

NYRSTAR MYRA FALLS

SITE-WIDE ML/ARD MANAGEMENT PLAN



January 2019

EXECUTIVE SUMMARY

This is the Site-Wide Metal Leaching and Acid Rock Drainage (ML/ARD) Management Plan for Nyrstar Myra Falls (NMF). It describes how sulphidic waste rock will be managed to prevent and/or mitigate potential water quality impacts due to future ML/ARD generation and provides an overview of how ML/ARD-impacted groundwater, mine water, and precipitation runoff are currently managed. Key aspects of future waste rock monitoring and management during mining operations in the Price, HW, and Lynx mines from 2019 to 2022 and ongoing management of existing ML/ARD via mine water, groundwater, and seepage interception are summarized below. Monitoring and reporting commitments for tailings and waste rock are also summarized and further detailed in Section 6.

Mine Plan and Waste Rock Inventory

NMF intends to produce 1,577,113 tonnes (t) of ore from 2019 to 2022. 85% of the ore will be produced from the HW and Battle Gap mines, which have been operated for decades and were last operated in 2015. The Price mine will account for approximately 13% of ore produced from 2019 to 2022 and the Lynx mine will account for the approximately 2% of the planned ore production (mined only in 2021). Approximately 720,549 t of waste rock is expected to be produced from 2019 to 2022. 92% will be from the HW and Battle Gap mines and the other 8% will be produced from the Price and Lynx mines. 85 to 90% of waste rock produced from the HW and Battle Gap mines will be conveyed to surface, whereas the majority (up to 90%) of future, run-of-mine waste rock from the Price and Lynx mines will be kept underground for use as roadbase or be used as backfill for mined-out stopes in the HW or Lynx mines.

In total, approximately 1,497,833 m³ of existing waste rock, run-of-mine waste rock, and development rock will be handled at surface from 2019 to 2022. This includes approximately 112,000 t of development rock from the Phillips Reach Decline Extension that will be trucked to surface and stored in the quarry area. In total, 1,155,453 m³ of Potentially Acid Generating (PAG) and Non-PAG waste rock from Waste Rock Dump (WRD)#2, WRD#3, and WRD#6 will be re-located to the upper Lynx Pit or used to construct the Lynx Tailings Disposal Facility (TDF) embankment berm, as per the Lynx Waste Rock Stabilization Permit Level Design (see Amec Foster Wheeler, 2017). Waste rock from WRD#4 is not explicitly scheduled for removal to construct the Lynx TDF embankment berm from 2019 to 2022 but waste rock from this dump may be removed as part of ongoing reclamation work.

Future Waste Management and Monitoring

Seepage from PAG waste rock in the historic WRDs has proven to yield ARD and most of the future PAG waste rock from the Price, HW, and Lynx mines is predicted to yield ARD as well. Some PAG and Non-PAG materials will likely yield Saline Drainage (SD) or Neutral Mine Drainage (NMD) that is less acidic but characterized by metal concentrations that are high enough to cause unacceptable environmental impacts downgradient. PAG and Non-PAG waste rock must therefore be placed in appropriate areas on site so that impacts to groundwater and Myra Creek can be prevented or mitigated. Non-sulphidic materials ($S_{total} <$

0.05%) are the only materials on site that will not generate any ARD, SD, or NMD. These materials do not require containment to prevent environmental impacts downgradient but will be handled and stored appropriately so they are preserved for future reclamation work, e.g. closure covers, etc.

Key aspects of future waste rock management and related monitoring/characterization testwork are summarized below:

- Waste rock re-located from WRD#1, WRD#2, WRD#3, WRD#4, and WRD#6 will be characterized by Acid Base Accounting (ABA), metals, and Shake Flask Extraction (SFE) to document the geochemical characteristics of waste rock incorporated into the Lynx TDF embankment berm. Results will not be used to segregate PAG and Non-PAG waste rock unless a specific use or placement area for Non-PAG waste rock within the embankment berm is identified by Wood PLC.
- Approximately 0.4 Mm³ of waste rock produced during future mining in the Price and HW mines will be required to raise the Lynx TDF embankment berm to its final design height. Most of this future, run-of-mine waste rock will be produced from the HW mine and will likely be PAG waste rock that will generate ARD and/or SD. 10 to 15% of the waste rock produced from the HW mine will be stored/disposed in underground areas that are below the post-closure flood level and the remainder will be hoisted to surface.
- Non-sulphidic development rock from the Phillips Reach Decline Extension will be stored in the quarry area until needed for closure covers or other reclamation work. This rock can be used for construction in areas where groundwater is not recovered by the site-wide SIS or incorporated into closure covers when they are required. Other non-sulphidic rock, i.e. crushed quarry rock, may also be used for these purposes and will be stored in the quarry area. Non-PAG waste rock will generate NMD or SD and must not be stored in the quarry area.
- Future waste rock will be characterized to determine whether substantial (>20,000 t) tonnages of non-sulphidic materials will be produced during certain periods of active mining in the Price and HW mines and/or mine development between mineralized areas. Potentially non-sulphidic areas will also be identified during ongoing exploration drilling and mine planning and then the rock will be verified as non-sulphidic as per the procedures outlined in this report.
- Sulphidic waste rock brought to surface during future mining will not be segregated unless a specific use for Non-PAG waste rock is identified by Wood PLC (see above). Waste rock brought to surface will be characterized to document the geochemical characteristics of the materials used for future raises of the Lynx TDF embankment berm so that the characteristics of these materials can be documented in future reclamation reports.
- PAG and Non-PAG waste rock will be stored in WRD#1 once the Ministry of Energy, Mines, and Petroleum Resources (MEMPR) approves the dump design currently under development by Wood PLC). PAG and Non-PAG waste rock will not be stored in any area other area on site other than WRD#1. Waste rock will be stored in WRD#1 until it is required for future dam raises. Material

placement in the Lynx berm is strictly controlled by engineering designs and will be supervised by Wood PLC.

- The Surface Department is responsible for waste rock management and will work with the Health Safety, Environment and Communities (HSEC) Department to resolve any indecision during operations regarding the appropriate use or storage area for a material. Any waste rock or development rock removed from the underground will be characterized per the programs detailed in this report unless otherwise specified by the Environment Department. Identifying high-sulphide PAG materials ($S_{\text{total}} > 10\%$) is the responsibility of the Geology Department. Ensuring these materials are identified in the mine plan is the responsibility of the Engineering Department and ensuring PAG materials are stored appropriately underground is the responsibility of the Mining department.

Water (ML/ARD) Management

Below is a summary of key aspects of water (ML/ARD) management:

- Groundwater quality in the Myra Valley Aquifer (MVA) is impacted primarily by seepage from the historic WRDs and the Lynx TDF embankment berm. Metal concentrations are highest in groundwater downgradient of Lynx TDF embankment berm and WRD#1. Approximately 37.4 t/year Zn reports to the MVA from all sources at surface. Together, WRD#1 and the Lynx TDF berm account for approximately 60% of this annual load. An unidentified source in the mill area accounts for an additional 20% of the annual Zn load and other sources, e.g. Seismic Upgrade Berm, seepage from the ETA/Cookhouse area account for the other 20% of the load to groundwater. Tailings account for less than 0.1% of the Zn load to groundwater in the MVA.
- The Old TDF under-drains are highly-effective and have recovered ~80% of the Zn load in groundwater since the NOD was installed/optimized and before the Phase I Lynx Seepage Interception System (SIS) began operating in October 2017. Drain bypass is minimal (<5% annually). Zn loads in Myra Creek are therefore related primarily to loads from impacted groundwater that discharges to the creek from the Lynx Reach and the Upper Old TDF Reach.
- Zn concentrations in Myra Creek often exceed provincial Water Quality Guidelines (WQGs) for Zn during lower flow periods when there is less dilution by flows from the upstream catchment. Cd and Cu sometimes exceed WQGs. The Phase I Lynx SIS is predicted to recover 32 t/year Zn, or about 80% of the Zn load intercepted by Old TDF under-drains. Zn concentrations in Myra Creek are predicted to decrease by three to five times and will likely be less than the provincial WQG (maximum) for most of the year. These lower concentrations are predicted to occur in 2019 once a new steady-state condition in the MVA is achieved during the operation of the Phase I Lynx SIS.
- The Old-TDF under-drains and the Lynx SIS (the site-wide SIS) will be operated in perpetuity to maintain acceptable Zn concentrations in Myra Creek. The site-wide SIS is predicted to be adequately protective of Myra Creek when the Lynx TDF embankment berm is expanded to its final

footprint area and larger loads report to groundwater as a result. The site-wide SIS is also predicted to be adequately protective of Myra Creek once loads from tailings to groundwater increase due to higher concentrations of Zn and other metals in tailings porewater at the base of tailings profile.

- PAG and Non-PAG waste rock (and co-disposed PAG tailings) are mainly stored below the 13L of the mine workings in the Lynx, Myra, and HW mines and will therefore be flooded post-closure. Flooding will prevent any future generation of ARD, NMD, or SD from these materials and any impacted mine water from waste rock or exposed sulphidic rock above the flood level will be directed to the water treatment system.
- When mining commences in Price mine, monthly monitoring of mine water flows from the Price 4L and 5L adits to the HW mine will be monitored monthly. These flows and associated loads can be handled by the HW 25L Main sump and the implications for the mine water management and treatment system are minimal. Gravity flows from the Price 13L adit to the Price Pond will be also be monitored monthly. Mine water quality in the Price mine is expected to deteriorate during operations and flows from the Price 13L adit will be monitored to characterize loads to the Price Pond. Thelwood Creek water quality monitoring results will be provided in future Surface Water and Groundwater Monitoring Reports.

Monitoring and Reporting Commitments

Geochemical monitoring results will be documented in the Annual Reclamation Report prepared by the Environment Department and submitted to the MEMPR by March 31st of the following year. A Qualified Person will review and/or contribute to sections of the annual reclamation reports that require interpretation of geochemical data. Further details on sampling frequencies, the types of testwork that will be completed, and related reporting are provided in Section 6. The performance of the site-wide SIS will be assessed periodically in the annual Surface Water and Groundwater Monitoring Report to confirm the predicted improvements in groundwater quality and water quality in Myra Creek. Further details on groundwater and surface water quality monitoring and water level monitoring related to the SIS performance assessment are provided in the Surface Water and Groundwater Monitoring Plan.

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List of Acronyms and Abbreviations

ABA	Acid Base Accounting
AP	Acid Potential
ARD	Acid Rock Drainage
ICP-MS	Inductively-Coupled Plasma Mass Spectrometry
M	Mega (or '10 ⁶ ')
MEMPR	Ministry of Energy, Mines and Petroleum Resources
MPA	Maximum Potential Acidity
ML	Metal Leaching
NMF	Nyrstar Myra Falls
NNP	Net Neutralization Potential
NP	Neutralization Potential
NPR	Neutralization Potential Ratio
PAG	Potentially Acid Generating
QA/QC	Quality Assurance/Quality Control
QP	Qualified Person
RGC	Robertson GeoConsultants Inc.
S _{SO4}	Sulphate Sulphur
S _{sulphide}	Sulphide Sulphur
S _{total}	Total Sulphur
SFE	Shake Flask Extraction
SIS	Seepage Interception System
TDF	Tailings Disposal Facility
TIC	Total Inorganic Carbon
VHMS	Volcanic-Hosted Massive Sulphide
WRD	Waste Rock Dump
XRD	X-Ray Diffraction

NYRSTAR MYRA FALLS

SITE-WIDE ML/ARD MANAGEMENT PLAN

1 INTRODUCTION

1.1 GENERAL

This is the Site-Wide Metal Leaching and Acid Rock Drainage (ML/ARD) Management Plan for Nyrstar Myra Falls (NMF). It was prepared by Dr. Paul Ferguson of Robertson GeoConsultants Inc. (RGC) and Armond Stansell, GIT (NMF Mine Geologist) and was reviewed by Shannon Shaw of pHase Geochemistry Inc. This plan will be implemented in 2019 upon approval by the Ministry of Energy, Mines, and Petroleum Resources (MEMPR) and be reviewed annually and updated as required.

1.2 TERMS OF REFERENCE

The Myra Falls mine has been operated since 1966 by several companies under Permit M-26. Nyrstar, a global multi-metals business, purchased the mine in 2011 from Breakwater Resources and operated the mine until June 2015 when mining/milling ceased. Mining and milling activities resumed in 2018 and a mine plan that details production in the Price, HW, and Lynx mines through 2022 has been conditionally approved by the MEMPR. According to Permit M-26, “all materials with the potential to generate ML/ARD shall be placed in a manner that minimizes the production and release of metals and contaminants to levels that assure protection of environmental quality”. Historically, most of the waste rock from the Lynx pit or that brought to surface from the underground mines at NMF has been Potentially Acid Generating (PAG) waste rock that was deposited in several historic Waste Rock Dumps (WRDs) (see **Figure 1-1**). The WRDs contain lesser quantities of Non-PAG waste rock that was not segregated from PAG waste rock when deposited (see RGC, 2015).

Since 2008, PAG and Non-PAG waste rock sourced from the historic WRDs and waste rock produced during mining in the HW mine has been used to construct the Lynx Tailings Disposal Facility (TDF) embankment berm. The Lynx TDF is constructed around the former Lynx pit and is the only active tailings disposal facility at surface (see Amec Foster Wheeler, 2018). Seepage (primarily ARD) from the historic WRDs and the Lynx TDF embankment berm reports to groundwater in the Myra Valley Aquifer (MVA) that underlies the WRDs and the berm. ML/ARD-impacted groundwater then discharges to Myra Creek downgradient in the Lynx Reach or the Upper and Lower Old TDF Reaches of the creek (see RGC, 2018a).

NMF operates a site-wide Seepage Interception System (SIS) to recover ML/ARD-impacted groundwater that would otherwise discharge to Myra Creek. The SIS consists of a system of under-drains beneath the Old TDF and a fence of pumping wells near the Lynx TDF that is referred to as the Phase I Lynx SIS.

Groundwater recovered by the SIS and mine water flows from the underground report to the water treatment system. Gravity flows from several adits and mine de-watering flows from the underground workings also report to the water treatment system. The SIS and other water management facilities are critical to ongoing water (ML/ARD) management on site and will continue to operate during future mining operations and post-closure (see RGC, 2018a).

1.3 PLAN OBJECTIVES

The objectives of the Site-Wide ML/ARD Management Plan are to:

- Describe how sulphidic waste rock will be characterized, classified, and handled underground and at surface to prevent and/or minimize future ML/ARD generation during care and maintenance and future operations.
- Describe how ML/ARD-impacted mine water, groundwater, and precipitation runoff will be collected and treated during future operations and post-closure to mitigate potential water quality impacts to Myra Creek.

1.4 REGULATORY FRAMEWORK AND GUIDELINES

Aspects of the Site-Wide ML/ARD Management Plan that pertain to solids testing and waste rock management were developed in accordance with Section 10.1.16 of the Health, Safety and Reclamation Code for Mines in British Columbia and Permit M-26 Part D.1.iv. and are consistent with Price and Errington (1998), 'Guidelines for Metal Leaching and Acid Rock Drainage at Mine Sites in British Columbia'. The Site-Wide ML/ARD Management Plan is also consistent with the GARD Guide (www.gardguide.com)¹, wherein methods and procedures for sample collection and analytical testwork related to ML/ARD are comprehensively reviewed and documented.

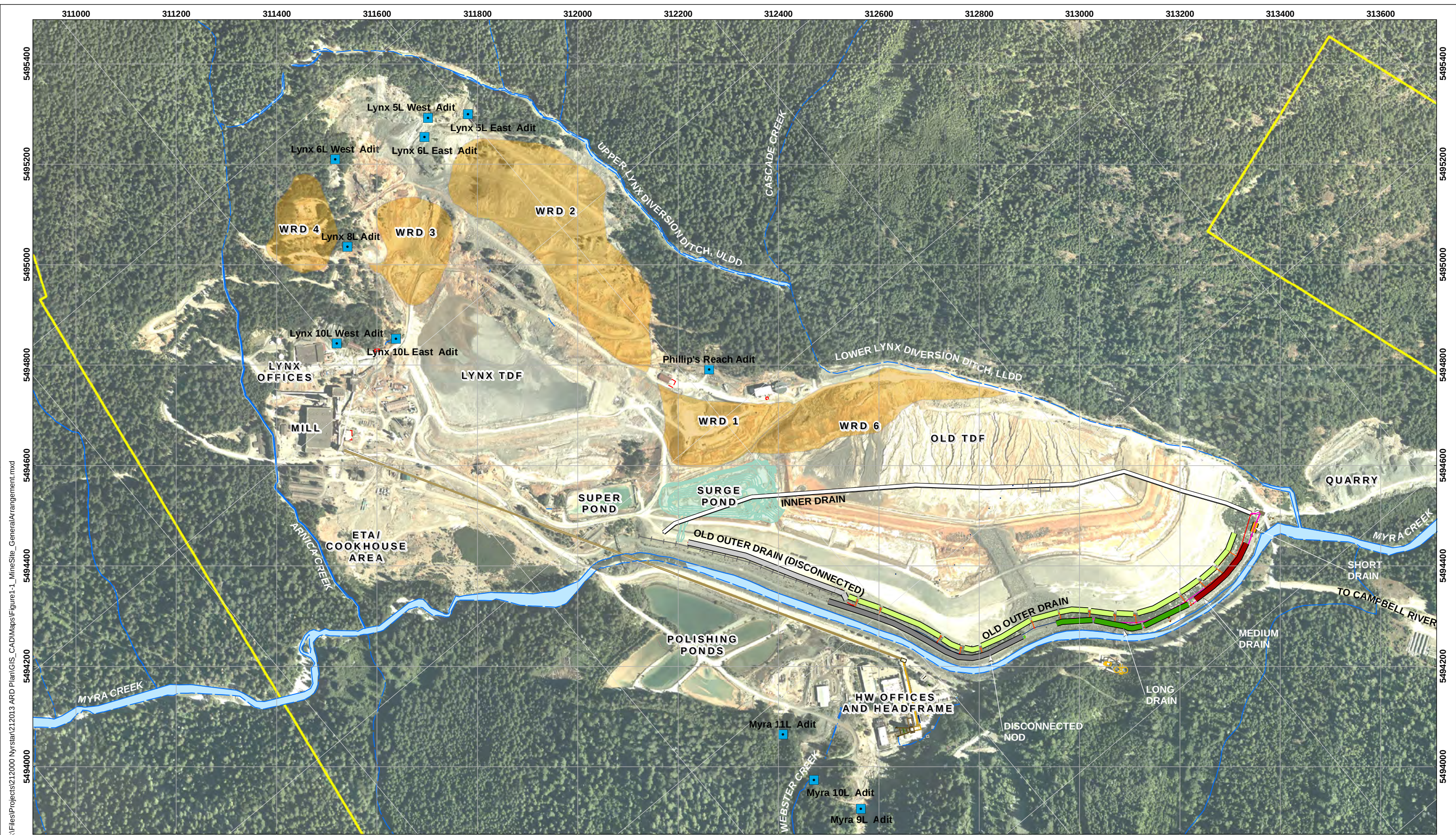
Aspects of the Site-Wide ML/ARD Management Plan that pertain to the management of ML/ARD-impacted mine water, groundwater, and precipitation runoff are based on findings from RGC (2018a). That report documents the Site-Wide Load Balance (SWLB), which includes a calibrated groundwater model developed in the software MODFLOW/MT3D and a load balance model for the water treatment system and Myra Creek developed in the software Goldsim. The SWLB was developed by adapting the site-wide, operational Water Balance Model (WBM) developed in March 2018 (see RGC, 2018b). A regulatory standard for this

¹ The Global Acid Rock Drainage (GARD) Guide addresses the prediction, prevention, and management of drainage produced from sulfide mineral oxidation, often termed Acid Rock Drainage (ARD), Saline Drainage (SD), Neutral Mine Drainage (NMD). The GARD Guide is published and maintained by the International Network for Acid Prevention (INAP), see www.gardguide.com

type of modeling and predictive work is not available but the methods and approaches are considered leading practice for the mining industry based on RGC's international project experience.

1.5 PLAN SCOPE

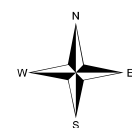
Operational aspects of tailings management underground and tailings disposal in the Lynx TDF are beyond the scope of this Site-Wide ML/ARD Management Plan. The reader is referred to the Operations, Maintenance, and Surveillance (OMS) manual for the site (see Amec Foster Wheeler, 2018) and various other reports by Amec Foster Wheeler (now Wood PLC) for further details on tailings management and disposal. Future tailings characterization is discussed, as are potential groundwater quality impacts due to contaminant loads from tailings are discussed in this report as these impacts are relevant to ongoing and future ML/ARD management on site.



S:\Files\Projects\212000 Nyrstar\212013 ARD Plan\GIS_CAD\Maps\Figure1-1_MineSite_GeneralArrangement.mxd

Legend

— Class B Park Boundary



Scale 1:7,000

0 50 100 200 300 400 500 Meters

NAD83 UTM Zone10N

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General Mine Arrangement 2018, Nyrstar Myra Falls

Client: 	Figure: 1-1
Project: Site-Wide ML/ARD Management Plan	Last Update: Dec 18, 2018
Report: RGC 212012/1	Drawn: L.R.
Original File: Figure1-1_MineSite_GeneralArrangement.mxd	

2 BACKGROUND

2.1 LOCAL GEOLOGY

2.1.1 *Key Rock Types*

The Myra Falls orebody is a classic Volcanic Hosted Massive Sulphide (VHMS) deposit. It is a composite of sulphide lenses that were emplaced in a very dynamic, rapidly changing environment of submarine volcanism, massive debris flow, and constant tectonic activity. This active period was followed by a time of quiet, widespread sedimentation (cherts and argillites). A second cycle of volcanic activity and mineral emplacement subsequently occurred producing the Lynx-Myra-Price deposits.

Sulphide ore deposits are structurally controlled along narrow rift and trough features that have produced a system that is at least 10 km in length. The Myra ore deposits are situated in a Paleozoic group of rocks known as the Sicker Group, which comprises four main lower units that make up the stratigraphic package hosting the Price Deposit. The units that are proximal to the project area are the Price Formation, Myra Formation, Thelwood Formation, and Flower Ridge Formation (**Figure 2-1**). The Myra and Price Formations are unconformably overlain by the rocks of the Thelwood Formation and the Flower Ridge Formation (**Figure 2-2**) (see Juras, 1987 and Muller, 1980).

All planned ore production from 2019 to 2022 will be from the Myra Formation, which consists of andesitic to rhyolitic flows and pyroclastic deposits, volcanic sediments and hydrothermal sulphide mineralization related to the magmatic arc assemblage and intra-back arc rifting. The Myra Formation has been subdivided into ten stratigraphic units based on surface outcrop mapping of the Price hillside located towards the southeast end of the property (Juras, 1987). These units from oldest to youngest are: H-W Horizon, H-W Hangingwall Andesite, Ore Clast Breccia, Lower Mixed Volcaniclastic Rocks, Upper Dacite, Lynx-Myra-Price Horizon, G-Flow, Upper Mixed Volcaniclastic rocks, Upper Rhyolite, and, the Upper Mafic Unit. The Thelwood Formation and Flower Ridge Formation lie stratigraphically above the mineralized zones.

2.1.2 *Ore Horizons*

The H-W Horizon (H-W Rhyolite and Sulphide Facies) and the Lynx-Myra-Price Horizon are the main ore-producing units at NMF. The HW Horizon is the oldest unit of the Myra Formation. It is predominantly a rhyolitic volcano-sedimentary package, comprising coarse volcaniclastics, sandstones, and mudstones, with massive quartz-feldspar porphyry bodies near the top of the horizon. The horizon may be further subdivided to include massive to semi-massive sulphide, chert, argillite-silt, fine to medium-grained rhyolitic volcaniclastic rocks, coarse-grained rhyolitic volcaniclastic rocks, ore clast breccias, and quartz-feldspar porphyry (Jones, 2001).

Massive to semi-massive sulphides occur in thick lenses, up to 35 m thick, of massive and banded ore, within the H-W Horizon. These sulphide lenses form the HW, Extension, Battle, and Ridge Zone orebodies, and the smaller more discontinuous and un-mined Marshall and Trumpeter Zones. The ore is associated

with coarse-grained rhyolitic and mixed andesitic-rhyolitic volcanoclastics, close to the contact with the underlying Price Andesite. Chalcopyrite, sphalerite, pyrite and galena are the dominant sulphide species with lesser bornite and tetrahedrite, and accessory chalcocite, colusite, and gold. Upper zone sulphides also occur in the mid-upper part of the HW horizon, above both the HW and Battle deposits. These upper zones differ from the main sulphide bodies at the base of the horizon, as they are predominantly Zn-Pb-barite-rich and pyrite-poor (Jones, 2001).

The Lynx-Myra-Price Horizon is a deformed and discontinuous rhyolitic package that occurs near the top of the Myra Formation and hosts Lynx-Myra-Price mineralization. The thickness of the rhyolitic unit is variable, ranging from 1 to 45 m thick. The unit consists of massive and bedded, fine to coarse-grained quartz-feldspar phyric rhyolitic volcanoclastics, laminated chert and massive and semi-massive sulphides in the Lynx, Myra and Price orebodies. The dominant sulphide species are chalcopyrite, pyrite, sphalerite and galena, and the orebodies of this horizon may be characterised by abundant barite.

Further details on these units are provided in Jones (2001) and Juras (1987).

2.1.3 Sulphide Mineralogy

The alteration mineralogy at Myra Falls includes sericite and silica with subordinate chlorite, albite, and carbonate. Sulphide mineralogy of pyrite+/-chalcopyrite+/-sphalerite+/-galena+/-tennantite is also present in varying modal percentages as disseminations and veinlets (**Table 2-1**). The overall depth and lateral distribution of the hydrothermal system for the Myra Falls deposits has not yet been defined. Zones of pyrite stringer mineralization have been observed to underlie the H-W, Battle, Lynx and Myra deposits (Juras, 1987). Sinclair (2000) has identified three main mineral assemblages that occur within the Myra Falls stratigraphy. These are a polymetallic Cu-Pb-Zn-Fe rich mineral assemblage that can be found within the H-W, Battle Gap, Extension and Ridge zones, a Cu-rich mineral assemblage that is typically a basal unit and found in close relation to the bottom of the sulphide mineralization, and a late stage Ag-Au rich assemblage that is commonly associated with the upper mineralized units of the H-W Horizon.

Historical mining at Myra Falls has included a significant amount of H-W Main Zone in the mine plans. Future mine planning is expanding development in the Ridge, Marshall, Price and Battle Gap zones which will significantly reduce the amount of pyrite that will be mined. Grade control data taken from the mine database between 1999 and 2005 shows that the Fe% for the mine production averaged 16%. The period between 2005 and 2010 averaged 11% as the H-W Main ore started to decrease and be replaced with Battle Gap ore. The Fe% decreased again from 2010 to 2015 to 9% Fe as HW Main Zone ore disappeared and further Battle Gap, Ridge and HW East ore was targeted. In the current mine plan, it is estimated that the total Fe% will be around 7% as the pyrite content of ore decreases.

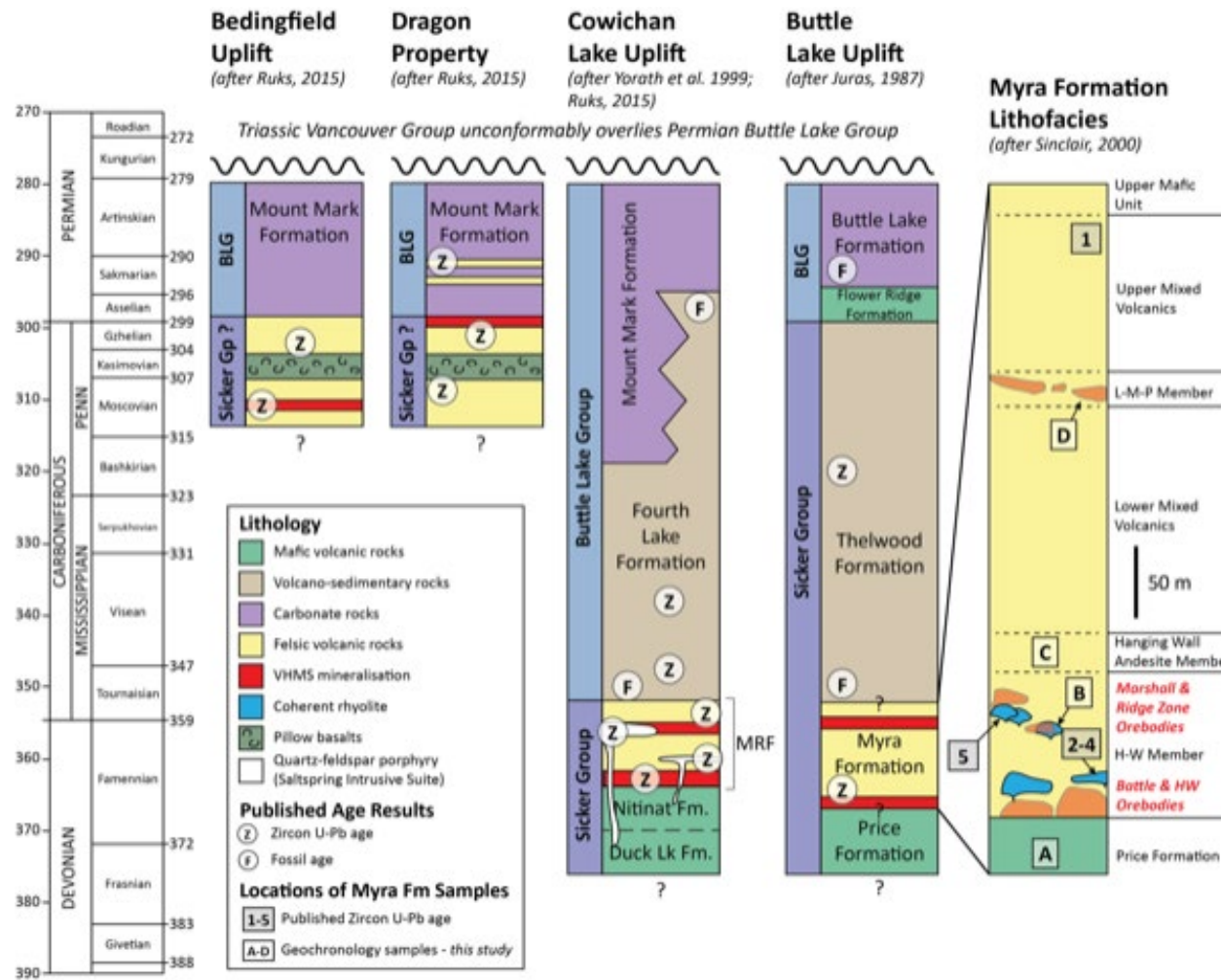


Figure 2-1. Comparative chronostratigraphic columns illustrating the temporal relationships of the Paleozoic rocks of Vancouver Island (modified from Massey, 1992; Juras, 1987; Sinclair, 2000; Ruks, 2015; McNulty, 2018) with the location of published age constraints and new geochronology samples at Nyrstar Myra Falls. Figure from McNulty (2018).

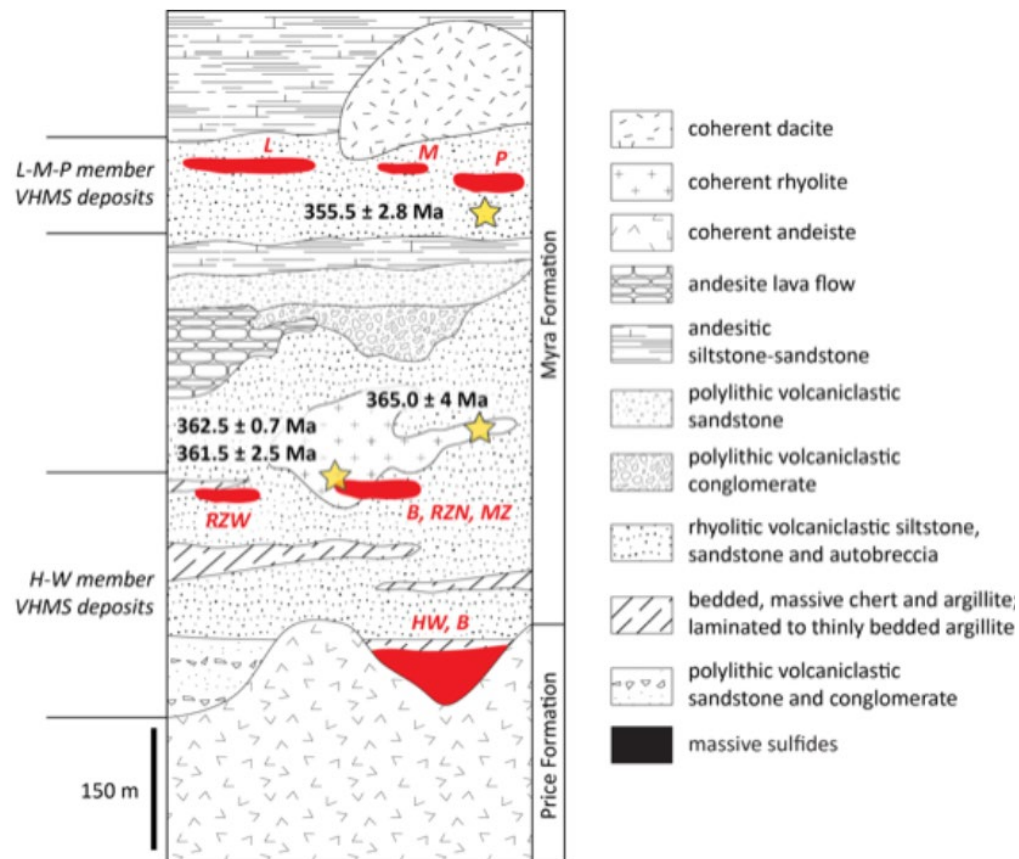


Figure 2-2. Stratigraphic reconstruction of Myra Falls district, showing the new age constraints from this study and previous age results. Figure from McNulty (2018).

Abbreviations: B, Battle; L, Lynx; M, Myra; Mz, Marshall Zone; P, Price; RZN, Ridge Zone North; RZW, Ridge Zone West.

Table 2-1
Common mineral assemblages associated with ore facies at Myra Falls

Assemblage	Type	Mineral	General Formula	Other elements	Inclusions - Impurities	Comments	Source
Cu-Pb-Zn-Fe	Sulphides	Pyrite	FeS ₂	Ni, As	Zn, Cd, Cu, Pb, As, Mn, Au	Honey and dark grey sph varieties due to Fe content	Wilson (1993), Sinclair (2000)
		Sphalerite	ZnS	Fe, Cd, Cu			Sinclair (2000)
		Galena	PbS	Se, Te	Zn, Fe, Cu		Sinclair (2000)
		Chalcocopyrite	Cu ₂ FeS ₂	Se, In	Ba, Zn, Au		Wilson (1993), Sinclair (2000)
		Pyrrhotite	Fe _{1-x} S				Walker (1985)
	Sulphosalts	Arsenopyrite	FeAsS				Walker (1985)
		Tennantite	(Cu ₁₀ Ag) Zn ₇ Fe(As ₃ , Sb)S ₁₂	Fe, Se, Ag, Cd		Wilson (1993); Sinclair (2000)	
	Trace Minerals	Rutile	TiO ₂		Si, Al, Fe	Sinclair (2000)	
		Colusite	Cu ₂ (As, Ge, V)S ₄	Ba, Sb	Ag, Mo, Zn, Fe	Gap and Upper Zone ores only.	Robinson (1992); Sinclair (2000)
	Tellurides	Altaite	PbTe			Microscopic inclusions within tt and gn	Sinclair (2000)
		Hessite	Ag ₂ Te ₃			Microscopic inclusions within tt and gn	Sinclair (2000)
		Pfessite	Bi ₂ Te ₃			Microscopic inclusions within tt and gn	Sinclair (2000)
Cu-Rich	Sulphides	Bornite	Cu ₅ FeS ₄	Ag, Ba	Zn, Cd		Sinclair (2000)
		Covellite	CuS			Associated with strom; H-W deposit	Becherer
		Renierite	Cu ₁₀ (Zn _{1-x} Cu) _x Ge _{2-x} As _x Fe ₄ S ₁₆	V, Sb, Ba		Also known as orange bornite	Robinson (1992); Sinclair (2000)
		Anilite	Cu ₂ (Ag)S	Ag, Ba		Chalcocite group	Robinson (1992); Sinclair (2000)
Late Ag-Au Rich	Sulphides	Stromeyerite	CuAgS	Fe		Associated with cpy, bo, and anilite	Chrysosoulis (1989), Sinclair (2000)
	Precious metals	Electrum	AuAg			Coarse variety- strom-filled fractures and strom-bo-sph grains	Sinclair (2000)
Gangue						Fine variety- pyrite fractures and grain boundaries	Wilson (1993)
		Native silver	Ag			Exsolution blebs in tt; wires to 1 cm length (Lynx S-zone pit)	Becherer
		Barite	BaSO ₄				Sinclair (2000)
		Quartz	SiO ₂				Sinclair (2000)
		Muscovite	K ₂ Al ₂ (Si ₄ Al ₂ O ₁₀)(OH,F) ₄				Sinclair (2000)
		Epidote	Ca ₂ (Al,Fe) ₃ Si ₂ O ₁₂ (OH)				
		Calcite	CaCO ₃				
		Gypsum	CaSO ₄ ·2H ₂ O			Myra and Lynx pit; hangingw all contact; sw allow tail tw ins	Becherer
		Anhydrite	CaSO ₄			Myra deposit - at hangingw all contact	Becherer
		Jasper	SiO ₂		Fe		
		Specularite	Fe ₂ O ₃			Lynx; fracture fillings in purple and green unit	Becherer
Smithsonite	ZnCO ₃			Oxidation zone of sphalerite in Lynx pit	Becherer		
Data after Robinson (1994), Wilson (1993), Sinclair (2000), and M. Becherer (pers. comm., 2003)						Abbreviations: an - anilite; bo - bornite; cpy - chalcocopyrite;	
Assemblages adopted from Battle-Gap study by Sinclair (2000)						gn - galena; py - pyrite; sph - sphalerite; strom - stromeyerite; tt - tennantite	

2.2 MINE PLAN

2.2.1 Near-Term (4-year) Mine Plan

Approximately 1,577,113 t of ore is planned to be produced from 2019 to 2022 (**Table 2-2**). 85% of the ore will be produced from the HW and Battle Gap mines. The HW and Battle Gap mines have been operated since the 1980s and were last operated in 2015. The Price mine will account for approximately 13% of ore produced from 2019 to 2022. The Price ore body was first accessed in the early 1980s when the 4L, 5L, and 13L workings were initially developed. The ore body was not mined once the HW orebody was discovered. The Price mine consists of three main levels: 4L, 5L, and 13L and it has a 3-year mine life. The mine will be operated using a crown and pillar method that does not require mined-out stopes to be backfilled. The Lynx mine will account for the approximately 2% of the planned ore production from 2019 to 2022. It will be mined in 2021.

2.2.2 Future Mine Planning

Currently, a mine plan until the end of 2022 has been created by mine engineers based on predicted rates of production and long-term economic consideration and the MEMPR requires a detailed 5-year mine plan by January 31st, 2021. Upon submission of this plan it is assumed that there will be a detailed mine plan available that will describe the amounts of waste rock to be generated and ore produced from 2021 up to January 31st, 2026.

Table 2-2
Planned Ore Production from HW, Price, and Lynx Mines, 2019 to 2022

Ore Production Rates	2019	2020	2021	2022
<i>HW and Battle Gap (HW horizon of Myra Formation)</i>				
Stope Tonnes, t	295,185	329,806	304,362	119,453
Ore Development Tonnes, t	41,254	89,978	73,835	98,816
Sub-total:	336,439	419,784	378,197	218,269
<i>Price Mine (Lynx-Myra-Price horizon of Myra Formation)</i>				
Stope Tonnes, t	70,104	99,610	0	0
Ore Development Tonnes, t	25,326	4,851	0	0
Sub-total:	95,430	104,461	0	0
<i>Lynx Mine (Lynx-Myra-Price horizon of Myra Formation)</i>				
Stope Tonnes, t	0	0	19,652	0
Ore Development Tonnes, t	0	0	4,881	0
Sub-total:	0	0	24,533	0
TOTAL (ore tonnes):	431,869	524,245	402,730	218,269

Note: Planned production tonnages for each year include Battle Gap, Extension, HW, and Ridge)

2.3 EXPECTED WASTE INVENTORY

2.3.1 Future Waste Rock and Development Rock

Approximately 720,549 t of waste rock is expected to be produced from 2019 to 2022 (**Table 2-3**). 92% will be from the HW and Battle Gap mines. 10 to 15% of waste rock from the HW and Battle Gap mines will remain underground at HW mine to be used to fill stopes and decommissioned drifts as well as used for road construction underground. However, the remainder (85 to 90%) of waste rock will be conveyed to surface and tonnages could decrease as mining progresses. Approximately 5% and 2% are expected to be produced from the Price mine and Lynx mine, respectively. In early 2019, 112,000 t of development rock from the Phillips Reach Extension Decline will also be brought to surface (see Section 2.2.3).

When mining resumes, ore from Price mine will be brought to surface via 13L portal for the first year of production, then via the HW shaft. Run-of-mine waste rock from the Price and Lynx mines will be kept underground for use as roadbase or be used as backfill for mined-out stopes in the HW or Lynx mines. All empty drifts in the Price mine are currently at capacity and filled with development rock so future waste rock from Price all waste rock development will be placed into emptied stopes as they are mined out. Up to 45,800 t of existing waste rock stored near the Price 4L, 5L, and 13L adits will also be used to backfill the stopes further. This is the estimated tonnage of waste removed from the Price 4L and 5L workings before any new (recent) internal developments.

All future development waste in the Lynx mine will be mucked into stopes that were emptied during mining activities in 2018.

Table 2-3
Expected Waste Rock Tonnages, 2019 to 2022

Waste Rock Tonnages	2019	2020	2021	2022
<i>HW and Battle Gap (HW horizon of Myra Formation)</i>				
Lateral Waste Tonnes (t)	223,060	201,676	149,921	80,015
Vertical Waste Tonnes (t)	0	0	7,454	0
Sub-Total:	223,060	201,676	157,375	80,015
<i>Price Mine (Lynx-Myra-Price horizon of Myra Formation)</i>				
Lateral Waste Tonnes (t)	31,407	1,731	0	0
Vertical Waste Tonnes (t)	0	0	0	0
Sub-Total:	31,407	1,731	0	0
<i>Lynx Mine (Lynx-Myra-Price horizon of Myra Formation)</i>				
Lateral Waste Tonnes (t)	0	0	25,285	0
Vertical Waste Tonnes (t)	0	0	0	0
Sub-Total:	0	0	25,285	0
TOTAL (waste tonnes):	254,467	203,407	182,660	80,015

2.3.2 Existing Waste Rock Volumes at Surface

The historic WRDs contained approximately 4.5 Mm³ in 2009 (NMF, 2009). This is the total volume of waste rock removed from the Lynx pit and brought to surface from the Lynx, Myra, and HW underground mines since mining began in 1966. WRD#1 was reported to contain approximately 60% of waste rock deposited at surface in Myra Valley. A portion of WRD#1 is buried by tailings in the Old TDF. The remainder is exposed at surface to the north of the Surge Pond or buried beneath WRD#6. WRDs #2, #3, and #4, i.e. the 'Lynx WRDs', contained about 25% waste rock at surface in Myra Valley. The remainder of waste rock was deposited in WRD#5 and WRD#6. Waste rock from WRD#5 was used to construct Lynx TDF starter dam² in 2008 and some of the waste rock in WRD#6 was re-located in 2017 and 2018 (see NMF, 2017).

Approximately 1,566,969 m³ of existing waste rock, run-of-mine waste rock, and development rock will be handled at surface from 2019 to 2022 (**Table 2-4**). This includes approximately 112,000 t (or 53,900 m³) of development rock from the Phillips Reach Decline Extension that will be trucked to surface and stored in the quarry as per NMF (2017). In total, 1,262,089 m³ of waste rock from WRD #1, WRD#2, WRD#3, and WRD#6 is to be re-located to the upper Lynx Pit or used to construct the Lynx TDF embankment berm. The

² Tailings removed from the Emergency Tailings Area (ETA) were also used for starter dam.

volumes to be re-located are estimated internally by NMF and are intended achieve the objectives outlined in the Lynx Waste Rock Stabilization Permit Level Design (see Amec Foster Wheeler, 2017). Waste rock from WRD#4 is not explicitly scheduled for use to construct the Lynx TDF embankment berm from 2019 to 2022 according to Amec Foster Wheeler (2017) but it will be utilized as opportunity and construction needs dictate prior to 2014.

Table 2-4
Handled/Re-Located Waste Rock and Development Rock, 2019

Source	Storage or Disposal Location	Units	Planned 2019	2020	Forecast 2021	2022	Total (2019 to 2022)
<i>Existing waste rock from historic WRDs</i>							
Waste rock (WRD#2)	Upper Lynx Pit	m ³	50,000	100,000	50,000	0	200,000
J-Zone stockpiles and WRD#1	Lynx TDF berm	m ³	18,372	43,603	45,000	48,842	155,817
Waste rock (WRD#2)	Lynx TDF berm	m ³	33,132	87,934	87,934	0	209,000
Waste rock (WRD#3)	Lynx TDF berm	m ³	150,000	150,000	120,818	120,818	541,636
Waste rock (WRD#6)	Lynx TDF berm	m ³	0	0	39,919	115,717	155,636
Sub-Total:			251,504	381,537	343,671	285,377	1,262,089
<i>Hoisted waste from HW underground</i>							
Run-of-mine waste rock	WRD#1*	m ³	54,652	75,658	63,524	71,818	265,652
Sub-Total:			54,652	75,658	63,524	71,818	265,652
<i>Non-sulphidic materials</i>							
Development rock**	Quarry	m ³	53,900	0	0	0	53,900
Fabricated rock***	Quarry	m ³	9,228	10,000	10,000	10,000	39,228
Sub-Total:			63,128	10,000	10,000	10,000	39,228
TOTAL:			369,284	467,195	417,195	367,195	1,566,969

* When dump design approved by MEMPR

** Estimated volume from Phillips Reach Decline Extension, assuming 2.7 t/m³ and 30% swell factor

*** From quarry or imported

The volume required to raise the Lynx TDF embankment berm to its ultimate height in 2024 is approximately 1,570,000 m³. The estimated volume of waste rock sourced from WRD#1, WRD#2, WRD#3, and WRD#6 from 2019 to 2022 represents approximately 80% of this requirement. Some of the existing waste rock from the WRDs, however, will not be appropriate for construction due to the presence of boulders or other physical characteristics. Approximately 265,652 m³ of future, run-of-mine waste rock that will be brought to surface from 2019 to 2022 will also be used to construct the berm. This rock will be stored in construction stockpiles located on WRD#1, WRD#6 or on the TDF footprint until it is dry enough to be used to construct the Lynx TDF embankment berm (see Amec Foster Wheeler, 2017). Further details on waste rock storage and disposal is provided in Section 4 of this report.

3 MINE WASTE CHARACTERISTICS

This section describes the methods used to characterize waste rock and the geochemical data that are available to characterize future, run-of-mine waste rock from the mines and existing waste rock in the historic WRDs. New results for rock samples from the Price 4L mine and existing development rock at surface near the Price 4L, 5L, and 13L adits are provided and selected results for existing waste rock compiled from RGC (2015) are included for reference.

3.1 METHODS AND APPROACH

3.1.1 Static Tests

Waste rock in the existing WRDs has been characterized by (i) static tests related to Acid Base Accounting (ABA), (ii) near-total concentrations by *aqua regia* digestion and ICP-MS finish and (iii) Shake Flask Extractions (SFEs). ABA is a standardized procedure that is used to classify sulphidic geologic materials as either PAG or Non-PAG material. A SFE is the recommended short-term leach test used to determine the masses of soluble constituents in a sulphidic sample. Testing involves mixing a sample of solids with nanopure water at a specified ratio (typically 3:1 liquid-to-solids) and agitating the mixture for 24 hours to ensure continuous exposure of surfaces and mixing of the rinse solution. Near-total metal concentrations in a sulphidic sample are determined by a strong acid (*aqua regia*) digestion to estimate the metal content of a sample in % or mg/kg (see RGC, 2015).

ABA involves several static tests to determine the acid-generating potential of a geologic material (mainly from pyrite oxidation) and the quantity of acidity that can be neutralized by alkalinity released primarily from carbonate minerals in the material. Key calculated parameters used to classify sulphidic waste rock are Acid Potential (AP), Neutralization Potential (NP), and Neutralization Potential Ratio (NPR) (**Table 3-1**). Further details on these parameters is provided in the GARD Guide (www.gardguide.com) and in RGC (2015). Any sample from NMF that is submitted for ABA is typically submitted for near-total metal concentrations. SFEs are typically done on selected samples once ABA results are available so that samples with a relatively high sulphide content (and low NP) can be selected. This selection approach ensures that samples with the highest potential to generate ARD are tested so SFE results can be considered a credible upper bound for soluble constituents yielded by a mixture of waste rock with varying sulphide content. Samples for SFE are typically selected by RGC or other consultants for a specific study or investigation.

3.1.2 Kinetic Testing

Some kinetic testing of low-sulphide PAG waste rock placed in the Seismic Upgrade Berm has been done (see RGC, 2015) but there are currently no column tests or humidity cells being operated. This is because sulphidic waste rock has proven to yield ARD or other impacted drainages and estimating the timing of ARD onset from waste rock is not required. Instead, ML/ARD and other mine drainages related to the

oxidation of sulphidic waste rock is actively managed underground and at surface when it occurs to prevent/mitigate impacts to Myra Creek (see Section 5 for further details).

Table 3-1
Summary of Measured and Calculated ABA Parameters and Other Tests

Abbreviation	Description	Units	Method
<i>Measured Parameters for ABA</i>			
Paste pH	Paste pH (solids)	-	1:2 liquid-to-solid ratio (pulverized sample)
S _{total}	Total sulphur content	wt. %	Measured by Leco combustion method
S _{sulphate}	Sulphate sulphur content	wt. %	Determined by 25% HCl Leach with S by ICP Finish
S _{sulphide}	Sulphide sulphur content	wt. %	Determined by Sobek 1:7 Nitric Acid with S by ICP Finish
<i>Calculated Parameters for ABA</i>			
S _{insoluble}	Insoluble sulphur content	wt. %	$S_{insoluble} = S_{total} - (S_{sulphate} + S_{sulphide})$
S _{sulphide (calc)}	Sulphide sulphur content	wt. %	$S_{sulphide (calc)} = S_{total} - S_{sulphate}$
MPA	Maximum Potential Acidity	kg CaCO ₃ eq./t	$S_{total} = S_{sulphide} \times 31.25$
AP	Acid Potential	kg CaCO ₃ eq./t	$AP = S_{sulphide} \times 31.25$
NP	Neutralization Potential	kg CaCO ₃ eq./t	Reaction with HCl and titration to pH 7 with NaOH
NP _{CaCO3}	NP from carbonate minerals	kg CaCO ₃ eq./t	$NP = TIC (\%) \times 83.3$
NNP	Net Neutralization Potential	kg CaCO ₃ eq./t	$NNP = NP - AP$
NPR	Neutralization Potential Ratio	Unitless	$NPR = NP/AP$
<i>Other tests</i>			
Rinse pH	Rinse pH (leachable acidity)		2:1 liquid-to-solid ratio (standard) and ICP-MS finish
SFE	Shake Flask Extraction	mg/L	3:1 liquid-to-solid ratio (standard) and ICP-MS finish
Metals	Near-total metal concentrations	% or ppm	Aqua regia digestion and ICP-MS finish

3.2 WASTE CLASSIFICATION CRITERIA

3.2.1 Regulatory Context

According to Permit M-26, when mining resumes, all (100%) of the waste rock produced from the Price mine will be considered PAG material and must not be used for construction purposes except where specifically approved by the Chief Inspector. Waste rock from the Lynx and HW mines must also be considered PAG material unless proven otherwise by a geochemical assessment that is approved by the MEMPR. Also, no changes shall be made to waste handling procedures, mitigation strategies, or materials monitoring program without the written approval of the Chief Inspector.

3.2.2 Intended Material Uses

PAG waste rock is preferentially stored/disposed of underground (where possible) or it is hoisted to surface via the HW shaft. Non-PAG waste rock (when identified) is used underground as roadbase because it is

harder and therefore more durable than PAG waste rock. When possible, Non-PAG and non-sulphidic waste will be prioritized for surface storage to ensure adequate underground storage for PAG waste is maximized. The only intended use for PAG and Non-PAG waste rock at surface is to construct the Lynx TDF embankment berm, as per designs by Amec Foster Wheeler (Wood PLC). The permit condition that all (100%) of waste rock be considered PAG material therefore has no practical implication for NMF because there is currently no specific requirement for Non-PAG waste rock during construction of the Lynx TDF embankment berm. Instead, any waste rock that meets the physical specifications provided by Wood PLC will be used identically during future dam raises regardless of its geochemical characteristics. Future and re-located waste rock will therefore be characterized only so that the volumes of PAG and Non-PAG waste rock incorporated into the Lynx TDF embankment berm can be documented in future Annual Reclamation Reports.

Development rock will be routinely characterized to identify non-sulphidic materials that will not generate any acidity and can therefore be used for closure covers and other reclamation work, including road crush, rip rap, cover materials, and for general construction around the site. Aside from borrow materials and crushed quarry rock, development rock from the Phillips Reach Decline Extension will likely be the only non-sulphidic material available and will be handled/stored in the quarry to preserve it for future reclamation work. No other materials will be placed in the quarry area, including sulphidic Non-PAG waste rock from future mining (see Section 4.4.1).

3.2.3 Classification Criteria

The following criteria will be used to classify geologic materials at NMF:

- Non-sulphidic materials: $S_{\text{total}} < 0.05 \text{ wt. \%}$.
- Non-PAG materials: $\text{NPR} > 2$.
- PAG materials: $\text{NPR} < 2$.

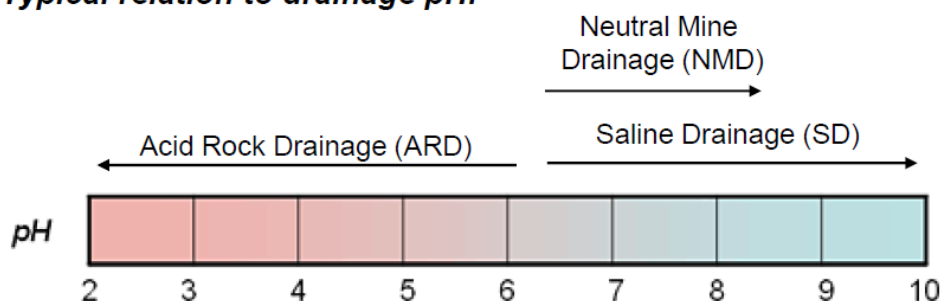
These criteria are consistent with provincial guidelines outlined in Section 10.1.16 of the Health, Safety and Reclamation Code for Mines in British Columbia and have been accepted at other mines in B.C.

3.2.4 Predicted Drainage Types

ABA is used by convention to classify sulphidic geologic materials as either PAG or Non-PAG material. PAG materials are predicted to generate ARD because the NP they contain is insufficient to neutralize the acidity released during sulphide oxidation. Non-PAG materials are predicted to generate NMD or SD depending on their AP and NP content. Samples with high AP and high NP, for instance, may generate SD with elevated concentrations of major ions, e.g. Mg, SO_4 , Ca, and bicarbonate ions, but relatively low metal concentrations (see **Figure 3-1**). Further details on these general drainage types are provided in the GARD Guide (www.gardguide.com).

At NMF, PAG waste rock (en masse) has proven to yield ARD and Non-PAG waste rock yields either SD or NMD. The terms “PAG” and “Non-PAG” are therefore used by convention at NMF to differentiate waste rock that will yield either ARD or less impacted SD or NMD. Seepage water quality observations and groundwater quality impacts near the historic WRDs and the Lynx TDF embankment berm are the most reliable indication that PAG and Non-PAG waste rock are generating ARD and other impacted drainage (see Section 4.1.4). Historic seepage monitoring results indicate that seepage from PAG waste rock is acidic (pH<5) and characterized by elevated concentrations of SO₄ and dissolved metals. This is consistent with recent samples of perched seepage near the Lynx TDF embankment berm and Super Pond and groundwater quality impacts downgradient of key sources on site. Further details on these sources and current groundwater quality impacts are provided in Section 5.

Typical relation to drainage pH:



Typical drainage characteristics:

Acid Rock Drainage (ML/ARD)	Neutral Mine Drainage (NMD)	Saline Drainage (SD)
• Acidic pH • High SO₄ • Moderate to high metals, e.g. Al, Fe, Cu, Co, Ni, Pb, and Zn	• Near-neutral to alkaline pH • Low to moderate SO₄ • Low to moderate metals. May have elevated Zn, Cd, Mn, As, and Se	• Near-neutral to alkaline pH • Low metals (may have moderate Fe) • Moderate SO₄, Ca, and Mg

Figure 3-1. Overview of Drainage Types. See GARD Guide (www.gardguide.com) for further details.

3.3 GEOCHEMICAL CHARACTERISTICS OF WASTE ROCK

3.3.1 Future Waste Rock and Development Rock

Preliminary ABA results for rock samples collected underground from the Price 4L mine suggest most of the waste rock from this mine will be PAG material (**Table 3-2**). Two of the samples are low-sulphide, Non-

PAG waste rock and the other seven samples are classified as PAG material. S_{sulphide} values for the PAG waste rock from the Price mine range 1.9 to 6.3% and several samples are characterized by less than 5 kg CaCO_3 eq./t. The samples with low NP, i.e. $\text{NPR} < 0.1$, are predicted to generate ARD and the other samples are predicted to generate ARD and/or NMD and SD depending on NP.

Table 3-2

ABA results for rock samples from Price 4L and Phillips Reach Decline Extension

Sample ID	Lithology	Paste pH	TIC, %	S_{total} , %	S_{sulphate} , %	S_{sulphide} , %	AP, kg CaCO_3 eq./t	NP, kg CaCO_3 eq./t	NNP, kg CaCO_3 eq./t	NPR	Class
<i>Samples of existing waste at surface near Price adits*</i>											
Price 4L	-	8.4	1.0	1.2	0.05	1.1	35.0	91.4	56.4	2.6	Non-PAG
Price 5L - 1	-	5.6	0.0	2.4	0.11	2.3	70.3	6.1	-64.2	0.1	PAG
Price 5L - 2	-	8.6	0.8	3.0	0.08	2.9	90.9	63.6	-27.3	0.7	PAG
Price 5L - 3	-	8.8	0.7	1.3	0.01	1.3	41.3	60.3	19.1	1.5	PAG
PR - 13L	-	9.1	0.3	0.03	0.01	0.02	0.8	30.7	30.0	40.9	Non-sulphidic
<i>Rock samples from Price 4L underground</i>											
4251	Dacite/quartz Por Int.	8.8	0.6	0.09	0.01	0.06	1.9	46.7	44.8	24.9	Non-PAG
4252	Quartz/feldspar Int.	8.8	1.0	0.1	0.01	0.09	2.8	85.8	83.0	30.5	Non-PAG
4253	Quartz/carbonate veining	8.4	0.5	1.9	0.02	1.8	55.0	42.5	-12.5	0.8	PAG
4254	Altered dacite flow/andesite	8.3	0.8	3.0	0.05	2.0	62.8	70.0	7.2	1.1	PAG
4255	Altered rhyolite	8.2	1.2	2.4	0.03	2.1	66.9	100.0	33.1	1.5	PAG
4256	Mafic dike/fault/shear zone	6.6	0.05	2.4	0.12	2.1	66.6	4.2	-62.4	0.1	PAG
4257	Altered rhyolite ± sulphide stringer	5.8	0.01	4.0	0.13	3.1	96.3	0.8	-95.5	0.01	PAG
4258	Altered rhyolite + QFP-Dike/Int.	6.0	0.01	6.0	0.13	5.2	163.4	0.8	-162.6	0.01	PAG
4259**	Altered rhyolite ± polymetallic sulphide	7.8	0.05	6.3	0.04	3.8	120.0	4.2	-115.8	0.03	PAG
<i>Phillips Reach Decline Extension</i>											
4709	-	8.8	1.5	0.02	0.01	0.01	0.3	127	121	>400	Non-sulphidic
4710	-	9.2	3.0	0.03	0.01	0.01	0.3	248	199	>800	Non-sulphidic

Note: AP, NP, and NNP are expressed in kg CaCO_3 eq./t

* AP calculated from S_{sulphide} (calc)

** Sample collected inside the ore wireframe

Samples of future waste rock from the Price 5L and HW mine have not been collected but the geochemical properties of waste rock from these mines is expected to be comparable to the results for Price 4L, implying most future waste rock will be PAG material that will generate ARD and/or SD. This is consistent with ABA results for existing waste rock in the historic WRDs that has (and continues to) generate ARD and/or NMD (see Section 2.6.3). Near-total metal concentrations and SFE results for selected samples are summarized in **Table 3-3** and **Table 3-4**, respectively. SFE results suggest future waste rock from the Price 4L underground support the assertion that this rock will generate ARD. SFE results for samples of existing waste rock piled near the Price 4L and 5L adits suggest lower concentrations in seepage from this waste rock than future, run-of-mine waste rock from the Price mine (see Section 3.3.3).

Development rock from the Phillips Reach Extension Decline appears to be non-sulphidic material. Available results are for samples collected at the drift collar location of the decline. Additional drilling sub-parallel to the planned decline began on December 13th and drill core samples for ABA and other tests will be collected at each significant lithological change. These results will be reviewed in 2019 to (i) confirm that the development rock from Phillips Reach Extension Decline is mainly non-sulphidic and (ii) identify development areas/zones where PAG and/or Non-PAG materials could be present. Initial indications are

that that 85 to 90% of the development rock from the Phillips Reach Decline Extension will be non-sulphidic (A. Stansell, personal communication).

Table 3-3

Near-Total Metal Concentrations, Price 4L and Phillips Reach Decline Extension

Sample ID	Lithology	S, %	Ag, ppm	Cu, ppm	Ni, ppm	Pb, ppm	Zn, ppm	Al, %	Fe, %	Mn, ppm	As, ppm	Cd, ppm	Co, ppm	Se, ppm
<i>Price 4L Mine</i>														
4251	Dacite/quartz Por Int.	0.1	0.12	42.7	5.3	26.6	253	2.1	2.8	577	6	0.9	9.8	1
4252	Quartz/feldspar Int.	0.1	0.1	30.2	132	14.8	168	2.8	4.4	972	5	0.4	23.1	1
4253	Quartz/carbonate veining	2.0	0.45	76.9	4.7	36.7	514	1.5	3.2	754	10	2.3	9.8	1
4254	Altered dacite flow/andesite	2.3	6.89	427	4.9	199	728	1.7	3.6	1040	110	2.7	11.8	1
4255	Altered rhyolite	2.4	0.36	68.7	23.8	37.7	328	2.5	4.2	1670	18	0.7	15.1	1
4256	Mafic dike/fault/shear zone	2.5	1.41	416	3.6	258	425	0.4	2.4	110	83	2.2	5.2	1
4257	Altered rhyolite ± sulphide stringer	4.2	4.93	4030	3.2	292	2200	0.3	3.6	41	749	11.3	4.8	3
4258	Altered rhyolite + QFP-Dike/Int.	>5	4.49	4060	6.6	327	1350	0.3	5.4	40	772	7.4	7.7	4
4259*	Altered rhyolite ± polymetallic sulphide	>5	5.39	932	18	2950	>10000	0.2	3.9	57	150	81.7	2.8	4
<i>Phillips Reach Decline Extension</i>														
4709		0.02	0.06	73.8	34.6	0.5	90	3.67	5.13	1310	1	0.06	24.7	1
4710		0.03	0.07	79.8	45.3	0.8	101	2.64	5.98	1660	1	0.13	24.8	1

* Collected inside the ore wireframe

Table 3-4

Shake Flask Extraction (SFE) Results for Selected Samples, Price Mine

Sample ID	pH	EC	Acidity (to pH 4.5)	Total Acidity (to pH 8.3)	Alkalinity	SO ₄	Hardness	Al	Cd	Cu	Fe	Pb	Mn	Ni	Se	Zn
		uS/cm	mg/L CaCO ₃	mg/L CaCO ₃	mg/L CaCO ₃	mg/L	mg/L CaCO ₃	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
<i>Samples of existing waste at surface near Price adits</i>																
Price 4L	8.0	140	-	3	40	23	62.2	0.0	0.0011	0.004	0.015	0.0226	0.0232	0.0001	0.0005	0.05
Price 5L - 1	7.1	310	-	7	10	141	146.0	0.0	0.0041	0.0019	0.077	0.0029	0.869	0.0001	0.0007	1.2
Price 5L - 2	8.0	103	-	3	40	9	46.2	0.1	0.0005	0.0018	0.007	0.0044	0.0322	0.0001	0.0004	0.01
<i>Rock samples from Price 4L underground</i>																
4257	5.4	977	-	60	1	544	481.0	0.2	0.0964	1.53	0.651	2.51	1.21	0.0188	0.0018	34.3
4258	6.6	835	-	35	3	417	428.0	0.0	0.0722	0.893	0.126	1.64	1.06	0.0172	0.0040	20.7
4259*	7.7	155	-	4	30	39	59.9	0.0	0.0071	0.0007	0.007	0.0875	0.316	0.002	0.0010	0.6
<i>WRD #1</i>																
S13-9	2.6	2144	416	591	-	747	175	29.7	0.0472	5.9	49.8	0.0	1.6	0.064	0.0022	9.9
S13-10	2.6	2061	306	458	-	715	261	23.1	0.0683	4.8	27.9	0.0	3.6	0.065	0.0018	14.5
S13-11	2.7	1547	214	339	-	479	171	22.8	0.0614	2.5	5.9	0.0	1.4	0.039	0.0029	13.1
S13-12	3.2	1172	108	303	-	582	285	20.7	0.2330	7.2	0.2	0.1	6.1	0.092	0.0023	46.8
S13-13	2.6	2221	410	604	-	820	217	43.2	0.0859	9.0	24.2	0.0	1.9	0.086	0.0039	19.8
S13-14	4.3	355	10	103	-	162	63	4.0	0.0760	8.3	0.1	1.2	5.2	0.031	0.0018	20.3
S13-15	4.2	263	14	52	-	90	49	2.1	0.0169	1.3	0.1	0.0	3.7	0.009	0.0003	2.3

3.3.2 Existing Waste Rock in Myra Valley

Most of the waste rock in the historic WRDs has been classified as PAG material (**Table 3-5**). Waste rock from WRD#1 and WRD#2 consists primarily of felsitic schistose rock that occurs near the contact with an ore body underground. WRD#6 is on top of WRD#1 and waste rock from this dump has ravelled onto the Amalgamated Paste Area (APA). Waste rock from WRD#6 is high-sulphide material from crown pillar of the Lynx pit that likely generates substantial ARD. WRD#1, #2, #3, and #4 are characterized by a mixture

of PAG and Non-PAG materials with variable AP and NP values (see **Figure 3-2**). None of the samples collected from the historic dumps is non-sulphidic.

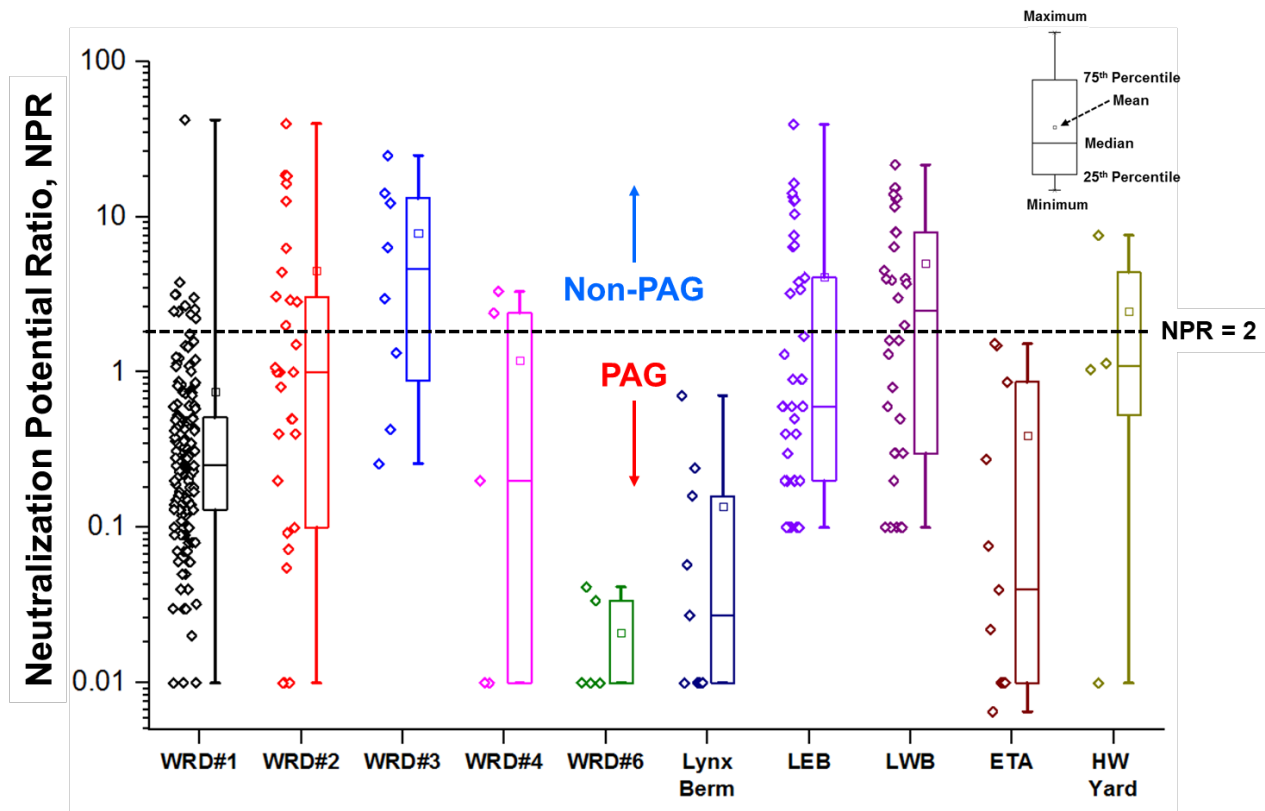


Figure 3-2. Box Plots with NPR Values for Existing Waste Rock at Surface. NPR criterion of two shown for reference. Data compiled by RGC (2015).

Table 3-5
Summary of ABA and SFE (Zn) Results for Existing Mine Waste

Sample ID	Code	Description	Rinse pH	Rinse EC	Paste pH	S _{total} %	S _{sulphate} %	S _{sulphide} %	AP, kg CaCO ₃ eq./t	NP, kg CaCO ₃ eq./t	NPP, kg CaCO ₃ eq./t	NPR	Class	SFE (Zn), mg/L
<i>Construction stockpile (Lower East Borrow)</i>														
S13-5	F-WR	silty fine sand with coarse gravel	7.2	1,755	8.0	6.8	0.2	6.7	207.8	33.0	-174.8	0.2	PAG	0.1
S13-6	RS	fine sand (tailings)	6.2	1,846	7.3	15.6	0.2	15.6	486.3	13.2	-473.0	0.0	PAG	7.7
S13-7	F-WR	silty coarse gravel with fine sand	7.5	663	6.1	4.2	0.2	4.1	126.9	30.6	-96.3	0.2	PAG	0.0
TP13-6 (0.0 to 0.5 m)	F-WR	Sandy gravel with fines	4.1	1,603	5.7	3.0	0.3	2.8	86.3	5.0	-81.3	0.1	PAG	39.8
TP13-6 (1.0 to 1.5 m)	F-WR	Sandy gravel with fines	4.1	1,707	4.4	4.7	0.7	4.0	125.3	1.1	-126.4	0.0	PAG	44.9
TP13-6 (2.0 to 2.5 m)	F-WR	Sandy gravel with fines	3.0	2,580	5.1	0.8	0.3	0.5	16.3	1.4	-17.6	0.1	PAG	2.7
TP13-6 (2.5 to 3.0 m)	F-WR	Sandy gravel with fines	3.7	2,240	4.7	0.5	0.2	0.3	8.1	3.1	-11.2	0.4	PAG	42.9
<i>Lynx TDF Berm</i>														
S13-3	W-WR	sandy poorly graded gravel with silt	6.4	313	7.5	0.4	0.0	0.4	12.5	8.9	-3.6	0.7	PAG	0.1
S13-4	W-WR	sandy gravel with silt	2.6	3,520	3.4	2.9	0.9	2.0	62.2	6.0	-68.2	0.1	PAG	89.1
<i>WRD #1</i>														
S13-9	W-WR	gravely sand with fines	2.5	1,932	3.7	1.8	0.5	1.2	38.1	3.9	-42.0	0.1	PAG	9.9
S13-10	W-WR	clayey sand with gravel	2.6	2,010	4.1	1.1	0.4	0.7	22.2	2.5	-24.7	0.1	PAG	14.5
S13-11	W-WR	gravely sand with fines	2.6	1,558	3.6	0.9	0.5	0.5	15.3	4.1	-19.4	0.3	PAG	13.1
S13-12	W-WR	clayey sand with some gravel	3.1	1,243	3.6	1.2	0.7	0.4	13.8	7.9	-21.6	0.6	PAG	46.8
S13-13	W-WR	sand with fine gravel and silt/clay	2.6	1,898	4.1	1.3	0.7	0.5	15.9	6.4	-22.3	0.4	PAG	19.8
S13-14	W-WR	sand with fine gravel and silt/clay	3.7	679	5.5	5.3	0.1	5.2	162.8	5.2	-157.6	0.0	PAG	20.3
S13-15	W-WR	sandy gravel	3.3	567	5.0	1.9	0.2	1.7	54.1	1.6	-52.4	0.0	PAG	2.3
TP01/31 Surface	W-WR	-	5.9	-	-	1.0	0.4	-	18	82	64	4.6	Non-PAG	-
TPD1-01-01F	W-WR	-	7.6	7	-	16.7	0.2	-	516.3	21	-495.3	0.1	PAG	-
<i>WRD#6</i>														
TP13-16 (0.0 to 1.0 m)	W-WR	clayey and gravely sand	2.5	4,130	4.3	3.2	0.8	2.5	76.6	1.7	-78.3	0.02	PAG	50.4
TP13-16 (1.0 to 2.0 m)	W-WR	clayey and gravely sand	3.0	2,450	5.7	4.4	0.4	4.0	123.8	5.1	-118.6	0.04	PAG	48.2
TP13-17 (0.5 to 1.0 m)	W-WR	clayey and gravely sand	3.5	2,780	5.3	4.0	0.6	3.4	106.9	3.6	-103.3	0.03	PAG	117
<i>WRD#2</i>														
S13-16	W-WR	gravely sand with fines	2.5	2,430	5.9	7.9	0.4	7.6	236.9	13.1	-223.8	0.1	PAG	104.0
S13-17	W-WR	gravely sand with fines	6.8	3,420	8.5	0.2	<0.01	0.2	6.9	43.0	36.1	6.3	Non-PAG	0.0
S13-18	W-WR	gravely sand with fines	6.5	2,810	8.2	0.8	0.1	0.7	22.5	45.0	22.5	2.0	Non-PAG	0.1
S13-22	W-WR	gravely sand with fines	2.6	3,380	5.6	3.4	0.5	2.9	90.6	8.4	-82.3	0.1	PAG	128.0
S13-25	W-WR	sandy gravel with fines	2.6	2,040	3.2	1.2	0.4	0.8	23.8	3.2	-27.0	0.1	PAG	3.2
S13-28	W-WR	sandy gravel with fines	3.4	699	5.9	2.1	0.2	1.9	58.8	4.2	-54.5	0.1	PAG	11.9
S13-33	W-WR	sandy gravel with fines	2.7	1,353	3.9	1.0	0.3	0.8	23.4	2.2	-25.7	0.1	PAG	14.6
S13-34	W-WR	sandy gravel with fines	2.6	1,668	4.6	1.0	0.4	0.6	18.4	0.4	-18.8	0.0	PAG	6.2
S13-36	W-WR	sandy gravel with fines	2.7	2,260	4.2	1.6	0.2	1.3	41.9	0.7	-42.6	0.0	PAG	7.5
S13-39	W-WR	sandy gravel with fines	3.3	423	4.1	0.7	0.4	0.4	10.9	4.2	-15.2	0.4	PAG	12.9
TP01/07 1 meter	W-WR	-	7.2	-	-	0.1	0.0	-	3	53	50	16.3	Non-PAG	-
TP01/08 3 meter	W-WR	-	5.3	-	-	0.1	0.0	-	2	35	33	18.4	Non-PAG	-
TP01/09 1 meter	W-WR	-	7.3	-	-	0.2	0.0	-	5	59	54	12.5	Non-PAG	-
TP01/21 3 meter	W-WR	-	8.5	-	-	0.6	0.0	-	18	55	37	3.0	Non-PAG	-
TP01/22 2 meter	W-WR	-	5.5	-	-	1.7	0.1	-	51	54	4	1.1	PAG	-
CF02-012-02	W-WR	-	6.6	-	-	2.4	0.2	-	67.2	25.2	-42	0.4	PAG	-
CF02-012-04	W-WR	-	6.2	-	-	2.1	0.1	-	60	3.4	-56.6	0.1	PAG	-
CF02-013-02	W-WR	-	7.4	-	-	4.4	0.2	-	131.9	29.5	-102.4	0.2	PAG	-
CF02-013-04	W-WR	-	6.8	-	-	1.0	0.0	-	30.3	10.7	-19.6	0.4	PAG	-
CF02-013-06	W-WR	-	7.8	-	-	0.1	0.0	-	2.2	2.3	0.1	1	PAG	-
<i>WRD#3</i>														
S13-46	W-WR	sandy gravel with fines	6.5	313	8.0	1.4	0.1	1.3	39.1	51.8	12.7	1.3	PAG	1.2
S13-47	W-WR	sandy gravel with fines	4.2	354	7.0	1.8	0.1	1.7	52.8	13.6	-39.2	0.3	PAG	10.0
S13-43	W-WR	well graded gravel	2.5	3,910	3.6	16.7	0.6	16.2	504.7	5.6	-510.3	0.0	PAG	235.0
S13-45	W-WR	sandy gravel with fines	2.8	4,090	4.2	5.1	1.4	3.7	116.6	9.5	-126.1	0.1	PAG	187.0
TP01/24 1 meter	W-WR	-	7.9	-	-	0.2	0.0	-	6	70	64	12.2	Non-PAG	-
TP01/25 1.5 meter	W-WR	-	7.7	-	-	5.5	0.1	-	171	73	-98	0.4	PAG	-
TP01/26 Surface	W-WR	-	7.9	-	-	0.5	0.0	-	16	49	33	3.0	Non-PAG	-
TP01/27 Surface	W-WR	-	8.3	-	-	0.4	0.0	-	11	152	141	14.1	Non-PAG	-
TP01/28 Surface	W-WR	-	7.7	-	-	0.3	0.0	-	9	54	45	6.3	Non-PAG	-
TPD3-01-01F	W-WR	-	8.6	8	-	0.3	n/a	-	8.8	25.5	16.8	2.9	Non-PAG	-
TPD3-02-01F	W-WR	-	7.8	7	-	0.5	0.0	-	14.4	6.5	-7.9	0.5	PAG	-
TPD3-03-01F	W-WR	-	8.7	8	-	0.2	n/a	-	5.9	8.9	2.9	1.5	PAG	-
TPD3-04-01F	W-WR	-	6.4	6	-	0.01	n/a	-	0.3	0.3	-0.1	0.8	PAG	-
TPD3-05-01F	W-WR	-	8.5	7	-	0.5	0.01	-	14.7	7.6	-7.1	0.5	PAG	-
TPD3-06-01F	W-WR	-	8.7	8	-	0.7	0.0	-	21.3	21.6	0.4	1	PAG	-
TP01/29 Top of dump3	W-WR	-	6.9	-	-	0.1	0.0	-	2	52	50	24.9	Non-PAG	-
TP01/23 Lynx Pit	W-WR	-	7.9	-	-	0.2	0.0	-	5	61	57	12.8	Non-PAG	-
CF02-014-02	W-WR	-	7.2	-	-	0.2	0.0	-	4.4	4.5	0.1	1	PAG	-
CF02-014-04	W-WR	-	8.0	-	-	0.4	0.0	-	10.6	46.7	36.1	4.4	Non-PAG	-
<i>WRD #4 (n = 2)</i>														
S13-48	W-WR	sandy gravel with very fine fines	3.2	420	4.7	1.7	0.2	1.6	48.8	1.5	-47.3	0.0	PAG	0.5
S13-50	W-WR	fine sand with some gravel and fines	3.1	370	4.0	1.4	0.5	1.0	29.7	2.9	-32.6	0.1	PAG	7.3

Notes: F-WR: Frech waste rock, RS: reclaim sand, W-WR: weathered waste rock

WRDs #3 and #4 (the smallest dumps) contain mostly andesite that occurs further from the deposits and is the least acid-generating material at surface. According to Amec Foster Wheeler (2017), the lower portion of WRD#4 may contain sand-rich tailings. These tailings have not been characterized and their presence is inferred mainly from old photographs. Residual tailings and waste rock are also found in the former ETA/Cookhouse area and the mill area. Some of these materials were characterized in 2015 (see RGC. 2015) and will not be re-located in the near-future.

The Lynx TDF embankment berm consists of PAG and Non-PAG waste rock and tailings that have been placed and compacted according to designs by Wood PLC. Tailings from the ETA and high-sulphide PAG

rock from the former WRD5 were used to construct the Lynx starter dam. WRD#5 (the 'Super Pile') was not characterized but anecdotal evidence suggests the sulphide content of the waste rock in this dump was likely comparable to waste rock in WRD#6. The remainder of the berm is likely PAG waste rock with variable sulphide content produced from the HW mine from 2008 to 2018 (when the last berm raise was completed). A few samples of waste rock stockpiled near the berm were collected by RGC in 2013. Samples for ABA were not collected during previous dam raises. Seepage and groundwater quality downgradient of the Lynx TDF embankment berm suggests it primarily contains high-sulphide PAG material that generates substantial volumes of ARD. Metal concentrations are likely comparable to seepage from WRD#1 and WRD#6. Seepage water quality is not expected to improve during operations or post-closure. ML/ARD-impacted groundwater and seepage at surface is currently collected and treated in the water treatment system (see Section 5).

3.3.3 Existing Waste Rock in Thelwood Valley

Five samples of waste near the Price 4L, 5L, and 13L adits were collected in November 2018. Each of the samples collected near the Price 5L adit was classified as PAG material (**Table 3-2**). A sample collected near the Price 4L adit was non-sulphidic and a sample collected near the Price 13L adit was Non-PAG rock. These results suggest that most of the waste rock and/or development rock yields ARD or SD that has (since the 1980s) reported to groundwater near the adits or the Price Pond.

4 FUTURE WASTE ROCK MANAGEMENT

This section describes how future, run-of-mine waste rock and any existing waste rock removed from the historic WRDs will be characterized, handled, stored, and ultimately deposited in final waste rock disposal areas underground and at surface. An overview is provided in **Figure 4-1** and further details are provided in the sub-sections below.

4.1 GEOCHEMICAL CHARACTERIZATION PROCEDURES

4.1.1 *Initial Characterization Underground*

Block models and diamond drilling are used to track mineralization and visual confirmation of contacts by mine geologists are identified to decide whether mined rock is ore or waste rock. Ore is differentiated from waste rock by mine geologists based on zinc, copper, lead, silver, and gold grades and Net Smelter Return (NSR). PAG and Non-PAG material boundaries cannot be reliably differentiated by visual inspection or NSR because the distribution of metal within the ore and the concentration of each payable metal is variable. When mining resumes, waste rock will be initially characterized by the Geology Department to identify high-sulphide ($S_{\text{total}} > 10\%$) that will be prioritized for disposal underground. This will be done visually and in conjunction with a portable XRF to estimate the percentages of iron (Fe) and sulphur (S) content of a sample. Fe and S can typically be determined within 0.05% with the XRF and the set of standards used internally at NMF. If a sample visually contains abundant sulphide minerals then it can be quickly established that whether or not a specific sample will contain $> .05\%$ S. The portable XRF can assist when sulphide content is low, i.e. $< 5\%$.

One of every ten rock samples analyzed with the portal XRF will be sent to the on-site laboratory operated by Bureau Veritas (Maxxam) for further testing via a 4-acid digestion with ICP-ES finish. Typical turnaround time is less than one week and the process (Method Code MA370) has a detection limit of 0.05% for sulphur (S) and an upper limit of 30% S. Samples for external analysis by an accredited third party laboratory will be selected to (i) confirm the sulphur content (element wt. %) of waste rock kept underground and (ii) to characterize the sulphide content of the range of lithologies that are encountered while mining in the Price, HW, and Lynx mines and (iii) approximate the volume of non-PAG, Non-sulphidic and PAG wastes stored on surface. Mine geologists will determine which units to sample in consultation with the Environment Department, if necessary. Development rock produced during the Phillips Reach Decline Extension will be characterized in a similar manner to verify that the development rock is non-sulphidic.

Results from the initial characterization program will be reviewed and interpreted internally by mine geologists to determine what waste rock will be brought to surface. The results are intended for decision-making during operations and it is the responsibility of the Geology Department to interpret these data as needed. The Environment Department will be responsible for further sampling of waste rock brought to surface and the results will be documented in their Annual Reclamation Report (see Section 4.1.2).

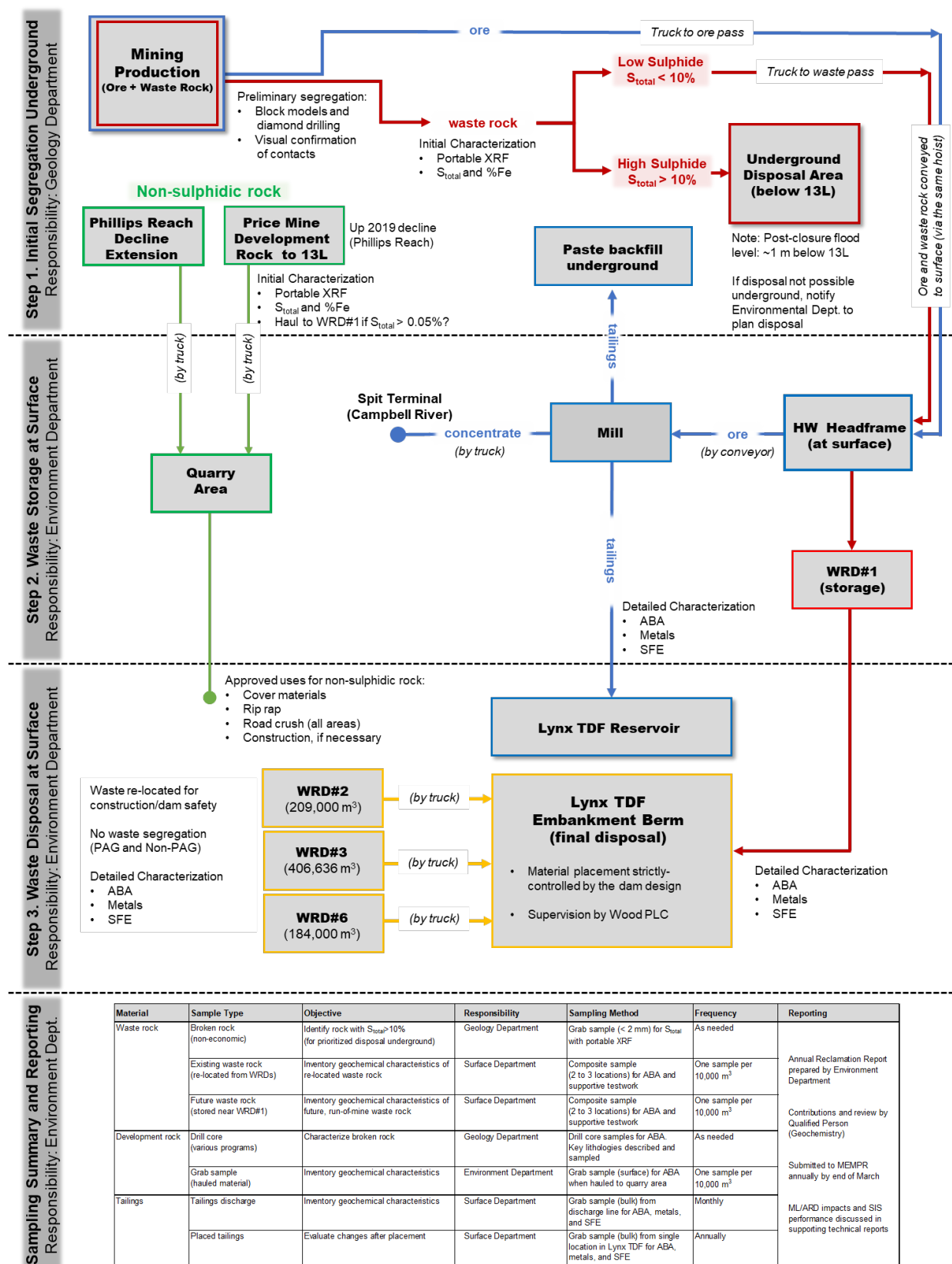


Figure 4-1. Flow Sheet for Operational Waste Rock Management and Characterization

4.1.2 Detailed Sampling and Confirmatory Testing at Surface

Samples of waste rock brought to surface will be collected and submitted to an accredited lab for ABA, near-total metal concentrations, and SFE. Samples will be collected from stockpiled waste rock once it has been placed in WRD#1 to confirm the characteristics of waste rock that will be sourced to construct the Lynx TDF embankment berm. Sampling locations will be selected to characterize, to the extent practical, the volume of waste rock stockpiled since the last sampling campaign, i.e. up to several months. No further testing of waste rock in the historic WRDs will be undertaken until this rock is re-located. When re-located, the sampling frequency used for future, run-of-mine waste rock will be used, i.e. one sample per 10,000 m³. Indicative sampling requirements for tailings and waste rock from 2019 to 2022 are summarized in **Table 4-1**. This table is a guide and is subject to change should the volumes re-located change or the scope of sampling for a certain year be revised based on previous results. Waste rock sampling (and management in general) is the responsibility of the Surface Department, who will coordinate with the Environment Department and the HSEC if necessary to coordinate sampling and/or reporting.

Waste rock samples will be collected with a hand trowel from a depth of least 10 cm at several locations along a 10 m transect of the dump or stockpile. Samples from each location will be composited into a single sample that will be split into +150mm and the -150 mm size fractions in the field. The location of each sample will be photographed and recorded with a handheld GPS. The sampling date and the person sampling will be noted and a description of the sample that includes colour, the presence of cobbles and boulders nearby, visual evidence of sulphide minerals and rock type will be recorded in a fieldbook dedicated to tailings and waste rock sampling at surface. The relative proportion (in %) of the +150mm and -150mm size fractions will be estimated in the field and the +150 mm size fraction of each composite sample will also be visually assessed in the field for signs of oxidation. For routine sampling, 0.5 kg of waste rock that is less than the 12.5 mm (~0.5 inch) in diameter will be bagged and sent to an accredited laboratory for ABA, near-total metal concentrations, and SFEs. Once per year, a more detailed sampling program may be undertaken to characterize the geochemical properties of individual size fractions of waste rock. This will involve sieving the -150 mm size fraction of a representative sample from each WRD into the following size fractions: >19mm, 19mm-12.5mm, 12.5mm-2mm and <2mm in the field. Each size fraction will be weighed on site and samples of the <2mm size fraction will be submitted for further testing. This testing could be assisted or directed by a Qualified Person (Geochemistry) who can provide further details on the sieving procedures and recommended sampling.

Monthly tailings samples will be collected and analyzed for ABA, near-total metal concentrations, and SFE. These samples should be collected from the tailings discharge line to the Lynx TDF and do not require any sieving or preservation aside from storing them in sealed, medium-sized Ziploc freezer bags in a refrigerator prior to shipment. Air should be squeezed from each bag prior to sealing. Placed tailings in the Lynx TDF will be collected annually from the Lynx TDF and handled in the same manner and analyzed for ABA, metals, and SFE.

Table 4-1
Indicative Sampling Requirements for Tailings and Waste Rock

Source	Storage or Disposal Location	Predominant Material Type	ML/ARD Potential	Number of samples collected			
				2019	2020	2021	2021
Tailings to Lynx TDF							
Tailings	Lynx TDF	PAG	High	12	12	12	12
Sub-Total:				12	12	12	12
Existing waste rock from historic WRDs							
Waste rock (WRD#2)	Upper Lynx Pit	PAG	High	5	10	5	0
J-Zone stockpiles and WRD#1	Lynx TDF berm	PAG	High	2	4	5	5
Waste rock (WRD#2)	Lynx TDF berm	PAG	High	3	9	9	0
Waste rock (WRD#3)	Lynx TDF berm	PAG	Moderate	15	15	12	12
Waste rock (WRD#6)	Lynx TDF berm	PAG	Very High	0	0	4	12
Sub-Total:				25	38	35	29
Hoisted waste from HW underground							
Run-of-mine waste rock	WRD#1	PAG	Moderate	5	5	5	5
Sub-Total:				5	5	5	5
Non-sulphidic materials							
Development rock*	Quarry	Non-sulphidic	None	5	-	-	-
Fabricated rock	Quarry	Non-sulphidic	None	1	1	1	1
Sub-Total:				6	1	1	1
TOTAL:				48	56	53	47

* Development rock from Phillips Reach Decline Extension

** From quarry or imported

4.1.3 QA/QC Procedures

Quality assurance/quality control (QA/QC) will consist of duplicate analyses on 10% of samples, method blanks, and analysis of appropriate reference materials by accredited external laboratories. Relative percent difference (RPD) values will be determined internally to verify data reliability and an internal set of standards for the portable XRF will be used to ensure accurate readings. Duplicate samples will also be collected periodically by site staff and submitted an accredited external laboratory for analysis.

4.2 WASTE SEGREGATION AND HANDLING

4.2.1 Initial Segregation Underground

Historically, all waste rock destined for surface has been considered PAG material because ore and waste rock were skipped to surface via the same conveyance so any Non-PAG waste rock was typically contaminated with sulphidic material. The same conveyance system will be used when the Price mine and HW mine are operated in 2019. Waste will therefore be segregated underground to differentiate high sulphide PAG materials ($S_{total} > 10\%$) and any rock that may be non-sulphidic. Other waste rock, i.e. PAG

and Non-PAG waste rock will be skipped to surface and characterized once it has been stockpiled in WRD#1 (see above). An exception to typical waste handling procedure will be the Phillips Reach Decline Extension. Development rock will be trucked to surface (not hoisted) so there is little potential for contamination with ore or PAG waste rock from other areas. PAG and Non-PAG waste rock from the Phillips Reach Decline Extension will not be segregated from non-sulphidic materials unless these materials represent more than 10% of the tonnage being hauled to surface.

4.2.2 Surface Handling

Waste rock will be trucked from the HW headframe to WRD#1. The volume of waste rock being handled will be tracked internally by the Mining Department and communicated to the HSEC Department to ensure a representative number of samples can be collected while waste rock is freshly deposited and the fines component is more easily sampled, i.e. samples will be collected weekly or monthly during depositional periods as access allows and not after all the rock has been deposited. Other aspects of surface waste rock management will be dictated by the timing and volume requirements for dam construction, as per designs by Wood PLC.

4.3 WASTE ROCK STORAGE AREAS

4.3.1 Non-Sulphidic Materials

Non-sulphidic materials ($S_{\text{total}} < 0.05\%$) that will be used for construction and/or reclamation work are to be stored in the clean fill stockpile in the rock quarry. These materials are (i) 112,000 t of development rock from Phillips Reach Decline Extension and (ii) crushed quarry rock. Non-sulphidic materials can be used for road crush, rip rap, cover materials, and for construction around the site. No other materials will be placed in the quarry area, including sulphidic Non-PAG waste rock from future mining.

4.3.2 Future PAG and Non-PAG Waste Rock

Some Non-PAG, run-of-mine waste rock will be used underground as roadbase and most future PAG waste rock will be placed in one of several underground areas, including abandoned drifts in Lynx and HW mines that are no longer needed for mining. These areas have been designated as waste rock storage areas and some have been previously-filled with waste rock from different areas within the mine. These areas are below the post-closure flood level and will therefore be inundated post-closure (see Section 4.1). High sulphide PAG waste rock ($S_{\text{total}} > 10\%$) will be prioritized for underground storage so the volume hoisted to surface is minimized. Waste rock will also be used to backfill mined-out areas of the Price 4L and 5L. These levels are above the post-closure flood level and will therefore not be inundated. Future ARD and other impacted drainage from this waste rock will therefore be actively managed via the HW 25L Main sump and the Environment Department will ensure that mine water (ARD) from these levels does not report to the

Price 13 level adit unless the capacity/effectiveness of the Price Pond to handle this water has been confirmed and potential water quality implications for Thelwood Creek have been evaluated.

PAG and Non-PAG waste rock brought to surface will be used to raise the Lynx TDF embankment berm (see Section 4). Material placement in the Lynx TDF embankment berm is strictly-controlled by the dam design and must be supervised by Wood PLC. Any re-located or future waste rock to be used for future dam raises will therefore be stored in WRD#1 or in a construction stockpile developed following the stockpiling methods developed by Wood PLC for this purpose, within the groundwater seepage collection area. WRD#1 will be the only approved waste rock dump at surface once mining operations re-commence. WRD#1 will be re-configured once engineering designs by Wood PLC are approved by MEMPR so the dump can accommodate approximately 60,000 m³ of additional waste rock for permanent storage (see Wood PLC, 2018). Approximately 200,000 m³ of waste rock from WRD#2 will be re-located to the upper Lynx Pit and PAG waste rock (likely from WRD#6) will be placed under the cover planned for the Old TDF, as per the site's closure plan. Sulphidic waste rock will not be deposited in any other area of the site regardless of its geochemical characteristics.

4.3.3 Existing PAG and Non-PAG Waste Rock

PAG and Non-PAG waste rock from the WRD#2 and portions of WRD#3, WRD#4 and WRD#6 will be used to raise the Lynx TDF embankment berm. WRD#6 contains highly-sulphidic PAG material that will not be used for any purpose other than constructing the berm, including roadbase. WRD#2 and WRD#3 contain a mixture of PAG and Non-PAG materials that are more appropriate for roadbase within the confines of the site if non-sulphidic materials are not available. Waste rock from WRD#2, WRD#4, and WRD#6 were not segregated during deposition and cannot be practically differentiated during re-location. During dam construction, waste rock samples will be collected to classify the type of waste rock being incorporated into the berm. This information will appear in future Annual Reclamation Reports but will not be used to segregate waste rock. Instead, PAG and Non-PAG waste rock will be used identically during construction unless dam designs by Wood PLC specify a specific use for Non-PAG materials. Waste rock from the existing WRDs will likely be sourced directly from the dumps when needed for dam construction so it will not be stored in WRD#1.

4.4 FINAL WASTE ROCK DISPOSAL AREAS

4.4.1 Underground Disposal Areas

PAG and Non-PAG materials kept underground in storage areas or used as roadfill below the 13L workings in the HW and Lynx mines will be flooded post-closure. PAG storage areas in these mines therefore represent the final disposal site for these materials. In the Price mine, levels with PAG waste rock will be closed in such a way that mine water (ARD) from these levels is directed to the water treatment system via the HW mine and thereby managed in perpetuity.

4.4.2 Surface Disposal Areas

Approximately 1.1 Mm³ of PAG and Non-PAG waste rock from the WRD#2 and portions of WRD#3 and WRD#6 will be used to raise the Lynx TDF embankment berm. The Lynx TDF embankment berm is therefore the final disposal site for (i) existing waste rock that is not in WRD#1, WRD#4, and the portion of WRD#3 that is below the tailings level in the Lynx TDF and (ii) future, run-of-mine waste rock that is used during future raises. The Lynx TDF embankment berm will be covered with a closure cover that consists of compacted rock and till (see Amec Foster Wheeler, 2016a). Closure covers that contain a geomembrane liner will be placed on WRD#1 (see Amec Foster Wheeler, 2016b). A closure covers for WRD#4 has not been designed and WRD#3 (partially buried by tailings in Lynx TDF) will not require a cover because waste rock will be removed to an elevation that is equivalent to the tailings elevation in the TDF.

5 WATER (ML/ARD) MANAGEMENT

This section summarizes how ML/ARD-impacted groundwater and mine water is managed and treated at NMF to mitigate potential impacts to Myra Creek. Further details are provided in RGC (2018a), which describes the structure and calibration of the SWLB for NMF and water quality predictions for Myra Creek. Further descriptions of the Myra Valley Aquifer (MVA) and existing groundwater and surface water quality impacts are also provided in RGC (2018a) and are summarized below. A detailed description of water monitoring is provided in the Surface Water and Groundwater Monitoring Plan, which is referred to as necessary throughout this section.

5.1 CURRENT CONTAMINANT SOURCES

5.1.1 *Waste Rock and Tailings*

Seepage from waste rock in the historic WRDs and the Lynx TDF embankment berm are the main sources of Zn and other contaminants to groundwater in the MVA. However, few direct measurements of current waste rock seepage are available, as there are no surface expressions of undiluted waste rock seepage at ground surface. This is because the toe of WRD#1 (the largest and thickest dump) is buried by tailings and seepage from the other historic WRDs tends to be directed downward towards groundwater and not laterally towards a well-defined toe. Instead, seepage areas in Myra Valley are typically expressions of impacted groundwater that, to some extent, represents diluted seepage from upgradient sources. These include the car bridge seep, pipe bridge seep, and seepage that occurs near Myra Creek at MC+800 m (see RGC, 2018a).

RGC (2016a) assumes 150 mg/L Zn in seepage (ARD) from WRD#1 and the Lynx TDF embankment berm and 15 mg/L Zn in lower-strength seepage from the Lynx WRDs to simulate Zn loads recovered by the Old TDF under-drains and observed in Myra Creek. These concentrations were intended to represent seepage (en masse) from waste rock in the WRDs and the Lynx TDF embankment berm to groundwater. They are derived from historic seepage water quality observations and are consistent with SFE results, spot samples of ponded seepage near WRD#6 and the Lynx TDF embankment berm, and potentially perched seepage near the Lynx TDF (**Table 5-1**). Source terms for waste rock were recently modified in RGC (2018a) during the calibration of the groundwater flow and transport model within the SWLB (**Table 5-2**). The calibrated source terms are therefore consistent with calibrated recharge to the MVA and observed Zn concentrations in groundwater downgradient of the main sources and recovered by the site-wide SIS.

Tailings are currently a minor source of Zn and other contaminants to groundwater in the MVA despite being highly acid-generating when exposed to atmospheric conditions (see RGC, 2015). Loads to groundwater are small because seepage rates from tailings are very low due to their low permeability, i.e. $\sim 10^{-8}$ m/s or lower, and tailings porewater at the base of the tailings profile in the Old TDF consists of

alkaline process water from the mill that is characterized by low concentrations of major ions and dissolved metals (see RGC, 2015).

Table 5-1
Selected Seepage and Groundwater Quality Observations (Source Areas)

Well	Date	Screened Interval, m	Screened lithology	pH	SO ₄ , mg/L	Cd, µg/L	Cu, mg/L	Zn, mg/L
<i>Ponded seepage on or near WRD#6 or Lynx embankment berm</i>								
WRD#6	Jun-13	n/a	n/a	2.6	3,110	695	43	155
Lynx berm	Jun-13	n/a	n/a	2.7	2,680	202	0.09	109
<i>Impacted groundwater or seepage near Lynx TDF embankment berm</i>								
SP-Hill Seep	Dec-14	n/a	n/a	3.0	3,340	351	16.60	146
Rip Rap Seep	Dec-14	n/a	n/a	3.2	2140	212	8.98	88
#25S-Seep	Dec-14	n/a	n/a	3.8	1,200	92	7.0	54
<i>Impacted groundwater or seepage near Lynx TDF embankment berm</i>								
MW13-06S	Dec-17	12.8 to 15.9	-	5.1	1,090	111	0.9	44
MW13-06D	Dec-17	35.4 to 41.5	Glaciofluvial	6.9	743	36	0.6	37
MW14-04S	Nov-17	3.1 to 6.1	Gravel	2.6	3,540	744	35	171
MW14-04S	Feb-15	3.1 to 6.1	Gravel	-	3,860	695	23	158
MW14-04D	Dec-17	18.7 to 21.7	Sandy Gravel	3.0	3,140	640	28	153
MW17-01	Apr-18	20.7 to 23.8	Colluvium	7.1	822	16	0.3	44
MW17-02S	Jan-18	32.6 to 34.1	Colluvium	3.3	2,840	226	3.6	112
<i>Porewater from WRD#1^a</i>								
10-1	Feb-82	11.0 to 17.1	Waste rock	-	-	310	27	110
10-1	Jan-82	11.0 to 17.1	Waste rock	-	-	-	18	92
<i>Seepage and groundwater from collection pipes near toe of WRD#1^b</i>								
S-1	Apr-82	4.6 to 5.5	Gravel	3.9	-	220	8.5	68
S-2	Apr-82	4.6 to 5.5	Gravel	4.4	-	310	11	86
S-3	Apr-82	15.9 to 16.8	Sand and gravel	4.8	-	50	0.6	41
S-4	Apr-82	4.6 to 5.5	Gravel	4.0	-	140	4.4	46
<i>Impacted groundwater (pH < 5) from shallow bedrock aquifer beneath WRD#1^c</i>								
16-1	Nov-90	29.1 to 30.0	Bedrock	4.6	10,884	110	1.0	110
16-1	May-91	29.1 to 30.0	Bedrock	4.8	11,463	36	0.3	100
16-1A	Oct-88	29.1 to 30.0	Bedrock	3.3	3,200	130	4.1	37
P3	Nov-90	-	Bedrock	3.4	1,628	210	9.6	64
P3	May-91	-	Bedrock	4.1	701	160	8.6	48
45-1	Nov-89	-	Bedrock	4.4	640	120	3.6	23
47-1	Nov-90	-	Bedrock	3.4	1,613	560	29	120
<i>Impacted groundwater from MVA downgradient of WRD#1</i>								
TD13-04D	Sep-13	41.4 to 44.5	Glaciofluvial	4.5	833	150	6.7	51
MW17-01	Oct-18	20.8 to 23.8	Colluvium	7.1	822	163	0.3	45
MW17-03	Oct-17	39.3 to 40.8	Glaciofluvial	4.7	436	52	1.7	19
MW17-02D	Oct-17	21.7 to 23.2	Glaciofluvial	5.1	424	35	0.9	14
<i>Tailings porewater (observed; see RGC, 2014c)</i>								
SFE, (1:1 tailings)		Base of tailings profile	n/a	9.2	325	300	0.003	0.03

^a Piezometer 10-1 was installed in WRD#1 in 1981 as part of Simco Groundwater Research's investigations of ARD impacts on groundwater and Myra Creek before tailings were stored sub-aerially in the Old TDF Cd, Cu, and Zn concentrations are thought to be reasonably representative of porewater from WRD#1.

^b Samples from the shallowest piezometers installed along the toe of WRD#1 in 1981 to design the original under-drain system (see Simco, 1982). Samples were collected from thirteen piezometers every two weeks in April and May 1982.

^c Data from piezometers installed by Northwest Geochem in 1988 and 1990 after tailings covered a portion of WRD#1; water quality data represent diluted seepage from wells screened in shallow bedrock beneath WRD#1

Table 5-2

Calibrated Recharge, Source Term Concentrations, and Loads to Groundwater in MVA from the Lynx Reach, Upper Old TDF Reach, and Lower Old TDF Reach

Source to Groundwater	Area, km ²	Flux, L/s	Recharge		[Zn], mg/L	Zn Load	
			mm/yr	% of MAP		t/year	%
Lynx Reach							
Lynx TDF Berm	0.042	1.9	1436	58	110	6.6	17.6%
Mill area (side-hill)	-	3.5	-	-	50	5.5	14.8%
Perched seepage (near Lynx TDF)	0.002	0.6	-	-	150	2.6	7.0%
Mill area	0.122	3.3	862	35	15	1.6	4.2%
Lynx side hill	-	1.0	-	-	50	1.6	4.2%
Former ETA/Cookhouse area	0.171	3.8	631 to 915	20.1 to 36.9	77	1.5	4.0%
Lynx Ditch (Lynx 10L East adit flows)	-	3.0	-	-	10	0.9	2.5%
Surface waste near Super Pond	0.052	1.1	631 to 789	25.4 to 31.8	22	0.3	0.8%
North of Lynx pit	0.075	0.3	142	6	20	0.2	0.6%
Arnica Creek	-	3.5	-	-	0.003	0.0	0.0%
Sub-Total:		22.0				20.8	55.7%
Upper Old TDF Reach							
WRD#6	0.039	1.8	1436	58	125	7.0	18.7%
WRD#1 (East)	0.030	1.4	1436	58	125	5.4	14.4%
WRD#1 (West)	0.014	0.6	1436	58	125	2.5	6.6%
Surge Pond	0.027	0.7	773	31	25	0.5	1.4%
HW office area	0.052	1.0	631	25	12	0.4	1.0%
Seismic Upgrade Berm (West)	0.089	1.4	492	20	5	0.2	0.6%
Polishing Ponds Area	0.082	0.7	264	11	0.004	0.0	0.0%
Sub-Total:		7.5				16.0	42.7%
Lower Old TDF Reach							
Seismic Upgrade Berm (East)	0.088	1.4	492	20	10	0.4	1.2%
PAG Rockfill	0.008	0.2	750	30	55	0.2	0.5%
Strip Area	0.132	1.3	300	12	0.03	0.0	0.0%
Old TDF Tailings	0.084	0.8	300	12	0.03	0.0	0.0%
Sub-Total:		3.6				0.6	1.6%
TOTAL:		33.2				37.4	

5.1.2 Mine Water

Gravity flows of mine water from various portals in Myra Valley, including the Lynx 10L East adit and the Myra 10L and 11L adits are characterized by circum-neutral to alkaline pH values and low concentrations of dissolved metals that are typical of NMD. Mine de-watering flows from the various underground sumps are typically more acidic and characterized by much higher concentrations of Zn and other metals because ARD from exposed, sulphidic rocks underground is collected by these sumps. This mine water, primarily from the HW 25L Main sump, is managed underground and does not represent a source to groundwater in the MVA or to Myra Creek.

Mine water flows from the Price 13L adit are currently circum-neutral and characterized by low metal concentrations due to minimal exposure of sulfides during initial mine development in the 1980s. Gravity flows from the Price 13L workings are directed to the Price Pond. Gravity flows from the Price 4L and 5L adits are directed to the Price 13L workings beyond a land divide towards Myra Valley so these flows report

to the HW mine and eventually to the Super Pond via the HW 25L Main sump. Note, there are no assumed source terms for underground mine waste in RGC (2018a) as water quality observations and simulated flows from RGC (2018b) are used to simulate loads to the mine water management system. Further details on how mine water from the Lynx mine is managed are provided in Section 5.2.1.

5.2 WATER MANAGEMENT AND TREATMENT SYSTEMS

5.2.1 *Mine Water Management Systems*

The HW 25L Main sump, the Myra 12L and 13L sumps, and the Lynx 15L sump are the key components of the underground mine de-watering system. Flows from HW and Myra sumps are a mixture of ARD, SD, and NMD from underground sources, including exposed cuts, backfill, and stored waste rock. Flows from these sumps report to the Myra/HW sump but are not routinely monitored. RGC (2018a) simulates de-watering flows to range from 35 to 103 L/s (see **Table 5-3** and **Table 5-4**). The planned development of Price Mine is expected to increase these flows by only a small percentage given the fact that the size of the ultimate Price Mine will only be a small fraction of the size of the existing mine workings.

Once mining ceases, flows from the Price 13L adit will continue at current, if not higher rates, and mine water quality could deteriorate (see RGC, 2018a). This mine water will be directed to the Price Pond, which is effectively a storage pond with no treatment component. Flows and mine water quality from the Price 13L adit will be monitored during operations and the capacity and effectiveness of Price Pond will be periodically assessed by the Environment Department. Potential impacts to groundwater quality and Thelwood Creek will also be assessed during operations. Flows directed from the Price 4L and 5L to the HW 25L sump are predicted to be predominantly ARD. RGC (2018a) suggests loads will be relatively small in comparison to mine water loads from other areas of the underground and there will likely be no implications for water management via the HW 25L Main sump.

Table 5-3

Calibrated and Predicted Flows and Loads to the Water Treatment System, Low Loading Condition

Flow/Source to Super Pond	Old TDF under-drains only*					Phase I Lynx SIS Operating				
	Flow,		[Zn],	Zn Load,		Flow		[Zn],	Zn Load,	
	L/s	%	mg/L	t/year	%	L/s	%	mg/L	t/year	%
<i>Groundwater flows</i>										
Old TDF under-drains via Pumphouse No. 4	139	73%	6.2	27	74%	138	59%	3.6	16	35%
Phase I Lynx SIS (pumping wells)	-	-	-	-	-	47	20%	13	19	43%
Sub-total:	139	73%	-	27	74%	185	79%	-	34.9	78%
<i>Mine de-watering flows</i>										
Lynx 15L sump (Phillips Reach)	10	5%	1.3	0.4	1%	10	4%	1.3	0.4	1%
HW 25L Main sump	17	9%	16	8.7	23%	17	7%	16	8.7	19%
Myra 12L and 13L sumps	7	4%	0.9	0.2	1%	7	3%	0.9	0.2	0%
Sub-total:	35	18%	-	9.3	25%	35	15%	-	9.3	21%
<i>Gravity flows from Lynx and Myra adits</i>										
Myra 10L adit	4	2%	1.6	0.2	0%	4	2%	1.6	0.2	0%
Lynx 10L East adit	4	2%	0.3	0.0	0%	4	2%	0.3	0.0	0%
Sub-total:	8	4%	-	0.2	1%	8	3%	-	0.2	0%
<i>Other flows</i>										
Supernatant pumped from Lynx TDF	8	4%	1.0	0.2	1%	8	3%	1.0	0.2	1%
Sub-total:	8	4%	-	0.2	1%	8	3%	-	0.2	1%
TOTAL:	190	100%	6.2	37	100%	235	100%	6.0	45	100%

* Calibrated flows and loads from RGC (2018)

** Predicted flows and loads for Scenario 1 from RGC (2018)

Table 5-4

Calibrated and Predicted Flows and Loads to the Water Treatment System, High Loading Condition

Flow/Source to Super Pond	Old TDF under-drains only*					Phase I Lynx SIS Operating				
	Flow,		[Zn],	Zn Load,		Flow		[Zn],	Zn Load,	
	L/s	%	mg/L	t/year	%	L/s	%	mg/L	t/year	%
<i>Groundwater flows</i>										
Old TDF under-drains via Pumphouse No. 4	237	41%	7.8	58	48%	235	36%	4.5	34	26%
Phase I Lynx SIS (pumping wells)	-	-	-	-	-	75	12%	14	34	26%
Lynx Springs Drain	7	1%	0.3	0.1	0%	6.6	1%	0.3	0.1	0%
Sub-total:	243	42%	-	58	49%	316	49%	-	67.1	52%
<i>Mine de-watering flows</i>										
Lynx 15L sump (Phillips Reach)	31	5%	0.3	0.3	0%	31	5%	0.3	0.3	0%
HW 25L Main sump	51	9%	16	26	21%	51	8%	16	26	20%
Myra 12L and 13L sumps	21	4%	0.9	0.6	0%	21	3%	0.9	0.6	0%
Sub-total:	103	18%	-	26.4	22%	103	16%	-	26.4	21%
<i>Gravity flows</i>										
Myra 10L adit	11	2%	1.6	0.5	0%	11	2%	1.6	0.5	0%
Lynx 10L East adit (and Lynx Road sump)	65	11%	0.3	0.6	1%	65	10%	0.3	0.6	0%
Sub-total:	76	13%	-	1.2	1%	76	12%	-	1.2	1%
<i>Other flows</i>										
Supernatant pumped from Lynx TDF	72	12%	1.0	2.3	2%	72	11%	1.0	2.3	2%
Precipitation runoff (decant) from Surge Pond	78	14%	13	32	27%	78	12%	13	32	25%
Local runoff to Super In channel	5	1%	0	0.0	0%	5.3	1%	0.0	0.0	0%
Sub-total:	155	27%	-	34	29%	155	24%	-	34.3	27%
TOTAL:	577	100%	6.6	120	100%	650	100%	6.3	129	100%

* Calibrated flows and loads from RGC (2018)

** Predicted flows and loads for Scenario 1 from RGC (2018)

5.2.2 Site-Wide Seepage Interception System (SIS)

The site-wide SIS consists of the Old TDF under-drain system, including the New Outer Drain (NOD), and the Phase I Lynx SIS. The NOD was constructed between 2004 and 2005 as part of the Seismic Upgrade Project. The NOD was installed to replace the older Area II Outer Drain because there was concern this drain could be damaged during construction of the Seismic Upgrade Berm. The NOD was intended to reduce the bypass of impacted groundwater to Myra Creek primarily in the reach from Stations 1+050 to 1+250. The Old TDF under-drain system has operated in its current configuration, i.e. with the NOD, has operated since 2005. The NOD is typically run at a setting of “10-0-10”, representing 10% opening for the Medium Drain, 0% opening for the Short Drain and 10% opening for the Long Drain (see RGC, 2016b, for further details). Flows captured by the Old TDF typically range from 100 to 300 L/s depending on the time of year and account for up to three-quarters of the overall flows to the water treatment system during low loading periods (see **Table 5-3** and **Table 5-4**).

The Phase I Lynx SIS has been operating since the end of September 2017. It consists of a fence of pumping wells (PW14-01, PW14-03, and PW14-04) near the Lynx TDF and in the mill area. PW14-03 is located about 150 m downstream of the mill and PW14-01 and PW14-04 are west and east of the Super Pond, respectively. Flows from the Phase I Lynx SIS account for approximately 10 to 20% of the flows to the water treatment system and captured about the same Zn load as the Old TDF under-drains, despite the lower flows that are captured. This is related to higher Zn concentrations in groundwater captured by the Phase I Lynx SIS, which is designed to capture groundwater that is severely impacted by seepage from the nearby Lynx TDF embankment berm and other sources near the Superpond and in the mill area.

An interim Phase II Lynx that consists of four pumping wells (PW18 well series) near Myra Creek has been installed but is not yet operating. This interim Phase II Lynx SIS is intended to intercept shallow, potentially perched seepage near the Duck Pond. This interim system was installed and will be operated at the behest of the Ministry of Environment and Climate Change Strategy (MoECCS) to reduce seasonal flows of seepage and surface runoff to Myra Creek (see RGC, 2018c).

5.2.3 Water Treatment System

Simulated flows and Zn loads to the water treatment system during low flow and high flow conditions on site are summarized above in **Table 5-3** and **Table 5-4**, respectively. Flows and loads prior to the operation of the Phase I Lynx SIS and during the operation of this system (since October 2017) are provided. Groundwater flows from the site-wide SIS comprise most of the flows (and Zn load) to the water treatment system during low flow and high flow periods. Flows and Zn loads recovered by the Old TDF under-drains increase during higher flow periods but represent a smaller proportion of the flows and Zn loads to the treatment system during these periods due to higher flows of mine water and precipitation runoff during these periods.

When mining resumes, gravity flows from the Price 4L and 5L workings to the HW 25L Main sump will likely increase due to larger surface area underground that will be exposed during mining. The magnitude of these flows is not well-constrained, but they are estimated to be small (< 5 L/s) based on a calculation of the extent of the Price mine compared to the extent of the HW, Battle Gap, and Myra mines that are dewatered by the HW 25L Main sump. Contaminant loads are estimated to be small as well and few implications for water management via the HW 25L sump are expected (see RGC, 2018a).

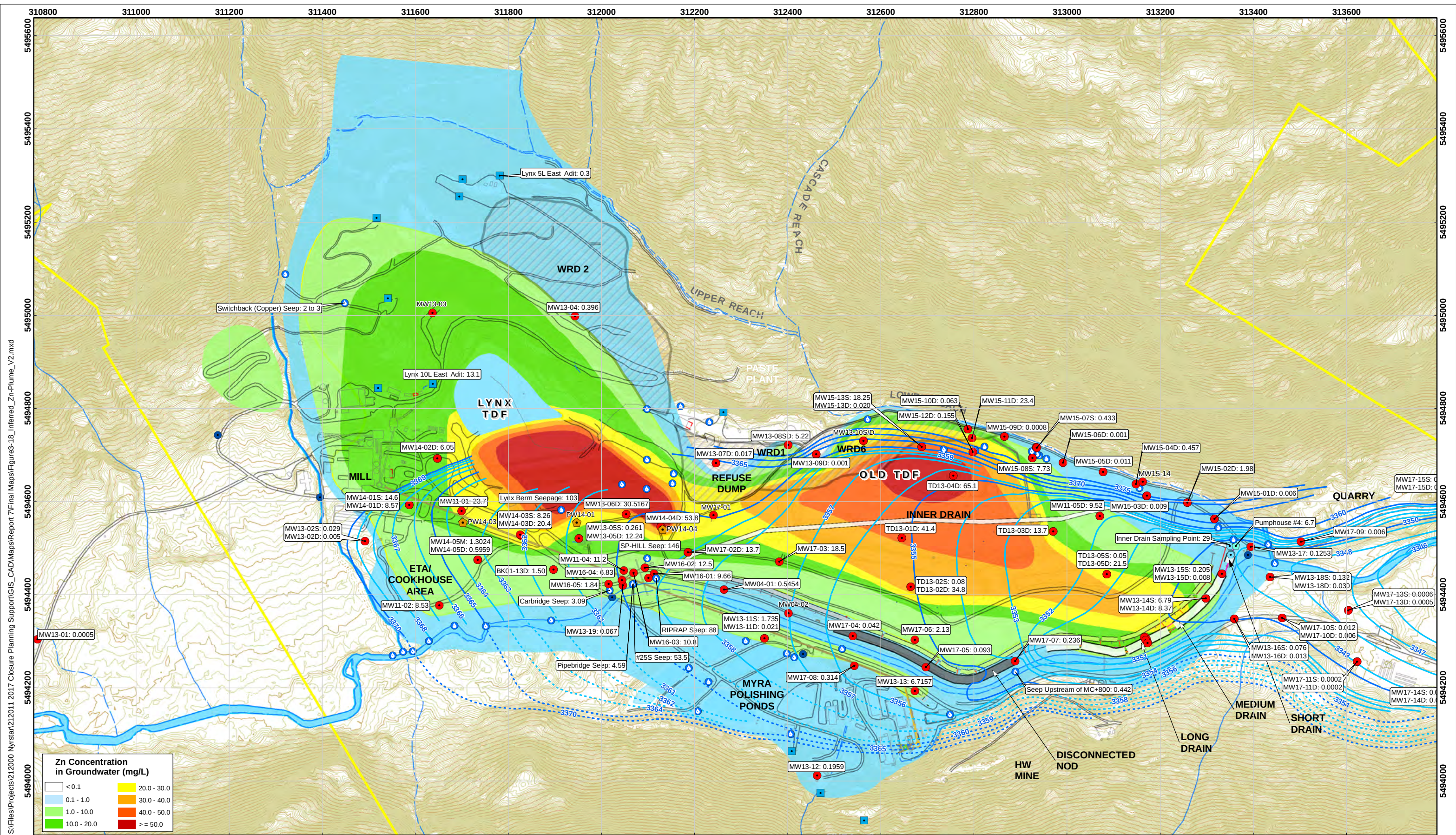
5.3 CURRENT ML/ARD IMPACTS TO GROUNDWATER

5.3.1 *Lynx Reach*

Groundwater in the Lynx Reach is characterized by more than 50 mg/L near the Super Pond and the Lynx TDF embankment berm (**Figure 5-1**). Key sources in this area are the Lynx TDF embankment berm and an unidentified (sub-surface) source in the mill area that is inferred from high Zn concentrations at PW14-03. Potentially perched seepage downgradient of the Lynx TDF embankment berm is characterized by up to 150 mg/L Zn and several surface seeps, e.g. SP-Hill seep, is characterized by similar Zn concentrations. Groundwater in the MVA near Myra Creek in the Lynx Reach is typically characterized by less than 10 mg/L Zn.

5.3.2 *Old TDF Reach*

In the Upper Old TDF Reach, groundwater quality is primarily impacted by impacted groundwater flows from the Lynx Reach and groundwater impacted by seepage from the eastern portion of WRD#1 (Figure 5-1). Downgradient in the Lower Old TDF Reach, groundwater is often slightly acidic and characterized by up to 50 mg/L Zn due to seepage to groundwater in the MVA beneath the Old TDF from the buried portion of WRD#1.



Legend

- Monitoring Well
- Pumping Well
- Surface Water Station
- Seep or Surface Water
- Creek Monitoring Station
- Adit (Mine Water)
- Class B Park Boundary
- Average [Zn] Concentration (2015-2017) in mg/L

Groundwater Quality and Inferred Zn Plume, Nyrstar Myra Falls

Scale 1:7,000

0 55 110 220 330 440 550 Meters

NAD83 UTM Zone10N

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Client: nyrstar	Figure: 5-1
Project: Site-Wide ARD Plan	Last Update: Nov 19, 2018
Report: RGC 212012/1	Drawn: L.R.
Original File: Figure3-18_Inferred_Zn-Plume_V2.mxd	

5.4 RECENT SIS PERFORMANCE

5.4.1 *Old TDF Under-Drains*

RGC (2016b) provides a detailed assessment of the hydraulic performance of the Old TDF under-drains and the degree of bypass to Myra Creek and results from that report were incorporated into RGC (2018a). Water levels within the under-drains, the surrounding MVA, and Myra Creek suggest the under-drains provides adequate hydraulic control when sluice gates are set to 10-0-10, meaning hydraulic gradients are generally directed towards the drain system suggesting that shallow seepage flow is largely captured. Groundwater quality observations suggest some seepage regularly bypasses the under-drains at selected locations, e.g. near Station MC 1+250 (Medium Drain).

Groundwater from monitoring wells at the downstream end of the Medium Drain are, however, characterized by only slightly elevated Zn concentrations, suggesting the drain is performing well at this location with respect to loads and/or dilution from the creek is occurring. Water quality observations for Myra Creek suggest an additional Zn load to Myra Creek within the Lower Old TDF Reach. Bypass appears to vary temporally with no clear pattern (see RGC, 2016b). The inferred Zn load, however, only represents about 10% of the overall load in Myra Creek at MC-TP4 due to the much larger contributions from groundwater that discharges the creek upstream in the Lynx Reach and the Upper Old TDF Reach.

Zn concentrations in groundwater downgradient of the Old TDF (in the Downstream Reach) are only slightly elevated (see Section 5.5.1), indicating there is very limited underflow of impacted groundwater leaving the mine site. Together, these findings demonstrate that the Old TDF under-drains are working as intended and that it effectively captures most of the ML/ARD-impacted groundwater in the Lower Old TDF Reach that would otherwise discharge to Myra Creek. Further reductions in Zn concentrations in Myra Creek can likely be achieved by operating the Phase I Lynx SIS (see Section 5.4.2) but there is little opportunity (or necessity) to improve the performance of the Old TDF under-drains. The Old TDF under-drains will therefore be operated in perpetuity at their current setting unless water quality objectives for Myra Creek substantially change and a much greater capture efficiency is required.

5.4.2 *Phase I Lynx SIS Performance*

The Phase I Lynx SIS captured 32 t/year Zn during the first twelve months it operated from October 2017 to October 2018 (see RGC, 2018a). This is approximately 80% of the Zn load captured by the Old TDF under-drains during this period. Combined, pumping wells PW14-03 and PW14-04 captured about 70% of the Zn load captured by the Phase I Lynx SIS because groundwater intercepted by these pumping wells is more impacted and they operated near-continuously. Pumping well PW14-01 captured less load because of lower concentrations in groundwater and electrical problems lead to several prolonged shutdown periods in 2018. The Phase I Lynx SIS also captured 0.06 t/year Cd and 0.7 t/year Cu. PW14-04 captured the highest loads of Cd and Cu due to the acidic nature of the groundwater within the capture zone for this

pumping well. Cd and Cu are the two other primary Constituents of Concern (CoC) for Myra Creek, according to Nautilus Environmental (2018), and concentrations are predicted to decrease during operation of the Phase I Lynx SIS (see RGC, 2018a).

The Phase I Lynx SIS is predicted to effectively intercept the entire Zn load from the mill area and Lynx TDF embankment berm once the groundwater system has reached steady-state. A substantial decrease in Zn concentrations in groundwater in the Super Pond area and the southern portion of the Upper and Lower Old TDF Reaches is therefore predicted. Continued interception of the residual Zn plume in the northern portion of Old TDF Reach that originates primarily from WRD#1 by the Old TDF under-drains is also predicted, meaning groundwater that will discharge to Myra Creek in the Lynx Reach and Upper Old TDF Reaches will only be modestly-impacted by ARD, i.e. < 0.3 mg/L Zn (**Figure 5-2a**). This is predicted to reduce the Zn loads from groundwater to Myra Creek to less than 0.1 t/yr Zn during low loading conditions (or about 65 times lower than current loads). This is the result of reduced loads to Myra Creek in the Lynx Reach and Upper Old TDF Reach once the plume in these areas is intercepted by the pumping wells (see **Figure 5-2b**).

Transient results from the groundwater model suggest that Zn concentrations in the MVA would decline and approach steady-state conditions within two to five years of start of operation of the Lynx SIS. Zn loads to Myra Creek are predicted to decrease faster (within about 6 to 12 months) because the travel distance from the Phase I Lynx SIS pumping wells to the main discharge areas along Myra Creek (Lynx Reach and Upper Old TDF reach) is shorter (see RGC, 2018a, for details). Lower Zn loads to Myra Creek are therefore predicted in 2019 and a three-fold decrease in Zn concentrations in Myra Creek is predicted for years when loads to Myra Creek are relatively low, i.e. the low-loading condition described in RGC (2018a). Further monitoring and performance assessments are needed to confirm the predicted decreases in groundwater and Myra Creek and the proportions of Zn loads intercepted by the Old TDF under-drains and Phase I Lynx SIS (see Section 6).

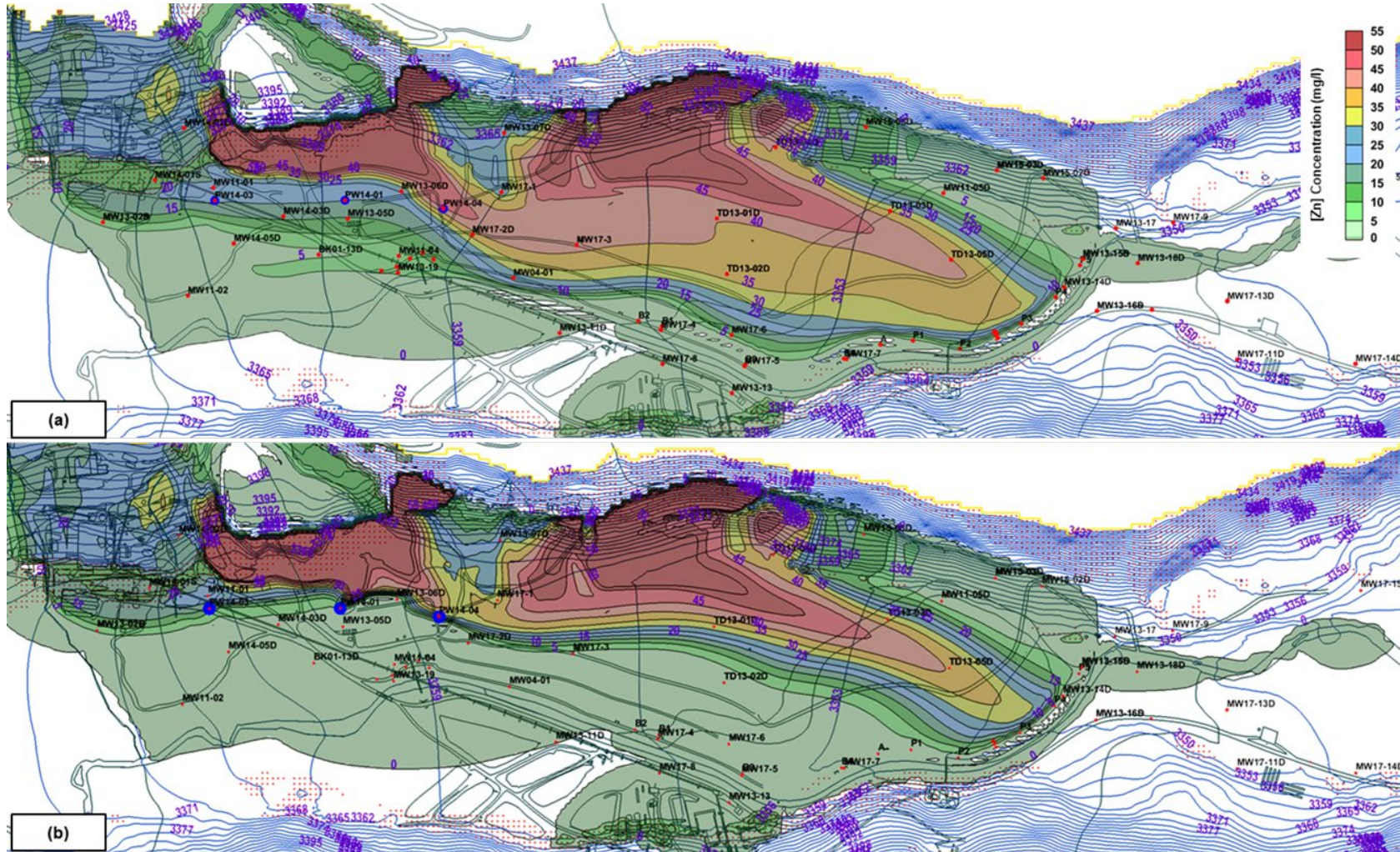


Figure 5-2 (a) Simulated Heads and Zn Concentrations for Base Case Calibration and **(b)** Predicted Heads and Zn Concentrations when Phase 1 Lynx SIS Operating (from RGC, 2018a).

5.5 DOWNSTREAM IMPACTS

5.5.1 Groundwater

Groundwater downstream of the site is currently characterized by less than 0.1 mg/L Zn and low concentrations of other metals, e.g. Cd, Cu, etc. These low concentrations are primarily due to the effectiveness of the Old TDF under-drains, which capture most of the ML/ARD-impacted groundwater in the MVA that reaches the Lower Old TDF Reach (**Figure 5-3**). Slightly elevated concentrations in groundwater are primarily related to flows of impacted water from Myra Creek to groundwater in the MVA downstream of the site. Groundwater quality in this area is therefore predicted to improve once Zn concentrations in Myra Creek are decreased by operating the Phase I Lynx SIS. These concentrations (and associated loads) are not an environmental concern and do not warrant any further remediation or monitoring aside from the routine monitoring conducted by NMF staff. Key wells in this area are routinely monitored to characterize bypass and groundwater quality impacts, as per the Surface Water and Groundwater Monitoring Plan.

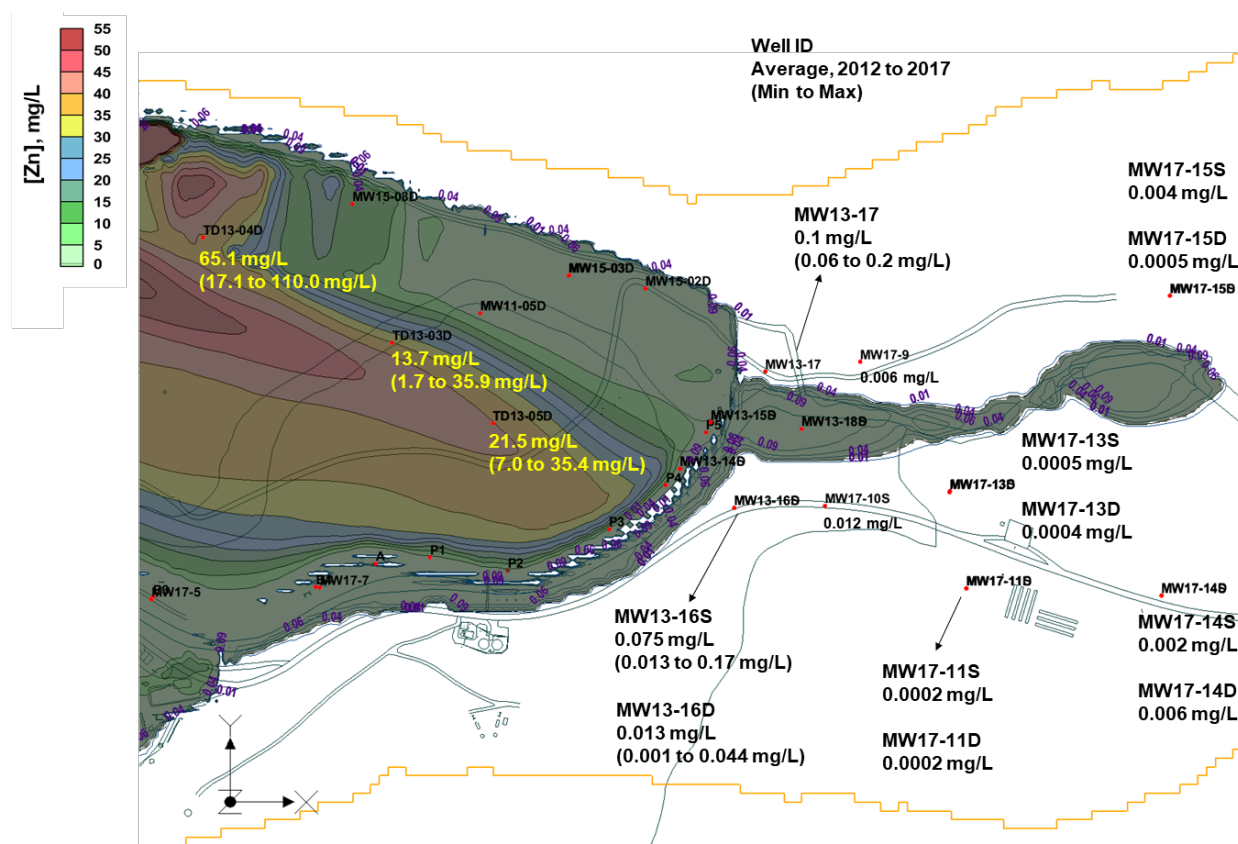


Figure 5-3. Simulated Zn Plume Downstream of Old TDF and Observed Zn Concentrations in Groundwater from Selected Wells

5.5.2 Myra Creek

Myra Creek downstream of the site at station MC-TP4 is characterized by elevated Zn concentrations due to impacted groundwater discharge to the creek from the Lynx Reach and Upper Old TDF Reach and, to a much lesser extent, inflows of treated effluent from the Polishing Ponds. Current Zn concentrations are well-explained for extended periods by either a low load from groundwater (6.5 t/year Zn) or a high load (12.9 t/year Zn) from groundwater (see RGC, 2018a for further details). The average Zn concentrations in August and September 2012 (when the low load from groundwater applied) was 0.05 mg/L Zn and the average Zn concentrations was 0.09 mg/L Zn in November 2017 when the high load from groundwater applied (**Figure 5-4**). Zn concentrations are predicted to decrease to 0.01 mg/L Zn (low load) and 0.03 mg/L Zn (high load) during operation of the Phase I Lynx SIS. These predicted concentrations are 3 to 5 times lower than observed concentrations and are predicted to occur within 6 to 12 months of the Phase I Lynx began operating in October 2017, i.e. in 2019. These predictions will be evaluated in future Surface Water and Groundwater Monitoring Reports and supporting technical studies, if needed.

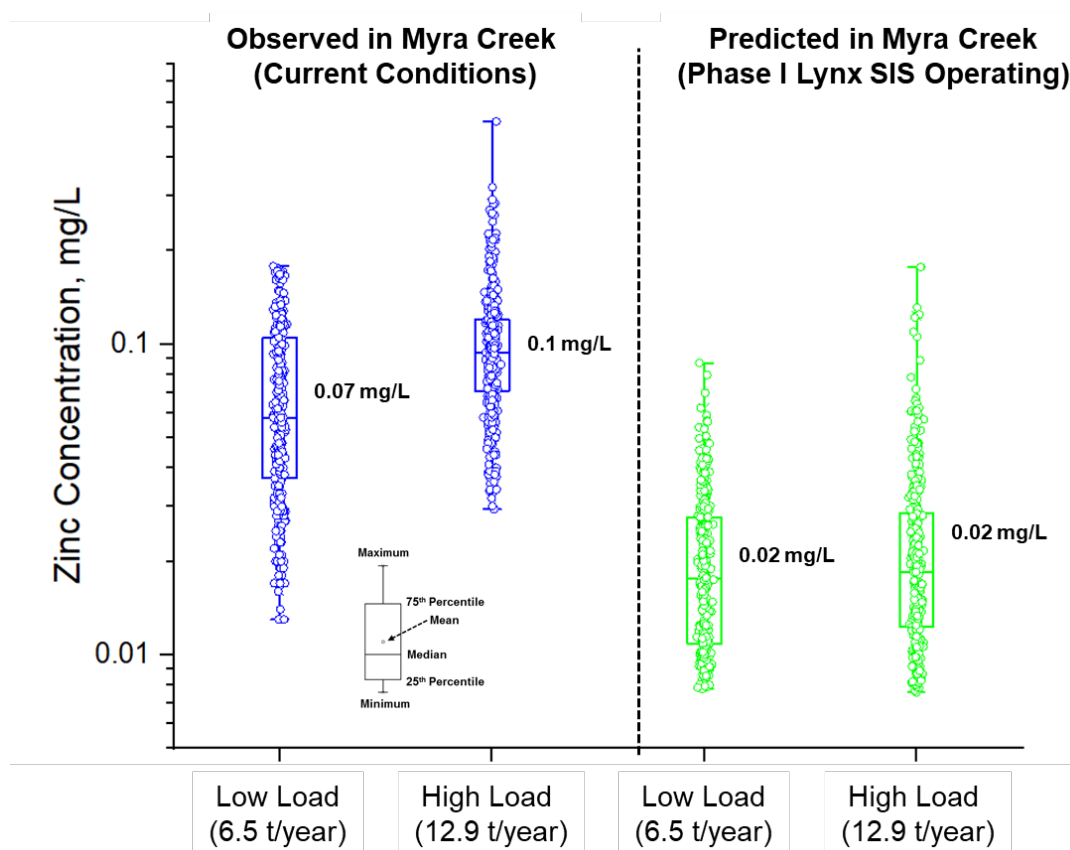


Figure 5-4. Observed and Predicted Zn Concentrations in Myra Creek at MC-TP4 for low load (6.5 t/year Zn) in August and September 2012 and high load (12.9 t/year Zn) in November 2017.

6 MONITORING AND REPORTING COMMITMENTS

Selected monitoring commitments and department responsibilities that pertain to ongoing ML/ARD management and characterization are summarized in **Table 6-1**. Below is a summary of reporting and review requirements that pertain to tailings and waste rock characterization and future SIS performance monitoring and a comprehensive list of water sampling requirements is provided in the Surface Water and Groundwater Monitoring Plan.

6.1 TAILINGS AND WASTE ROCK CHARACTERIZATION

Geochemical monitoring results will be compiled and reviewed quarterly by the Environment Department to determine whether the appropriate data are being collected and to confirm the tonnages of PAG and Non-PAG materials that were deposited in WRD#1. Results will be reviewed primarily to ensure the correct procedures and records are being kept throughout the year. Geochemical data, selected seepage and groundwater monitoring results, and achieved tonnages will be reported in the Annual Reclamation Report prepared by the Environment Department and submitted to the MEMPR by March 31st of the following year. A Qualified Person will review and/or contribute to sections of the Annual Reclamation Report that require the interpretation of geochemical data, including a comparison of seepage and groundwater quality results to SFE results to refine source terms. The Qualified Person will also provide recommendations regarding changes to the operational protocols for waste rock management and routine sampling frequencies and analytical procedures and will review monitoring results periodically during the year if requested.

6.2 SIS PERFORMANCE MONITORING

Routine groundwater and surface water monitoring results will be reviewed and interpreted annually in a Surface Water and Groundwater Monitoring Report prepared by Qualified Professionals with assistance from NMF's Environment Department. The performance of the site-wide SIS will be periodically assessed within that report to confirm the predicted improvements in groundwater quality and water quality in Myra Creek. The first SIS performance assessment will be completed once groundwater and surface water quality results have been reviewed and a new streamflow gauge is operating. Further details on groundwater and surface water quality monitoring and water level monitoring related to the SIS performance assessment are provided in the Surface Water and Groundwater Monitoring Plan.

Table 6-1
Summary of Selected Monitoring Commitments and Departmental Responsibilities

Material	Sample Type	Objective	Responsibility	Sampling Method	Frequency
Waste rock	Broken rock (non-economic)	Identify rock with $S_{total} > 10\%$ (for prioritized disposal underground)	Geology Department	Grab sample (< 2 mm) for S_{total} with portable XRF	As needed
	Existing waste rock (re-located from WRDs)	Inventory geochemical characteristics of re-located waste rock	Surface Department	Composite sample (2 to 3 locations) for ABA and supportive testwork	One sample per 10,000 m ³
	Future waste rock (stored near WRD#1)	Inventory geochemical characteristics of future, run-of-mine waste rock	Surface Department	Composite sample (2 to 3 locations) for ABA and supportive testwork	One sample per 10,000 m ³
Development rock	Drill core (various programs)	Characterize broken rock	Geology Department	Drill core samples for ABA. Key lithologies described and sampled	As needed
	Grab sample (hailed material)	Inventory geochemical characteristics	Environment Department	Grab sample (surface) for ABA when hauled to quarry area	One sample per 10,000 m ³
Tailings	Tailings discharge	Inventory geochemical characteristics	Surface Department	Grab sample (bulk) from discharge line for ABA, metals, and SFE	Monthly
	Placed tailings	Evaluate changes after placement	Surface Department	Grab sample (bulk) from single location in Lynx TDF for ABA, metals, and SFE	Annually
Mine water	Gravity flows (Price mine)	Assess mine water quality (flows from Price 13L adit to Price Pond)	Environment Department	Water sample and flow rate estimate from adit with bucket and stopwatch	Monthly
	Gravity flows (Price mine)	Assess mine water quality (flows from Price 4L and 5L)	Environment Department	Water sample and flow rate estimate from drainhole(s) with bucket and stopwatch	Monthly
	Mine de-watering flows (all mines)	Assess mine water quality (25L Main sump)	Environment Department	Water sample of inflows (pumped) to Myra/HW sump	Quarterly
	Gravity flows (Lynx mine)	Assess inputs to Super Pond from Lynx 10L East adit and Lynx runoff (minor)	Environment Department	Water sample from Mill Ditch (near Super In channel)	Quarterly
Seepage	Surface seeps	Assess seepage water quality at surface near Myra Creek	Environment Department	Water samples and visual flow rate estimate	Monthly (when flowing)
	Waste rock seepage	Characterize seepage from WRDs	Environment Department	Water sample and visual flow rate estimate	Semiannually
Groundwater	Captured groundwater (Phase I Lynx SIS)	Characterize groundwater captured by Phase I Lynx SIS	Environment Department	Water sample from each Lynx SIS pumping well	Monthly
	Captured groundwater (Old TDF under-drains)	Characterize groundwater captured by Old TDF under-drains	Environment Department	Water sample from dissipater Note: Runoff from Old TDF may contribute to dissipater	Quarterly
	Captured groundwater (drain segments)	Characterize groundwater flows to each drain segment	Environment Department	Water sample from each drain segment	Quarterly
	Groundwater	Characterize groundwater quality	Environment Department	Monitoring wells (various locations)	Monthly to annually
Surface Water	Myra Creek (auto-sampler)	Characterize surface water quality and contaminant loads	Environment Department	Water samples from auto-sampler at Station MC-TP4 (for Cu and Zn)	Daily
	Myra Creek (creek profile)	Characterize incremental surface water quality changes	Environment Department	Sampling every 50 m from MC+0m to MC+1300m	Monthly (when safe)
	Myra Creek (multiple stations)	Characterize surface water quality downstream of site	Environment Department	Water sample from MC-TP4 and MC-M2	Monthly
	Myra Creek (multiple stations)	Characterize surface water quality upstream and downstream of site	Environment Department	Stations MC-M1 (upstream) and MC-TP4 and MC-M2	Quarterly
	Thelwood Creek	Characterize surface water quality	Environment Department	Grab sample (near mouth)	Quarterly

Note: A comprehensive list of monitoring commitments and further details on water sampling are provided in the Surface Water and Groundwater Monitoring Plan

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