evaluated in Year 1 and Year 5; See Surface Water Flow Monitoring Study for frequency of flow monitoring.	Nyrstar staff trained by a Third-party consultant (qualified professional)
			• Erosion and other damage	• Visual assessment of presence of erosion and other damage.		
			• Sediment	• Visual assessment of sediment accumulation occurring within the ditch and upstream sediment sources		
		<u>Surface Water Flow Monitoring Study.</u> This study is a collection of baseline data to understand seasonal variability and effectiveness of the reclamation plans throughout the year; therefore, Quantifiable Performance Objectives and indicators do not apply. Monitoring of the channels will provide baseline data and is described in this table.	• Manual flow measurements	• Not applicable	5 to 10 per year, starting in 2020 and continuing to Years 1 to 5.	Nyrstar staff trained by a Third-party consultant (qualified professional)
			• Hydrometric Data	• Not applicable	Starting in 2020 and continuing to Years 1 to 10	Third-party consultant (qualified professional)
		<u>Myra Creek Geomorphology Monitoring Study.</u> The restored portion of Myra Creek should reflect the creek’s natural behavior as observed at the reference site(s).	• Longitudinal profiles	• Presence, frequency, and size of riffles and pools.	Prior to reclamation, immediately after and every 3 to 5 years post closure. Also, after large peak flow event when visual assessment indicates changes to the channel.	Third-party consultant (qualified professional)
			• Cross Sections	• Monitor 1D channel changes, cross section of scour and fill, and bed sediment assessment	Prior to reclamation, immediately after and annually post closure. Also, after large peak flow event when visual assessment indicates changes to the channel.	Third-party consultant (qualified professional)
	Aquatic Habitat Reclamation Monitoring Plan	<u>Habitat Monitoring Study:</u> Habitat in reclaimed watercourses is stable and provides similar productive capacity for cutthroat trout as reference sites	• Riparian vegetation cover, composition, and survival • Instream habitat characteristics comparable to reference sites	• Riparian vegetation survival, and % bank coverage • Instream characteristics important to cutthroat trout (e.g., average thalweg depth, % total cover; % pool, and riffle/pool ratio in late summer low flow period) • Substrate composition (e.g., % cobble in riffle-run areas; % gravel in riffles and pool tail-outs; % fines in riffle-run areas and pool tail-outs used for spawning)	Annual, Year 1 to 5	Third-party consultant (qualified professional)
		<u>Bed Sediment Monitoring Study:</u> Channel bed and banks are stable and provide suitable habitat for different cutthroat trout life stages.	• Channel substrates that are favorable for various cutthroat trout life stages.	• Size distribution of bank sediments and channel substrates (e.g., Wolman pebble count)	Annually	Third-party consultant (qualified professional)
		<u>Fish Habitat Utilization Monitoring Study:</u> Reclaimed watercourses have the same fish abundance and age structure as reference streams	• Relative abundance (CPUE) and age-class distribution of cutthroat trout population is comparable to reference sites	• Relative abundance (CPUE) of different age-classes of cutthroat trout	Seasonally	Third-party consultant (qualified professional)



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Table 2 Monitoring Activities - Criteria, Indicators, Frequencies, and Roles and Responsibilities

Reclamation Research Theme	Research Design Program Activities	Quantifiable Performance Objective	Criteria	Indicators	Frequency	Roles and Responsibilities
Terrestrial Reclamation Plan	Soil Erosion and Sediment Delivery Assessment Program	<ul style="list-style-type: none">Limit Erosion rill and gully soil erosion lossErosion control measures are effective	<ul style="list-style-type: none">Occurrence and extent on the of rill erosion by slope gradients, slope lengths, material types and facilities on the mine site;Occurrence and volume soil lost by gully erosionChanges in rill and gully erosion after revegetation /soil erosion and sediment delivery mitigations	<ul style="list-style-type: none">Areas and depth of Rill and Gully ErosionTonnes per ha of soil loss	Frequently (e.g., after major storm events) for Temporary Erosion and Sediment Control Yearly for overview survey	Third-party consultant (qualified professional) Nyrrstar (Temporary Erosion and Sediment Control)
	Soil Compaction and Decompaction Program	<ul style="list-style-type: none">Soils on the reclaimed landscape are not compacted to a degree that inhibits root growth and vegetation establishmentDecompaction Prescriptions results in ameliorated soil with reduced soil bulk density values and improved revegetation performance	<ul style="list-style-type: none">Soil bulk densities are within a range that do not hinder plant root growthVegetation is healthy and vigorousDecompaction treatments result in amelioration of soil bulk densitiesStatistical difference in soil bulk density and measures plant parameters in treated verses non treated decompaction trials	<ul style="list-style-type: none">Soil bulk density range, mean and standard deviation on the reclaimed mine site by facility, and reclamation site preparationSoil bulk density before and after treatmentSoil bulk density in treated verses non treated areasPlant vigour parameters	Yearly	Third-party consultant (qualified professional)
	Revegetation Prescriptions Plan	<ul style="list-style-type: none">Revegetation efforts will reduce soil erosion and start the Ecological succession trajectory towards post closure terrestrial ecosystems that meet end land use and productivity objectives	<ul style="list-style-type: none">Seeding for Erosion Control	<ul style="list-style-type: none">Percent vegetative coverPlant growth and vigourIncidence and extent of rill Erosion	4 months and then the following year after seeding	Third-party consultant (qualified professional)
			<ul style="list-style-type: none">Seeding for Tree and Shrub Establishment	<ul style="list-style-type: none">Seedling/Propagule growth and vigourSeedling/Propagule ability to compete with surrounding vegetationPlant species diversity	6 months and then yearly	Third-party consultant (qualified professional)
			<ul style="list-style-type: none">Natural Vegetation Establishment on Soil Covers	<ul style="list-style-type: none">Discernable differences of vegetative cover, plant species diversity and plant growth and Vigour between soil cover types (e.g., direct soil placement verses non cover soil placement)	6 months and then yearly	Third-party consultant (qualified professional)
			<ul style="list-style-type: none">Seedling/Vegetation Transplants	<ul style="list-style-type: none">Seedling/Vegetation pad survivabilitySeedling/Vegetation pad growth and vigourAbility to compete with surrounding vegetationPlant species diversity	6 months and then yearly	Third-party consultant (qualified professional)
			<ul style="list-style-type: none">Planted Seedlings and Propagules	<ul style="list-style-type: none">Planted seedlings/propagules survivability by speciesSeedling/Propagule growth and vigourSeedling/Propagule ability to compete with surrounding vegetation	6 months and then yearly	Third-party consultant (qualified professional)
	Wildlife Habitat Restoration Plan	Wildlife use of reclaimed areas	<ul style="list-style-type: none">Presence of target wildlife species on reclaimed areas	<ul style="list-style-type: none">Species occurrence, composition and relative abundance	Year 1, Year 3, Year 5	Third-party consultant (qualified professional)
		Wildlife forage available	<ul style="list-style-type: none">Planted species and natural recruitment species are native, and include forage species for target wildlifeLevel of wildlife browsing on vegetation increases over time without negative impact on plant survival and spread	<ul style="list-style-type: none">Vegetation indicators (Section 2.3.3),% cover of forage species,% browsed	Year 1, Year 3, Year 5	Third-party consultant (qualified professional)
		Thermal/security cover present	<ul style="list-style-type: none">Security requisites for target species	<ul style="list-style-type: none">Examples could include:Distance to forest cover, presence of boulder piles	Year 1, Year 3, Year 5	Third-party consultant (qualified professional)



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Table 2 Monitoring Activities - Criteria, Indicators, Frequencies, and Roles and Responsibilities

Reclamation Research Theme	Research Design Program Activities	Quantifiable Performance Objective	Criteria	Indicators	Frequency	Roles and Responsibilities
		Landscape connectivity present	<ul style="list-style-type: none">Distance between undisturbed forest patches is reduced over time	<ul style="list-style-type: none">Wildlife observations (tracks, wildlife corridors)	Year 1, Year 3, Year 5	Third-party consultant (qualified professional)
		Habitat elements present	<ul style="list-style-type: none">Habitat elements present for target species (e.g., open areas for common nighthawk nesting, woody debris)	<ul style="list-style-type: none">Area, number of elements	Year 1, Year 3, Year 5	Third-party consultant (qualified professional)
	Research for Old-Growth Attributes Program	Wildlife use of research trials	<ul style="list-style-type: none">Wildlife use of research trials for intended purpose (e.g., nesting, cover security)	<ul style="list-style-type: none">Proportion of used versus unused features	6 months after installation, Year 3, Year 5	Third-party consultant (qualified professional)
		Research trials provide similar habitat conditions to old-growth attributes	<ul style="list-style-type: none">Research trials support life requisites of target species	<ul style="list-style-type: none">Examples could include:<ul style="list-style-type: none">Cover, volume and density of coarse woody debrisDensity, height and decay class of snags	6 months after installation, Year 3, Year 5	Third-party consultant (qualified professional)
	Soil Cover Plan	Volumes and reclamation suitability of material on site	<ul style="list-style-type: none">Suitability of reclamation materials in disturbed areasVolume and suitability of Growth medium and alternate materials	<ul style="list-style-type: none">Volumes of materials are sufficient for reclamation requirementsGrowth mediums and alternate materials are suitable for reclamation	Year 1	Third-party consultant (qualified professional)
Metal Uptake Monitoring Plan	Soil and Vegetation Baseline and Uptake Program	<ul style="list-style-type: none">Soil CoPC meet CCME guidelines and off-site reference site conditionsVegetation CoPC meet guidelines and off-site reference site conditions	<ul style="list-style-type: none">Soil and vegetation CoPC concentrationsSoil and vegetation CoPC concentrations on the reclaimed landscape and off-site reference sitesSoil and Vegetation CoPC concentrations decrease over time or are at concentrations comparable to off-site reference sites	<ul style="list-style-type: none">Concentration of CoPCs	Soil - Year 1, as newly reclaimed areas are available for reclamation and Year 6 Vegetation - Yearly	Third-party consultant (qualified professional)
	Wildlife Exposure Risk Study	Wildlife are not exposed to Constituents of potential concern (CoPC) that exceed concentrations safe for wildlife (the CCME WQGs, the Approved Water Quality Guidelines for Aquatic Life, Wildlife and Agriculture, and permit guidelines for water, soils or vegetation)	<ul style="list-style-type: none">Wildlife exposure pathways	<ul style="list-style-type: none">Concentration of CoPCs in soil, vegetation and waterWildlife occurrence and behavior in areas that exceed CoPC guidelines	Year 2, 3, 5	Third-party consultant (qualified professional)
		CoPC uptake concentrations in wildlife meet guidelines and regional baseline conditions	<ul style="list-style-type: none">No statistically significant differences in metal uptake concentrations measured between wildlife on site and baseline levels for wildlife in the region	<ul style="list-style-type: none">CoPC concentration in biological samples	Year 2, 3, 5	Third-party consultant (qualified professional)
	Water Quality Monitoring Program	CoPC concentrations in water do not exceed permit guidelines and are statistically comparable to concentrations in water at reference sites	<ul style="list-style-type: none">Adherence to guideline limits as per CCME WQGs, Approved Water Quality Guidelines for Aquatic Life, Wildlife and Agriculture & Drinking Water Protection Regulation Permit AMID-927USGCoPC concentrations and water quality parameters in reclaimed and reference streams	<ul style="list-style-type: none">Concentration of identified CoPCs (zinc, copper and cadmium) in waterWater quality parameters (e.g., pH, DO, temperature and conductivity)	Monthly, throughout the 5-year monitoring plan. During freshet periods increase frequency to 5 days in every 30 days.	Water quality sampling by Nyrstar internally, and results reviewed and interpreted by a third-party consultant (qualified professional)
	Metals Uptake in Aquatic Organisms Monitoring Program	No statistically significant differences in cutthroat trout early life stage survival, growth, or condition between reclaimed watercourses and reference sites	<ul style="list-style-type: none">Larval cutthroat trout survival, length and weight, and body condition in reclaimed watercourses compared to reference sites	<ul style="list-style-type: none">Larval cutthroat trout survivalLarval cutthroat trout length and weightLarval cutthroat trout body condition	Every 3 years	Third-party consultant (qualified professional)



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2.5.2 Trigger, Action, and Response Plan

Table 3 presents the Trigger, Action, and Response Plan for each monitoring activity and reclamation theme.

The Trigger, Action, and Response Plan for the Myra Creek Geomorphology Monitoring Study and the Diversion Ditch Assessment, part of the Water Infrastructure Decommissioning and Reclamation Monitoring Program, will be finalized after reference site data collection and analysis. These data will act as a benchmark for monitoring reclamation success and are therefore critical in developing the triggers. A preliminary Trigger, Action, and Response Plan has been developed for these monitoring studies and will be updated once reference data is collected and analysis as part of adaptive management. Surface Water Flow Monitoring Study is the baseline data that will inform the Diversion Ditch Assessment and therefore a Trigger, Action, and Response Plan does not apply and is not included in the following table.



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Table 3 Trigger, Action, and Response Plan

	Monitoring Activity		Trigger	Action/Response/Potential Mitigation Technique	Roles and Responsibilities
Long-term Watercourse Reclamation Plan	Water Infrastructure Decommissioning and Reclamation Monitoring Program	Performance Assessment of Diversion Ditches	Erosion or sediment deposition has changed the hydraulic conveyance of the diversion ditch (at designated monitoring location)	<ul style="list-style-type: none">Repairs and/or redesign may be required based on judgment of a qualified third-party consultant.	Nyrstar staff trained by a Third-party consultant (qualified professional)
			Sediment delivered from upstream sources not being transported downstream	<ul style="list-style-type: none">Modification to the diversion can be done to improve sediment throughput. Additionally, sediment that has accumulated within the ditch can be excavated and re-introduced into Myra Creek via a gravel supplementation program.	Third-party consultant (qualified professional)
		Myra Creek Geomorphology Study	The relative geomorphic change within the reclaimed portion Myra Creek exceeds that of the upstream control sites	<ul style="list-style-type: none">Additional instream works may be required to rectify the discrepancy. Once issues have been corrected, monitoring programs will need to be adjusted accordingly.	Third-party consultant (qualified professional)
			The relative geomorphic change of the downstream portion of Myra Creek relative to the upstream control sites	<ul style="list-style-type: none">Assess whether change is related to inputs from upstream or is a result of localized instability. If related to project work, additional instream works may be required within the reclaimed portion to rectify the discrepancy. Once issues have been corrected, monitoring programs will need to be adjusted accordingly.	Third-party consultant (qualified professional)
	Aquatic Habitat Reclamation Monitoring Plan	Habitat Monitoring Study	Habitat in reclaimed watercourses is not stable or is not developing towards a similar productive capacity for cutthroat trout as reference sites.	<ul style="list-style-type: none">If monitoring data shows riparian vegetation composition, stream cover or instream habitat characteristics objectives are not met by current designs, a re-design or revised revegetation strategy may be required	Third-party consultant (qualified professional)
		Bed Sediment Monitoring Study	Channel bed and banks are unstable, or sediment size and distribution at affected sites is not developing toward instream habitat characteristics required for various life stages of cutthroat trout.	<ul style="list-style-type: none">An assessment may need to be conducted to understand what factors are affecting the size distribution of bank sediment and channel substrates in reclaimed watercourses and in reference sites (i.e., hydraulic assessment of sheer stresses during peak flood events) and a revised strategy may be requiredChannel re-designs or substrate additions/manipulations may be required	Third-party consultant (qualified professional)
		Fish Habitat Utilization Monitoring Study	Reclaimed watercourses do not have the same fish abundance or age distribution as found in reference streams	<ul style="list-style-type: none">Increase effort, alter fish sampling technique used or increase the frequency of sampling throughout a season.Follow-up management will be required to review causes and implement a revised strategy if relative abundance of cutthroat trout is not trending toward numbers in reference sites or show sign of parallelism between affected and reference sites.	Third-party consultant (qualified professional)
Terrestrial Reclamation Plan	Soil Erosion and Sediment Delivery Assessment Program		Soil rill and gully loss are at unacceptable levels	<ul style="list-style-type: none">Review soil rill and gully erosion to determine likely causes of accelerated erosion (e.g., lack of plant soil cover, concentration of surface water flow, steep slope gradients)Identify appropriate revegetation efforts or soil erosion and sediment delivery mitigationsImplement revegetation/soil erosion and sediment delivery mitigations (if required).Monitor effectiveness of revegetation/soil erosion and sediment delivery mitigations.	Third-party consultant (qualified professional) Nyrstar (Implementation)
			Mitigation for soil erosion is not effective	<ul style="list-style-type: none">Review reasons that revegetation/soil erosion and sediment delivery mitigations were not effectiveInitiate and implement revised erosion control measures (if required)Monitor treated areas, and review ongoing monitoring regime to evaluate if it is sufficient	Third-party consultant (qualified professional) Nyrstar (Implementation)
	Soil Compaction and Decompaction Program		Soil Compaction is identified as an issue (e.g., high soil bulk densities and poor vegetative growth)	<ul style="list-style-type: none">Provide an explanation of possible causes of soil compaction (e.g., repeated passages of machinery, high pounds/square inch loading of machinery) and provide recommendation on how to future reclamation site preparation strategies that will lessen soil compaction.Identify and implement decompaction strategies on areas with high identified soil compactionMonitor and evaluate any new soil placement techniques employed on the mine site	Third-party consultant (qualified professional) Nyrstar (Implementation)
			Soil decompaction trials are not successful in alleviating soil compaction issues	<ul style="list-style-type: none">Identify additional soil decompaction strategies/technologiesImplement newly identified soil decompaction strategies/technologies on newly reclaimed areas or on existing soil decompaction trial areas (if required)Monitor treated areas and evaluate if they are effective in alleviating soil compaction issues.	Third-party consultant (qualified professional) Nyrstar (Implementation)



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	Monitoring Activity	Trigger	Action/Response/Potential Mitigation Technique	Roles and Responsibilities
Terrestrial Reclamation Plan	Revegetation Prescriptions Program	Revegetation efforts/trials are not successful in establishing a vegetation cover and community that starts an Ecological succession trajectory towards post closure terrestrial ecosystems including <ul style="list-style-type: none">Poor survivability of planted seedlings and propagulesPoor revegetation survivability and plant cover establishment of seeding trialsPoor revegetation survivability and plant cover establishment of soil cover soil trialsPoor revegetation and plant cover establishment of seedling/vegetation transplant trials	<ul style="list-style-type: none">Review revegetation efforts/trials to determine likely causes poor survivability and/or lack of vigorous plant cover establishmentIdentify appropriateness of revegetation efforts/trialsIdentify revegetation efforts required on areas of poor performance (e.g., replanting or supplemental seedlings/propagules, supplemental planting, cover soil replacement).Implement revised revegetation effort (if required)Continue monitor treated areas and evaluate revegetation efforts are successful.	Third-party consultant (qualified professional)
	Wildlife Habitat Restoration Plan	<ul style="list-style-type: none">Poor vegetation development leading to low habitat value	<ul style="list-style-type: none">Review vegetation and wildlife monitoring results to determine the cause(s) of poor vegetation development and low habitat valueIdentify required modifications to restoration design to improve habitat value for wildlife, and complete remedial work in areas of poor vegetation establishmentIntensify monitoring in treated areas during re-establishment, and review ongoing monitoring regime to evaluate if it is adequate	Third-party consultant (qualified professional)
		<ul style="list-style-type: none">Absence of target wildlife species in reclaimed areas (i.e., species associated with disturbed habitats in structural stages 1-3), and/or undesired wildlife community inhabiting restored areas	<ul style="list-style-type: none">Review wildlife monitoring results and compare to desired trajectory to determine why performance objectives are not being met (e.g., lack of appropriate habitat requirements, low habitat connectivity)Identify appropriate mitigation technique (e.g., supplemental planting, habitat enhancement installation, or additional landscape modification)Complete mitigation technique, as selected, in areas with poor wildlife useMonitor treated areas, and review ongoing monitoring regime to evaluate if it is sufficient	Third-party consultant (qualified professional)
	Research for Old-Growth Attributes Program	<ul style="list-style-type: none">Wildlife use is not detected in research trials	<ul style="list-style-type: none">Review monitoring results to determine likely reasons for lack of wildlife useIdentify if design modifications are necessaryImplement modifications if requiredContinue monitoring wildlife use in research trials	Third-party consultant (qualified professional)
		<ul style="list-style-type: none">Change in wildlife mortality risk	<ul style="list-style-type: none">Review monitoring results to determine cause of mortality riskImplement mitigation measures and identify if design modifications are necessaryImplement modifications if requiredContinue monitoring wildlife use in research trials	Third-party consultant (qualified professional)
	Soil Cover Plan	Soil sampling program determines some materials are not suitable for reclamation (e.g., high acid generating potential) Volumes of suitable materials for reclamation are insufficient.	<ul style="list-style-type: none">Identify mitigation methods that will be employed in areas with unsuitable reclamation materialsIdentify alternate reclamation techniques that will be employed.	Third-party consultant (qualified professional)



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	Monitoring Activity	Trigger	Action/Response/Potential Mitigation Technique	Roles and Responsibilities
Metal Uptake Monitoring Plan	Soil and Vegetation Baseline and Uptake Program	Soil and Plant Constituents of potential concern (CoPC) exceed CCME guidelines	<ul style="list-style-type: none">Identify mitigation methods that will be employed in areas COPC exceedancesDevelop mitigation plan for areas of exceedancesMonitor the COPC constituents after mitigation	Third-party consultant (qualified professional)
		Soil and Plant CoPC are at levels much higher than off-site reference site levels	<ul style="list-style-type: none">Determine he need to conduct pathway analysisContinue to monitor CoPC to evaluate trends	Third-party consultant (qualified professional)
	Wildlife Exposure Risk Study	CoPC exceed levels safe for wildlife in terrestrial and/or aquatic systems	<ul style="list-style-type: none">Complete wildlife use monitoring in areas with elevated CoPC concentrations to determine if exposure pathways exist	Third-party consultant (qualified professional)
		Wildlife exposure pathway confirmed in areas with elevated CoPC's (i.e., consumption of contaminated soil, vegetation or water)	<ul style="list-style-type: none">Determine the need for mitigation measures in areas with elevated CoPC concentrationsComplete biological sampling to evaluate metal uptake in wildlife that are exposed to elevated CoPC concentrationsContinue to monitor wildlife use in areas with elevated CoPC concentrations	Third-party consultant (qualified professional)
		Biological sampling of wildlife on site identifies elevated CoPC concentrations compared to regional wildlife baseline levels	<ul style="list-style-type: none">Identify and implement mitigation measuresMonitoring wildlife use and CoPC concentrations to evaluate the success of mitigation measuresReview ongoing monitoring regime to evaluate monitoring frequency	Third-party consultant (qualified professional)
	Water Quality Monitoring Program	Elevated CoPC concentration downstream of site	<ul style="list-style-type: none">Identify mitigation methods that will be employed in areas of CoPC exceedancesRevise strategy to reduce CoPC concentration in the water, e.g., through increased capping of waste rock, improved contact and non-contact water separation, improved contact water collection and conveyance, improved in-situ passive water treatment, alternative re-vegetation planning and active water treatmentMonitor the CoPC after mitigation measures have been put in place	Third-party consultant (qualified professional)
	Metals Uptake in Aquatic Organisms Monitoring Program	Statistically significant decrease in survival rate, development or condition of larval cutthroat trout in comparison to reference site	<ul style="list-style-type: none">Evaluation of potential cause-and-effect pathways, and (if applicable) identify mitigation measures to e.g., reduce metal concentrations in water or increase suitability of stream characteristics for cutthroat trout.Increase sampling frequency after mitigation to monitor and closely evaluate the success of the mitigation measures	Third-party consultant (qualified professional)



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3.0 CLOSURE AND NEXT STEPS

The overall implementation of the proposed RMP as presented herein will inform the development of the closure and reclamation plan for the site. Results of the proposed reclamation research program and its components are reported in the annual reclamation report, and re-evaluated and adjusted during the rolling five-year reclamation and closure report update. Nyrstar is in the process of engaging First Nations in the implementation process, and information from TLU Knowledge Holders, once available, can be incorporated into the proposed research and monitoring program. Stantec thanks IEG and Nyrstar for the opportunity to provide proposed research program components, activities, evaluation methods and monitoring activities, and is available to support the next steps for a successful implementation of the program and fulfilment of the site's regulatory requirements.



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