POLYMET
MINING

NorthMet Project

Water Management Plan - Plant

Version 7

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This document was prepared for Poly Met Mining, Inc.
by Barr Engineering Co.

I hereby certify that this report, with the exception of the sections listed below, was prepared by me or under my direct supervision and that I am a duly Licensed Professional Geologist under the laws of the state of Minnesota.

12/7/2017

Tina Pint, P.G., Barr Engineering Co.
PG #: 46154

Date

I hereby certify that portions of this report were prepared by me or under my direct supervision and that I am a duly Licensed Professional Engineer under the laws of the state of Minnesota, specifically the preliminary design of the FTB, FTB Seepage Containment System, and HRF in Sections 2.1.2, 2.1.4, 2.2.2, 4.1.1, 4.1.2, 4.1.4, 4.4.1, 4.4.2, and 4.4.3 of this report.

Thomas J. Radue

12/7/2017

Tom Radue, P.E., Barr Engineering Co.
PE #: 20951

Date

I hereby certify that portions of this report were prepared by me or under my direct supervision and that I am a duly Licensed Professional Engineer under the laws of the state of Minnesota, specifically the preliminary design of the Sewage Treatment System and Potable Water Treatment System in Sections 2.4 and 2.5 of this report.

12/7/2017

Jon Minne, P.E., Barr Engineering Co.
PE #: 25080

Date

I hereby certify that portions of this report were prepared by me or under my direct supervision and that I am a duly Licensed Professional Engineer under the laws of the state of Minnesota, specifically the preliminary design of the Stream Augmentation System and Flotation Tailings Basin South Seepage Management System in Section 2.1.3, 2.7, 0, and 4.4.4 of this report.

Anne M. Phares

12/7/2017

Anne Phares, P.E., Barr Engineering Co.
PE #: 42022

Date

I hereby certify that portions of this report were prepared by me or under my direct supervision and that I am a duly Licensed Professional Engineer under the laws of the state of Minnesota, specifically the preliminary design of the Plant Site Stormwater Management Systems in Sections 2.6 and 4.2 of this report.

12/7/2017

Brian LeMon, P.E., Barr Engineering Co.
PE #: 20789

Date

I hereby certify that portions of this report were prepared by me or under my direct supervision and that I am a duly Licensed Professional Engineer under the laws of the state of Minnesota, specifically the preliminary design of the Waste Water Treatment System in Sections 2.3, 4.1.5, and 4.4.5 of this report.

Don E. Richard, P.E. Barr Engineering Co.
PE #: 21193

12/7/2017
Date

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Acronyms, Abbreviations, and Units

Acronym	Stands For
BMP	best management practice
CIP	clean-in-place
Cliffs Erie	Cliffs Erie, LLC
DNR	Minnesota Department of Natural Resources
FSP	Field Sampling Plan
FTB	Flotation Tailings Basin
gpm	gallons per minute
HRF	Hydrometallurgical Residue Facility
LTVSMC	LTV Steel Mining Company
MPCA	Minnesota Pollution Control Agency
MPP	Mine to Plant Pipelines
N/A	not applicable
NA	not available
NPDES	National Pollutant Discharge Elimination System
OSLA	Overburden Storage and Laydown Area
PTM	Permit to Mine
QAPP	Quality Assurance Project Plan
SAP	Sampling and Analysis Plan
SDS	State Disposal System
SPCC	Spill Prevention Control and Countermeasures
SWPPP	Stormwater Pollution Prevention Plan
TSS	Total suspended solids
USGS	U.S. Geological Survey
WWTS	Waste Water Treatment System

1.0 Introduction

This document presents the Water Management Plan - Plant for Poly Met Mining, Inc.'s (PolyMet's) NorthMet Project (Project). The Plant Site includes:

- a Beneficiation Plant for processing ore within existing and new buildings
- the existing Plant Reservoir, pipeline to Colby Lake, and Colby Lake Pumphouse
- a Hydrometallurgical Plant
- a Hydrometallurgical Residue Facility (HRF)
- a Tailings Basin, which consists of the existing former LTV Steel Mining Company (LTVSMC) tailings basin with a new Flotation Tailings Basin (FTB) constructed atop
- an FTB South Seepage Management System and an FTB Seepage Containment System (collectively known as the FTB seepage capture systems) to manage seepage from the Tailings Basin
- a Waste Water Treatment System (WWTS)
- existing and new supporting infrastructure (such as roads, electrical supply, rail connections, Area 1 Shop, Area 2 Shop, and a Sewage Treatment System)
- in reclamation, cover systems on the FTB beaches and pond bottom, to manage seepage and oxygen infiltration

Several specifically defined types of water will be managed at the Plant Site. During the environmental review process, all the following types of water were referred to as "process water:"

- "Process water" is water that has been used in the beneficiation process or hydrometallurgical process.
- "Tailings basin water" is water in the FTB Pond or in pores of the tailings, which includes the following sources: process water resulting from the beneficiation process; treated mine water routed from the WWTS; construction mine water conveyed from the Mine Site; Overburden Storage and Laydown Area (OSLA) runoff; tailings basin seepage collected by the FTB seepage capture systems and returned to the FTB Pond; treated water from the Sewage Treatment System; greensand filter backwash and clean-in-place (CIP) wastes from the WWTS; and precipitation and runoff from within the FTB dams and tributary to the FTB Pond.

- "Tailings basin seepage" is tailings basin water that infiltrates through Flotation Tailings, LTVSMC tailings, and/or Tailings Basin dams and migrates through the base or the external dam faces of the Tailings Basin.

- "HRF water" is water collected and stored within the HRF, which includes the following: process water resulting from the hydrometallurgical process and routed to the HRF as part of the residue slurry, and precipitation and runoff from within the HRF dams.

- "Mine water" is water that has contacted surfaces disturbed by mining activities, such as drainage collected on stockpile liners, pit dewatering, and runoff contacting ore, waste rock, and Mine Site haul road surfaces. Mine water is collected from areas of the Mine Site and conveyed by pipe to the Equalization Basin Area for further conveyance to the Plant Site (either the WWTS or FTB) via the Mine to Plant Pipelines (MPP) or, in later years, used in the flooding of the East and Central Pits.

This document describes the design and operation of water management infrastructure associated with the Plant Site. It also presents operating plans, water quality and quantity monitoring plans, reporting requirements, and adaptive management approaches. Information from this report is included in the Minnesota Department of Natural Resources (DNR) Permit to Mine (PTM) application, the Consolidated Water Appropriation Permit Application, and Minnesota Pollution Control Agency (MPCA) National Pollutant Discharge Elimination System (NPDES) / State Disposal System (SDS) Permit Application. This and other Management Plans have evolved through the environmental review and permitting phases of the Project.

In this document, Flotation Tailings are the Project bulk Flotation Tailings; the FTB is the newly constructed NorthMet Flotation Tailings impoundment; the Tailings Basin is the combined existing former LTVSMC tailings basin and the FTB; the Emergency Basin is the existing former LTVSMC Emergency Basin; and Residue is the Project combined hydrometallurgical residue stored in the HRF.

The Plant Site is shown on Large Figure 1. The area that contains the Beneficiation Plant and the Hydrometallurgical Plant and other auxiliary buildings and facilities is referred to as the Process Plant and is shown on Large Figure 1. Additional features located within the Plant Site, including the WWTS and the Plant Reservoir, are shown on Large Figure 2.

In addition to the management of water at the Plant Site, this document also briefly describes the Plant Site water balance, as explained in detail in Section 6 of the Water Modeling Data Package Volume 2 – Plant Site (Reference (1)) and the quantity of water that will be discharged from the WWTS in operations, reclamation, closure and postclosure maintenance, as modeled in Reference (1).

Several other Management Plans contain information that relates to the water management at the Plant Site. The NorthMet Project Flotation Tailings Management Plan (Reference (2)) includes design details for the FTB. The NorthMet Project Residue Management Plan (Reference (3)) includes design details for the HRF. The NorthMet Project Adaptive Water Management Plan (Reference (4)) contains details of adaptive engineering controls (WWTS and FTB Pond Bottom Cover System) to support compliance with applicable water quality standards at appropriate evaluation points.

Note that some terminology associated with the WWTS has changed since the environmental review process. Changes are associated with the relocation of the mine water treatment trains that were previously at the Mine Site Waste Water Treatment Facility (WWTF) to the Plant Site WWTS, and the relocation of the Mine Site equalization basins, Central Pumping Station, and Construction Mine Water Basin south of Dunka Road. To aid review of documents prepared for the Final Environmental Impact Statement (FEIS) which are referenced in this plan, Attachment A explains the WWTS terminology changes.

1.1 Objective

The objective of the Water Management Plan - Plant is to describe a safe and reliable system for managing the water at the Plant Site in a manner that results in compliance with applicable surface water and groundwater quality standards at appropriate Plant Site compliance points and is in accordance with conditions of Project NPDES/SDS Permits and Water Appropriation Permits.

1.2 Outline

The outline of this document is:

Section 1.0 Introduction, objective, and description of the Plant Site baseline data and existing conditions

Section 0 Description of the water management systems at the Plant Site associated with the Beneficiation Plant, Hydrometallurgical Plant, WWTS, stormwater, and stream augmentation

Section 3.0 Description of key outcomes, including quantity of water required to be appropriated from Colby Lake and estimated water quality

Section 4.0 Description of operational management plans

Section 5.0 Description of water quantity and quality monitoring, including internal waste streams at the Project, stormwater from the Plant Site, Project surface water discharges, surface water, and groundwater. The specifics of monitoring, including specific locations, nomenclature, frequency, and parameters which will be finalized upon completion of the NPDES/SDS and Water Appropriation permitting processes have been incorporated into each of those permit applications.

Section 6.0 Description of monthly and annual reporting requirements including comparison to modeled outcomes and compliance, adaptive management plans, and available mitigations

Because this document has evolved through the environmental review and permitting (NPDES/SDS, Water Appropriation, and PTM) processes, a Revision History is included at the end of the document.

1.3 Existing Conditions

The Plant Site was previously used as a taconite processing facility by LTVSMC; existing features within the Plant Site and from the previous operation are shown on Large Figure 2. Several water management components have been acquired from LTVSMC for use on this Project, including:

- buildings and infrastructure at the Process Plant
- the Plant Reservoir
- the Colby Lake Pumphouse and pipeline from Colby Lake to the Plant Reservoir
- the potable water pipeline from the Potable Water Treatment Plant near the Plant Reservoir to the Area 1 Shops and Area 2 Shops
- the LTVSMC tailings basin and associated water management systems
- the Emergency Basin

Existing flow patterns at the Plant Site are shown on Large Figure 1. Most of the runoff leaving the Process Plant area and the Area 1 Shops and Area 2 Shops flows south to Second Creek.

The LTVSMC tailings basin is unlined and was constructed in stages beginning in the 1950's. It is configured as a combination of three adjacent cells, identified as Cell 1E, Cell 2E, and Cell 2W, shown on Large Figure 1. The LTVSMC tailings basin was developed by first constructing perimeter starter dams and placing tailings from the iron ore process directly on native material. Perimeter dams were initially constructed from rock, and subsequent perimeter dams were constructed of coarse tailings using upstream construction methods. The LTVSMC tailings basin operations were shut down in January 2001 and have been inactive since then except for reclamation activities consistent with a DNR-approved Closure Plan currently managed by Cliffs Erie, LLC (Cliffs Erie).

As shown on Large Figure 1, there are several permitted surface discharge points along the perimeter of the LTVSMC tailings basin. In 2011, temporary pumpback systems were installed near (upstream of) surface discharge stations SD004, SD006, and SD026 to return seepage to the LTVSMC tailings basin pond as part of a short-term mitigation as required by a Consent Decree between Cliffs Erie and the MPCA. Large Figure 1 shows the locations of the existing surface discharge locations and the temporary pumpback systems around the LTVSMC tailings basin.

When first installed, the existing SD026 pumpback system recovered an estimated 200 to 1,400 gallons per minute (gpm) of seepage near the toe of the railroad embankment fill that forms the southern boundary of Cell 1E. System improvements were completed in fall 2014, which has resulted in an increase in recovered flows. The railroad embankment is a massive structure consisting of a mix of small to large diameter rock and overburden. The existing slope angle of the embankment fill averages approximately 1.4 (horizontal) to 1.0 (vertical). The maximum fill height, occurring at seeps 32 and 33 (Section 1.4.3), is approximately 160 feet. Seepage at this location does not currently represent a concern from a slope stability standpoint.

The existing SD026 pumpback system is located approximately 50 to 150 feet downstream (south) of seeps 32 and 33 and upstream of SD026. It consists of an impoundment that blocks the seepage and redirects it into a seepage recovery trench, where it is currently being pumped back into the LTVSMC tailings basin pond. Under the Consent Decree between Cliffs Erie and the MPCA, periodic data collection will continue to assess the efficiency of this pumpback system and its effect on downstream water quality and quantity.

1.4 Baseline Data

Section 4 of Reference (1) describes the baseline climate, land use, geology, surface water, and groundwater data used in the water quantity and quality modeling at the Plant Site. This section provides a summary of the baseline surface water and groundwater data from of Reference (1).

1.4.1 Surface Water Baseline Data

As described in Section 4 of Reference (1), the Plant Site is primarily located within the Embarrass River watershed, upstream of the Embarrass River chain of lakes (Large Figure 3). Approximately 20% of the Plant Site, including the SD026 discharge from the LTVSMC tailings basin and stormwater from the Process Plant area, is tributary to Second Creek, which joins the Partridge River downstream of Colby Lake (Large Figure 3).

Upstream of the U.S. Geological Survey (USGS) gaging station 04017000 (Large Figure 3), the Embarrass River watershed covers approximately 88.3 square miles. The Embarrass River watershed upstream of surface water evaluation point PM-13, which receives approximately 80% of Plant Site runoff covers approximately 111.8 square miles. Tributaries to the Embarrass River located between the Tailings Basin and the Embarrass River that could potentially be affected by the Project include (east to west) Unnamed (Mud Lake) Creek, Trimble Creek, and Unnamed Creek. Other tributaries located between the Tailings Basin and the Embarrass River that are not expected to be affected by the Project include (east to west) Spring Mine Creek, which drains

LTVSMC's former Mine Area 5N, an unnamed creek, and Heikkilla Creek (Large Figure 1 to Large Figure 4). Section 4.4 of Reference (1) provides additional detail on the Embarrass River watershed, and Section 4.5 of Reference (1) and Section 4.4 of Reference (1) provide additional detail on the Partridge River watershed.

Daily flow data is available for the Embarrass River from the USGS gaging station 04017000 from 1942 to 1964. The hydrology data has been analyzed and validated for use on this Project, as described in Section 4.4.1 and Section 4.4.2 of Reference (1). Daily flow is also available for Second Creek from the USGS gaging station 04015500 from 1955 to 1980. The hydrology data from this gage on Second Creek is heavily impacted by mine pit dewatering between the SD026 discharge and the USGS gage (Large Figure 3); therefore, this data has not been used for this Project.

Several surface water locations within the Embarrass River watershed have been monitored for water quality at some time since 2004, with the frequency of monitoring and list of parameters varying by location. These locations are shown on Large Figure 4 and include five monitoring stations on the Embarrass River above the chain of lakes, two locations along Spring Mine Creek, three locations along Unnamed (Mud Lake) Creek, two locations along Trimble Creek, two locations on Unnamed Creek, and six locations in Wynne Lake, Sabin Lake, and Embarrass Lake. The results of baseline monitoring upstream of the Embarrass River chain of lakes is presented in Large Table 4 of Reference (1). Baseline monitoring data from water collected in Wynne Lake, Sabin Lake, and Embarrass Lake is presented in Large Table 6 of Reference (1). Monitoring conducted from 2004 to 2008 generally includes fewer locations and a wider parameter list to characterize the baseline conditions within the Embarrass River watershed. Monitoring from 2008 to 2011 generally focused on a smaller list of constituents and locations to resolve specific issues with the data (e.g., ratio of dissolved to total aluminum, inadequate thallium detection limits). More extensive baseline monitoring was resumed in 2012, including additional locations along Embarrass River tributaries and a larger list of constituents.

Baseline water quality monitoring was performed at location PM-7 (Large Figure 3) in the Second Creek watershed in 2004, 2006, and 2007. Cliffs Erie continues to monitor this location as part of their ongoing NPDES/SDS monitoring requirements; this site is identified as surface discharge station SD026 for NPDES/SDS monitoring (Section 1.4.5). Data collected at PM-7 and SD026 is presented in Large Table 5 of Reference (1).

1.4.2 Groundwater Baseline Data

The quantity of water flowing through the saturated unconsolidated deposits in the vicinity of the Tailings Basin can be estimated based on observed hydraulic gradients and estimates of hydraulic conductivity and aquifer thickness. Inferred groundwater contours within the surficial aquifer are shown on Large Figure 5. These water table contours were developed using a combination of measured groundwater elevations in the monitoring wells surrounding the Tailings Basin, measured pond water elevations, and contours from the Plant Site MODFLOW model of current conditions. The thickness of the surficial deposits and surficial aquifer increases to the north and northwest, from the Tailings Basin to the Embarrass River. The average hydraulic gradient is approximately -0.00444 to the north of Cell 2E, -0.00514 to the north of Cell 2W, and -0.00736 to the west of Cell 2W. Assuming a mean hydraulic conductivity of 13.2 feet per day (ft/day) and a porosity of 0.3, the average linear velocity of groundwater north and west of the Tailings Basin ranges from 0.2 to 0.3 ft/day (Section 4.3.3 of Reference (1)). Locally, actual velocities likely range over several orders of magnitude, due to local variations in hydraulic gradient and hydraulic conductivity of the aquifer materials.

Sixteen existing monitoring wells provide information on groundwater in the surficial deposits in the area of the Plant Site. Some of the wells (GW001 through GW008, with the exception of GW003 and GW004, which have been dry in recent years) have been sampled regularly for more than 10 years as part of the NPDES/SDS permit for the existing LTVSMC tailings basin. The groundwater monitoring well network also includes four wells installed in 2009 specifically for evaluation of baseline conditions for this Project, and three additional wells installed as part of the Cliffs Erie Consent Decree in 2010. Finally, a new well, GW016, was installed in 2013 as a replacement for well GW014 which is believed to be influenced by surface water. Groundwater monitoring data collected from monitoring wells in the surficial deposits are summarized in Large Table 3 in Reference (1). The locations of the groundwater monitoring wells are shown on Large Figure 5.

1.4.3 Tailings Basin Surface Seepage

Surface seepage from the LTVSMC tailings basin generally exits at or near the toe of slope of the existing dams or through existing pipes but is occasionally evident on the side slope of the existing dams slightly above the toe elevation. The surface seepage tends to occur in a random pattern in both vertical and horizontal dimensions along the toe and face of the lower portions of the existing dams.

The surface seeps along the LTVSMC tailings basin where flow was observed from 2007 through 2014 are shown on Large Figure 6 and listed in Large Table 1.

1.4.4 Waste Streams (WSxxx) as Defined in NPDES/SDS Permit MN0054089

The existing NPDES/SDS permit for the LTVSMC tailings basin (MN0054089) includes 12 waste stream stations, summarized in Table 1-1 and shown on Large Figure 6 (with the exception of WS008, WS014, and WS015, which are waste streams for chemical dust suppressants that do not have a specific location).

Table 1-1 Existing NPDES/SDS Permit MN0054089 Waste Stream Stations

Station	Local Name	Status
WS001	NW side of Emergency Basin	Will be inactivated following construction of the FTB Seepage Containment System; existing permit requirements not anticipated to carry into the Project NPDES/SDS Permit.
WS002	NW Seepage Collection Return Pumping to TB	No longer active because this waste stream was associated with LTVSMC operations; existing permit requirements not anticipated to carry into the Project NPDES/SDS Permit.
WS003	NE Seepage Collection Return Pumping to TB	No longer active because this waste stream was associated with LTVSMC operations; existing permit requirements not anticipated to carry into the Project NPDES/SDS Permit.
WS006	Biosolids transferred to POTW	No longer active because this waste stream was associated with LTVSMC operations; existing permit requirements not anticipated to carry into the Project NPDES/SDS Permit.
WS007	Treated Sewage to Emergency Basin	No longer active because this waste stream was associated with LTVSMC operations and their former sewage treatment plant, which will not be used; existing permit requirements will not carry into the Project NPDES/SDS Permit.
WS008	Ligninsulfonate applied for Dust Control	No specific location; dependent on location of application. No longer active; separate permit requirements for dust control are anticipated in the Project NPDES/SDS Permit.
WS009	Culvert under RR grade, NE side of Cell 1E	Monitoring of flow and water quality; existing permit requirements anticipated to carry into the Project NPDES/SDS Permit until East Dam cuts off this inflow.
WS011	Tailings Basin Seep 1	Seep currently dry; location will be disturbed by construction of HRF; existing permit requirements not anticipated to carry into the Project NPDES/SDS Permit.
WS012	Tailings Basin Seep 2	Seep currently dry; location will be disturbed by construction of HRF; existing permit requirements not anticipated to carry into the Project NPDES/SDS Permit.
WS013	Tailings Basin Seep 3	Seep currently dry; location will be disturbed by construction of HRF; existing permit requirements not anticipated to carry into the Project NPDES/SDS Permit.
WS014	Coherex applied for Dust Control	No specific location; dependent on location of application. No longer active; separate permit requirements for dust control are anticipated in the Project NPDES/SDS Permit.
WS015	Nalco Dust-Bas 8803 for Dust Control	No specific location; dependent on location of application. No longer active; separate permit requirements for dust control are anticipated in the Project NPDES/SDS Permit.

1.4.5 Surface Discharges (SDxxx) as Defined in NPDES/SDS Permit MN0054089 and MN0042536

The existing NPDES/SDS permit for the LTVSMC tailings basin (MN0054089) includes five surface discharge stations, summarized in Table 1-2. The existing NPDES/SDS permit for the Hoyt Lakes Mining Area (MN0042536) includes one surface discharge station relevant to the Project, summarized in Table 1-3. All six of these stations are shown on Large Figure 6. Three of these existing surface discharge stations (SD004, SD005, and SD006) will be combined into the internal waste stream of tailings basin seepage collected by the FTB Seepage Containment System. Only surface discharge station SD026, or a location near it, is expected to be included in future permit requirements as a surface water discharge station for this Project.

Table 1-2 Existing NPDES/SDS Permit MN0054089 Surface Discharge Stations

Station	Local Name	Status
SD001	Northwest Seepage Collection Ditch	This location is no longer considered a surface discharge station; permit requirements not anticipated to carry into the Project NPDES/SDS Permit.
SD002	Northeast Seepage Collection Ditch	This location is no longer considered a surface discharge station; permit requirements not anticipated to carry into the Project NPDES/SDS Permit.
SD004	Tailings Basin Cell 2W Seep A	Seepage at this location will be collected by the FTB Seepage Containment System and will be part of a new internal waste stream included in the Project NPDES/SDS Permit.
SD005	Tailings Basin Cell 2W Seep B	Seepage at this location will be collected by the FTB Seepage Containment System and will be part of a new internal waste stream included in the Project NPDES/SDS Permit.
SD006	Power Line Access Road Culvert	Seepage at this location will be collected by the FTB Seepage Containment System and will be part of a new internal waste stream in the Project NPDES/SDS Permit.

Table 1-3 Existing NPDES/SDS Permit MN0042536 Surface Discharge Stations

Station	Local Name	Status
SD026	Second Creek headwaters	Seepage upstream of this location will be collected by the FTB South Seepage Management System and will be part of a new internal waste stream in the Project NPDES/SDS Permit. Second Creek, near SD026, will be a surface water discharge station for the WWTS.

1.4.6 Surface Waters (SWxxx) as Defined in NPDES/SDS Permit MN0054089

Existing NPDES/SDS Permit MN0054089 has three surface water stations, summarized in Table 1-4 and shown on Large Figure 4. These monitoring stations are expected to be included in Project monitoring (Section 5.0).

Table 1-4 Existing MN0054089 Surface Water Monitoring Stations

Station	Local Name	Status
SW003	Unnamed Creek tributary to Embarrass River	This location is the same as PM-11.
SW004	Embarrass River at CR620	This location is the same as PM-12.
SW005	Embarrass River at Hwy 135 Bridge	This location is the same as PM-13.

2.0 Water Management System Design

Water at the Plant Site will be managed to provide adequate water quantity and quality for operations and to control impacts to off-site water resources (refer to Large Figure 2). Water used in the operation of the Beneficiation and Hydrometallurgical Plants will be recycled through the FTB and the HRF, and Plant Site stormwater within the FTB and the HRF will be collected for use in mineral processing. Stormwater within the Process Plant area, Area 1 Shops, and Area 2 Shops will be kept separate from process water, mine water, tailings basin water, tailings basin seepage, and HRF water, and will be routed off-site.

The Beneficiation Plant will use water as a means to move the ground ore, concentrate, and Flotation Tailings in beneficiation processes, and the Hydrometallurgical Plant will use water as a means to move concentrate, precipitates, and Residue in the hydrometallurgical processes. Process water from the Beneficiation Plant will be pumped with Flotation Tailings to the FTB. Water will be pumped from the Beneficiation Plant to the Hydrometallurgical Plant with the concentrate, and from the Hydrometallurgical Plant to the HRF with the Residue. Water required by the Beneficiation Plant and the Hydrometallurgical Plant will primarily be drawn from the FTB Pond and the HRF Pond, respectively, with make-up water pumped from the Plant Reservoir, as needed.

The FTB will serve as the primary reservoir for water used at the Beneficiation Plant. In addition to receiving process water from the Beneficiation Plant in the Flotation Tailings slurry, it will also receive mine water from the Mine Site, directly (construction mine water and OSLA runoff) and indirectly from the WWTS (treated mine water), as well as treated effluent from the Sewage Treatment System. Tailings basin seepage will be collected around the Tailings Basin by the FTB seepage capture systems. Because the FTB seepage capture systems will cut off seepage from the existing LTVSMC tailings basin that recharges downstream tributaries, the Project will augment these streams to avoid hydrologic impacts to them. During Project operations, the Plant Site will typically be a net water consumer, with discharge to the environment limited to what is necessary for stream augmentation; tailings basin seepage will be treated at the WWTS before being discharged for stream augmentation.

The Plant Reservoir is a 10-million-gallon-capacity concrete structure that is fed by water from Colby Lake. It will supply:

- make-up water for the Beneficiation and Hydrometallurgical Plants, if additional water is needed beyond that supplied by the FTB Pond and the HRF Pond, respectively

- the Potable Water Treatment System – after use, this water reports to the new Plant Site Sewage Treatment System or the septic systems at the Area 1 Shop or Area 2 Shop

- service water used for cooling, seals, air emission control systems, and other applications that require clean water – after use, this water reports to the Beneficiation or Hydrometallurgical Plant water systems
- fire water – only used in an emergency
- water for dust control
- miscellaneous Project water needs for construction and operation, including filling the FTB Pond prior to startup

The following sections describe the major components of the Plant Site water management systems.

2.1 Beneficiation Plant

Within the Beneficiation Plant, process water carries the ground ore and concentrate through the ore grinding and flotation steps, and then transports the Flotation Tailings to the FTB. To the extent possible, water that is used to transport Flotation Tailings to the FTB will be recycled to the Beneficiation Plant; however, some losses will occur through evaporation, seepage, and storage within the pores of the deposited Flotation Tailings.

2.1.1 Beneficiation Plant Water Balance

The Beneficiation Plant water balance is detailed in Section 6.1.1 of Reference (1) and summarized below. Most of the water used in the Beneficiation process is decanted tailings basin water from the FTB Pond. This water supply includes mine water that is piped to the FTB from the Mine Site through the MPP and treated mine water from the WWTS (Reference (5)). A relatively small amount of make-up water is pumped from the Plant Reservoir to meet the full demand of the Beneficiation Plant. The Beneficiation Plant discharges to the FTB in two methods: directly to the pond for subaqueous disposal of the Flotation Tailings and spigotting of Flotation Tailings along the dams to construct the beaches. The split between these two methods is dependent on the geometry of the basin, so that the beaches and pond rise at the same rate, and therefore the rate from each method varies over time. Table 2-1 summarizes the main flows of the Beneficiation Plant water balance at three different years in the life of the project: Mine Year 2 when only Cell 2E is operational, Mine Year 10 when Cell 2E and Cell 1E are combined (as Cell 1/2E), and Mine Year 20 when operations are coming to a close prior to the FTB being prepared for reclamation.

Table 2-1 Beneficiation Plant Water Balance

Flow Stream	Mine Year 2(1)		Mine Year 10(2)		Mine Year 20(3)	
	Average Annual Flow (gpm)(4)	90th Percentile Flow (gpm)(4)	Average Annual Flow (gpm)(4)	90th Percentile Flow (gpm)(4)	Average Annual Flow (gpm)(4)	90th Percentile Flow (gpm)(4)
Inflows to Beneficiation Plant						
From FTB Pond	12,273	13,017	13,146	13,167	12,738	13,165
From Plant Reservoir (make-up water)	897	1,618	24	62	432	1,023
Other Inflows(5)	652	652	652	652	652	652
Outflows from Beneficiation Plant						
To FTB Pond	8,707	9,325	9,372	9,925	5,272	6,172
To FTB beaches	5,062	5,699	4,397	4,969	8,497	9,428
Other Outflows(6)	53	53	53	53	53	53

(1) Mine Year 2 represents 1 year < time ≤ 2 years
(2) Mine Year 10 represents 9 years < time ≤ 10 years
(3) Mine Year 20 represents 19 years < time ≤ 20 years
(4) Source of data: Section 6.1.1 of Reference (1). For the Average Annual Flow, the value represents the annual average of the mean model results for a given year. For the 90th Percentile Flow, the values represent the annual average of the 90th percentile for the given year.
(5) Other inflows include water in ore, water in reagents, gland water, and miscellaneous water inputs that result in minor individual flows.
(6) Other outflows include evaporation within the Beneficiation Plant and other minor flows.

2.1.2 Flotation Tailings Basin (FTB)

Flotation Tailings are transported to the FTB as a mixture of Flotation Tailings and process water. The Flotation Tailings settle out in the FTB, and tailings basin water is returned to the Beneficiation Plant for reuse. Construction mine water and OSLA runoff is routed to the FTB via the Construction Mine Water Pipeline. Mine water to be treated is routed to the WWTS via the High Concentration Mine Water Pipeline and Low Concentration Mine Water Pipeline and after treatment is discharged to the FTB (Section 2.1 of Reference (5)). Other water inputs to the FTB include tailings basin seepage collected by the FTB seepage capture systems, treated water from the Sewage Treatment System, greensand filter backwash and CIP wastes from the WWTS, and precipitation and runoff from within the FTB dams and tributary to the FTB Pond. The design and operation of the FTB is described in Reference (2). Water management elements for the Tailings Basin are shown on Large Figure 7.

2.1.3 Flotation Tailings Basin (FTB) South Seepage Management System

The FTB South Seepage Management System will collect tailings basin seepage from the south side of Tailings Basin Cell 1E. Bedrock and surface topography create a narrow valley at the headwaters of Second Creek in this location. Due to this topography, it is expected that essentially all seepage from the Tailings Basin to the south emerges as surface seeps within a short distance from the dam toe.

As described in Section 1.3, a temporary surface seepage pumpback system was installed in 2011 near the existing surface discharge station SD026 as part of a short-term mitigation required by a Consent Decree between Cliffs Erie and the MPCA. This system will become the FTB South Seepage Management System. The temporary pumpback system collects surface seepage from the south side of Cell 1E just upstream of SD026 (Large Figure 6 and Section 1.4.5). The pumpback system consists of a cutoff dam and trench placed approximately 200 to 250 feet downstream of the seepage face. A seep collection sump, pump, and pipe system route this seepage back into the Tailings Basin Cell 1E Pond.

Water from the FTB South Seepage Management System will go to the FTB Pond and/or to the WWTS. Drawings in Attachment B show the current design of the SD026 seepage pumpback system, with the location shown on Large Figure 8. PolyMet and Cliffs Erie are currently working together to assess the performance of this system. PolyMet has committed to collecting essentially all of the seepage from the Tailings Basin in this area and the design or operation will be modified if necessary.

2.1.4 Flotation Tailings Basin (FTB) Seepage Containment System

The FTB Seepage Containment System will collect tailings basin seepage along the toes of the north, northwest, west, and east Tailings Basin dams, as shown on Large Figure 8. The FTB Seepage Containment System is designed to intercept the seepage that emerges as surface water near the toes of the dams (within several hundred feet) and the seepage that remains in the ground as groundwater, as well as surface runoff from the small watershed between the dam toe and the containment system. This containment system will replace the SD006 and SD004 pumpback systems installed as short-term mitigation in 2011.

The FTB Seepage Containment System consists of a cutoff wall (a low permeability hydraulic barrier) placed into the existing surficial deposits, with a seepage collection system installed on the upgradient side (Figure 2-1). The collection system has a collection trench filled with granular drainage material and a perforated drain pipe located near the bottom of the trench. Vertical risers extending above ground surface from the drain pipe will collect surface seepage discharging upgradient of the containment system. The containment system also includes a series of subsurface gravity drain pipes, sumps, and lift stations installed between the cutoff wall and the toe of the FTB dams. A schematic plan view of the containment system alignment is shown on Figure 2-2.

During operations, a portion of the collected seepage will be recycled to the FTB Pond for reuse in the beneficiation process, and a portion will be routed to the WWTS for treatment prior to discharge at surface water discharge outfalls. Collected seepage will be distributed so as to meet stream augmentation requirements and manage the FTB pond level (Section 2.3 and 2.7). Water collected on the western and northern sides of the Tailings Basin will be conveyed to one of two main pump stations, centrally located and adjacent to each other on the northern side of the Tailings Basin (collectively referred to as the pump station). From there it will be routed back to the FTB Pond via one of the pump stations, or to the WWTS for treatment and discharge via the second pump station, depending on the needs of the Project. Water collected on the eastern side of the Tailings Basin will be routed back to the FTB Pond by a containment system pump station located on the east side of the Tailings Basin. Pumps in the containment system will be operated using level sensors so that a desired water level is maintained in the sumps and lift stations.

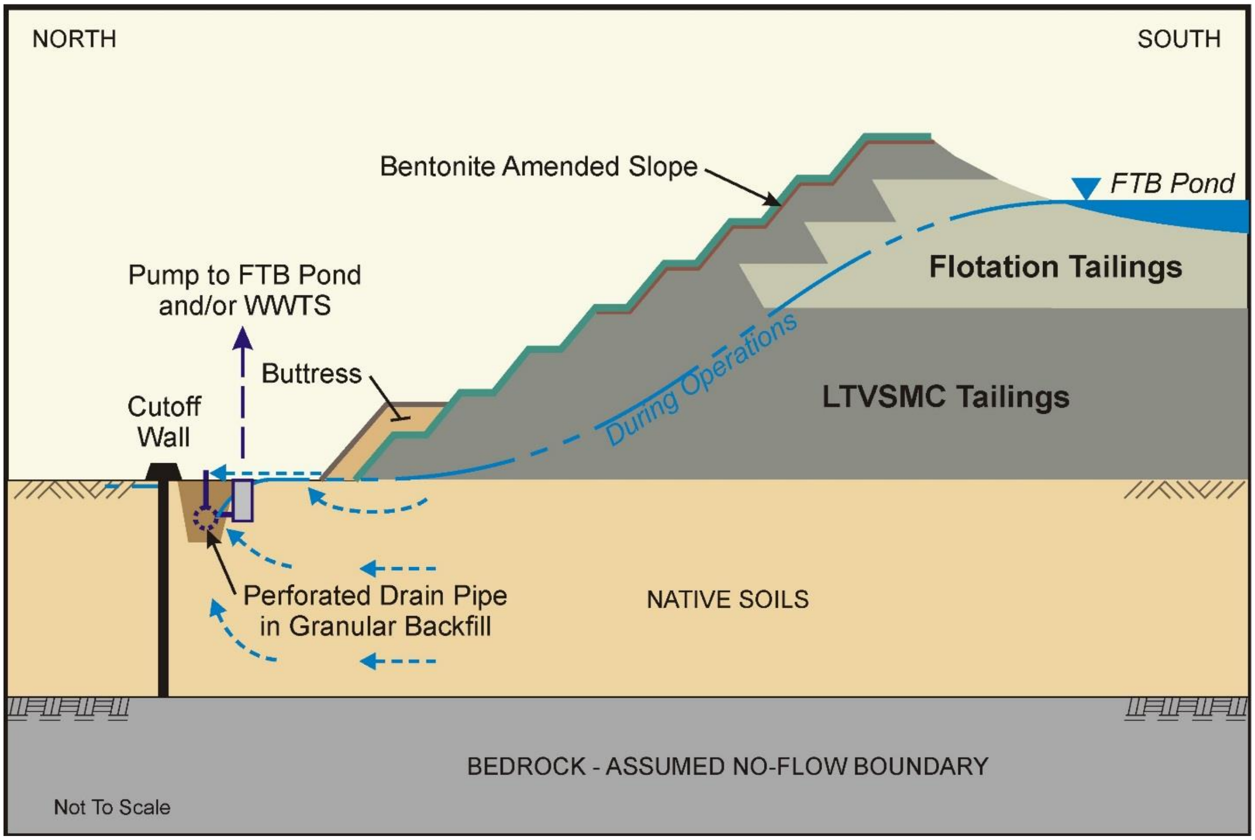

Figure 2-1 Conceptual Cross-Section: FTB Seepage Containment System

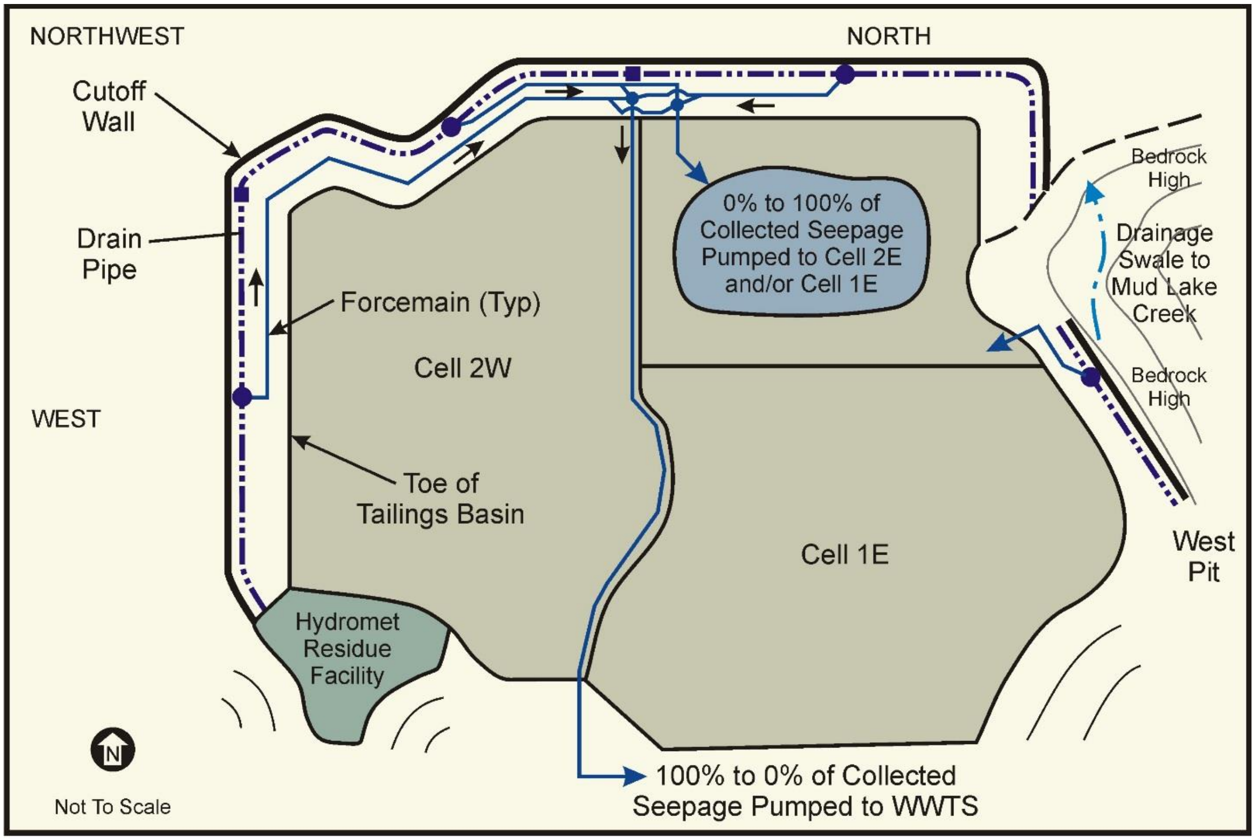

Figure 2-2 Conceptual Plan View: FTB Seepage Containment System

The containment system will collect the tailings basin seepage and draw down the water table on the Tailings Basin side of the cutoff wall, thereby maintaining an inward gradient along the cutoff wall and mitigating the potential for seepage to pass through the cutoff wall (i.e., leakage through the cutoff wall will be inward into the containment system). The cutoff wall will be extended to bedrock in order to minimize groundwater capture from downgradient of the system, thereby limiting the amount of water to be pumped and treated. The containment system alignment crosses a number of wetlands. Anticipated wetland impacts have been accounted for between the FTB and the FTB Seepage Containment System and downgradient of the FTB Seepage Containment System, as documented in the wetland permit applications.

Permit Application Support Drawings for the FTB Seepage Containment System are provided in Attachment C. The system will be designed and constructed in accordance with applicable requirements of Minnesota Rules, part 6132.2500, subpart 2. The choice of a slurry wall (often synonymous with cutoff wall), a geomembrane barrier, a natural clay barrier, or other type of hydraulic barrier is made on a project-specific basis, weighing factors such as characteristics of the surficial deposits to be excavated, rate of construction desired, and availability of construction materials. For this system, a variant of slurry wall technology (bentonite soil-filled trench; cutoff wall) was selected. Along the alignment of the containment system shown on the FTB Seepage Containment System Permit Application Support Drawings (Attachment C), the surficial deposits are up to 40 feet deep. Cutoff walls this deep can be constructed in-situ using continuous construction techniques which greatly reduce the need to dewater the surrounding soils. In the event that subsurface obstructions (i.e., cobbles or boulders) interfere with in-situ construction, then some open trenching will be used along these limited segments of the system and/or the system alignment will be modified to bypass the obstruction. Much of the collection trench can also be constructed using in-situ techniques; for short sections of the collection trench, particularly where manholes are required, some open excavations will be required. During construction, surface water in the area between the FTB Seepage Containment System and the Tailings Basin will continue to flow to the surrounding wetlands through temporary culverts in the FTB Seepage Containment System's access road; these culverts will be removed or sealed prior to the start of operations.

The containment system design is based on data obtained from geotechnical and hydrogeologic evaluations performed at the site. Prior to construction of the containment system, additional subsurface exploration work will be performed to confirm the subsurface conditions along the containment system alignment. Although the existing subsurface data do not show the presence of cobbles and boulders along the proposed alignment, the final alignment will be adjusted if needed to minimize impacts to construction caused by cobbles or boulders.

The expected capture efficiency of the FTB Seepage Containment System has been assessed by reviewing industry use of similar systems, groundwater modeling, and hydrogeologic assessment. The combined use of a cutoff wall and a collection system is acknowledged by academic, governmental, and industry authorities and by construction markets as detailed in Attachment D of Reference (6). This type of containment system is commonly used at facilities where there is a need to manage groundwater flow and surface seepage, such as landfills, tailings basins, and paper sludge disposal facilities.

A groundwater flow model was developed to assess the ability of the proposed containment system to collect seepage near the toe of the Tailings Basin dams and to estimate the average flow rate to the collection system (Attachment D). This modeling predicts that the cutoff wall and collection trench system will accomplish the water resource objectives (i.e., meet applicable surface water standards in the three Embarrass River tributaries, meet applicable groundwater standards at the property boundary, and meet MPCA criteria with regard to sulfate at the three tributary headwaters, at PM-13, and at the Embarrass River) (Attachment A of Reference (1)). Capture efficiency depends on how much flow enters the bedrock, so the groundwater flow modeling, described in Attachment D, estimated capture efficiency for three different thicknesses of the bedrock fracture zone: 25 feet, 50 feet, and 100 feet. Results show that the containment system will collect all of the seepage along the north and northwest flow paths under all three bedrock fracture zone thicknesses considered. Performance along the west flow path depends on the thickness of the upper fractured zone of the bedrock. The containment system will collect all of the seepage along the west flow path for bedrock fracture zone thicknesses of 25 feet and 50 feet. For a bedrock fracture zone 100 feet thick, up to 1% of the total seepage to this toe (7-8 gpm) is estimated to bypass the system. Given that site-specific bedrock fracture data indicate that the amount of fracturing decreases significantly in the upper 20 feet of the bedrock (Section

3.2.1 of Reference (7)), the estimates for the scenarios with the fracture zone assumed to be 25 and 50 feet are the most applicable, while the estimate for a bedrock fracture zone 100 feet thick should be considered conservative.

Hydrologic assessment was used to evaluate the performance of the eastern section of the FTB Seepage Containment System, which was not modeled. Along most of the eastern side of the Tailings Basin, elevated bedrock will prevent groundwater seepage. In the area of the East Dam, groundwater flow is currently from the east toward the Tailings Basin because of the high hydraulic head in the high ground east of the Tailings Basin. Construction of the East Dam and the tailings deposition behind the dam will result in hydraulic heads that will allow water from a limited area at the eastern edge of the FTB to flow east towards the toe of the East Dam. The hydraulic gradient across the containment system cutoff wall will be inward, toward the Tailings Basin, because the hydraulic heads further east of the dam (near Spring Mine Lake) are higher than the ground surface near the toe of the dam, and because the collection system drain pipe will be at an elevation lower than the drainage swale, located to the east (Section 2.7). Overall, based on the existing topography, inward hydraulic gradients, the design of the containment system, and the construction of the drainage swale to manage surface runoff, the eastern section of the FTB Seepage Containment System is expected to have a capture efficiency of 100%.

2.2 Hydrometallurgical Plant

Within the Hydrometallurgical Plant, water is used to extract and isolate metals and to transport the Residue to the HRF. To the extent possible, water that transports Residue to the HRF will be returned to the Hydrometallurgical Plant; however, losses will occur during processing and through evaporation or storage within the pores of the deposited Residue at the HRF. Make-up water will be supplied from the Plant Reservoir. PolyMet expects that the Hydrometallurgical Plant will be operational approximately two to four years after mining commences, which corresponds to Mine Years 3 to 5. However, the decision to process concentrates through the Hydrometallurgical Plant will be based on equipment maintenance schedules, customer requirements, and overall Project economics.

2.2.1 Hydrometallurgical Plant Water Balance

The water used in the hydrometallurgical process consists mainly of HRF water and make-up water from the Plant Reservoir. Because there are significant water losses through evaporation during processing, the demand for make-up water is much higher for the Hydrometallurgical Plant than for the Beneficiation Plant. The Hydrometallurgical Plant discharges process water to the HRF to transport the Residue. Table 2-2 summarizes the main flows in the Hydrometallurgical Plant water balance at three different years in the life of the project: Mine Year 5 which is early in the HRF life, Mine Year 10 and Mine Year 20 when operations are coming to a close prior to the HRF being prepared for reclamation. Details of the Hydrometallurgical Plant water balance are provided in Section 6.1.3 of Reference (1).

Table 2-2 Hydrometallurgical Plant Water Balance

Flow Stream	Mine Year 5(1)		Mine Year 10(2)		Mine Year 20(3)	
	Average Annual Flow (gpm)(4)	90th Percentile Flow (gpm)(4)	Average Annual Flow (gpm)(4)	90th Percentile Flow (gpm)(4)	Average Annual Flow (gpm)(4)	90th Percentile Flow (gpm)(4)
Inflows to Hydrometallurgical Plant						
Into Hydrometallurgical Plant from HRF Pond	182	219	172	203	163	197
Plant Reservoir Make-Up Water	224	252	235	262	244	276
Other Inflows(5)	36	36	36	36	36	36
Outflows from Hydrometallurgical Plant						
Discharge from Hydrometallurgical Plant to HRF	223	223	223	223	223	223
From Hydrometallurgical Plant with Concentrate	48	48	48	48	48	48
Other Outflows(6)	267	267	267	267	267	267

(1) Mine Year 5 represents 4 year < time ≤ 5 years
(2) Mine Year 10 represents 9 years < time ≤ 10 years
(3) Mine Year 20 represents 19 years < time ≤ 20 years
(4) Source of data: Section 6.1.3 of Reference (1). For the Average Annual Flow, the value represents the annual average of the mean model results for a given year. For the 90th Percentile Flow, the values represent the annual average of the 90th percentile model results for the given year.
(5) Other inflows include gland water and water in reagents; each of which result in minor individual flows.
(6) Other outflows include Hydrometallurgical Plant vents, evaporation within the Hydrometallurgical Plant, water in the product, and chemically consumed water; each of which result in minor individual flows.

2.2.2 Hydrometallurgical Residue Facility (HRF)

Residue is transported to the HRF as a mixture of solids and process water. The solids settle out in the HRF, and the HRF water is returned to the Hydrometallurgical Plant for reuse. The HRF is a lined facility with a leakage collection system that returns any leachate to the HRF Pond. The design and operation of the HRF is described in Reference (3); details about water management within the HRF provided in Section 4 of Reference (3).

2.3 Waste Water Treatment System (WWTS)

The WWTS will treat mine water to meet Project objectives before routing it to the FTB and will treat collected tailings basin seepage to meet applicable surface water discharge limits before routing it to be used as stream augmentation. The WWTS will be located near the FTB as shown on Large Figure 8.

As described in the Water Management Plan – Mine Site (Reference (5)), construction mine water and mine water are collected from areas of the Mine Site and conveyed by pipe to the Equalization Basin Area for further conveyance to the Plant Site via the MPP or used to flood the East and Central Pits in the second half of operations. Construction mine water and OSLA runoff will be routed to the FTB Pond. Other mine water will be segregated into two separate flows based on the quality and quantity – one with low volume and relatively high concentrations of dissolved constituents, and one with high volume and relatively low concentrations of dissolved constituents. High concentration mine water will report to chemical precipitation treatment units at the WWTS, and the low concentration mine water will report to membrane filtration treatment units at the WWTS. Treated mine water will then be blended together at the WWTS and routed to the FTB Pond.

Tailings basin seepage will be treated using a reverse osmosis unit or similar membrane separation technology designed to meet applicable effluent limitations and water quality standards, as determined through the NPDES/SDS Permit process. The details of the design of the WWTS are included in Reference (8). The design and treatment processes of the WWTS can be modified as needed. Because the design of the WWTS can be adapted as modeling and monitoring require, the details of the design are included in the Adaptive Water Management Plan (Reference (4)).

Treated tailings basin seepage from the WWTS will be discharged to three tributaries around the Tailings Basin (Trimble Creek, Unnamed Creek, and Second Creek), as described in Section 6.6 of Reference (1). The WWTS discharge will be distributed to wetlands in the headwater areas of Unnamed Creek and Trimble Creek (outside the FTB Seepage Containment System) and to the headwater area of Second Creek near SD026. Discharging to the downstream side of the containment system will most closely mimic existing conditions, where seepage from the Tailings Basin emerges in the wetland areas north and west of the basin. The WWTS discharge will be distributed to these tributaries in proportion to the flow required to prevent significant hydrologic impacts. See Section 2.7 for more details on stream augmentation.

Starting in Mine Year 11, a portion of the treated effluent from the WWTS and will be routed to the East Pit during pit flooding (Reference (5)).

2.4 Plant Site Sewage Treatment System

PolyMet will operate a Sewage Treatment System at the Plant Site to manage sewage in accordance with applicable regulations. Sewage generated at the Mine Site will be transported to the Plant Site for treatment and disposal. Sewage generated at the Area 1 Shops and Area 2 Shops will be managed separately by septic systems in each area.

The Plant Site Sewage Treatment System will consist of a refurbished existing sewage collection system (Section 2.4.1) and new stabilization ponds (Section 2.4.2), which will replace the existing mechanical sewage treatment plant. The Preliminary Sewage Treatment System Facility Plan, which provides the design basis of this system, is included in Attachment E. The design and operation of the facility will be in accordance with state requirements.

2.4.1 Sewage Collection System

The existing sewage collection system will be refurbished to meet current regulatory standards to properly transport sewage to the stabilization ponds. Existing piping will be refurbished to minimize infiltration and inflow (I/I) to the collection system. New piping and associated infrastructure will also be added to connect new Plant Site facilities to the collection system and the stabilization ponds. In addition to sewage, sedimentation tank and filter backwash waste from the Plant Site Potable Water Treatment Plant (as described in Section 2.5) will be routed to the sewage collection system.

2.4.2 Stabilization Ponds

Stabilization ponds will be constructed to treat Project sewage. Approximate locations of the stabilization ponds, which will be located west of the proposed Hydrometallurgical Plant, are shown on Large Figure 2.

The stabilization ponds will be designed in accordance with the MPCA Recommended Pond Design Criteria (Reference (9)) and will include lined ponds and a controlled discharge. The proposed stabilization ponds will consist of two primary ponds and one secondary pond with operating depths of approximately four feet. The secondary pond will discharge to the FTB Pond via a pump station. The controlled discharge will occur in the spring and fall of each year. Each controlled discharge will typically last 10 to 14 days, depending on weather conditions. Sewage Treatment System treated water will represent approximately 0.1% of the inflow to the FTB Pond (Section 6.1 of Reference (1)).

2.5 Potable Water Treatment Plant

Potable water is needed to supply drinking water to the Plant Site buildings, including the Area 1 Shops, Area 2 Shops, and the Administration Building. In addition to drinking water, the primary potable water use at the Plant Site will be restrooms and showers. PolyMet will either refurbish the existing Potable Water Treatment Plant, which would include upgrading the mechanical systems within the building, or demolish the existing plant to construct a new plant in the same location; this decision will be made in detailed design. The distribution system within the Plant Site will be evaluated in detailed design to determine if additional work is needed to the system.

Raw water will be supplied to the Potable Water Treatment Plant from the Plant Reservoir which will receive Colby Lake water, via the Colby Lake Pipeline. Before distribution, PolyMet will treat the Plant Reservoir water at the Potable Water Treatment Plant. Components of the Potable Water Treatment Plant will include clarification, flocculation, sedimentation, filtration, and disinfection. The Potable Water Treatment Plant will meet requirements established by Minnesota Department of Health and U.S. Environmental Protection Agency (USEPA) for a public, non-transient, non-community water supply system. Distribution systems will be constructed or refurbished to comply with applicable plumbing codes. Sedimentation tank and filter backwash waste from the Potable Water Treatment Plant will be routed to the Sewage Treatment System.

2.6 Stormwater Management

Three types of stormwater will be managed at the Plant Site:

- Non-contact stormwater is precipitation and runoff that contacts natural, stabilized, or reclaimed surfaces and has not been exposed to mining activities, construction activities (as defined in Minnesota Rules, part 7090.0080, subpart 4) or industrial activities (as defined in Minnesota Rules, part 7090.0080, subpart 6). This includes runoff from natural areas and from on-site features constructed of overburden once stabilized with permanent cover, but does not include runoff from new Tailings Basin dam exterior slopes or HRF dam exterior slopes (if constructed of exposed significant materials).

- Construction stormwater is associated with construction activities (as defined in Minnesota Rules, part 7090.0080, subpart 4). This includes precipitation, runoff, and dewatering water from construction areas at the Plant Site.

- Industrial stormwater is associated with industrial activities (as defined in Minnesota Rules, part 7090.0080, subpart 6). This includes precipitation and runoff from new Tailings Basin dam exterior slopes (where not captured by the FTB seepage capture systems), HRF dam exterior slopes (if constructed of exposed significant materials), and other industrial areas at the Plant Site that is composed entirely of stormwater and not combined with other water types (e.g., tailings basin seepage, tailings basin water, HRF water).

Over most of the Process Plant area, Area 1 Shops, Area 2 Shops, stormwater will be separated from process water, mine water, tailings basin water, tailings basin seepage, and HRF water using dikes, ditches, and storm sewers. The design basis for the Plant Site stormwater system is described in Attachment F, and the Plant Site Stormwater Permit Application Support Drawings (Plant Site Stormwater Drawings) are provided in Attachment G. The majority of the stormwater associated with the Tailings Basin will be collected either by the FTB seepage capture systems or within the FTB Pond and managed as tailings basin water or tailings basin seepage rather than as stormwater. In some areas, stormwater associated with runoff from the exterior slopes of the Tailings Basin and HRF will be diverted from the FTB Seepage Containment System and managed as industrial stormwater.

2.6.1 Stormwater Modeling

The flows and volumes from stormwater ditches, pipes, and sedimentation ponds were modeled using XP-SWMM, Version 12.4, which is a software package used to model stormwater, sanitary water, and river systems. The stormwater model was developed to evaluate the existing stormwater management system and identify areas where additional features are required or where the capacity of the existing features is not sufficient. Existing and proposed stormwater management features were evaluated using the 10-year, 24-hour nested distribution storm events with some features evaluated and sized to avoid hazards up to the 100-year, 24-hour storm. Rainfall depths for the Plant Site were obtained from NOAA's Atlas 14 precipitation frequency estimates (Reference (10)).

2.6.2 Existing Stormwater Conditions

The watersheds associated with the Plant Site are illustrated on Large Figure 3. The watershed divide between the Embarrass River watershed and the Partridge River watershed cuts across the northern portion of the Process Plant area. Water in the Embarrass River watershed generally flows to the north and water in the Partridge River watershed generally flows to the south. The Tailings Basin is mostly within the Embarrass River watershed and the Process Plant area is mostly within the Partridge River watershed (specifically the Second Creek subwatershed). The Process Plant area is further divided into two subwatershed areas within the Second Creek subwatershed: the West Plant subwatershed and the East Plant subwatershed.

Stormwater currently flows to the interior of the existing LTVSMC tailings basin from a subwatershed area bounded by the perimeter dam crests, high ground east of Cell 2E, high ground southeast of Cell 1E, and the Spring Mine Lake subwatershed east of Cell 1E. Stormwater runoff from the west and north dam exteriors flows west-northwest toward Unnamed Creek and north towards Trimble Creek and Unnamed (Mud Lake) Creek. Stormwater originating from the Cell 2W south dam exterior flows south and west to the Emergency Basin and Unnamed Creek. Stormwater from high ground southeast of Cell 1E flows south toward Second Creek in the Partridge River watershed. Existing stormwater runoff flow patterns associated with the Tailings Basin are depicted on Large Figure 1.

Stormwater from the West Plant is currently routed through a series of ditches and culverts to a large stormwater ditch in the southwest corner of the Plant Site before being discharged off-site to a system of ditches tributary to Second Creek.

Stormwater from the East Plant is routed through a series of ditches and culverts before being discharged off-site to a system of ditches tributary to Second Creek.

The Area 1 Shops and Area 2 Shops are also located within the Second Creek subwatershed. Stormwater from these areas generally flows from the areas as dispersed sheetflow or is routed through a series of ditches and culverts to tributaries of Second Creek.

2.6.3 Stormwater Management and Infrastructure during Operations

Stormwater at the Plant Site will be managed in accordance with applicable regulations. This will include use of best management practices (BMPs), including properly designed stormwater infrastructure. Stormwater infrastructure will be constructed or upgraded from existing conditions as necessary prior to commencement of Project operations.

The following sections describe stormwater management and infrastructure associated with the various portions of the Plant Site during Project operations.

2.6.3.1 Tailings Basin

During operations, relatively little precipitation or runoff associated with the Tailings Basin (Large Figure 7) will be managed as stormwater. Most precipitation and runoff will be:

- collected within the FTB Pond or within Tailings Basin Cell 2W and managed as tailings basin water
- collected by the FTB seepage capture systems and managed with tailings basin seepage

The portions of the Tailings Basin where precipitation and runoff will be managed as industrial stormwater are as follows:

- Runoff from the Tailings Basin Cell 2W south dam exterior will initially flow south to the existing Emergency Basin or west toward the Unnamed Creek subwatershed. After construction of the HRF, runoff from the southeastern portion will flow south and be routed through the West Plant stormwater system (Section 2.6.3.3) and runoff from the southwestern portion will be routed west and managed with runoff from the HRF dam exteriors (Section 2.6.3.2).

- Once constructed, runoff from the west-facing portion of the FTB south dam exterior will flow west, where it will be routed through the West Plant stormwater system (Section 2.6.3.3), and runoff from the easternmost portion of the FTB south dam exterior will flow south within the Second Creek watershed. (This does not include runoff from the central portion of the FTB south dam exterior, which will infiltrate into the FTB south buttress then be collected by the FTB South Seepage Management System and managed with tailings basin seepage.)

A drainage swale will be constructed east of the Tailings Basin (Large Figure 7) to re-route the non-contact stormwater (e.g., natural runoff) that currently flows into the Tailings Basin toward Unnamed (Mud Lake) Creek. Refer to Section 2.7 for further discussion on this drainage.

2.6.3.2 Hydrometallurgical Residue Facility

Precipitation and runoff within the interior of the HRF will be collected as HRF water and used for processing at the Hydrometallurgical Plant.

Runoff from the HRF dam exteriors will be managed as industrial stormwater as follows:

- Runoff from the east, southeast, and south HRF dam exteriors will flow either east or south, where it will be routed through the West Plant stormwater system (refer to Section 2.6.3.3).
- Runoff from the north, northwest, and southwest HRF dam exteriors will be routed either west or northwest through to be designed stormwater infrastructure.

Construction of the HRF will modify the local divide between the Embarrass River watershed and the Partridge River watershed because the HRF will block existing drainage patterns from the south side of the Tailings Basin toward the northwest within the Embarrass River watershed (Unnamed Creek subwatershed). During initial phases of the HRF development, a land-locked area may be created immediately east of the cell. PolyMet may allow surface water runoff in this area to discharge into the HRF Pond until elevations accommodate development of surface water pond that will divert runoff from this area away from the HRF Pond through the railroad embankment to the West Plant subwatershed. The design of stormwater flow around the HRF will be developed during the final design of the HRF.

2.6.3.3 West Plant Site

Stormwater improvements in the West Plant subwatershed will include repairing and replacing existing drainage features, re-sizing stormwater infrastructure where necessary, and constructing new stormwater ditches, pipes, and ponds. Three stormwater ponds are planned: the North Stormwater Pond, the Central Stormwater Pond, and the Southwest Stormwater Pond. The approximate locations of the stormwater ponds are shown on Large Figure 2.

Stormwater from the West Plant subwatershed will be routed to the stormwater ponds through a series of ditches, culverts, manholes, catch basins, and pipes and then will be generally routed from north to south. The North Stormwater Pond will be constructed west of the Concentrator, and the Central Stormwater Pond will be constructed west of the future Oxygen Plant. The Southwest Stormwater Pond, the largest and the last pond that stormwater from the West Plant will flow through before discharging off-site, is located in the southwest corner of the Plant Site where there currently is a long, wide ditch. This ditch will be widened to the west and a series of weirs or ditch blocks will be used to create a pond in this location. Water from the Southwest Stormwater Pond will flow off-site to the south through a culvert under the railroad grade as shown on Large Figure 2. This culvert discharges to a system of ditches tributary to Second Creek.

As the HRF is constructed, additional ditches and culverts will be constructed to route stormwater from the areas south and east of the HRF to the West Plant stormwater system.

Other stormwater-related infrastructure modifications at the Plant Site include:

- Roof drainage from Plant Site buildings will no longer be collected in pipes in the buildings and routed internally to discharge to the Emergency Basin. As part of the Plant Site renovations and design of new buildings, roof drainage will be rerouted and managed as stormwater within the West Plant and East Plant subwatersheds. Downgradient Plant Site stormwater infrastructure will be designed to handle this additional flow.

- Water collected in building floor drains will no longer be discharged with stormwater. Instead, water from floor drains will be routed to the existing overflow collection system with the buildings to be reused in the process.

2.6.3.4 East Plant Site

Stormwater improvements in the East Plant subwatershed will consist primarily of reinstalling site drainage features and re-sizing stormwater infrastructure where required. Existing infrastructure will be cleaned out and reused, or removed and replaced, as necessary. Stormwater ditches will be reestablished to provide the full drainage capacity as originally designed or upsized as necessary. There are no existing stormwater ponds associated with the East Plant, and no future need is anticipated for stormwater ponds to manage stormwater from the East Plant due to the existing vegetated swales which will naturally treat for TSS.

Stormwater from the East Plant subwatershed will primarily be routed through the existing infrastructure after it has been repaired and/or upgraded. There are currently two locations where stormwater leaves the East Plant via culverts; both of these locations will be maintained as stormwater outfalls as shown on Large Figure 2. These culverts discharge to a system of ditches tributary to Second Creek.

2.6.3.5 Areas 1 and 2

In Area 1, existing stormwater ditches and culverts will generally be adequate to manage stormwater during operations. These systems will be cleaned out and reused, or removed and replaced, as necessary, to maintain the existing drainage patterns to the extent practical. PolyMet will maintain these systems throughout operations.

In Area 2, in the vicinity of the Area 2 shops and along Dunka Road and the railroad corridor, existing stormwater ditches and culverts will generally be adequate to manage stormwater during operations. These systems will be cleaned out and reused, or removed and replaced, as necessary, to maintain the existing drainage patterns to the extent practical. PolyMet will maintain these systems throughout operations.

2.7 Stream Augmentation

Construction of the FTB Seepage Containment System will significantly reduce the amount of seepage leaving the Tailings Basin relative to existing conditions; therefore reducing the amount of streamflow available to four downstream creeks, including Unnamed Creek, Trimble Creek, Unnamed (Mud Lake) Creek, and Second Creek.

Flows to Unnamed Creek, Trimble Creek, and Second Creek will be augmented by WWTS discharge to offset potential hydrologic impacts to these creeks. Flow to Unnamed (Mud Lake) Creek will be augmented by the construction of a drainage swale east of the FTB. Currently, an area east of Cell 1E drains into the Tailings Basin. During the construction phase, a drainage swale will be constructed near the East Dam to reroute this watershed north to the Unnamed (Mud Lake) Creek watershed, as shown on Large Figure 7. The drainage swale will prevent water from pooling at the toe of the East Dam and augment streamflow in Unnamed (Mud Lake) Creek.

PolyMet's stream augmentation objective for Trimble Creek, Unnamed Creek, Second Creek, and Unnamed (Mud Lake) Creek is to maintain average annual flow within ±20% of existing conditions (i.e., before Cliff Erie's implementation of short-term mitigation measures at the former LTVSMC tailings basin under its Consent Decree with MPCA) for purposes of maintaining hydrology and existing aquatic ecology (Section 5.2.2.3.3 of Reference (11)). Stream augmentation is subject to multiple regulations, so implementation must account for a variety of applicable targets and requirements. Augmentation flow rates will be overseen by the DNR through conditions of the Water Appropriation Permits for the Project. Flow quantity will also be subject to the requirements of the New Source Performance Standard (NSPS), overseen by the MPCA through conditions of the NPDES/SDS Permit for the Project.

Stream augmentation will take into account the existing hydraulic characteristics of Trimble Creek, Unnamed Creek, Second Creek, and Unnamed (Mud Lake) Creek, although these existing conditions are subject to variability and uncertainty. These streams flow at very low velocity through wetlands with intermittent channels, which results in low precision for stream gages. In addition, water levels are largely influenced by beaver activities (which frequently change in location and configuration), causing flow variability at any potential surface water monitoring station.

Because of the considerations outlined above, streamflow data alone should not be used to assess Project performance relative to the goal of maintaining average annual flows within ±20% of existing conditions. Therefore, PolyMet proposes to implement stream augmentation using the following management principles:

- The total discharge from the WWTS will not exceed the NSPS limit, as specified in the NPDES/SDS Permit. This requirement could only affect the discharge during periods of extremely low precipitation. Water modeling indicates that there is less than a 1% likelihood that the NSPS limit will constrain the availability of WWTS discharge for stream augmentation.

- Flow from the WWTS will be distributed to headwater areas of Trimble Creek, Unnamed Creek, and Second Creek in proportion to the amount of seepage captured from their respective subwatersheds. Continuous flow monitors will measure the amount of seepage collected by the FTB seepage capture systems from each watershed.

- Flow to Unnamed (Mud Lake) Creek through the drainage swale will be monitored. The flow rate will be a function of net precipitation and runoff over the watershed area tributary to the swale.
- Stream augmentation flows may be adjusted during Project operations based on hydrologic and biologic monitoring results. Potential adaptive management of stream augmentation flows will consider the results of monitoring conducted under the Water Appropriation Permits, the Wetland Permits, and the NPDES/SDS Permit for the Project.

Stream augmentation will continue for as long as the FTB seepage capture systems are operating.

The Stream Augmentation System Permit Application Support Drawings are included in Attachment C.

3.0 Key Outcomes

Water modeling (detailed in Section 5 of Reference (1)) provides water quantity and quality estimates used in the design of Plant Site water management systems. This modeling also projects the expected water quantity and quality outcomes resulting from these water management systems.

3.1 Water Quantity

The water balances of the Beneficiation Plant (including water from the Mine Site), the Hydrometallurgical Plant, and the FTB seepage capture systems combine to determine the overall quantity of Project water to be appropriated from Colby Lake and to be discharged from the WWTS, as described in Section 0.

Key outcomes of the water quantity modeling described in Reference (1) related to Project make-up water demand are summarized in the Consolidated Water Appropriation Permit Application. Additional groundwater appropriation will be needed for groundwater collected during construction at the Plant Site and for precipitation collected in the HRF and the Plant Reservoir. Dewatering may be necessary during construction of the FTB Seepage Containment System, Plant Site stormwater infrastructure, Plant Site buildings and infrastructure, and Plant Site Sewage Treatment System. Estimated flows for these water appropriations are provided in the Consolidated Water Appropriation Permit Application. Tailings basin seepage collected by the FTB seepage capture systems will already have been appropriated from other sources; therefore, it will not require a water appropriation permit.

3.2 Water Quality

Key outcomes of the water quality modeling described in Reference (1) are provided as Large Tables:

- estimated water quality of the tailings basin water in the FTB Pond in Large Table 2
- estimated tailings basin seepage water quality in Large Table 3 to Large Table 6 from the north, northwest, west, south, and east toes, respectively
- estimated groundwater quality in Large Table 7 to Large Table 9 along the north, northwest, and west groundwater flow paths downstream of the Plant Site
- estimated surface water quality in Large Table 10 to Large Table 15 at three surface water locations along the Embarrass River and three surface water locations along the three tributaries (Unnamed (Mud Lake) Creek, Trimble Creek, and Unnamed Creek) downstream of the Plant Site

4.0 Operating Plan

During operations, water at the Plant Site must be continually monitored, treated at the WWTS, and pumped to augment downstream tributaries, as necessary, to protect the environment and allow the Plant Site to function efficiently. This section describes operating plans for the water management systems at the Plant Site during the operations phase of the Project.

4.1 Water for Mineral Processing

Water for mineral processing will primarily be contained within the FTB Pond and HRF Pond. Pond water levels will be maintained at safe operating elevations within these ponds. Tailings basin seepage collected in the FTB seepage capture systems and returned to the FTB will help to maintain the water level in the FTB Pond.

4.1.1 Flotation Tailings Basin (FTB) Pond Level

The key water quantity management point is the water level in the FTB Pond. The overall management objective is to keep the FTB pond level as high as possible without exceeding the dam safety criteria. Environmental impacts are minimized by setting the pond level as high as safely possible – smaller beaches minimize fugitive dust generation and reduce the potential for oxidation of exposed Flotation Tailings. FTB pond level management is detailed in Section 4.2 of Reference (2).

The FTB Pond has a negative water balance; that is, the sources of water to the pond are less than the losses from the pond when pumpback from the FTB seepage capture systems is not considered. The FTB pond level will be managed by adjusting the amount of tailings basin seepage sent to the pond from the FTB seepage capture systems and the amount of tailings basin water returned to the Beneficiation Plant.

4.1.2 Hydrometallurgical Residue Facility (HRF) Pond Level

Another water quantity management point is the water level in the HRF Pond. The overall management objective is to keep the HRF pond level as high as possible without exceeding the dam safety criteria, in order to minimize environmental impacts, similar to FTB pond level management described in Section 4.1.1. HRF pond level management is detailed in Section 4 of Reference (3).

The Hydrometallurgical Plant is a net water consumer, and the pond level will be managed by adjusting the amount of make-up water added to the Hydrometallurgical Process from the Plant Reservoir.

4.1.3 Flotation Tailings Basin (FTB) South Seepage Management System

The FTB South Seepage Management System is already functional, as described in Section 2.1.3, and will be required to function until the release rates of constituents from the FTB have decreased to the point where water resource objectives are achieved without mechanical treatment.

Tailings basin seepage collected by the FTB South Seepage Management System will be routed from the system pump station through pipes to the WWTS for treatment prior to discharge, or to the FTB Pond for reuse, depending on operational requirements and system design (Section 2.3). Water level controls at the FTB Pond and real time water balance data will dictate whether additional seepage will be diverted to the WWTS for treatment and discharge. The pump in the seepage management system will be operated using level sensors so that a desired water level is maintained in the sump and lift station.

The FTB South Seepage Management System will require periodic inspection and maintenance to remain effective. The periodic maintenance consists of visual inspection and testing of the pumping system.

4.1.4 Flotation Tailings Basin (FTB) Seepage Containment System

The FTB Seepage Containment System along the western and northern sides of the Tailings Basin must be functional when Flotation Tailings are first placed in the FTB and will be required to function until the release rates of constituents from the FTB have decreased to the point where water resource objectives are achieved without mechanical treatment or until non-mechanical treatment has been proven, as described in Section 6 of Reference (4). The eastern segment of the FTB Seepage Containment System will be constructed by Mine Year 7, prior to the merging of FTB Cells 2E and 1E and the construction of the East Dam. No seepage would be expected along the eastern side of the Tailings Basin prior to that time; FTB pond levels prior to that time are below an elevation that could induce seepage to the east.

Tailings basin seepage collected by the FTB Seepage Containment System along the northern and western sides of the Tailings Basin will be routed to the FTB Pond for reuse and/or to the WWTS for treatment. Collected seepage will be distributed so as to meet stream augmentation requirements and manage the FTB pond level. Water level controls at the FTB Pond and real time water balance data will dictate whether additional seepage, in excess of the minimum stream augmentation requirements, must be diverted to the WWTS for treatment and discharge. Tailings basin seepage collected by the segment of the FTB Seepage Containment System at the toe of the East Dam will be pumped back to the FTB Pond. All system pumps will be operated using level sensors so that a desired water level is maintained in the sumps and lift stations.

The FTB Seepage Containment System will require periodic maintenance to remain effective. The periodic maintenance will be consistent with industry practice and will include monitoring of flow volumes, monitoring upgradient and downgradient hydraulic heads, occasional pipe cleaning, and if a problem is suspected based on changes in flow volumes or hydraulic head differential, inspection will be performed via video camera of the drain pipe to make sure it is not blocked by sediments or collapsed. If sediments are observed during inspection and are determined to be inhibiting system performance, they will be cleaned out by flushing. If a collapse is observed, the collapsed section will be repaired. Video inspection or flushing techniques will be conducted if the amount of water collected by the containment system indicates there has been an unusual change in flow that could be caused by collapse or clogging. If it was determined that clogging of the trench was interfering with meeting system performance objectives, then corresponding segments of the trench will be cleaned as needed, and if pipe collapse were to occur, pipe design specifications and construction methods will be reviewed and pipes replaced as necessary. For a system of this type, pipe collapse is not expected because loading on the pipes is limited to that imposed by the collection trench backfill, something routinely designed for. While some pipe clogging could occur, particularly early in system operations due to normal construction related activities (i.e., sediment inflow to pipes), the potential for clogging thereafter should be limited due to the constant water flow anticipated in the system.

4.1.5 Waste Water Treatment System (WWTS)

During operations, a portion of the collected tailings basin seepage will be recycled to the FTB Pond for reuse in the beneficiation process, and a portion will be routed to the WWTS for treatment prior to discharge at surface water discharge outfalls. The WWTS will treat the tailings basin seepage to meet the appropriate discharge limits.

The construction mine water pipe will route construction mine water mixed with runoff from the OSLA to the FTB Pond for use in the beneficiation process. Treated mine water will also be routed to the FTB Pond from the WWTS. The operation of the WWTS is further discussed in Sections 2.2 and 4.2 of Reference (4).

4.2 Stormwater

Stormwater ponds will be inspected annually to determine the depth of sedimentation within the ponds. These ponds will be dredged if the depth of sedimentation reduces the required storage capacity to below what is needed based on the pond design.

The stormwater management infrastructure will be operated in accordance with the Construction Stormwater Pollution Prevention Plan (SWPPP), which will be developed prior to construction, and the Industrial SWPPP, which will be developed prior to the start of operations. These SWPPPs will be designed to meet the requirements of the Minnesota NPDES/SDS Construction Stormwater General Permit (Permit No. MN R100001) and the Minnesota NPDES/SDS Industrial Stormwater General Permit (Permit No. MNR050000), respectively.

A SWPPP is a “living” document that evolves with changes at the site. PolyMet will amend these SWPPPs whenever there is:

- a change in Plant Site facilities
- a change in the operating procedures of the facility
- a change that may impact the potential for pollutants to be discharged in stormwater

The intent of these SWPPPs is to protect water quality by preventing pollution of stormwater associated with construction and industrial activities. These SWPPPs will identify and describe controls and best management practices (BMPs) proposed for the Plant Site; these controls and BMPs are designed to minimize the discharge of potential pollutants in stormwater runoff.

Inspections and recording activities are important parts of the continued success of these SWPPPs. The frequency and extent of the inspections will be defined in each SWPPP. Documentation for these activities will be included with each SWPPP.

4.3 Spills

This section is a summary of the Plant Site Spill Prevention Control and Countermeasures (SPCC) Plan which will be developed prior to the threshold for need being met in accordance with 40 CFR 112.3. The SPCC Plan provides the procedures for response to spills. These procedures apply to all PolyMet employees, contractors, and vendors delivering, dispensing, or using petroleum or other products at the Plant Site. It is the policy of PolyMet to promote a long-term, continuous effort towards spill prevention first, and control and countermeasures where necessary. An SPCC Plan Administrator will be designated and is responsible for developing, implementing and maintaining the SPCC Plan. In the case of a spill, the procedures for emergency contacts and a spill contingency plan will be included in the SPCC Plan. Training sessions and spill prevention briefings for operating personnel will review the requirements of the SPCC Plan and highlight and describe recently developed precautionary measures.

4.4 Overflows

This section includes discussion of what will occur in the event of an overflow from the FTB, the HRF, the FTB seepage capture systems, the WWTS, or the Process Plant. An overflow may occur when a storm event exceeds the design storm or an extended power outage occurs at the Plant Site. In order to prevent and mitigate the effects of possible overflows, the following operational plan will be used.

In the unlikely event of overflows greater than the total design capacity of the controls in place to contain the overflows (sumps, ponds, etc.), overflows may ultimately flow into the Plant Site stormwater system and off-site. Actual location of discharge will depend on the location of the overflow.

4.4.1 Flotation Tailings Basin (FTB)

The FTB is designed as a closed system, with the pond level managed to remain at the design level (Section 4 of Reference (2)). No water will be released through overflow or outlet structures during operations. PolyMet designed the FTB to contain Flotation Tailings generated over 20 years of operation. Precipitation falling within the FTB will flow to the FTB Pond. The pond design has sufficient freeboard and emergency overflow infrastructure to safely accommodate the 72-hour PMP rainfall event based on Hydrometeorological Report 51, Probable Maximum Precipitation Estimates, United States East of the 105^{th} Meridian, and Hydrometeorological Report 52, Application of Probable Maximum Precipitation Estimates – United States East of the 105^{th} Meridian (Reference (52) and Reference (53)).

The design of the FTB based on the PMP rainfall event is discussed in more detail in Sections 2.2.3 and 2.5 of the Flotation Tailings Management Plan (Reference (2)). The PMP, which is defined as "the theoretically greatest depth of precipitation for a given duration over a particular drainage area…" is quantified by the Office of Hydrology of the National Oceanic and Atmospheric Administration. PMP rainfall events are rare, and such an event has a low likelihood of being experienced during the life of the basin. The PMP does not have an assigned return period, but has been estimated to range from 100,000 to 1 billion years (Reference (46)). On this basis, there is a low likelihood of overflow (rainfall would have to exceed 35-inch rainfall in 72 hours); however, it is standard practice in dam design to accommodate even low probability overflows in a manner that protects the integrity of the dams, and therefore an emergency overflow is included in the dam design. The 1/3 PMP represents approximately 11.7 to 12.7 inches, and the 2/3 PMP represents approximately 23.3 to 25.3 inches for the FTB over the 20-year mine life.

Overtopping of the dams will be avoided by operating the FTB Pond with sufficient freeboard to accommodate pond water level bounce due to a severe precipitation event, as described in Section 4 of Reference (2). Overtopping will further be avoided by construction of an emergency overflow that will be maintained throughout FTB operations. A closure overflow embedded in bedrock east of Cell 2E will be established during reclamation. The location and layout of the emergency and closure overflow channels are provided on Drawings FTB-008, FTB-011, FTB-015 to FTB-018, FTB-021, and FTB-024 in the Flotation Tailings Basin Permit Application Support Drawings. If pumping systems shut down due to a power outage simultaneous with a significant precipitation event, these overflow structures will prevent the washout of dams in the unlikely case of the water rising to elevations near the final dam elevation. Embedding the closure channel into bedrock will also minimize or eliminate any long-term maintenance requirements for the closure overflow channel. Both the emergency overflow channel that will be in place during operations and the closure overflow channel that will be in place after operations are complete are located along the eastern side of the FTB and would discharge to the Unnamed (Mud Lake) Creek watershed if an overflow were to occur (see Large Figure 7 for the location of the emergency overflow channel in Mine Year 20).

4.4.2 Hydrometallurgical Residue Facility (HRF)

Similar to the FTB, the HRF will function as part of a closed-loop system, with the pond level managed to remain at the design level (Section 4 of Reference (3)). The Hydrometallurgical Plant and HRF are a closed-loop system, where water is only lost to evaporation from the cell surface and entrapment within the Residue's pore space. Water from the HRF is kept separate from other water on the Project; there is no discharge of water from the HRF during operations, and the only make-up water is from Colby Lake.

Precipitation falling within the HRF will flow to the HRF Pond. Overtopping of the dams will be avoided by operating the HRF Pond with sufficient freeboard to accommodate pond water level bounce due to a severe precipitation event, as described in Section 4.1 of Reference (3). Water level bounce from storm events is expected to be minimal, because the tributary area for the HRF is relatively small, as described in Section 2.5 of Reference (3). The cell is sized to accommodate up to 3 feet of freeboard so that some wave run-up and water level bounce can safely occur. Initial operations will be used to refine the minimum freeboard requirements.

Overtopping could potentially occur if the Return Water System were to fail or be accidentally shutdown while the Residue Transport and Deposition System continued to operate. To avoid this situation, the controls of these two systems will be integrated such that shutdown of the Return Water System shuts down the Residue Transport and Deposition System.

The HRF is built within a low area, confined by bedrock on the southwest and southeast and by the existing tailings basin dam along the north. Based on the design of the HRF, if an overflow were to occur, it would most likely occur on the northwest side, with the liner slope directing flow to the northwest. Overflow over the northwest corner would be intercepted by the FTB Seepage Containment System, as shown on Large Figure 7. If the overflow were to overtop the dams to the west or the south instead of the northwest, the HRF water would enter the Plant Site stormwater system, which outlets to a tributary to Second Creek.

In reclamation, the HRF Pond will be dewatered and an engineered cover will be constructed to reduce future ponding within the HRF, as described in Section 7 of Reference (3).

4.4.3 Flotation Tailings Basin (FTB) Seepage Containment System

The FTB Seepage Containment System will collect tailings basin seepage from the FTB as described in Section 2.1.4 and Section 4.1.4. The current design, shown on the Flotation Tailings Basin Seepage Containment and Stream Augmentation Permit Application Support Drawings (Attachment C), includes two lift stations with pumps along the north side of the FTB. Flows along the containment system will be routed to these lift stations from subsurface drain pipes and six associated manhole pump stations. If the pumps in these lift stations and/or manhole pump stations are shut down due to a power outage, tailings basin seepage may back up, and an overflow from the seepage containment system may occur. The potential for overflow to occur and the quantity of any overflow will be dependent on the duration of a power outage. Excess water not contained will flow off-site at the existing surface discharge station SD002 (Section 1.4.5) and/or to Unnamed Creek, Trimble Creek and/or Unnamed (Mud Lake) Creek, dependent on where the overflow occurs.

4.4.4 Flotation Tailings Basin (FTB) South Seepage Management System

As described in Section 2.1.3 and Section 4.1.3, the FTB South Seepage Management System collects tailings basin seepage along the south side of the FTB. The current design, shown in Attachment B, includes an impoundment to block the seepage and a small sump with a submersible pump. An emergency overflow is designed into the system, as shown in Attachment B, at an elevation of 1530 feet, which is approximately 5 feet above the top of the collection sump and approximately 2 feet below the top of the dam impounding the collection system. If the pumps in these sumps are shut down due to a power outage, tailings basin seepage draining to this sump will be contained up to the overflow elevation. Seepage water that reaches the elevation of the overflow will flow off-site at existing surface discharge station SD026 (Section 1.4.5) to Second Creek.

4.4.5 Waste Water Treatment System (WWTS)

The rate of water entering the WWTS Lined Pretreatment Basin (Plant Site) and the Equalization Basin Area at the Mine Site will be controlled by the upstream pumping. If there is a loss of power at the WWTS, the upstream pumping systems to the WWTS will also be shut down, or rerouted to prevent an overflow of these basins. Water would be rerouted based on the source of the water. Tailings basin seepage would be rerouted to the FTB Pond, and mine water would be stored in the mine water sumps or ponds, routed to the mine pits, or, in an emergency, routed to the FTB Pond. If there was an overflow of the WWTS Lined Pretreatment Basin, it would flow into Cell 1E in earlier years before the south FTB dam is built. Once the south FTB dam is constructed, overflow would enter the Plant Site stormwater system, which outlets to a tributary to Second Creek.

4.4.6 Process Plant

The Hydrometallurgical Plant and the Beneficiation Plant designs include sufficient sump and process equipment capacity to prevent process water from leaving the Plant during power failure or other emergencies. Process water captured within these sumps will be recirculated back into their respective Plant systems. Due to the storage capacity of these systems, it’s highly unlikely there would be an overflow from these buildings. If an overflow did occur, process water would enter the Plant Site stormwater system, which outlets to a tributary to Second Creek.

4.5 Dust Suppression

Water will be used to control fugitive dust emissions. The appropriate water sources will be determined based on the location and runoff management for the road to be watered. At the Plant Site, fugitive emission control water for roads outside the footprint of the FTB seepage capture systems will be drawn from the Plant Reservoir. For roads inside the footprint of the FTB seepage capture systems (i.e., roads on the Tailings Basin), water could be drawn from the FTB Pond.

5.0 Water Quantity and Quality Monitoring

Proper long-term management of water quality and quantity at the Plant Site will depend, in part, on a systematic monitoring plan that will be finalized in NPDES/SDS and Water Appropriation permitting. As operations proceed, the monitoring plan will be updated as required. Monitoring will be used to determine Project compliance with permits, improve model accuracy, identify potential causes of changes to water quality or quantity, and identify options, if necessary, to adapt the Project to result in short-term and long-term compliance.

In aggregate, the NPDES/SDS and Water Appropriation monitoring plans will provide a comprehensive and thorough evaluation of water flow rates, water levels, and water quality on a continuous, monthly, or quarterly basis, depending upon the component being monitored. Monitoring information provided in this document as well as the applicable permit applications include specific locations, nomenclature, frequency, and parameters; the specifics of monitoring for the Project will be finalized during each applicable permitting process.

The proposed monitoring stations are divided between the Mine Site and the Plant Site. In the proposed monitoring plans, the Transportation and Utility Corridors are grouped with the Mine Site. This document presents the Plant Site monitoring plan as a series of figures and tables:

- Large Figure 9 through Large Figure 11 show the proposed monitoring stations for groundwater, surface water, surface water discharge, stormwater, and internal waste streams.

- Large Table 16 through Large Table 20 describe the purpose for monitoring, the type of monitoring, the proposed parameter groups to be monitored, the proposed frequency of monitoring, and the proposed frequency and method of reporting. These tables also denote which permit(s) (NPDES/SDS and/or Water Appropriation) each monitoring station is associated with. Many monitoring stations are associated with both permits. Large Table 21 lists the proposed parameters to be monitored for each type of monitoring.

Information included on the large figures and large tables are described further in the following sections.

5.1 Monitoring Types

Monitoring for the Project is categorized by monitoring type (e.g., compliance monitoring, performance monitoring) and station type (e.g., groundwater, surface water, stormwater, surface water discharge, and internal waste stream). Refer to the Plant Site monitoring plan tables (Large Table 16 through Large Table 20) for additional information on associated parameters, frequency, and reporting.

- Compliance Monitoring (groundwater stations): Compliance monitoring will be conducted at locations where the Project will need to demonstrate compliance. These locations are downgradient of potential Project impacts. Groundwater compliance monitoring stations are typically at or near the property boundaries.

- Indicator Monitoring (groundwater stations): Indicator monitoring will be conducted at locations between the compliance stations and Project features to allow for early detection of potential Project impacts.

- Performance Monitoring (groundwater stations): Performance monitoring will be conducted to monitor the performance of engineering infrastructure (liners systems, containment systems, etc.). Performance monitoring stations will include monitoring wells, paired monitoring wells, and paired piezometers

- Background Monitoring (groundwater and surface water stations): Background monitoring will be conducted to document surface water quality upstream and groundwater quality upgradient of the Project. Background monitoring stations will be located upstream/upgradient of potential Project impacts.

- Surface Water Discharge Monitoring (surface water discharge stations): Surface water discharge monitoring will be conducted at the discharge from the WWTS where the Project will need to demonstrate compliance with permit limits.

- Benchmark Stormwater Monitoring (stormwater stations): Benchmark stormwater monitoring will be conducted at benchmark stormwater monitoring stations to evaluate the potential impact of industrial activities on stormwater runoff. Results will be compared to applicable benchmark values to determine whether additional stormwater control measures may be necessary. These stations are proposed at outfalls of industrial stormwater from the Plant Site.

- Monitor-Only (groundwater, surface water, and internal waste stream stations): PolyMet proposes to conduct some monitoring that is not required for NPDES/SDS compliance. At monitor-only stations, no limits or standards will apply; however, there may be triggers that will initiate further investigation. Monitor-only stations are proposed for groundwater monitoring stations downgradient of potential Project impacts, surface water stations downstream of potential Project impacts, and for Project internal waste streams.

    - The surface water monitor-only stations will evaluate long-term water quality to identify potential changes that may be attributed to the Project; however, they will not be considered compliance points. The intent of the surface water monitor-only stations is to allow for a more holistic (i.e., multi-media) monitoring approach. If water quality impacts attributable to the Project are found at these monitoring stations, further investigation will be conducted and the overall monitoring plan will be evaluated to determine the root cause of the impacts and whether adaptive engineering controls or contingency mitigations are needed.

- The internal waste stream monitor-only stations will evaluate the potential for off-site impacts and aid in design and operation of the WWTS.
- The WWTS internal performance monitoring station will evaluate an internal WWTS stream prior to discharge, to provide advance notice so that adaptive management or contingency mitigation could be implemented to address any potential WWTS performance issues.

- <u>Water Appropriation Monitoring (groundwater, surface water, internal waste stream stations, and precipitation)</u>: Monitoring in connection with water appropriations will measure flow rates and water levels to document appropriation rates and monitor potential effects of permitted appropriations. Precipitation monitoring will also occur to correlate appropriated amounts with changes in precipitation. Water Appropriation Monitoring also serves to identify the effects of permitted appropriations and associated discharges on surface water flow downstream of the Plant Site.
  - Appropriation Source Monitoring will measure flows from Plant Site and Colby Lake infrastructure that will withdraw groundwater, surface water, and/or collected precipitation during operations, such as the Colby Lake Pumphouse, and will document the water levels in the lined and concrete ponds.
  - Internal Flow Monitoring will record Project flows that are not monitored for other regulatory purposes, but that are necessary to understand the overall Project water balance.
  - Seepage Flow Monitoring will record the amount of water collected by the FTB seepage capture systems from the headwater areas of Unnamed Creek, Trimble Creek, Unnamed (Mud Lake) Creek, and Second Creek.
  - Augmentation Flow Monitoring will record the amount of water the Project delivers to the headwater area of each creek.
  - Streamflow Monitoring will measure streamflow in the Embarrass River watershed to assess potential hydrologic effects associated with permitted appropriations and stream augmentation.
  - Aquatic Biota Monitoring will document the characteristics of the biotic community to assess potential ecological effects associated with permitted appropriations and stream augmentation.

5.2 Groundwater Monitoring

Groundwater at the Plant Site generally flows to the north and northwest. Large Table 16 presents the proposed Plant Site groundwater monitoring plan, which will consist of background, compliance, indicator, performance, monitor-only, and appropriation source monitoring at wells set in the surficial aquifer and in bedrock, as shown on Large Figure 9.

Proposed monitoring parameters were selected based on consideration of baseline monitoring results, FEIS modeling results, the existing Cliffs Erie Hoyt Lakes Tailings Basin Area NPDES/SDS Permit (Permit No. MN0054089), and best professional judgment.

5.3 Surface Water Monitoring

Approximately 80% of the Plant Site, including the majority of the FTB, is located in the Embarrass River watershed. Groundwater and stormwater in these areas flows north toward the Embarrass River and three of its tributaries (Unnamed (Mud Lake) Creek, Trimble Creek, and Unnamed Creek). Approximately 20% of the Plant Site is located in the Second Creek watershed. This includes the Process Plant, Area 1 Shops, Area 2 Shops, and the south side of the FTB, including the FTB South Seepage Management System.

Large Table 17 presents the proposed Plant Site surface water monitoring plan, which will consist of background, monitor-only, streamflow, and aquatic biota monitoring stations, as shown on Large Figure 10.

Proposed monitoring parameters were selected based on consideration of baseline monitoring results, FEIS modeling results, the existing Cliffs Erie Hoyt Lakes Tailings Basin Area NPDES/SDS Permit (Permit No. MN0054089), the existing Cliffs Erie Hoyt Lakes Mining Area NPDES/SDS Permit (Permit No. MN0042536), 40 CFR part 440, and best professional judgment.

5.4 Surface Water Discharge/Augmentation Flow Monitoring

Large Table 18 outlines the proposed Plant Site surface water discharge and augmentation flow monitoring plan, which will consist of surface water discharge and augmentation flow monitoring stations, as shown on Large Figure 10.

Water quality of the treated effluent will be monitored at the WWTS discharge point, referred to as SD001. Proposed monitoring parameters were selected based on consideration of 40 CFR part 440, FEIS modeling results, and best professional judgment.

5.5 Benchmark Stormwater Monitoring

Large Table 19 presents the proposed benchmark stormwater monitoring plan for the Plant Site, and monitoring station locations are shown on Large Figure 10.

Proposed monitoring parameters were selected based on consideration of Minnesota NPDES/SDS Industrial Stormwater General Permit (Permit No. MNR050000) Sector G and Sector P requirements.

5.6 Internal Waste Stream Monitoring

Large Table 20 presents the proposed Plant Site internal waste stream monitoring plan, which will consist of monitor only, appropriation source, internal flow, seepage flow, and internal performance monitoring stations, as shown on Large Figure 11.

Proposed monitoring parameters were selected based on consideration of FEIS modeling results and best professional judgment.

5.7 Wetland Monitoring

In addition to the monitoring that will be done under the NPDES/SDS Permit and the Water Appropriation Permits, wetland hydrology monitoring will be developed as part of wetland permitting and is expected to be similar to the baseline wetland hydrology monitoring program currently underway; see Section 17 of Reference (12).

5.8 Sampling and Analysis Plan and Quality Assurance Project Plan

These monitoring plan components will be detailed in the Sampling and Analysis Plans (SAPs) that will be prepared upon issuance of a NPDES/SDS permit or as required by other regulatory programs. Each SAP will detail the monitoring stations, sampling frequency, sample collection protocol, analytical methods and parameters, and quality assurance requirements. At a minimum, the SAP will consist of a Field Sampling Plan (FSP) and a Quality Assurance Project Plan (QAPP). The FSP will detail the field activities and documentation requirements for the sample collection and management in the field. The field activities and documentation requirements will be organized as Standard Operating Procedures (SOPs) specific to the various activities to be performed. The QAPP will detail the data quality objectives for the monitoring plans, list the monitoring stations, analytical methods, parameters, and quality control limits, data validation procedures, and data management practices.

The SAPs will incorporate analytical methods or standard practices approved by the USEPA or other agency, as appropriate. Sample collection frequency was selected based on conditions specified in permits for similar operations, and considered potential rate of transport where appropriate. Frequency of sampling will be finalized during the NPDES/SDS and Water Appropriations permitting processes.

6.0 Reporting and Adaptive Management

Adaptive management is a system of management practices based on clearly defined outcomes and monitoring requirements to determine if management actions are meeting the desired outcomes; and, if not, to implement changes that will best ensure that outcomes are met or re-evaluated. Adaptive management recognizes the uncertainty associated with estimates based on natural systems as a result of the baseline monitoring data, waste characterization, scale of plan, decisions on modeling inputs, and other limiting factors. Adaptive management measures will continue to be developed through the operations, reclamation, closure, and postclosure maintenance phases of the Project.

A key component of adaptive management for water is the Adaptive Water Management Plan (Reference (4)) that describes adaptive engineering controls that manage water quality and quantity. Fixed engineering controls (dams, pumps, pipes, etc.) are described in this and other management plans. Contingency mitigation options that could be applied if engineering controls do not manage water quality and quantity properly are described in this document.

6.1 NPDES/SDS Permit and Water Appropriation Permit Reporting

The NPDES/SDS Permit and the Water Appropriation Permits will require and will define routine water quality and quantity reporting. As required by the permits, water quality reports will be submitted to the MPCA and water quantity reports will be submitted to the DNR.

The content required for these reports will be defined in the relevant permits. In addition to water quantity and quality monitoring described in Section 5.0, PolyMet anticipates that both of these permits will also require the following information be included in the reports:

- precipitation data
- identification and explanation of variations from permit requirements, if any

PolyMet anticipates additional information required in the NPDES/SDS reports will include:

- the total gallons of water pumped between the FTB and Beneficiation Plant, from the FTB seepage capture system, and to the FTB from the Mine Site for the past year
- identification of any changes made to the FTB seepage capture system, or the HRF Leakage Collection System
- a summary of any previously reported variations from permit requirements
- identification of any changes planned for the FTB seepage capture system, or the HRF leakage collection system

PolyMet anticipates additional information required in the Water Appropriations reports will include:

- water movement reporting, including flow rates and total monthly volumes for all water movement on-site or discharged off-site
- water level monitoring of the lined and concrete ponds
- monthly and annual amounts of water appropriated, by installation
- stream flow data
- monthly records of augmentation flows from the WWTS and the drainage swale
- aquatic biota monitoring results

6.2 Permit to Mine Reporting

A PTM Report will be submitted to the DNR by March 31 of each year, in accordance with Minnesota Rules, part 6132.1300, subpart 1. A template for the Annual PTM Report is included in the PTM application. It includes:

- mining rates and production summary
- Transportation and Utility Corridors monitoring (ore car and track inspections)
- dust monitoring
- Floatation Tailings monitoring (sampling and in-situ testing, an general characteristics)
- FTB and HRF monitoring (material characteristics verification, HRF geosynthetics evaluation, and vegetation/erosion control monitoring)
- the total tons of Flotation Tailings placed in the FTB from the start of operations through the past year and remaining planned capacity
- a map showing where Flotation Tailings were placed and where vegetation was established for dust control or reclamation during the past year
- a map showing where Flotation Tailings are planned to be placed and where vegetation is planned to be established for dust control or reclamation during the coming year

- the total tons of Residue placed in the HRF from the start of operations through the past year and remaining planned capacity
- a map showing where Residue was placed and where vegetation was established for dust control or reclamation during the past year
- a map showing where Residue is planned to be placed and where vegetation is planned to be established for dust control or reclamation during the coming year
- identification of any planned changes in operations that could impact final reclamation

6.3 Annual GoldSim Model Assessment

Each year, PolyMet will update the Plant Site GoldSim model based on observed conditions from the previous year. Modeled water quality and quantity from the updated GoldSim model will be compared to observed water quality and quantity at major Project features and at select groundwater wells. PolyMet will conduct an annual decision process to confirm that the model assumptions and construct are appropriate for continued use, propose model refinements if necessary, and determine whether adaptive management actions or contingency mitigation measures are necessary.

The annual GoldSim model assessment will be documented in a report to be submitted to MPCA for the NPDES/SDS Permits and DNR for the Water Appropriation Permits, and the PTM. Additional detail regarding the annual model assessment and decision process for model refinements is provided in Reference (13).

6.4 Adaptive Management

If the annual GoldSim model assessment and decision process indicates that an unacceptable outcome could occur or the observed flows and concentrations exceed permit levels, adaptive management actions will be implemented. PolyMet will submit a work plan to initiate adaptive management actions to the MPCA and DNR to address the issue.

The work plan could include some or all of the following adaptive management actions:

1. Field studies that may be necessary to determine the root cause of the exceedance
2. Adjustments that can be made to the adaptive engineering controls described in Reference (2) that will remedy the root cause. Adjustments to the adaptive engineering controls include changing the scale or type of control and its design.
3. If the modeled exceedances persist, implementation of contingency mitigation (Section 6.5) that will remedy the root cause and include that contingency mitigation as an adaptive engineering control in Reference (2).

PolyMet will monitor and model effects to the environment with the new or adjusted engineering control or contingency mitigation measure until the issue no longer persists.

6.5 Contingency Mitigation

If monitoring or the refined model estimates show that with adaptive engineering controls water quantity or quality at compliance points is projected to not meet compliance parameters, mitigations are available that would address those situations. The contingency mitigations described in the following paragraphs are feasible but depend on site-specific conditions and do not include modifications to adaptive engineering controls that are described in Reference (4). These mitigations would be developed and designed if needed and coordinated with the DNR and MPCA as appropriate.

A. New surface seepage locations emerge as the FTB is developed.

    i. The FTB seepage capture system described in Sections 2.1.3 and 2.1.4 can be expanded to collect seepage from any new seepage locations.

B. FTB pond water quality is worse than expected.

    i. Additional treatment at the WWTS could be used to reduce solute load delivered to the FTB Pond.

    ii. Water from the FTB seepage capture systems that is returned to the FTB Pond is not currently planned to be treated. The collected seepage, or some portion of it, could be sent to the WWTS for treatment before being returned to the FTB Pond.

    iii. Pond water could be sent to the WWTS for treatment and returned to the FTB Pond.

    iv. The FTB Pond could be treated in-situ with iron salts, fertilizer, or other methods tailored to the constituent of concern. For example, certain pit lake remediation technologies have successfully treated billion-gallon pit lakes for contaminants including selenium, zinc, uranium, and nitrate. These technologies have been successfully applied at numerous sites and locations and have demonstrated successful remediation.

C. Groundwater or surface water downgradient of the FTB has compliance issues.

    i. The containment system around the FTB could be inspected for breaches and repaired or interception wells could collect groundwater flows impacted by a breach.

    ii. FTB pond water quality could be improved by implementing mitigations described in B above.

iii. Interception wells could collect groundwater flows impacted by a leak from the FTB Seepage Containment System.

Several of the potential mitigation options discussed above include additional treatment of water at the WWTS. The WWTS is, by design, adaptive, as described in Sections 2.2 and 4.2 of Reference (4). The WWTS treatment capacity can be expanded by adding additional parallel treatment trains to accommodate additional flow.

6.6 Periodic Evaluation of Models

In addition to the annual model assessment described in Section 6.3, PolyMet will conduct a periodic assessment of the underlying conceptual models and other supporting mathematical models that are used as inputs to the GoldSim models. The periodic model evaluation will be conducted approximately every five years, and a separate work plan will be developed for each of the periodic model evaluations that will identify the specific data sets and models to be evaluated. Additional detail regarding the periodic model evaluation is provided in Reference (13).

Revision History

Date	Version	Description
11/30/2011	1	Initial release
01/25/2013	2	Significant changes to incorporate project changes related to the decisions made in the AWMP Version 4 and 5 and Change Definition Forms pertaining to the Plant Site. These project changes include the use of long-term mechanical treatment, the potential for non-mechanical treatment in long-term closure and tributary flow augmentation.
01/12/2014	3	Project Description was updated to reflect the five main changes that have been incorporated into the Project since publishing of the SDEIS: 1) addition of the SAG mill (no change to this document), 2) Coal Ash Landfill relocation (no change to this document), 3) the addition of the east side of the FTB Seepage Containment System (changes to figures and text), 4) adjustments made to the stream augmentation plan and West Pit flooding (changes to figures and text), and 5) changes made for the sewage treatment system (changes to figures and text). Additional changes were made for clarification (various sections throughout), to address agency comments (various sections throughout), to incorporate minor design changes and project refinements (Sections 2 and 4), and to incorporate the results of water modeling (Section 3).
03/10/2015	4	Minor changes were made to address agency comments (Sections 1.0, 1.2, 1.3, 2.0, 2.1.4, 2.3, 5.4.1, 5.4.3, 6.1, and 6.2, Large Table 9, Large Table 11, Large Table 14, Large Table 18, and Large Figure 3). Additional minor changes were made to address formatting.
07/11/2016	5	Certification page added; minor changes made to Large Figures to account for changes to the WWTF footprint; the FTB Seepage Containment and Stream Augmentation permit application support drawings were certified for permitting (Attachment B); references to the SWPPPs and the SPCCs were modified, as they will be developed prior to construction and operations (rather than included in Attachments C, D, and E); a description was added of the Sewage Treatment System along with the design basis memorandum (Attachment E), and the design basis memorandum for the Plant Site stormwater was included (Attachment F). Details on future monitoring contained in figures, tables, and text removed as this information will be provided in permit applications.
08/28/2017	6	Updated to reflect Project design at time of update (August 2017). Changes included modifications to the Project designs, specifically to the WWTS, re-insertion of the monitoring plan, updated periodic evaluation of models discussion, and updated reference list. Former Section 7 was deleted because this document is specific to the construction and operations phases. Attachment A was added to explain the WWTS terminology changes.
12/7/2017	7	Updated for inclusion in PTM v3 to reflect response to DNR comments received on PTM v2 submittal. Additionally, minor errors noted or clarifications needed since v6 of the plan were addressed.

References

1. **Poly Met Mining Inc.** NorthMet Project Water Modeling Data Package Volume 2 - Plant Site (v11). March 2015.

2. **Poly Met Mining, Inc.** NorthMet Project Flotation Tailings Management Plan (v7). May 2017.

3. —. NorthMet Project Residue Management Plan (v6). May 2017.

4. —. NorthMet Project Adaptive Water Management Plan (v12). December 2017.

5. —. NorthMet Project Water Management Plan - Mine Site (v7). December 2017.

6. —. NorthMet Project Rock and Overburden Management Plan (v10). December 2017.

7. **Barr Engineering Co.** Hydrogeology of Fractured Bedrock in the Vicinity of the NorthMet Project (v3). December 2014.

8. —. Waste Water Treatment System: Design and Operation Report - NorthMet Project v2. future submittal 2017.

9. **Minnesota Pollution Control Agency.** Recommended Pond Design Criteria (wq-wwtp5-53). s.l. : Minnesota Pollution Control Agency, December 2009.

10. **Perica, Sanja, et al.** NOAA Atlas 14: Precipitation-Frequency Atlas of the United States - Volume 8 Version 2.0: Midwestern States. Silver Spring, Maryland : National Oceanic and Atmospheric Administration, National Weather Service, U.S. Department of Commerce;, 2013.

11. **Minnesota Department of Natural Resources, U.S. Army Corps of Engineers and U.S. Forest Service.** Final Environmental Impact Statement: NorthMet Mining Project and Land Exchange. November 2015.

12. **U.S. Department of Commerce; National Oceanic and Atmospheric Administration; U.S. Army Corps of Engineers.** Probable Maximum Precipitation Estimates, United States East of the l05th Meridian (Hydrometeorological Report No. 51). June 1978.

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14. **National Research Council.** *Estimating Bounds on Extreme Precipitation Events: A Brief Assessment.* Wahington, D.C. : National Academy Press, 1994.

15. **Barr Engineering Co.** NorthMet Project Wetland Replacement Plan (v2) Prepared for Poly Met Mining Inc. future submittal 2017.

16. —. GoldSim Model Assessment Work Plan - NorthMet Project. August 2017.

17. **Poly Met Mining Inc.** NorthMet Project Water Modeling Data Package Volume 1 - Mine Site (v14). February 2015.

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Large Table 1 LTVSMC Tailings Basin Surface Flows

Location[1]	Oct. 2007 (gallons per minute [gpm])	Aug. 2008 (gpm)	Oct. 2008 (gpm)	Oct. 2009 (gpm)	Oct. 2010 (gpm)	Oct. 2011 (gpm)	Oct. 2012 (gpm)	Oct. 2013 (gpm)	Oct. 2014 (gpm)	Oct. 2015 (gpm)	Oct. 2016 (gpm)
Seeps 13-17[2]	1	No Flow	No Flow	No Flow	No Flow	No Flow	No Flow	No Flow	No Flow	No Flow	No Flow
Culvert/ Pipe	1	1	1	1	0.5	0.5	0.5	0.3	0.5	0.5	0.5
SD006[3]	303	383	710	618	722	Not Applicable (N/A)	N/A	N/A	N/A	N/A	N/A
Seep 20	1.5	1.5	2.5	3	3	3.5	2.0	1.5	2.0	3.0	4
Seep 22 (SD004)	2	3	3	4	3	N/A	N/A	N/A	N/A	N/A	N/A
Seep 24	26	7	10	12	11	9	9	10	8.5	18	19
Seep 25	11	27	No Flow	No Flow	No Flow	No Flow	No Flow	No Flow	No Flow	No Flow	No Flow
Seep 30	54	206	100	189	161	121	182	64	82	46	86
Seeps 32 & 33 (upstream of SD026)[4]	490	195	600	781	1379	N/A	N/A	N/A	N/A	N/A	N/A
Inflow (culvert)[5]	745	Not Available (NA)	80	116	NA	No Flow	39	69	21	49	88

(1) See Large Figure 6
(2) Seeps 13 through 17 are all connected along a ditch with outflow at Seep 17; therefore, the flow reported is cumulative.
(3) SD006 currently includes inflows from the Emergency Basin watershed, which do not originate as surface seepage from the LTVSMC tailings basin.
(4) Seeps 32 and 33 are located approximately ½ mile upstream of SD026 near the SD026 pumpback system. SD026 has a larger watershed than just these two seeps; therefore, flows reported for SD026 are different than reported here.
(5) Inflow (culvert) consists of overland runoff flowing into the LTVSMC tailings basin (Cell 1E) from the northeast. There is no seepage from the LTVSMC tailings basin included in this flow.

Large Table 2 Estimated FTB Pond Water Quality

Constituent	Mine Year	Mine Year 5			Mine Year 20			Mine Year 30			Mine Year 60			Mine Year 100		
	Percentile	Average P10(1)	Average P50(1)	Average P90(1)	Average P10(1)	Average P50(1)	Average P90(1)	Average P10(1)	Average P50(1)	Average P90(1)	Average P10(1)	Average P50(1)	Average P90(1)	Average P10(1)	Average P50(1)	Average P90(1)
	Units															
Ag (Silver)	µg/L	0.20	0.20	0.20	0.20	0.20	0.20	0.10	0.11	0.13	0.05	0.06	0.08	0.05	0.06	0.07
Al (Aluminum)	µg/L	4.76	6.12	7.87	4.76	6.12	7.87	4.76	6.12	7.87	4.76	6.12	7.87	4.76	6.12	7.87
Alkalinity	mg/L	42.43	52.30	65.00	42.43	52.30	65.00	42.30	51.87	63.11	40.21	46.89	58.08	38.13	43.96	51.06
As (Arsenic)	µg/L	4.33	4.92	5.97	11.89	13.80	16.17	18.99	20.69	22.92	12.98	16.77	20.15	17.56	19.98	22.67
B (Boron)	µg/L	100.00	100.00	100.00	100.00	100.00	100.00	91.69	99.53	100.00	50.34	71.32	99.46	37.86	49.05	67.36
Ba (Barium)	µg/L	24.39	24.79	25.26	20.26	22.46	23.25	6.95	7.71	8.43	3.00	3.53	4.00	2.61	3.02	3.57
Be (Beryllium)	µg/L	0.36	0.39	0.40	0.36	0.40	0.40	0.26	0.30	0.35	0.18	0.22	0.29	0.18	0.21	0.24
Ca (Calcium)	mg/L	39.26	40.82	42.47	60.89	68.78	78.39	38.65	44.53	51.34	18.03	21.67	26.12	15.37	17.85	21.11
Cd (Cadmium)	µg/L	0.31	0.88	1.12	0.31	0.68	0.97	0.31	0.49	0.90	0.08	0.13	0.24	0.05	0.06	0.09
Cl (Chloride)	mg/L	22.19	24.78	28.94	21.00	25.12	31.16	4.68	5.50	6.66	0.97	1.13	1.36	0.92	1.10	1.35
Co (Cobalt)	µg/L	4.65	9.25	17.48	8.09	14.81	27.39	4.05	6.06	9.73	0.86	1.50	2.87	0.37	0.54	0.79
Cr (Chromium)	µg/L	1.45	1.57	1.71	2.11	2.39	2.66	2.14	2.44	2.72	0.47	0.62	0.93	0.33	0.40	0.50
Cu (Copper)	µg/L	23.87	39.72	119.42	23.87	39.72	121.82	23.86	38.69	73.96	5.32	6.39	7.71	3.11	3.68	4.39
F (Fluoride)	mg/L	0.66	0.72	0.78	0.41	0.48	0.54	0.19	0.22	0.25	0.05	0.05	0.06	0.05	0.05	0.06
Fe (Iron)	µg/L	23.78	39.19	53.71	23.78	39.19	53.71	23.78	39.19	53.71	23.78	39.19	53.71	23.78	39.19	53.71
K (Potassium)	mg/L	13.83	15.10	16.42	19.96	24.41	29.38	8.36	9.23	10.29	1.65	2.84	3.63	3.15	3.55	3.98
Mg (Magnesium)	mg/L	50.65	53.21	55.49	62.38	69.33	76.91	15.60	17.64	20.00	3.08	3.88	5.33	3.58	4.35	5.57
Mn (Manganese)	µg/L	145.20	212.71	274.82	145.20	212.71	274.88	145.20	212.71	274.88	45.52	59.59	85.67	49.88	65.80	90.18
Na (Sodium)	mg/L	68.11	74.66	81.71	63.34	75.95	89.12	14.43	16.37	18.57	1.59	1.80	2.31	1.46	1.74	2.19
Ni (Nickel)	µg/L	76.80	163.37	307.23	117.02	239.16	397.80	50.50	81.31	126.62	8.80	15.37	28.88	3.43	5.00	7.45
Pb (Lead)	µg/L	3.93	4.64	5.85	9.71	11.79	14.46	8.09	9.47	11.24	0.82	1.11	1.80	0.25	0.35	0.50
Sb (Antimony)	µg/L	7.51	8.32	9.16	6.06	7.13	8.15	5.75	6.62	7.54	3.37	3.89	4.42	3.63	4.11	4.63
Se (Selenium)	µg/L	1.52	1.66	1.83	1.51	1.73	2.04	1.21	1.49	1.84	0.30	0.39	0.56	0.25	0.30	0.37
SO_4 (Sulfate)	mg/L	188.30	199.75	210.20	233.80	254.82	276.81	61.08	68.30	76.86	12.09	16.62	21.46	17.32	20.13	23.73
Tl (Thallium)	µg/L	0.09	0.09	0.10	0.09	0.10	0.12	0.07	0.08	0.10	0.03	0.03	0.05	0.02	0.03	0.04
V (Vanadium)	µg/L	3.89	5.31	8.05	4.61	6.44	9.67	3.05	3.45	3.88	0.35	0.65	1.30	0.11	0.20	0.33
Zn (Zinc)	µg/L	33.02	68.60	85.15	33.02	56.48	71.10	30.39	40.89	59.66	5.21	8.74	17.07	2.74	3.64	5.39

(1) Values shown are the average of the monthly P10, P50, and P90 values, as indicated, for the referenced Mine Year; see Section 6.3 of Reference (1).

Large Table 3 Estimated Tailings Basin Seepage Water Quality from the North Toe

Constituent	Mine Year / Percentile / Units	Mine Year 5			Mine Year 20			Mine Year 30			Mine Year 60			Mine Year 100		
		Average P10(1)	Average P50(1)	Average P90(1)	Average P10(1)	Average P50(1)	Average P90(1)	Average P10(1)	Average P50(1)	Average P90(1)	Average P10(1)	Average P50(1)	Average P90(1)	Average P10(1)	Average P50(1)	Average P90(1)
Ag (Silver)	µg/L	0.16	0.17	0.17	0.19	0.19	0.20	0.18	0.18	0.19	0.15	0.16	0.18	0.15	0.16	0.18
Al (Aluminum)	µg/L	11.46	11.54	11.60	1.47	1.79	2.16	2.23	3.44	4.54	2.80	5.68	8.69	2.92	6.35	9.87
Alkalinity	mg/L	242.65	244.20	245.41	49.11	55.05	60.04	70.48	85.86	95.42	78.91	89.32	99.07	78.12	88.98	99.46
As (Arsenic)	µg/L	4.91	5.01	5.15	49.69	52.89	55.74	19.59	21.35	23.79	23.82	26.28	28.87	25.75	28.33	30.97
B (Boron)	µg/L	296.57	298.13	299.34	109.63	112.92	118.12	132.64	141.78	155.63	164.05	181.46	198.99	174.23	195.10	215.06
Ba (Barium)	µg/L	162.58	163.52	164.23	20.17	20.89	21.83	22.17	22.87	24.60	26.68	27.64	29.07	29.93	30.96	32.30
Be (Beryllium)	µg/L	0.29	0.29	0.29	0.39	0.40	0.41	0.39	0.41	0.44	0.35	0.42	0.49	0.35	0.44	0.52
Ca (Calcium)	mg/L	45.65	45.93	46.32	148.07	198.65	267.34	104.05	127.67	147.93	77.52	91.15	106.25	77.02	91.06	108.19
Cd (Cadmium)	µg/L	0.19	0.19	0.21	1.18	1.79	3.85	1.16	1.45	2.00	0.68	0.87	1.81	0.49	0.65	1.56
Cl (Chloride)	mg/L	22.26	22.45	22.65	25.28	27.76	32.33	21.28	23.35	27.44	14.54	15.83	17.76	11.92	12.99	14.33
Co (Cobalt)	µg/L	2.32	2.55	2.99	13.19	27.77	65.34	9.73	19.33	34.72	5.67	10.91	22.02	4.64	9.26	20.69
Cr (Chromium)	µg/L	0.68	0.72	0.78	5.97	6.28	6.58	3.07	3.28	3.71	2.83	3.07	3.34	2.40	2.63	2.90
Cu (Copper)	µg/L	16.03	21.79	29.75	310.47	473.97	649.85	282.63	426.45	591.80	245.81	375.91	514.67	248.04	376.15	509.79
F (Fluoride)	mg/L	3.72	3.74	3.75	1.11	1.18	1.26	0.70	0.76	0.89	0.42	0.45	0.50	0.31	0.33	0.35
Fe (Iron)	µg/L	3,838.08	3,869.43	3,893.63	149.26	178.61	206.18	226.23	314.99	394.71	412.25	651.70	852.42	437.38	717.67	945.69
K (Potassium)	mg/L	10.12	10.21	10.31	33.99	35.20	36.30	25.05	26.54	28.33	20.61	22.11	23.58	17.90	19.35	20.72
Mg (Magnesium)	mg/L	79.78	80.29	80.66	75.40	84.46	96.28	72.30	79.48	87.46	59.97	69.90	80.94	56.15	67.16	80.27
Mn (Manganese)	µg/L	368.82	391.24	415.29	443.79	629.74	863.60	479.48	680.90	879.24	566.56	738.17	926.77	606.98	780.59	967.30
Na (Sodium)	mg/L	70.29	70.79	71.21	98.66	105.50	113.19	77.40	82.25	88.54	48.25	52.38	56.67	37.69	41.79	45.89
Ni (Nickel)	µg/L	8.24	12.42	20.47	207.82	425.49	892.65	145.26	298.76	554.66	81.94	159.78	307.83	65.08	131.64	265.52
Pb (Lead)	µg/L	1.74	1.89	2.11	51.45	54.69	57.77	19.88	21.81	24.31	22.35	24.95	27.82	21.31	24.44	27.95
Sb (Antimony)	µg/L	0.67	0.71	0.74	13.60	16.34	19.03	9.55	10.63	11.85	6.15	6.78	7.60	5.28	5.89	6.66
Se (Selenium)	µg/L	0.76	0.77	0.78	3.92	4.82	5.75	2.66	3.15	3.75	1.59	1.83	2.13	1.33	1.55	1.82
SO_4 (Sulfate)	mg/L	335.79	338.29	340.16	342.74	377.24	423.79	261.86	286.99	318.32	160.27	182.14	201.98	135.14	155.73	176.56
Tl (Thallium)	µg/L	0.18	0.18	0.18	0.19	0.19	0.19	0.17	0.18	0.18	0.15	0.16	0.17	0.15	0.16	0.17
V (Vanadium)	µg/L	4.36	4.42	4.52	9.35	9.45	9.54	8.49	8.67	8.85	7.33	7.61	7.90	7.37	7.63	7.90
Zn (Zinc)	µg/L	14.53	15.01	15.74	129.04	160.40	257.26	122.12	141.34	170.87	67.95	81.14	129.31	47.00	57.68	104.92

(1) Values shown are the average of the monthly P10, P50, and P90 values, as indicated, for the referenced Mine Year; see Section 6.4 of Reference (1).

Large Table 4 Estimated Tailings Basin Seepage Water Quality from the Northwest Toe

Constituent	Mine Year	Mine Year 5			Mine Year 20			Mine Year 30			Mine Year 60			Mine Year 100		
	Percentile / Units	Average P10(1)	Average P50(1)	Average P90(1)	Average P10(1)	Average P50(1)	Average P90(1)	Average P10(1)	Average P50(1)	Average P90(1)	Average P10(1)	Average P50(1)	Average P90(1)	Average P10(1)	Average P50(1)	Average P90(1)
Ag (Silver)	µg/L	0.10	0.10	0.10	0.10	0.12	0.19	0.06	0.09	0.18	0.04	0.08	0.23	0.03	0.09	0.25
Al (Aluminum)	µg/L	21.25	21.32	21.39	16.49	22.14	27.84	10.77	17.66	24.69	9.59	21.46	33.52	8.76	22.11	35.46
Alkalinity	mg/L	228.89	229.68	230.41	221.70	238.15	254.64	169.45	189.36	208.88	193.59	227.41	261.20	194.14	232.48	270.96
As (Arsenic)	µg/L	1.31	1.31	1.32	5.85	6.61	7.50	5.20	6.00	6.94	1.40	1.89	2.85	1.41	1.99	3.00
B (Boron)	µg/L	465.67	467.30	468.80	456.85	488.25	522.16	349.46	387.59	426.93	400.35	466.44	530.85	403.24	476.01	550.53
Ba (Barium)	µg/L	23.94	24.02	24.10	24.33	25.05	26.28	18.83	19.61	21.03	20.97	22.14	24.51	21.32	22.53	25.13
Be (Beryllium)	µg/L	0.52	0.52	0.52	0.44	0.59	0.73	0.28	0.46	0.64	0.23	0.53	0.84	0.20	0.54	0.88
Ca (Calcium)	mg/L	94.31	94.65	94.96	108.62	118.02	127.33	86.17	96.66	106.48	81.76	95.64	109.89	81.98	97.94	113.91
Cd (Cadmium)	µg/L	0.12	0.12	0.12	0.28	0.36	0.56	0.13	0.22	0.43	0.05	0.11	0.26	0.04	0.11	0.28
Cl (Chloride)	mg/L	20.97	21.04	21.12	23.51	24.61	25.69	17.35	18.40	19.51	18.99	20.71	22.57	19.17	21.16	23.12
Co (Cobalt)	µg/L	2.13	2.15	2.19	3.49	5.41	9.68	2.60	4.55	8.48	1.08	2.12	4.76	0.95	2.11	5.13
Cr (Chromium)	µg/L	0.59	0.59	0.59	1.14	1.23	1.34	0.97	1.07	1.18	0.55	0.66	0.77	0.54	0.67	0.79
Cu (Copper)	µg/L	3.83	6.17	8.59	42.26	62.64	87.50	29.39	44.59	59.43	7.15	10.57	14.40	6.89	10.60	14.84
F (Fluoride)	mg/L	0.13	0.13	0.13	0.16	0.17	0.19	0.09	0.10	0.11	0.04	0.05	0.05	0.04	0.05	0.05
Fe (Iron)	µg/L	4,773.51	4,790.11	4,805.33	4,428.20	5,227.42	5,842.10	3,249.06	4,259.61	5,011.91	3,587.53	5,135.64	6,418.76	3,617.70	5,390.43	6,757.85
K (Potassium)	mg/L	9.85	9.89	9.92	12.93	14.01	15.13	9.79	11.06	12.34	8.16	10.21	12.29	8.04	10.36	12.67
Mg (Magnesium)	mg/L	161.05	161.61	162.13	156.47	172.75	193.70	116.54	136.43	161.28	124.35	159.07	201.56	124.35	161.92	208.56
Mn (Manganese)	µg/L	1,135.85	1,140.01	1,143.98	1,113.25	1,242.78	1,378.18	826.59	978.67	1,133.73	880.28	1,144.26	1,407.39	875.73	1,174.23	1,465.96
Na (Sodium)	mg/L	54.91	55.11	55.30	62.31	67.98	73.54	43.66	49.89	56.24	43.74	54.61	65.21	43.35	55.38	67.56
Ni (Nickel)	µg/L	5.02	5.43	6.23	27.99	54.26	103.38	21.96	42.91	89.39	5.15	9.10	15.71	4.46	8.71	15.44
Pb (Lead)	µg/L	0.20	0.20	0.21	4.95	5.63	6.49	4.61	5.39	6.29	0.79	0.93	1.12	0.76	0.92	1.12
Sb (Antimony)	µg/L	0.35	0.36	0.36	1.92	2.29	2.70	1.09	1.34	1.69	0.27	0.41	0.79	0.24	0.41	0.83
Se (Selenium)	µg/L	0.44	0.44	0.44	0.82	0.97	1.24	0.58	0.73	1.06	0.24	0.40	0.90	0.23	0.40	0.97
SO_4 (Sulfate)	mg/L	313.28	314.37	315.39	328.84	381.11	424.46	239.70	305.56	358.25	233.89	334.63	417.34	235.66	352.44	442.03
Tl (Thallium)	µg/L	0.07	0.07	0.07	0.07	0.09	0.13	0.05	0.06	0.12	0.03	0.05	0.14	0.02	0.06	0.15
V (Vanadium)	µg/L	0.89	0.90	0.91	1.83	1.96	2.09	1.30	1.42	1.55	0.71	0.88	1.05	0.71	0.90	1.09
Zn (Zinc)	µg/L	3.69	3.75	3.85	22.57	26.70	36.31	9.75	13.33	22.98	3.82	5.03	6.77	3.47	4.82	6.60

(1) Values shown are the average of the monthly P10, P50, and P90 values, as indicated, for the referenced Mine Year; see Section 6.4 of Reference (1).

Large Table 5 Estimated Tailings Basin Seepage Water Quality from the West Toe

Constituent	Mine Year	Mine Year 5			Mine Year 20			Mine Year 30			Mine Year 60			Mine Year 100		
	Percentile / Units	Average P10[(1)]	Average P50[(1)]	Average P90[(1)]	Average P10[(1)]	Average P50[(1)]	Average P90[(1)]	Average P10[(1)]	Average P50[(1)]	Average P90[(1)]	Average P10[(1)]	Average P50[(1)]	Average P90[(1)]	Average P10[(1)]	Average P50[(1)]	Average P90[(1)]
Ag (Silver)	µg/L	0.11	0.11	0.11	0.11	0.13	0.20	0.07	0.10	0.19	0.04	0.09	0.25	0.04	0.09	0.27
Al (Aluminum)	µg/L	21.31	21.38	21.44	14.28	19.83	25.64	10.00	17.12	24.42	9.28	21.21	33.28	8.59	21.80	35.04
Alkalinity	mg/L	230.39	231.10	231.75	200.45	217.04	233.31	164.81	185.47	205.84	191.17	225.04	259.20	191.71	229.86	267.85
As (Arsenic)	µg/L	1.42	1.42	1.43	11.04	12.40	14.01	4.96	5.65	6.47	1.81	2.35	3.44	1.87	2.52	3.64
B (Boron)	µg/L	464.55	465.98	467.31	416.30	447.46	480.52	340.10	380.18	420.87	395.36	462.17	526.42	398.60	471.13	544.52
Ba (Barium)	µg/L	26.27	26.35	26.42	23.62	24.36	25.74	18.96	19.85	21.56	20.53	21.77	24.36	20.86	22.12	24.90
Be (Beryllium)	µg/L	0.52	0.52	0.52	0.42	0.57	0.71	0.28	0.47	0.65	0.22	0.53	0.84	0.20	0.54	0.88
Ca (Calcium)	mg/L	93.60	93.89	94.16	109.73	120.89	132.89	81.61	91.55	101.41	81.55	95.59	109.83	81.77	97.77	113.50
Cd (Cadmium)	µg/L	0.12	0.12	0.12	0.37	0.51	0.87	0.20	0.29	0.47	0.07	0.13	0.30	0.06	0.13	0.32
Cl (Chloride)	mg/L	20.88	20.94	21.01	23.87	25.10	26.44	18.15	19.25	20.45	18.96	20.69	22.54	19.05	21.03	22.99
Co (Cobalt)	µg/L	2.30	2.31	2.33	4.54	7.48	13.74	2.85	4.63	8.23	1.24	2.44	5.38	1.12	2.43	5.74
Cr (Chromium)	µg/L	0.58	0.58	0.58	1.68	1.83	1.99	0.98	1.07	1.16	0.59	0.70	0.81	0.58	0.70	0.82
Cu (Copper)	µg/L	2.66	2.74	3.09	72.08	108.06	151.40	43.76	66.72	90.32	12.13	18.05	24.26	11.91	18.11	24.57
F (Fluoride)	mg/L	0.17	0.17	0.17	0.26	0.29	0.32	0.13	0.14	0.15	0.05	0.05	0.06	0.05	0.05	0.05
Fe (Iron)	µg/L	5,206.46	5,222.43	5,237.05	4,005.82	4,873.61	5,546.78	3,166.79	4,319.16	5,201.90	3,681.21	5,503.51	7,056.63	3,749.48	5,841.07	7,452.93
K (Potassium)	mg/L	9.78	9.81	9.84	15.32	16.52	17.70	10.50	11.79	13.05	8.38	10.44	12.54	8.18	10.52	12.79
Mg (Magnesium)	mg/L	159.99	160.48	160.94	145.82	162.39	182.63	113.66	134.36	159.86	122.77	157.59	200.24	122.84	160.00	206.20
Mn (Manganese)	µg/L	1,125.68	1,129.25	1,132.72	1,051.18	1,177.19	1,311.50	821.52	981.70	1,142.35	875.84	1,138.53	1,402.86	873.32	1,166.27	1,454.54
Na (Sodium)	mg/L	54.81	54.98	55.14	66.18	71.91	77.70	46.08	52.77	59.55	43.81	54.77	65.41	43.28	55.18	67.16
Ni (Nickel)	µg/L	5.23	5.41	5.79	44.78	87.51	166.84	24.49	46.90	86.10	7.38	12.39	20.92	6.24	11.50	19.89
Pb (Lead)	µg/L	0.20	0.20	0.20	10.32	11.71	13.27	4.38	5.01	5.68	1.15	1.32	1.55	1.10	1.29	1.55
Sb (Antimony)	µg/L	0.36	0.37	0.37	3.14	3.68	4.33	1.50	1.75	2.07	0.40	0.56	0.97	0.36	0.54	1.01
Se (Selenium)	µg/L	0.47	0.48	0.48	1.10	1.31	1.58	0.60	0.74	1.07	0.28	0.45	1.00	0.26	0.46	1.09
SO_4 (Sulfate)	mg/L	340.63	341.69	342.66	330.56	387.27	437.30	238.50	316.26	376.80	242.44	361.22	460.74	245.57	383.10	488.38
Tl (Thallium)	µg/L	0.08	0.08	0.08	0.09	0.10	0.15	0.05	0.07	0.13	0.03	0.06	0.16	0.03	0.06	0.17
V (Vanadium)	µg/L	0.84	0.84	0.85	2.62	2.80	2.99	1.72	1.85	1.98	0.85	1.02	1.19	0.85	1.04	1.22
Zn (Zinc)	µg/L	3.75	3.78	3.81	33.42	39.53	59.97	17.90	21.28	29.70	5.43	6.93	9.24	4.68	6.30	8.50

(1) Values shown are the average of the monthly P10, P50, and P90 values, as indicated, for the referenced Mine Year; see Section 6.4 of Reference (1).

Large Table 6 Estimated Tailings Basin Seepage Water Quality from the South Toe

Constituent	Mine Year	Mine Year 5			Mine Year 20			Mine Year 30			Mine Year 60			Mine Year 100		
	Percentile	Average P10(1)	Average P50(1)	Average P90(1)	Average P10(1)	Average P50(1)	Average P90(1)	Average P10(1)	Average P50(1)	Average P90(1)	Average P10(1)	Average P50(1)	Average P90(1)	Average P10(1)	Average P50(1)	Average P90(1)
	Units															
Ag (Silver)	µg/L	0.12	0.13	0.13	0.20	0.20	0.20	0.16	0.17	0.18	0.13	0.14	0.16	0.13	0.14	0.16
Al (Aluminum)	µg/L	10.27	10.28	10.29	1.24	1.35	1.49	2.72	4.50	6.13	3.50	7.79	12.68	3.58	8.55	13.73
Alkalinity	mg/L	202.63	203.21	203.78	39.41	42.06	44.67	80.74	99.24	112.90	89.54	104.32	120.83	90.43	107.43	126.76
As (Arsenic)	µg/L	3.94	3.98	4.04	96.91	98.44	99.43	73.66	78.73	83.58	59.34	65.55	71.09	59.03	64.89	70.63
B (Boron)	µg/L	258.25	258.43	258.64	104.80	106.28	107.87	144.62	159.42	176.42	190.58	220.34	254.77	199.04	235.35	269.94
Ba (Barium)	µg/L	153.82	154.03	154.22	17.95	18.83	19.66	17.98	19.36	21.41	28.72	30.49	32.82	30.14	32.03	34.16
Be (Beryllium)	µg/L	0.26	0.26	0.26	0.40	0.40	0.41	0.37	0.41	0.45	0.33	0.44	0.55	0.33	0.45	0.58
Ca (Calcium)	mg/L	39.09	39.24	39.39	197.41	280.79	392.55	231.31	320.77	467.97	132.59	185.36	247.72	138.49	190.65	263.74
Cd (Cadmium)	µg/L	0.15	0.16	0.16	0.54	1.69	5.34	0.46	1.28	4.90	0.08	0.47	3.35	0.08	0.53	3.19
Cl (Chloride)	mg/L	21.36	21.56	21.80	27.35	30.28	35.72	16.15	19.96	25.55	5.55	6.71	8.23	6.18	7.51	8.93
Co (Cobalt)	µg/L	1.46	1.70	2.18	16.89	37.39	96.70	16.06	38.72	110.13	3.73	15.74	52.30	3.92	15.99	55.95
Cr (Chromium)	µg/L	0.52	0.53	0.54	9.82	9.91	9.99	7.54	8.10	8.66	6.16	6.76	7.30	6.13	6.69	7.24
Cu (Copper)	µg/L	5.19	7.37	16.64	328.96	511.11	694.83	260.13	401.13	548.86	213.73	336.57	462.23	212.12	334.83	458.77
F (Fluoride)	mg/L	4.03	4.05	4.06	1.33	1.42	1.51	0.74	0.87	1.03	0.30	0.35	0.40	0.30	0.34	0.40
Fe (Iron)	µg/L	1,846.23	1,853.76	1,861.83	161.38	190.21	220.42	394.56	521.12	671.71	384.56	577.44	765.97	413.92	636.89	849.24
K (Potassium)	mg/L	8.68	8.77	8.83	45.71	46.55	47.40	36.13	38.69	40.96	30.77	33.71	36.19	30.83	33.85	36.36
Mg (Magnesium)	mg/L	67.73	67.91	68.05	85.85	99.13	117.54	105.05	123.71	150.86	65.77	82.25	101.34	68.97	88.39	111.90
Mn (Manganese)	µg/L	330.26	365.28	402.30	416.45	603.65	893.09	484.21	652.48	855.61	535.14	764.81	968.94	558.89	793.82	1,012.96
Na (Sodium)	mg/L	67.92	68.37	68.79	111.50	121.23	132.34	64.80	76.92	92.07	22.71	28.74	35.70	21.14	27.75	33.96
Ni (Nickel)	µg/L	6.37	11.07	20.55	265.91	551.74	1,249.01	248.58	560.70	1,378.10	46.23	209.26	627.55	47.56	214.59	654.95
Pb (Lead)	µg/L	1.32	1.36	1.42	97.70	98.67	99.54	72.96	77.84	82.64	58.99	65.41	70.95	58.90	64.77	70.50
Sb (Antimony)	µg/L	0.60	0.64	0.68	16.29	20.24	24.94	10.08	13.76	18.66	3.84	5.51	7.93	3.95	5.60	8.17
Se (Selenium)	µg/L	0.58	0.59	0.60	4.94	6.36	7.89	4.41	5.99	8.05	2.00	2.69	3.54	2.03	2.76	3.69
SO_4 (Sulfate)	mg/L	197.37	198.05	198.69	414.19	475.81	552.91	399.68	469.82	575.82	152.35	183.34	227.34	157.06	191.34	235.36
Tl (Thallium)	µg/L	0.15	0.15	0.15	0.20	0.20	0.20	0.16	0.16	0.18	0.12	0.14	0.15	0.12	0.14	0.15
V (Vanadium)	µg/L	4.05	4.13	4.28	9.81	9.91	9.99	7.44	7.92	8.38	6.18	6.78	7.30	6.18	6.74	7.29
Zn (Zinc)	µg/L	13.59	14.26	14.81	58.30	118.74	316.74	46.35	102.65	265.93	7.33	36.91	208.55	7.10	37.78	205.92

(1) Values shown are the average of the monthly P10, P50, and P90 values, as indicated, for the referenced Mine Year; see Section 6.4 of Reference (1).

Large Table 7 Estimated Water Quality along the North Groundwater Flow Path at the Property Boundary

Constituent	Mine Year	Water Quality Standard	Mine Year 1			Mine Year 50			Mine Year 100			Mine Year 160			Mine Year 200[2]		
	Percentile		Average P10[1]	Average P50[1]	Average P90[1]	Average P10[1]	Average P50[1]	Average P90[1]	Average P10[1]	Average P50[1]	Average P90[1]	Average P10[1]	Average P50[1]	Average P90[1]	Average P10[1]	Average P50[1]	Average P90[1]
	Units																
Ag (Silver)	µg/L	30	0.10	0.11	0.12	0.09	0.10	0.11	0.08	0.09	0.10	0.08	0.09	0.10	0.08	0.09	0.10
Al (Aluminum)[3]	µg/L	--	22.27	29.98	40.10	29.99	38.82	50.01	36.25	45.69	58.63	41.29	51.25	64.69	42.88	53.01	66.43
Alkalinity	mg/L	--	182.09	215.31	241.43	151.99	180.79	207.59	123.68	152.31	181.78	93.17	120.92	155.20	84.72	102.21	135.85
As (Arsenic)	µg/L	10	2.48	3.21	3.76	2.47	3.21	3.75	2.46	3.20	3.74	2.45	3.19	3.73	2.45	3.18	3.72
B (Boron)	µg/L	1000	162.57	211.35	247.61	123.62	161.80	202.18	85.43	122.44	163.82	53.95	83.77	127.53	46.78	66.90	103.13
Ba (Barium)	µg/L	2000	131.47	157.48	178.33	107.64	131.93	154.87	85.70	111.16	135.80	58.59	85.97	117.07	50.44	70.72	103.84
Be (Beryllium)[4]	µg/L	0.49	0.18	0.19	0.20	0.18	0.19	0.20	0.17	0.19	0.20	0.17	0.19	0.22	0.18	0.20	0.23
Ca (Calcium)	mg/L	--	33.33	36.16	38.30	30.80	33.58	36.13	28.66	31.58	34.70	28.88	32.54	40.94	29.63	34.57	43.56
Cd (Cadmium)	µg/L	4	0.12	0.13	0.13	0.12	0.13	0.13	0.12	0.13	0.14	0.12	0.15	0.28	0.14	0.20	0.34
Cl (Chloride)	mg/L	250	11.78	15.34	18.02	8.90	11.67	14.65	6.08	8.72	11.82	4.20	6.41	9.31	3.50	5.32	8.04
Co (Cobalt)	µg/L	--	0.79	1.02	1.20	0.60	0.79	0.98	0.45	0.63	0.84	0.48	0.80	3.01	0.59	1.33	3.86
Cr (Chromium)	µg/L	100	0.62	0.68	0.79	0.68	0.77	0.87	0.73	0.84	0.97	0.83	1.01	1.42	0.94	1.19	1.52
Cu (Copper)	µg/L	--	1.93	2.04	2.19	1.93	2.05	2.19	1.93	2.05	2.19	1.93	2.05	2.19	1.93	2.05	2.19
F (Fluoride)	mg/L	2	**2.13**	**2.84**	**3.38**	1.56	**2.11**	**2.71**	0.99	1.53	**2.14**	0.41	0.92	1.59	0.22	0.55	1.21
Fe (Iron)[3]	µg/L	--	1,115.10	1,495.30	1,779.30	810.23	1,108.90	1,422.60	516.07	798.35	1,118.80	244.05	507.17	847.56	151.12	325.84	666.22
K (Potassium)	mg/L	--	5.88	7.27	8.37	4.63	5.83	6.93	3.53	4.68	5.80	3.25	4.32	5.92	3.34	4.46	6.53
Mg (Magnesium)	mg/L	--	41.50	52.51	60.82	32.24	41.49	50.18	23.85	32.36	41.63	18.78	25.30	34.04	17.15	22.96	30.53
Mn (Manganese)[3],[4]	µg/L	1,506	239.80	263.52	289.10	229.89	265.47	301.92	221.51	269.05	314.00	228.19	287.03	351.92	241.41	308.71	383.53
Na (Sodium)	mg/L	--	37.56	49.56	58.42	28.10	37.45	47.33	18.74	27.60	37.79	12.86	20.04	29.42	10.41	16.31	25.28
Ni (Nickel)	µg/L	100	3.36	3.58	3.94	3.36	3.58	3.95	3.36	3.58	3.95	3.36	3.59	3.96	3.37	3.59	3.96
Pb (Lead)	µg/L	--	0.80	1.00	1.15	0.64	0.80	0.96	0.52	0.68	0.87	0.60	1.24	4.57	0.84	2.67	5.81
Sb (Antimony)	µg/L	6	0.32	0.35	0.39	0.32	0.35	0.39	0.32	0.35	0.39	0.32	0.35	0.39	0.32	0.35	0.40
Se (Selenium)	µg/L	30	0.64	0.68	0.72	0.66	0.71	0.77	0.68	0.74	0.82	0.71	0.82	1.07	0.77	0.93	1.10
SO_4 (Sulfate)	mg/L	250	118.58	158.45	188.42	86.26	117.57	150.78	56.24	85.40	119.15	37.60	63.70	94.17	29.54	51.65	82.02
Tl (Thallium)	µg/L	0.6	0.16	0.17	0.18	0.15	0.17	0.19	0.15	0.17	0.19	0.15	0.17	0.20	0.15	0.17	0.20
V (Vanadium)	µg/L	50	4.75	4.88	5.07	4.83	5.02	5.24	4.92	5.15	5.41	5.03	5.36	5.82	5.19	5.55	5.97
Zn (Zinc)	µg/L	2,000	12.12	12.74	13.69	12.08	13.04	14.23	12.10	13.47	15.29	12.90	16.16	27.55	14.39	20.75	31.09

NOTE: Values above the applicable water quality standard are shown in bold with light red shading.
(1) Values shown are the average of the monthly P10, P50, and P90 values, as indicated, for the referenced Mine Year; see Section 6.5 of Reference (14).
(2) Model runs evaluated through Mine Year 200.
(3) Not evaluated against the secondary groundwater standard.
(4) Evaluated against the site-specific evaluation criteria shown.

Large Table 8 Estimated Water Quality along the Northwest Groundwater Flow Path at the Property Boundary

Constituent	Mine Year / Percentile / Units	Water Quality Standard	Mine Year 1			Mine Year 50			Mine Year 100			Mine Year 160			Mine Year 200[2]		
			Average P10[1]	Average P50[1]	Average P90[1]	Average P10[1]	Average P50[1]	Average P90[1]	Average P10[1]	Average P50[1]	Average P90[1]	Average P10[1]	Average P50[1]	Average P90[1]	Average P10[1]	Average P50[1]	Average P90[1]
Ag (Silver)	µg/L	30	0.09	0.10	0.10	0.08	0.09	0.10	0.08	0.09	0.09	0.07	0.08	0.09	0.07	0.08	0.10
Al (Aluminum)[3]	µg/L	--	25.15	31.65	41.39	32.51	40.28	49.99	37.81	47.46	58.44	43.03	52.84	64.84	45.08	54.76	66.89
Alkalinity	mg/L	--	161.62	185.36	205.31	137.16	158.71	179.54	115.02	137.34	159.08	100.00	119.17	139.69	96.33	112.87	131.91
As (Arsenic)	µg/L	10	0.83	0.95	1.04	0.83	0.95	1.04	0.83	0.94	1.04	0.83	0.94	1.04	0.83	0.94	1.04
B (Boron)	µg/L	1000	257.56	324.12	383.19	185.26	245.91	305.06	122.10	180.33	243.40	81.78	127.67	187.71	72.54	110.30	165.81
Ba (Barium)	µg/L	2000	29.98	36.47	46.36	33.45	42.33	54.30	36.55	47.47	61.48	38.34	50.80	67.22	38.87	51.72	68.73
Be (Beryllium)[4]	µg/L	0.49	0.18	0.19	0.20	0.18	0.19	0.20	0.17	0.19	0.20	0.17	0.19	0.23	0.18	0.21	0.26
Ca (Calcium)	mg/L	--	62.19	72.80	81.84	50.73	60.36	69.72	41.03	50.31	60.03	35.33	42.62	51.65	33.47	39.69	48.56
Cd (Cadmium)	µg/L	4	0.11	0.11	0.12	0.11	0.12	0.12	0.11	0.12	0.13	0.12	0.13	0.14	0.11	0.13	0.15
Cl (Chloride)	mg/L	250	11.75	14.65	17.19	8.65	11.20	13.78	5.91	8.33	11.10	4.16	6.18	8.76	3.77	5.35	7.76
Co (Cobalt)	µg/L	--	1.18	1.49	1.76	0.86	1.13	1.40	0.58	0.84	1.13	0.46	0.71	1.03	0.39	0.66	1.07
Cr (Chromium)	µg/L	100	0.68	0.73	0.82	0.73	0.81	0.90	0.77	0.86	0.97	0.81	0.92	1.05	0.83	0.94	1.06
Cu (Copper)	µg/L	--	2.11	2.25	2.37	2.11	2.25	2.37	2.11	2.25	2.37	2.11	2.25	2.37	2.11	2.24	2.37
F (Fluoride)	mg/L	2	0.09	0.10	0.11	0.10	0.11	0.13	0.11	0.12	0.14	0.12	0.13	0.15	0.12	0.13	0.15
Fe (Iron)[3]	µg/L	--	2,537.30	3,264.00	3,903.30	1,759.50	2,415.20	3,053.80	1,077.40	1,700.50	2,382.90	647.55	1,136.60	1,812.40	545.82	965.39	1,550.50
K (Potassium)	mg/L	--	6.01	7.25	8.32	4.70	5.81	6.88	3.57	4.63	5.79	2.91	3.75	4.87	2.71	3.44	4.54
Mg (Magnesium)	mg/L	--	89.70	112.59	132.89	64.48	85.60	105.42	42.46	62.60	84.61	28.98	44.95	66.00	25.99	39.86	58.35
Mn (Manganese)[3],[4]	µg/L	1,506	722.93	860.30	974.49	575.81	702.07	821.89	446.77	575.62	707.95	358.90	472.11	605.98	335.81	439.25	559.15
Na (Sodium)	mg/L	--	30.76	38.35	45.05	22.40	29.43	36.08	15.34	21.90	29.06	10.87	16.21	23.21	9.63	14.20	20.63
Ni (Nickel)	µg/L	100	4.45	4.73	4.96	4.45	4.72	4.96	4.45	4.72	4.96	4.45	4.72	4.96	4.45	4.72	4.96
Pb (Lead)	µg/L	--	0.21	0.22	0.23	0.22	0.23	0.23	0.23	0.24	0.26	0.24	0.35	0.74	0.29	0.47	0.73
Sb (Antimony)	µg/L	6	0.31	0.33	0.37	0.30	0.33	0.37	0.30	0.33	0.37	0.30	0.33	0.37	0.30	0.33	0.38
Se (Selenium)	µg/L	30	0.52	0.56	0.63	0.57	0.62	0.70	0.61	0.68	0.77	0.65	0.73	0.83	0.66	0.75	0.84
SO_4 (Sulfate)	mg/L	250	165.63	212.30	**253.08**	116.24	158.07	198.56	73.21	112.57	155.86	46.90	78.22	120.45	39.58	66.93	105.53
Tl (Thallium)	µg/L	0.6	0.09	0.10	0.13	0.10	0.12	0.15	0.11	0.13	0.16	0.12	0.15	0.18	0.12	0.15	0.18
V (Vanadium)	µg/L	50	1.80	2.39	3.12	2.58	3.21	3.85	3.17	3.88	4.49	3.74	4.42	4.95	3.98	4.56	5.06
Zn (Zinc)	µg/L	2,000	5.52	6.89	8.86	7.22	8.67	10.66	8.44	10.30	12.40	9.88	12.15	14.43	10.66	12.64	14.80

NOTE: Values above the applicable water quality standard are shown in bold with light red shading.
(1) Values shown are the average of the monthly P10, P50, and P90 values, as indicated, for the referenced Mine Year; see Section 6.5 of Reference (14).
(2) Model runs evaluated through Mine Year 200.
(3) Not evaluated against the secondary groundwater standard.
(4) Evaluated against the site-specific evaluation criteria shown.

Large Table 9 Estimated Water Quality along the West Groundwater Flow Path at the Property Boundary

Constituent	Mine Year	Water Quality Standard	Mine Year 1			Mine Year 50			Mine Year 100			Mine Year 160			Mine Year 200(2)		
	Percentile		Average P10(1)	Average P50(1)	Average P90(1)	Average P10(1)	Average P50(1)	Average P90(1)	Average P10(1)	Average P50(1)	Average P90(1)	Average P10(1)	Average P50(1)	Average P90(1)	Average P10(1)	Average P50(1)	Average P90(1)
	Units																
Ag (Silver)	µg/L	30	0.09	0.10	0.11	0.08	0.09	0.10	0.08	0.09	0.10	0.07	0.08	0.09	0.07	0.08	0.09
Al (Aluminum)(3)	µg/L	--	29.64	37.41	48.27	35.30	43.65	55.22	39.48	49.15	61.47	43.35	54.01	66.82	45.30	56.31	69.68
Alkalinity	mg/L	--	142.90	168.35	190.34	128.56	147.91	170.05	112.73	130.94	153.69	97.97	115.62	138.00	92.11	108.15	128.71
As (Arsenic)	µg/L	10	0.83	0.97	1.11	0.83	0.97	1.11	0.83	0.97	1.10	0.83	0.97	1.10	0.83	0.96	1.10
B (Boron)	µg/L	1000	200.60	272.52	339.02	159.06	213.79	279.45	114.37	163.55	228.28	73.82	118.59	179.65	61.40	95.72	153.04
Ba (Barium)	µg/L	2000	35.40	42.16	53.79	37.37	46.37	59.85	38.91	49.89	65.35	40.05	53.04	70.21	40.56	53.85	72.08
Be (Beryllium)(4)	µg/L	0.49	0.18	0.19	0.20	0.17	0.19	0.20	0.17	0.18	0.20	0.17	0.18	0.21	0.17	0.19	0.22
Ca (Calcium)	mg/L	--	52.89	63.86	73.96	46.57	55.00	64.94	39.48	47.25	57.41	33.10	40.07	49.89	31.40	36.96	46.40
Cd (Cadmium)	µg/L	4	0.12	0.12	0.13	0.12	0.12	0.13	0.11	0.12	0.13	0.12	0.12	0.13	0.12	0.13	0.14
Cl (Chloride)	mg/L	250	9.21	12.37	15.24	7.48	9.89	12.68	5.47	7.66	10.43	3.79	5.64	8.35	3.21	4.74	7.23
Co (Cobalt)	µg/L	--	1.00	1.36	1.70	0.79	1.07	1.40	0.57	0.82	1.14	0.41	0.61	0.91	0.36	0.55	0.83
Cr (Chromium)	µg/L	100	0.70	0.78	0.88	0.74	0.83	0.93	0.77	0.87	0.99	0.80	0.91	1.05	0.82	0.94	1.08
Cu (Copper)	µg/L	--	2.15	2.34	2.52	2.14	2.34	2.52	2.14	2.34	2.52	2.14	2.34	2.52	2.14	2.34	2.52
F (Fluoride)	mg/L	2	0.16	0.17	0.18	0.16	0.17	0.18	0.15	0.16	0.17	0.14	0.16	0.17	0.14	0.15	0.17
Fe (Iron)(3)	µg/L	--	2,066.40	2,905.20	3,680.10	1,584.60	2,217.20	2,989.00	1,054.20	1,636.40	2,390.70	582.66	1,105.30	1,825.60	444.57	841.48	1,512.70
K (Potassium)	mg/L	--	4.96	6.26	7.44	4.24	5.20	6.31	3.35	4.26	5.41	2.65	3.47	4.52	2.46	3.15	4.07
Mg (Magnesium)	mg/L	--	69.04	92.93	115.48	55.28	73.49	94.99	40.06	56.34	78.13	26.62	40.76	61.71	22.01	33.43	53.13
Mn (Manganese)(3),(4)	µg/L	1,506	611.82	743.70	866.48	519.07	630.09	753.66	422.69	537.91	662.34	345.45	447.28	571.84	312.39	410.32	525.85
Na (Sodium)	mg/L	--	24.43	32.72	40.19	19.60	25.90	33.49	14.35	20.12	27.47	9.96	14.91	22.18	8.39	12.61	19.12
Ni (Nickel)	µg/L	100	4.51	4.86	5.17	4.51	4.86	5.17	4.50	4.86	5.17	4.50	4.86	5.17	4.50	4.85	5.17
Pb (Lead)	µg/L	--	0.22	0.22	0.23	0.22	0.23	0.24	0.23	0.24	0.24	0.23	0.24	0.36	0.24	0.29	0.59
Sb (Antimony)	µg/L	6	0.32	0.35	0.40	0.31	0.35	0.40	0.31	0.35	0.40	0.31	0.35	0.40	0.31	0.35	0.40
Se (Selenium)	µg/L	30	0.57	0.63	0.69	0.61	0.67	0.74	0.64	0.70	0.78	0.66	0.74	0.83	0.68	0.76	0.84
SO_4 (Sulfate)	mg/L	250	138.20	192.57	243.27	106.45	148.14	197.84	72.08	110.08	159.62	42.39	75.82	122.03	32.96	59.56	101.75
Tl (Thallium)	µg/L	0.6	0.10	0.12	0.14	0.11	0.13	0.16	0.12	0.14	0.17	0.13	0.15	0.18	0.13	0.15	0.19
V (Vanadium)	µg/L	50	2.32	2.99	3.73	2.92	3.54	4.14	3.41	4.04	4.62	3.89	4.51	5.04	4.14	4.72	5.20
Zn (Zinc)	µg/L	2,000	6.83	8.39	10.40	8.07	9.61	11.45	8.99	10.72	12.62	9.98	11.86	14.11	10.50	12.66	14.76

NOTE: Values above the applicable water quality standard are shown in bold with light red shading.
(1) Values shown are the average of the monthly P10, P50, and P90 values, as indicated, for the referenced Mine Year; see Section 6.5 of Reference (14).
(2) Model runs evaluated through Mine Year 200.
(3) Not evaluated against the secondary groundwater standard.
(4) Evaluated against the site-specific evaluation criteria shown.

Large Table 10 Estimated Surface Water Quality for the Embarrass River at PM-12 (Existing NPDES Station SW004)

Constituent	Mine Year	Water Quality Standard	Mine Year 2			Mine Year 13			Mine Year 25			Mine Year 40			Mine Year 100(2)		
	Percentile		Average P10(1)	Average P50(1)	Average P90(1)	Average P10(1)	Average P50(1)	Average P90(1)	Average P10(1)	Average P50(1)	Average P90(1)	Average P10(1)	Average P50(1)	Average P90(1)	Average P10(1)	Average P50(1)	Average P90(1)
	Units																
Ag (Silver)	µg/L	1	0.09	0.11	0.12	0.09	0.11	0.12	0.09	0.11	0.13	0.09	0.11	0.13	0.09	0.11	0.13
Al (Aluminum)	µg/L	125	60.61	93.74	**185.15**	58.96	92.09	**164.57**	61.45	92.46	**172.10**	61.63	93.31	**165.92**	62.75	93.48	**172.45**
Alkalinity	mg/L	--	9.81	43.30	85.65	10.21	42.88	84.79	9.86	43.51	91.08	10.42	43.09	84.14	9.54	43.24	87.35
As (Arsenic)	µg/L	53	0.40	1.04	3.48	0.37	1.03	3.78	0.39	1.06	3.61	0.38	1.07	4.36	0.40	1.04	3.65
B (Boron)	µg/L	500	16.11	21.88	26.19	16.14	21.91	26.25	16.35	21.88	26.39	16.09	21.84	26.13	16.11	21.87	26.32
Ba (Barium)	µg/L	--	5.08	16.60	47.55	5.07	16.96	47.48	5.06	16.86	47.21	5.07	16.75	47.79	5.07	16.73	47.07
Be (Beryllium)	µg/L	--	0.07	0.10	0.15	0.07	0.10	0.15	0.07	0.10	0.15	0.07	0.10	0.15	0.07	0.10	0.15
Ca (Calcium)	mg/L	--	3.93	12.77	22.72	3.57	12.93	23.07	3.78	12.92	22.28	3.60	12.95	23.14	3.82	12.82	22.24
Cd (Cadmium)(3)	µg/L	--	0.08	0.09	0.11	0.07	0.09	0.11	0.08	0.09	0.11	0.08	0.09	0.11	0.07	0.09	0.11
Cl (Chloride)	mg/L	230	2.50	4.24	8.95	2.55	4.24	8.98	2.50	4.23	8.96	2.49	4.27	9.15	2.56	4.18	8.95
Co (Cobalt)	µg/L	5	0.38	0.85	2.31	0.39	0.85	2.36	0.39	0.84	2.42	0.38	0.84	2.50	0.38	0.85	2.45
Cr (Chromium)	µg/L	11	0.20	0.66	1.45	0.19	0.67	1.69	0.20	0.67	1.53	0.20	0.66	1.61	0.19	0.67	1.63
Cu (Copper)(3)	µg/L	--	0.22	0.99	1.87	0.21	0.98	1.85	0.22	0.98	1.91	0.23	0.98	1.95	0.22	0.98	1.90
F (Fluoride)	mg/L	--	0.02	0.09	0.18	0.03	0.09	0.19	0.02	0.09	0.18	0.02	0.09	0.20	0.02	0.09	0.18
Fe (Iron)	µg/L	--	1,154.60	3,305.21	10,828.00	1,186.30	3,247.56	11,264.00	1,137.50	3,205.58	10,495.00	1,164.90	3,274.75	10,839.00	1,237.00	3,273.76	10,795.00
K (Potassium)	mg/L	--	0.19	0.91	1.89	0.19	0.92	1.97	0.21	0.93	2.08	0.18	0.91	2.07	0.18	0.93	1.97
Mg (Magnesium)	mg/L	--	1.54	5.69	10.45	1.52	5.62	11.24	1.44	5.64	10.60	1.29	5.67	10.57	1.43	5.62	10.34
Mn (Manganese)	µg/L	--	64.98	289.35	1,141.60	69.33	289.69	1,099.90	69.19	291.02	1,025.50	74.08	288.95	971.86	76.08	291.11	1,061.50
Na (Sodium)	mg/L	--	1.99	3.53	5.00	1.98	3.56	4.88	1.95	3.56	5.13	1.95	3.53	4.79	2.02	3.55	4.99
Ni (Nickel)(3)	µg/L	--	0.46	1.30	3.13	0.45	1.32	3.17	0.45	1.32	3.15	0.45	1.30	3.11	0.46	1.30	3.16
Pb (Lead)(3)	µg/L	--	0.12	0.24	0.44	0.11	0.24	0.45	0.12	0.24	0.45	0.12	0.24	0.46	0.12	0.24	0.45
Sb (Antimony)	µg/L	31	0.21	0.24	0.35	0.21	0.24	0.35	0.21	0.24	0.35	0.21	0.24	0.35	0.21	0.24	0.35
Se (Selenium)	µg/L	5	0.27	0.53	0.74	0.27	0.53	0.75	0.26	0.53	0.75	0.25	0.53	0.75	0.27	0.53	0.74
SO_4 (Sulfate)	mg/L	--	0.74	3.94	10.83	0.64	3.99	12.19	0.63	3.91	10.97	0.66	3.95	11.65	0.66	3.96	10.45
Tl (Thallium)	µg/L	0.56	0.00	0.04	0.13	0.00	0.04	0.12	0.00	0.04	0.12	0.00	0.04	0.13	0.00	0.04	0.13
V (Vanadium)	µg/L	--	0.20	1.35	3.61	0.20	1.38	3.65	0.20	1.38	3.61	0.19	1.36	3.58	0.19	1.36	3.58
Zn (Zinc)(3)	µg/L	--	1.10	6.80	14.97	1.31	6.87	15.81	1.29	6.76	18.89	1.31	6.79	16.56	1.23	6.80	16.45
Hardness	mg/L	500	21.45	57.67	94.09	19.95	57.77	95.50	20.23	57.81	93.46	21.35	57.74	93.48	20.67	57.43	92.43

NOTE: Values above the applicable water quality standard are shown in bold with light red shading.
(1) Values shown are the average of the monthly P10, P50, and P90 values, as indicated, for the referenced Mine Year; see Section 6.7 of Reference (14).
(2) Model runs evaluated through Mine Year 100.
(3) Standard is hardness-based and variable; see Section 6.7.1.2 and Section 6.7.2 of Reference (1).

Large Table 11 Estimated Surface Water Quality for the Embarrass River at PM-12.2

Constituent	Mine Year / Percentile / Units	Water Quality Standard	Mine Year 2			Mine Year 13			Mine Year 25			Mine Year 40			Mine Year 100[(2)]		
			Average P10[(1)]	Average P50[(1)]	Average P90[(1)]	Average P10[(1)]	Average P50[(1)]	Average P90[(1)]	Average P10[(1)]	Average P50[(1)]	Average P90[(1)]	Average P10[(1)]	Average P50[(1)]	Average P90[(1)]	Average P10[(1)]	Average P50[(1)]	Average P90[(1)]
Ag (Silver)	µg/L	1	0.10	0.11	0.13	0.10	0.11	0.13	0.10	0.11	0.13	0.10	0.11	0.13	0.10	0.11	0.13
Al (Aluminum)	µg/L	125	53.86	83.13	**178.00**	54.30	81.02	**158.65**	53.90	81.61	**165.11**	53.82	82.55	**158.79**	53.98	82.47	**165.43**
Alkalinity	mg/L	--	12.80	48.28	86.90	13.40	47.77	85.66	13.28	48.37	92.82	13.56	47.95	81.47	12.43	47.93	84.68
As (Arsenic)	µg/L	53	0.43	1.07	3.38	0.40	1.06	3.75	0.42	1.08	3.42	0.42	1.10	4.15	0.43	1.07	3.53
B (Boron)	µg/L	500	22.18	41.50	67.40	22.34	41.79	69.19	22.09	41.61	69.30	22.15	41.74	68.75	22.26	41.55	69.37
Ba (Barium)	µg/L	--	5.03	13.90	37.09	5.02	14.11	37.40	5.01	13.99	37.14	5.02	13.99	37.58	5.02	13.90	37.68
Be (Beryllium)	µg/L	--	0.08	0.10	0.14	0.08	0.10	0.14	0.08	0.10	0.14	0.08	0.10	0.14	0.08	0.10	0.14
Ca (Calcium)	mg/L	--	7.29	23.23	40.00	7.12	23.40	40.92	7.21	23.34	40.81	7.16	23.42	40.75	7.38	23.28	40.97
Cd (Cadmium)[(3)]	µg/L	--	0.08	0.09	0.11	0.08	0.09	0.11	0.08	0.09	0.11	0.08	0.09	0.11	0.08	0.09	0.11
Cl (Chloride)	mg/L	230	2.72	4.33	8.69	2.78	4.33	8.80	2.65	4.33	8.73	2.79	4.36	8.96	2.72	4.27	8.82
Co (Cobalt)	µg/L	5	0.41	0.81	2.22	0.39	0.81	2.29	0.40	0.80	2.33	0.38	0.80	2.41	0.39	0.81	2.38
Cr (Chromium)	µg/L	11	0.21	0.63	1.41	0.20	0.63	1.64	0.21	0.63	1.49	0.22	0.63	1.53	0.20	0.63	1.58
Cu (Copper)[(3)]	µg/L	--	0.29	1.07	1.87	0.27	1.07	1.85	0.29	1.07	1.90	0.30	1.07	1.91	0.28	1.07	1.88
F (Fluoride)	mg/L	--	0.03	0.09	0.17	0.03	0.10	0.18	0.03	0.09	0.17	0.03	0.09	0.19	0.03	0.09	0.18
Fe (Iron)	µg/L	--	986.42	2,923.51	10,131.00	946.71	2,883.70	10,988.00	902.86	2,865.64	9,837.10	934.80	2,917.76	10,179.00	962.70	2,939.88	10,321.00
K (Potassium)	mg/L	--	2.27	8.31	17.65	2.25	8.32	18.15	2.26	8.31	18.33	2.21	8.34	18.07	2.25	8.35	18.29
Mg (Magnesium)	mg/L	--	11.58	40.37	83.82	11.44	40.44	87.30	11.23	40.20	86.65	11.15	40.37	86.24	11.16	40.26	87.45
Mn (Manganese)	µg/L	--	99.74	368.84	1,127.80	100.56	371.30	1,089.00	103.45	370.91	1,044.00	104.25	367.63	952.55	106.90	373.03	1,048.20
Na (Sodium)	mg/L	--	5.60	15.88	31.47	5.63	15.96	32.45	5.62	15.89	32.63	5.65	15.93	32.10	5.69	15.89	32.48
Ni (Nickel)[(3)]	µg/L	--	0.57	1.57	3.31	0.57	1.59	3.36	0.57	1.58	3.34	0.57	1.58	3.30	0.57	1.57	3.33
Pb (Lead)[(3)]	µg/L	--	0.12	0.22	0.43	0.12	0.22	0.44	0.12	0.22	0.43	0.12	0.22	0.44	0.12	0.22	0.44
Sb (Antimony)	µg/L	31	0.21	0.24	0.33	0.21	0.24	0.32	0.21	0.24	0.33	0.21	0.24	0.33	0.21	0.24	0.33
Se (Selenium)	µg/L	5	0.28	0.55	0.73	0.28	0.55	0.73	0.28	0.55	0.74	0.27	0.54	0.73	0.29	0.55	0.73
SO_4 (Sulfate)	mg/L	--	41.55	159.47	352.30	41.79	160.69	367.07	42.03	160.09	365.88	41.24	161.35	363.98	41.10	160.27	366.68
Tl (Thallium)	µg/L	0.56	0.01	0.05	0.12	0.01	0.05	0.12	0.01	0.05	0.12	0.01	0.05	0.12	0.01	0.05	0.12
V (Vanadium)	µg/L	--	0.39	1.85	4.16	0.38	1.88	4.22	0.38	1.88	4.18	0.38	1.87	4.16	0.38	1.86	4.17
Zn (Zinc)[(3)]	µg/L	--	1.17	5.97	13.54	1.39	6.06	14.55	1.37	5.95	18.28	1.36	5.96	15.93	1.29	6.02	15.53
Hardness	mg/L	500	71.40	224.89	440.33	70.94	226.20	456.86	70.19	224.74	456.46	70.52	225.90	453.55	69.89	224.62	461.32

NOTE: Values above the applicable water quality standard are shown in bold with light red shading.
(1) Values shown are the average of the monthly P10, P50, and P90 values, as indicated, for the referenced Mine Year; see Section 6.7 of Reference (14).
(2) Model runs evaluated through Mine Year 100.
(3) Standard is hardness-based and variable; see Section 6.7.1.2 and Section 6.7.2 of Reference (14).

Large Table 12 Estimated Surface Water Quality for the Embarrass River at PM-13 (Existing NPDES Station SW005)

Constituent	Mine Year / Percentile / Units	Water Quality Standard	Mine Year 2 Average P10(1)	Mine Year 2 Average P50(1)	Mine Year 2 Average P90(1)	Mine Year 13 Average P10(1)	Mine Year 13 Average P50(1)	Mine Year 13 Average P90(1)	Mine Year 25 Average P10(1)	Mine Year 25 Average P50(1)	Mine Year 25 Average P90(1)	Mine Year 40 Average P10(1)	Mine Year 40 Average P50(1)	Mine Year 40 Average P90(1)	Mine Year 100(2) Average P10(1)	Mine Year 100(2) Average P50(1)	Mine Year 100(2) Average P90(1)
Ag (Silver)	µg/L	1	0.10	0.11	0.12	0.11	0.12	0.15	0.11	0.12	0.13	0.09	0.11	0.13	0.09	0.11	0.13
Al (Aluminum)	µg/L	125	43.99	79.59	**178.59**	36.46	72.87	**154.23**	43.25	77.15	**165.62**	43.18	79.10	**160.66**	45.42	77.96	**163.99**
Alkalinity	mg/L	--	12.72	53.85	92.85	13.16	52.25	91.55	12.70	51.57	93.34	12.99	52.58	90.11	12.15	53.65	89.24
As (Arsenic)	µg/L	53	0.52	1.65	3.47	0.65	2.84	5.49	0.60	2.44	4.40	0.61	2.43	4.52	0.63	2.57	4.77
B (Boron)	µg/L	500	22.20	67.67	151.32	21.33	57.29	136.09	20.98	51.38	116.22	20.88	53.09	107.13	23.02	64.44	144.08
Ba (Barium)	µg/L	--	5.09	13.77	33.23	5.08	13.28	30.95	5.07	13.78	32.88	5.09	13.77	33.14	5.07	13.58	33.61
Be (Beryllium)	µg/L	--	0.08	0.12	0.19	0.08	0.15	0.30	0.08	0.13	0.26	0.08	0.12	0.24	0.08	0.13	0.29
Ca (Calcium)	mg/L	--	5.76	19.20	32.95	5.50	20.01	33.87	5.46	19.19	33.02	5.35	19.12	32.96	5.56	19.25	32.13
Cd (Cadmium)(3)	µg/L	2.36	0.08	0.10	0.13	0.09	0.23	0.69	0.09	0.21	0.70	0.08	0.13	0.27	0.08	0.12	0.26
Cl (Chloride)	mg/L	230	2.60	4.14	8.61	2.38	3.97	8.67	2.55	4.13	8.74	2.59	4.15	8.98	2.50	3.92	8.73
Co (Cobalt)	µg/L	5	0.48	1.20	2.36	0.58	1.71	2.81	0.57	1.51	2.45	0.57	1.49	2.58	0.58	1.56	2.61
Cr (Chromium)	µg/L	11	0.21	0.63	1.41	0.30	1.62	3.36	0.28	1.28	2.48	0.23	0.77	1.57	0.23	0.79	1.63
Cu (Copper)(3)	µg/L	8.93	0.30	1.63	3.48	0.39	2.45	5.29	0.36	2.09	4.51	0.37	2.08	4.49	0.40	2.22	4.37
F (Fluoride)	mg/L	--	0.03	0.09	0.17	0.03	0.09	0.18	0.03	0.09	0.17	0.03	0.09	0.19	0.03	0.09	0.17
Fe (Iron)	µg/L	--	859.61	2,873.88	10,268.00	724.99	2,707.10	10,814.00	782.18	2,834.36	9,768.60	811.50	2,872.94	10,348.00	789.08	2,794.44	10,310.00
K (Potassium)	mg/L	--	0.92	2.97	5.77	0.90	2.79	5.43	0.92	2.95	5.95	0.87	2.97	5.92	0.90	2.92	5.96
Mg (Magnesium)	mg/L	--	5.16	16.32	30.82	4.98	15.32	28.64	4.91	16.16	30.93	4.78	16.11	30.91	4.79	15.47	30.66
Mn (Manganese)	µg/L	--	81.43	280.03	1,124.30	79.82	268.49	1,068.40	78.85	280.01	1,024.50	83.66	279.79	933.86	84.23	274.00	1,008.10
Na (Sodium)	mg/L	--	3.23	7.32	12.22	3.24	6.99	11.52	3.22	7.29	12.33	3.24	7.25	12.13	3.25	7.00	12.13
Ni (Nickel)(3)	µg/L	49.95	0.59	3.34	10.22	1.00	9.75	25.95	0.84	7.69	20.82	0.83	7.57	20.88	0.96	8.20	19.66
Pb (Lead)(3)	µg/L	2.98	0.14	0.39	0.65	0.18	0.73	1.60	0.17	0.62	1.28	0.16	0.62	1.29	0.18	0.65	1.22
Sb (Antimony)	µg/L	31	0.21	0.30	0.53	0.29	1.66	4.21	0.28	1.63	4.37	0.24	0.76	1.88	0.24	0.73	1.89
Se (Selenium)	µg/L	5	0.28	0.53	0.72	0.32	0.81	1.42	0.32	0.91	1.83	0.27	0.57	0.86	0.29	0.56	0.86
SO_4 (Sulfate)	mg/L	--	14.58	51.25	108.40	14.65	48.19	104.70	14.62	50.84	111.47	14.36	51.20	110.94	14.14	49.21	111.43
Tl (Thallium)	µg/L	0.56	0.01	0.06	0.14	0.01	0.06	0.15	0.01	0.06	0.14	0.00	0.05	0.12	0.00	0.05	0.12
V (Vanadium)	µg/L	--	0.29	1.78	4.16	0.34	2.52	5.86	0.30	2.10	5.01	0.27	1.54	3.49	0.29	1.57	3.66
Zn (Zinc)(3)	µg/L	114.72	1.28	7.09	14.02	2.79	19.24	46.37	2.41	16.83	41.75	1.82	9.69	21.32	1.69	8.91	18.89
Hardness	mg/L	500	41.44	117.04	203.82	39.67	115.05	197.03	38.36	116.58	203.16	39.17	115.72	203.69	39.23	113.71	201.95

NOTE: Values above the applicable water quality standard are shown in bold with light red shading.
(1) Values shown are the average of the monthly P10, P50, and P90 values, as indicated, for the referenced Mine Year; see Section 6.7 of Reference (14).
(2) Model runs evaluated through Mine Year 100.
(3) Standard is hardness-based and hardness-based and evaluated at a hardness of 95 mg/L. See Section 6.7.1.2 and Section 6.7.4 of Reference (14).

Large Table 13 Estimated Surface Water Quality for Unnamed (Mud Lake) Creek at MLC-2

Constituent	Mine Year / Percentile / Units	Water Quality Standard	Mine Year 2 Average P10(1)	Mine Year 2 Average P50(1)	Mine Year 2 Average P90(1)	Mine Year 13 Average P10(1)	Mine Year 13 Average P50(1)	Mine Year 13 Average P90(1)	Mine Year 25 Average P10(1)	Mine Year 25 Average P50(1)	Mine Year 25 Average P90(1)	Mine Year 40 Average P10(1)	Mine Year 40 Average P50(1)	Mine Year 40 Average P90(1)	Mine Year 100(2) Average P10(1)	Mine Year 100(2) Average P50(1)	Mine Year 100(2) Average P90(1)
Ag (Silver)	µg/L	1	0.09	0.11	0.12	0.09	0.11	0.12	0.09	0.11	0.13	0.09	0.11	0.13	0.08	0.11	0.12
Al (Aluminum)	µg/L	125	53.08	85.37	**184.35**	54.42	83.51	**163.75**	53.86	84.37	**171.54**	54.38	85.75	**165.94**	56.35	86.44	**171.58**
Alkalinity	mg/L	--	11.88	64.01	132.01	11.76	63.00	128.20	11.92	63.26	127.90	11.97	61.49	124.60	10.72	57.98	112.05
As (Arsenic)	µg/L	53	0.42	1.32	3.51	0.40	1.30	3.82	0.42	1.32	3.69	0.42	1.34	4.44	0.41	1.31	3.68
B (Boron)	µg/L	500	18.21	41.24	94.54	18.25	41.19	91.29	17.78	40.20	89.10	17.45	39.01	84.49	17.55	34.56	68.46
Ba (Barium)	µg/L	--	5.68	31.43	92.38	5.67	32.08	91.53	5.64	31.26	90.29	5.59	30.52	89.54	5.49	27.92	81.40
Be (Beryllium)	µg/L	--	0.07	0.11	0.18	0.07	0.11	0.18	0.07	0.11	0.18	0.07	0.11	0.18	0.07	0.11	0.18
Ca (Calcium)	mg/L	--	4.26	15.54	28.96	3.86	15.71	29.70	4.01	15.67	29.25	3.83	15.52	29.03	3.99	15.18	28.21
Cd (Cadmium)(3)	µg/L	--	0.08	0.10	0.13	0.08	0.10	0.13	0.08	0.10	0.13	0.08	0.10	0.13	0.08	0.10	0.13
Cl (Chloride)	mg/L	230	2.81	5.65	9.31	2.86	5.61	9.18	2.75	5.53	9.27	2.88	5.48	9.24	2.73	4.96	9.07
Co (Cobalt)	µg/L	5	0.42	0.85	2.32	0.45	0.85	2.36	0.43	0.84	2.41	0.43	0.83	2.51	0.38	0.81	2.44
Cr (Chromium)	µg/L	11	0.19	0.66	1.45	0.19	0.67	1.70	0.20	0.68	1.53	0.20	0.67	1.60	0.19	0.69	1.64
Cu (Copper)(3)	µg/L	--	0.23	1.11	2.12	0.21	1.11	2.13	0.23	1.11	2.13	0.24	1.11	2.15	0.24	1.11	2.16
F (Fluoride)	mg/L	--	0.05	0.38	1.13	0.05	0.38	1.09	0.05	0.37	1.05	0.04	0.34	0.97	0.04	0.28	0.74
Fe (Iron)	µg/L	--	883.32	2,977.96	10,518.00	846.15	2,927.65	11,246.00	810.41	2,882.04	10,260.00	788.03	2,929.38	10,717.00	734.07	2,887.23	10,711.00
K (Potassium)	mg/L	--	0.25	1.65	3.78	0.26	1.65	3.68	0.27	1.62	3.64	0.24	1.56	3.48	0.22	1.45	2.97
Mg (Magnesium)	mg/L	--	2.06	10.93	25.94	2.01	10.86	24.84	1.88	10.64	24.44	1.72	10.41	23.37	1.76	9.30	19.87
Mn (Manganese)	µg/L	--	66.94	274.29	1,140.50	67.90	278.85	1,090.70	67.65	277.33	1,030.20	72.36	277.62	978.50	73.29	279.47	1,046.80
Na (Sodium)	mg/L	--	2.53	8.39	20.96	2.51	8.34	20.21	2.45	8.14	19.49	2.45	7.78	18.35	2.36	6.72	14.54
Ni (Nickel)(3)	µg/L	--	0.46	1.54	3.84	0.46	1.57	3.95	0.46	1.56	3.91	0.46	1.55	3.87	0.46	1.55	3.98
Pb (Lead)(3)	µg/L	--	0.13	0.34	0.54	0.12	0.33	0.53	0.13	0.33	0.52	0.13	0.32	0.50	0.13	0.30	0.46
Sb (Antimony)	µg/L	31	0.21	0.25	0.38	0.21	0.25	0.39	0.21	0.25	0.39	0.21	0.25	0.39	0.21	0.25	0.39
Se (Selenium)	µg/L	5	0.27	0.55	0.78	0.27	0.55	0.79	0.26	0.55	0.79	0.25	0.55	0.80	0.28	0.56	0.80
SO_4 (Sulfate)	mg/L	--	2.04	20.59	63.05	1.86	20.51	60.61	1.75	19.61	58.10	1.70	18.79	53.95	1.43	14.82	41.04
Tl (Thallium)	µg/L	0.56	0.00	0.06	0.16	0.00	0.06	0.17	0.00	0.06	0.16	0.00	0.06	0.17	0.00	0.06	0.17
V (Vanadium)	µg/L	--	0.21	1.72	4.84	0.21	1.77	4.89	0.21	1.76	4.89	0.21	1.75	4.82	0.21	1.77	4.88
Zn (Zinc)(3)	µg/L	--	1.15	7.48	15.11	1.35	7.59	16.14	1.37	7.45	18.97	1.40	7.51	16.59	1.22	7.64	16.50
Hardness	mg/L	500	24.86	85.38	174.99	23.09	85.61	173.08	22.91	84.55	171.14	23.89	83.03	164.61	22.23	77.62	148.87

NOTE: Values above the applicable water quality standard are shown in bold with light red shading.
(1) Values shown are the average of the monthly P10, P50, and P90 values, as indicated, for the referenced Mine Year; see Section 6.7 of Reference (14).
(2) Model runs evaluated through Mine Year 100.
(3) Standard is hardness-based and variable; see Section 6.7.1.2 and Section 6.7.3.1 of Reference (14).

Large Table 14 Estimated Surface Water Quality for Trimble Creek at TC-1

Constituent (Mine Year / Percentile)	Units	Water Quality Standard	Mine Year 2			Mine Year 13			Mine Year 25			Mine Year 40			Mine Year 100[2]		
			Average P10[1]	Average P50[1]	Average P90[1]	Average P10[1]	Average P50[1]	Average P90[1]	Average P10[1]	Average P50[1]	Average P90[1]	Average P10[1]	Average P50[1]	Average P90[1]	Average P10[1]	Average P50[1]	Average P90[1]
Ag (Silver)	µg/L	1	0.11	0.12	0.12	0.14	0.18	0.21	0.12	0.15	0.19	0.07	0.09	0.14	0.06	0.10	0.19
Al (Aluminum)	µg/L	125	12.64	28.47	109.15	4.18	19.66	88.81	6.17	23.58	104.92	7.81	27.20	106.63	8.20	28.70	107.05
Alkalinity	mg/L	--	39.65	88.96	100.00	38.01	73.28	100.00	37.94	75.31	100.00	36.54	85.36	100.00	43.98	89.78	100.00
As (Arsenic)	µg/L	53	1.92	4.09	5.10	3.97	8.84	10.00	3.36	8.56	10.00	3.22	8.56	10.00	3.79	8.77	10.00
B (Boron)	µg/L	500	91.03	248.15	314.31	66.11	148.36	244.55	65.82	145.76	241.94	62.49	158.92	215.06	109.76	225.70	356.22
Ba (Barium)	µg/L	--	4.67	4.93	5.00	4.71	4.94	5.00	4.67	4.93	5.00	4.67	4.93	5.00	4.70	4.94	5.00
Be (Beryllium)	µg/L	--	0.12	0.22	0.27	0.19	0.37	0.48	0.16	0.33	0.50	0.13	0.27	0.45	0.15	0.32	0.64
Ca (Calcium)	mg/L	--	14.22	30.72	35.10	15.82	31.58	35.10	13.46	30.75	35.10	13.12	30.72	35.10	14.78	31.30	35.10
Cd (Cadmium)[3]	µg/L	--	0.09	0.13	0.18	0.31	0.80	1.67	0.26	0.85	1.98	0.14	0.32	0.67	0.14	0.28	0.65
Cl (Chloride)	mg/L	230	1.30	1.89	5.58	1.30	1.79	5.59	1.30	1.88	5.84	1.30	1.91	5.75	1.30	1.79	5.10
Co (Cobalt)	µg/L	5	1.07	2.61	4.85	2.30	4.49	5.00	1.96	4.37	5.00	1.80	4.33	5.00	2.06	4.41	5.00
Cr (Chromium)	µg/L	11	0.35	0.59	1.04	2.19	5.17	6.59	1.58	4.24	5.44	0.65	1.43	1.81	0.72	1.38	1.76
Cu (Copper)[3]	µg/L	--	1.18	4.74	8.86	3.27	7.80	9.00	2.59	7.56	9.00	2.57	7.54	9.00	3.13	7.75	9.00
F (Fluoride)	mg/L	--	0.03	0.05	0.12	0.04	0.05	0.11	0.03	0.05	0.11	0.03	0.05	0.11	0.03	0.05	0.11
Fe (Iron)	µg/L	--	300.00	916.49	5,661.00	300.00	802.97	5,570.40	271.81	897.90	5,925.00	300.00	911.73	6,182.60	300.00	829.80	6,043.70
K (Potassium)	mg/L	--	0.30	0.50	1.18	0.31	0.50	1.07	0.31	0.50	1.23	0.28	0.50	1.30	0.32	0.50	1.14
Mg (Magnesium)	mg/L	--	2.07	3.02	6.52	2.12	3.02	6.36	1.94	3.01	6.94	1.88	3.01	6.32	1.99	3.01	5.86
Mn (Manganese)	µg/L	--	50.00	78.19	712.15	50.00	74.12	507.26	49.71	80.20	568.06	50.00	79.78	568.58	49.96	74.28	588.20
Na (Sodium)	mg/L	--	1.93	2.15	3.59	1.95	2.12	3.56	1.92	2.15	3.80	1.93	2.15	3.62	1.96	2.13	3.52
Ni (Nickel)[3]	µg/L	--	3.03	15.14	46.17	16.16	42.80	50.00	12.41	41.27	50.00	11.83	41.08	50.00	15.17	42.25	50.00
Pb (Lead)[3]	µg/L	--	0.49	1.12	1.32	1.12	2.60	3.00	0.89	2.51	3.00	0.89	2.51	3.00	1.07	2.58	3.00
Sb (Antimony)	µg/L	31	0.28	0.60	1.99	2.72	7.32	11.15	2.45	8.84	13.50	1.12	3.49	6.28	1.03	3.11	6.08
Se (Selenium)	µg/L	5	0.39	0.56	0.67	0.95	1.84	2.45	1.15	2.82	4.26	0.48	0.77	1.20	0.46	0.69	1.33
SO_4 (Sulfate)	mg/L	--	3.44	8.09	9.66	4.00	8.25	9.82	3.36	8.07	9.64	3.29	8.07	10.19	3.61	8.21	9.39
Tl (Thallium)	µg/L	0.56	0.04	0.13	0.16	0.06	0.14	0.18	0.04	0.12	0.16	0.02	0.06	0.10	0.02	0.06	0.13
V (Vanadium)	µg/L	--	1.19	3.62	4.45	2.71	6.79	8.72	1.64	5.43	7.07	0.69	2.06	2.61	0.97	2.19	3.01
Zn (Zinc)[3]	µg/L	--	4.70	11.01	14.25	28.14	67.46	99.50	21.21	68.75	100.00	9.84	24.75	44.56	8.65	18.52	40.86
Hardness	mg/L	500	49.55	90.68	100.05	53.54	92.48	100.05	46.83	90.53	100.05	46.04	90.37	100.05	50.38	91.84	100.05

NOTE: Values above the applicable water quality standard are shown in bold with light red shading.
(1) Values shown are the average of the monthly P10, P50, and P90 values, as indicated, for the referenced Mine Year; see Section 6.7 of Reference (14).
(2) Model runs evaluated through Mine Year 100.
(3) Standard is hardness-based and variable; see Section 6.7.1.2 and Section 6.7.3.2 of Reference (14).

Large Table 15 Estimated Surface Water Quality for Unnamed Creek at PM-11 (Existing NPDES Station SW003)

Constituent	Mine Year / Percentile / Units	Water Quality Standard	Mine Year 2			Mine Year 13			Mine Year 25			Mine Year 40			Mine Year 100[2]		
			Average P10[1]	Average P50[1]	Average P90[1]	Average P10[1]	Average P50[1]	Average P90[1]	Average P10[1]	Average P50[1]	Average P90[1]	Average P10[1]	Average P50[1]	Average P90[1]	Average P10[1]	Average P50[1]	Average P90[1]
Ag (Silver)	µg/L	1	0.11	0.12	0.13	0.12	0.16	0.20	0.11	0.14	0.18	0.08	0.10	0.14	0.07	0.10	0.19
Al (Aluminum)	µg/L	125	12.80	49.31	**156.15**	4.96	39.93	**137.63**	7.79	45.14	**151.37**	8.87	48.50	**146.45**	10.60	47.81	**151.36**
Alkalinity	mg/L	--	18.33	71.86	99.98	18.47	62.77	99.85	18.04	62.02	99.95	17.66	68.87	99.89	19.56	73.93	99.96
As (Arsenic)	µg/L	53	0.89	3.33	4.86	1.52	6.92	10.00	1.40	6.48	9.99	1.35	6.44	9.99	1.45	6.77	9.98
B (Boron)	µg/L	500	35.56	177.09	312.96	31.18	114.20	237.58	29.79	106.61	234.54	29.16	115.87	207.91	41.03	166.33	338.81
Ba (Barium)	µg/L	--	4.58	4.82	5.00	4.59	4.84	5.00	4.58	4.82	5.00	4.57	4.82	5.00	4.58	4.84	5.00
Be (Beryllium)	µg/L	--	0.08	0.18	0.27	0.10	0.29	0.47	0.09	0.25	0.48	0.09	0.21	0.43	0.09	0.24	0.61
Ca (Calcium)	mg/L	--	7.02	24.08	35.07	7.40	25.70	35.09	6.46	24.19	35.07	6.35	24.20	35.06	7.00	25.19	35.03
Cd (Cadmium)[3]	µg/L	--	0.08	0.12	0.16	0.14	0.60	1.63	0.12	0.61	1.91	0.09	0.25	0.65	0.10	0.22	0.63
Cl (Chloride)	mg/L	230	1.31	2.75	7.67	1.30	2.58	7.99	1.31	2.74	8.01	1.31	2.78	8.18	1.31	2.58	7.45
Co (Cobalt)	µg/L	5	0.66	2.16	4.39	1.13	3.64	5.00	0.96	3.46	4.99	0.93	3.40	4.99	1.02	3.56	4.98
Cr (Chromium)	µg/L	11	0.23	0.57	1.33	0.81	3.90	6.42	0.61	3.18	5.34	0.34	1.19	1.74	0.34	1.17	1.74
Cu (Copper)[3]	µg/L	--	0.51	3.41	8.16	1.12	5.89	9.00	0.89	5.48	8.99	0.89	5.45	8.98	1.08	5.76	8.97
F (Fluoride)	mg/L	--	0.02	0.05	0.15	0.03	0.05	0.16	0.02	0.05	0.15	0.02	0.05	0.14	0.03	0.05	0.15
Fe (Iron)	µg/L	--	306.27	1,804.93	9,248.50	301.51	1,613.01	9,569.10	305.58	1,762.20	8,786.20	306.42	1,804.40	9,799.70	312.61	1,669.21	8,881.10
K (Potassium)	mg/L	--	0.19	0.50	1.58	0.20	0.50	1.49	0.21	0.50	1.67	0.18	0.50	1.78	0.19	0.51	1.72
Mg (Magnesium)	mg/L	--	1.50	3.09	8.91	1.53	3.06	8.81	1.40	3.07	8.83	1.30	3.07	8.54	1.39	3.07	8.25
Mn (Manganese)	µg/L	--	50.13	124.31	1,039.30	50.01	115.13	903.24	50.11	127.70	857.56	50.19	127.12	832.69	49.91	119.49	914.73
Na (Sodium)	mg/L	--	1.86	2.38	4.42	1.90	2.34	4.44	1.84	2.38	4.65	1.88	2.39	4.34	1.92	2.34	4.25
Ni (Nickel)[3]	µg/L	--	1.04	9.85	38.22	4.29	31.26	49.98	3.14	28.71	49.93	3.03	28.42	49.89	4.00	30.15	49.79
Pb (Lead)[3]	µg/L	--	0.24	0.86	1.31	0.43	1.97	3.00	0.35	1.83	3.00	0.34	1.82	2.99	0.40	1.93	2.99
Sb (Antimony)	µg/L	31	0.23	0.46	1.55	0.84	5.32	9.74	0.72	6.19	12.01	0.42	2.48	5.40	0.41	2.25	5.25
Se (Selenium)	µg/L	5	0.30	0.53	0.70	0.49	1.46	2.40	0.52	2.09	4.10	0.33	0.68	1.17	0.34	0.62	1.26
SO_4 (Sulfate)	mg/L	--	1.56	6.61	10.39	1.64	6.95	11.22	1.41	6.61	10.44	1.42	6.63	11.36	1.46	6.86	9.86
Tl (Thallium)	µg/L	0.56	0.01	0.09	0.16	0.02	0.10	0.18	0.01	0.08	0.16	0.01	0.04	0.10	0.01	0.04	0.13
V (Vanadium)	µg/L	--	0.39	2.53	4.38	0.78	4.93	8.51	0.49	3.83	6.85	0.27	1.46	2.54	0.34	1.61	2.93
Zn (Zinc)[3]	µg/L	--	2.21	9.16	14.49	8.77	50.09	97.40	7.31	48.90	99.17	3.71	19.14	42.74	3.63	14.72	38.33
Hardness	mg/L	500	29.92	76.11	100.00	31.66	79.12	100.04	27.88	76.33	99.99	27.78	76.07	99.99	28.31	78.12	99.96

NOTE: Values above the applicable water quality standard are shown in bold with light red shading.
(1) Values shown are the average of the monthly P10, P50, and P90 values, as indicated, for the referenced Mine Year; see Section 6.7 of Reference (14).
(2) Model runs evaluated through Mine Year 100.
(3) Standard is hardness-based and variable; see Section 6.7.1.2 and Section 6.7.3.3 of Reference (14).

Large Table 16 Plant Site Proposed Groundwater Monitoring

Existing Station ID	Proposed Station ID	Bedrock or Surficial Aquifer	Description	Parameter Group(s)	Frequency	Reporting	Monitoring Type	Permit(s)
Background Monitoring								
GW002	GW002	Surficial Aquifer	Monitor baseline conditions west and upgradient of the Flotation Tailings Basin (FTB) and Hydrometallurgical Residue Facility (HRF).	Plant Site Groundwater Quality Surficial Aquifer Parameter List; Water Levels	Quarterly Water Quality; Monthly Water Levels; Year-round	Quarterly Discharge Monitoring Reports (DMRs); Annual Report	Background	NPDES/SDS
GW015	GW015	Surficial Aquifer	Monitor baseline conditions west and downgradient of Cell 2W at the western property boundary. (This well has been shown to be unimpacted by *tailings basin seepage*, as documented in the Water Modeling Data Package - Plant Site.)	Plant Site Groundwater Quality Surficial Aquifer Parameter List; Water Levels	Quarterly Water Quality; Monthly Water Levels; Year-round	Quarterly DMRs; Annual Report	Background	NPDES/SDS
(New Station)	GW115	Bedrock	Monitor baseline conditions west and downgradient of Cell 2W at western property boundary.	Plant Site Groundwater Quality Bedrock Parameter List; Water Levels	Quarterly Water Quality; Monthly Water Levels; Year-round	Quarterly DMRs; Annual Report	Background	NPDES/SDS
Compliance Monitoring								
GW009	GW009	Surficial Aquifer	Monitor groundwater downgradient from FTB Cell 2E, beyond the property boundary.	Plant Site Groundwater Quality Surficial Aquifer Parameter List; Water Levels	Quarterly Water Quality; Monthly Water Levels; Year-round	Quarterly DMRs; Annual Report	Compliance	NPDES/SDS
GW010	GW010	Surficial Aquifer	Monitor groundwater at northern property boundary, downgradient of the FTB.	Plant Site Groundwater Quality Surficial Aquifer Parameter List; Water Levels	Quarterly Water Quality; Monthly Water Levels; Year-round	Quarterly DMRs; Annual Report	Compliance	NPDES/SDS
GW016	GW016	Surficial Aquifer	Monitor groundwater at northwestern property boundary, downgradient of Cell 2W.	Plant Site Groundwater Quality Surficial Aquifer Parameter List; Water Levels	Quarterly Water Quality; Monthly Water Levels; Year-round	Quarterly DMRs; Annual Report	Compliance	NPDES/SDS
Performance Monitoring								
(New Station)	GW117	Bedrock	Monitor groundwater along and downgradient of the northern side of FTB Cell 2E. (This well is outside the FTB Containment System but within the property boundary.)	Plant Site Groundwater Quality Bedrock Parameter List; Water Levels	Quarterly Water Quality; Monthly Water Levels; Year-round	Quarterly DMRs; Annual Report	Performance	NPDES/SDS
(New Station)	GW118	Bedrock	Monitor groundwater along and downgradient of the northern side of FTB Cell 2E. (This well is outside the FTB Containment System but within the property boundary.)	Plant Site Groundwater Quality Bedrock Parameter List; Water Levels	Quarterly Water Quality; Monthly Water Levels; Year-round	Quarterly DMRs; Annual Report	Performance	NPDES/SDS
(New Station)	GW119	Bedrock	Monitor groundwater along and downgradient of the northern toe of Cell 2W and outside the FTB Containment System.	Plant Site Groundwater Quality Bedrock Parameter List; Water Levels	Quarterly Water Quality; Monthly Water Levels; Year-round	Quarterly DMRs; Annual Report	Performance	NPDES/SDS
(New Station)	GW120	Bedrock	Monitor groundwater along and downgradient of the western toe of Cell 2W and outside the FTB Containment System.	Plant Site Groundwater Quality Bedrock Parameter List; Water Levels	Quarterly Water Quality; Monthly Water Levels; Year-round	Quarterly DMRs; Annual Report	Performance	NPDES/SDS
(New Stations)	GW200-GW201	Surficial Aquifer	Monitor water quality downstream of barrier and monitor water levels for hydraulic head with paired wells to evaluate the performance of the FTB Seepage Containment System.	Plant Site Groundwater Quality Surficial Aquifer Parameter List; Water Levels	Quarterly Water Quality; Monthly Hydraulic Head and Water Levels; Year-round	Quarterly DMRs; Annual Report	Performance	NPDES/SDS

Existing Station ID	Proposed Station ID	Bedrock or Surficial Aquifer	Description	Parameter Group(s)	Frequency	Reporting	Monitoring Type	Permit(s)
(New Stations)	GW202-GW203	Surficial Aquifer	Monitor water levels for hydraulic head with paired piezometers to evaluate the performance of the FTB Seepage Containment System.	Water Levels	Monthly; Year-round	Monthly DMRs; Annual Report	Performance	NPDES/SDS
(New Stations)	GW204-GW205	Surficial Aquifer	Monitor water quality downstream of barrier and monitor water levels for hydraulic head with paired wells to evaluate the performance of the FTB Seepage Containment System.	Plant Site Groundwater Quality Surficial Aquifer Parameter List; Water Levels	Quarterly Water Quality; Monthly Hydraulic Head and Water Levels; Year-round	Quarterly DMRs; Annual Report	Performance	NPDES/SDS
(New Stations)	GW206-GW207	Surficial Aquifer	Monitor water levels for hydraulic head with paired piezometers to evaluate the performance of the FTB Seepage Containment System.	Water Levels	Monthly; Year-round	Monthly DMRs; Annual Report	Performance	NPDES/SDS
(New Stations)	GW208-GW209	Surficial Aquifer	Monitor water quality downstream of barrier and monitor water levels for hydraulic head with paired wells to evaluate the performance of the FTB Seepage Containment System.	Plant Site Groundwater Quality Surficial Aquifer Parameter List; Water Levels	Quarterly Water Quality; Monthly Hydraulic Head and Water Levels; Year-round	Quarterly DMRs; Annual Report	Performance	NPDES/SDS
(New Stations)	GW210-GW211	Surficial Aquifer	Monitor water levels for hydraulic head with paired piezometers to evaluate the performance of the FTB Seepage Containment System.	Water Levels	Monthly; Year-round	Monthly DMRs; Annual Report	Performance	NPDES/SDS
(New Stations)	GW212-GW213	Surficial Aquifer	Monitor water quality downstream of barrier and monitor water levels for hydraulic head with paired wells to evaluate the performance of the FTB Seepage Containment System.	Plant Site Groundwater Quality Surficial Aquifer Parameter List; Water Levels	Quarterly Water Quality; Monthly Hydraulic Head and Water Levels; Year-round	Quarterly DMRs; Annual Report	Performance	NPDES/SDS
(New Stations)	GW214-GW215	Surficial Aquifer	Monitor water levels for hydraulic head with paired piezometers to evaluate the performance of the FTB Seepage Containment System.	Water Levels	Monthly; Year-round	Monthly DMRs; Annual Report	Performance	NPDES/SDS
(New Stations)	GW216-GW217	Surficial Aquifer	Monitor water quality downstream of barrier and monitor water levels for hydraulic head with paired wells to evaluate the performance of the FTB Seepage Containment System.	Plant Site Groundwater Quality Surficial Aquifer Parameter List; Water Levels	Quarterly Water Quality; Monthly Hydraulic Head and Water Levels; Year-round	Quarterly DMRs; Annual Report	Performance	NPDES/SDS
(New Stations)	GW218-GW219	Surficial Aquifer	Monitor water levels for hydraulic head with paired piezometers to evaluate the performance of the FTB Seepage Containment System.	Water Levels	Monthly; Year-round	Monthly DMRs; Annual Report	Performance	NPDES/SDS
(New Stations)	GW220-GW221	Surficial Aquifer	Monitor water quality downstream of barrier and monitor water levels for hydraulic head with paired wells to evaluate the performance of the FTB Seepage Containment System.	Plant Site Groundwater Quality Surficial Aquifer Parameter List; Water Levels	Quarterly Water Quality; Monthly Hydraulic Head and Water Levels; Year-round	Quarterly DMRs; Annual Report	Performance	NPDES/SDS
(New Stations)	GW222-GW223	Surficial Aquifer	Monitor water levels for hydraulic head with paired piezometers to evaluate the performance of the FTB Seepage Containment System.	Water Levels	Monthly; Year-round	Monthly DMRs; Annual Report	Performance	NPDES/SDS
Monitor Only Monitoring								
(New Station)	GW109	Bedrock	Monitor groundwater downgradient from FTB Cell 2E, beyond the property boundary.	Plant Site Groundwater Quality Bedrock Parameter List; Water Levels	Quarterly Water Quality; Monthly Water Levels; Year-round	Quarterly DMRs; Annual Report	Monitor Only	NPDES/SDS

Existing Station ID	Proposed Station ID	Bedrock or Surficial Aquifer	Description	Parameter Group(s)	Frequency	Reporting	Monitoring Type	Permit(s)
(New Station)	GW110	Bedrock	Monitor groundwater at northern property boundary, downgradient of the FTB.	Plant Site Groundwater Quality Bedrock Parameter List; Water Levels	Quarterly Water Quality; Monthly Water Levels; Year-round	Quarterly DMRs; Annual Report	Monitor Only	NPDES/SDS
(New Station)	GW116	Bedrock	Monitor groundwater at northwestern property boundary, downgradient of Cell 2W.	Plant Site Groundwater Quality Bedrock Parameter List; Water Levels	Quarterly Water Quality; Monthly Water Levels; Year-round	Quarterly DMRs; Annual Report	Monitor Only	NPDES/SDS
Indicator Monitoring								
(New Station)	GW236	Surficial Aquifer	Monitor water level near the East Dam to confirm that flow is entering the Tailings Basin.	Water Levels	Monthly; Year-round	Monthly DMRs; Annual Report	Indictor	NPDES/SDS
(New Station)	GW237	Surficial Aquifer	Monitor water level near the East Dam to confirm that flow is entering the Tailings Basin.	Water Levels	Monthly; Year-round	Monthly DMRs; Annual Report	Indictor	NPDES/SDS
Water Appropriation Source								
(New Station)	GW496	Surficial Aquifer	Monitor flow from the Hydrometallurgical Residue Facility (HRF) wick drain system (if installed).	Continuous Flow Monitoring	Continuous Flow Monitoring; Year-round	Annual Report	Water Appropriation Source	Water Appropriation

Large Table 17 Plant Site Proposed Surface Water Monitoring

Existing Station ID	Proposed Station ID	Water Body	Description	Parameter Group(s)	Frequency	Reporting	Monitoring Type	Permit(s)
Background Monitoring								
PM-12.2	SW008	Embarrass River	Monitor existing conditions upstream of the Tailings Basin and downstream of Area 5 to establish background conditions. Data collected will be compared to SW005.	Plant Site Surface Water Quality Parameter List	Monthly Water Quality; Year-round	Monthly Discharge Monitoring Reports (DMRs); Annual Report	Background	NPDES/SDS
Monitor Only								
PM-7 / SD026	SW020	Second Creek	Monitor Second Creek downstream of stream augmentation and the Flotation Tailings Basin (FTB) South Seepage Management System.	Plant Site Surface Water Quality Parameter List; Aquatic Biota Survey	Monthly Water Quality; Year-round Annual Macroinvertebrate Survey; Periodic Fish Survey	Monthly DMRs; Annual Report	Monitor Only; Aquatic Biota	NPDES/SDS; Water Appropriation
PM-11 / SW003	SW003	Unnamed Creek	Monitor Unnamed Creek downstream of stream augmentation and the FTB Seepage Containment System. Only sulfate will be monitored after the FTB Seepage Containment System is in place.	Sulfate; Aquatic Biota Survey	Monthly Water Quality; Year-round Annual Macroinvertebrate Survey; Periodic Fish Survey	Monthly DMRs; Annual Report	Monitor Only; Aquatic Biota	NPDES/SDS; Water Appropriation
PM-13 / SW005	SW005	Embarrass River	Monitor Embarrass River downstream of the Tailings Basin to assess changes from background conditions at SW008 after the performance of the FTB Seepage Containment System and stream augmentation. Only sulfate will be monitored after the FTB Seepage Containment System is in place.	Sulfate; Continuous Flow Monitoring	Monthly Water Quality; Continuous Flow Monitoring; Year-round	Monthly DMRs; Annual Report	Monitor Only; Streamflow	NPDES/SDS; Water Appropriation
TC-1a	SW006	Trimble Creek	Monitor Trimble Creek downstream of stream augmentation and the FTB Seepage Containment System. Only sulfate will be monitored after the FTB Seepage Containment System is in place.	Sulfate	Monthly Water Quality; Year-round	Monthly DMRs; Annual Report	Monitor Only	NPDES/SDS
MLC-1	SW007	Unnamed (Mud Lake) Creek	Monitor Unnamed (Mud Lake) Creek downstream of the swale and the FTB Seepage Containment System. Only sulfate will be monitored after the FTB Seepage Containment System is in place.	Sulfate	Monthly Water Quality; Year-round	Monthly DMRs; Annual Report	Monitor Only	NPDES/SDS
Streamflow								
(New Station)	SW041	Embarrass River	Monitor Embarrass River upstream of the Plant Site.	Continuous Flow Monitoring	Continuous Flow Monitoring; Year-round	Annual Report	Streamflow	Water Appropriation
(New Station)	SW042	Unnamed (Mud Lake) Creek	Monitor Unnamed (Mud Lake) Creek.	Continuous Flow Monitoring	Continuous Flow Monitoring; Year-round	Annual Report	Streamflow	Water Appropriation
(New Station)	SW043	Embarrass River	Monitor Embarrass River downstream of the Plant Site. This is the location of the historical USGS gage 04017000.	Continuous Flow Monitoring	Continuous Flow Monitoring; Year-round	Annual Report	Streamflow	Water Appropriation
(New Station)	SW044	Second Creek	Monitor Second Creek.	Continuous Flow Monitoring	Continuous Flow Monitoring; Year-round	Annual Report	Streamflow	Water Appropriation

Existing Station ID	Proposed Station ID	Water Body	Description	Parameter Group(s)	Frequency	Reporting	Monitoring Type	Permit(s)
(New Station)	SW045	Trimble Creek	Monitor Trimble Creek in a channelized location.	Continuous Flow Monitoring	Continuous Flow Monitoring; Year-round	Annual Report	Streamflow	Water Appropriation
(New Station)	SW046	Bear Creek	Monitor Bear Creek in a channelized location.	Continuous Flow Monitoring	Continuous Flow Monitoring; Year-round	Annual Report	Streamflow	Water Appropriation
Aquatic Biota								
(New Station)	SW009	Bear Creek	Monitor Bear Creek as an off-site reference point that is not affected by the Project.	Aquatic Biota Survey	Annual Macroinvertebrate Survey; Periodic Fish Survey	Annual Report	Aquatic Biota	Water Appropriation
(New Station)	SW048	Unnamed (Mud Lake) Creek	Monitor Unnamed (Mud Lake) Creek in a channelized location, downstream of the drainage swale.	Aquatic Biota Survey	Annual Macroinvertebrate Survey; Periodic Fish Survey	Annual Report	Aquatic Biota	Water Appropriation
(New Station)	SW049	Trimble Creek	Monitor Trimble Creek in a channelized location, downstream of surface water discharge.	Aquatic Biota Survey	Annual Macroinvertebrate Survey; Periodic Fish Survey	Annual Report	Aquatic Biota	Water Appropriation

Large Table 18 Plant Site Proposed Surface Water Discharge Monitoring

Existing Station ID	Proposed Station ID	Water Body	Description	Parameter Group(s)	Frequency	Reporting	Monitoring Type	Permit(s)
Surface Water Discharge Monitoring								
(New Station)	SD001	WWTS Discharge	Monitor Waste Water Treatment System (WWTS) discharge to the three streams (Unnamed Creek, Trimble Creek, Second Creek) for stream augmentation. Monitoring point is at WWTS.	Plant Site Surface Water Outfall Parameter List	Weekly 24-hour Composite; Year-round	Monthly Discharge Monitoring Reports (DMRs); Annual Report	Surface Water Discharge	NPDES/SDS
(New Station)	SD002	Headwater Wetlands of Unnamed Creek	Monitor discharge of treated effluent from the WWTS to the headwater wetlands of Unnamed Creek for stream augmentation. Monitor associated WWTS discharge flow at the WWTS or applicable splitter structure.	Continuous Flow Monitoring	Continuous Flow Monitoring; Year-round	Monthly DMRs; Annual Report	Surface Water Discharge; Augmentation Flow	NPDES/SDS; Water Appropriation
(New Station)	SD003	Headwater Wetlands of Unnamed Creek	Monitor discharge of treated effluent from the WWTS to the headwater wetlands of Unnamed Creek for stream augmentation. Monitor associated WWTS discharge flow at the WWTS or applicable splitter structure.	Continuous Flow Monitoring	Continuous Flow Monitoring; Year-round	Monthly DMRs; Annual Report	Surface Water Discharge; Augmentation Flow	NPDES/SDS; Water Appropriation
(New Station)	SD004	Headwater Wetlands of Trimble Creek	Monitor discharge of treated effluent from the WWTS to the headwater wetlands of Trimble Creek for stream augmentation. Monitor associated WWTS discharge flow at the WWTS or applicable splitter structure.	Continuous Flow Monitoring	Continuous Flow Monitoring; Year-round	Monthly DMRs; Annual Report	Surface Water Discharge; Augmentation Flow	NPDES/SDS; Water Appropriation
(New Station)	SD005	Headwater Wetlands of Trimble Creek	Monitor discharge of treated effluent from the WWTS to the headwater wetlands of Trimble Creek for stream augmentation. Monitor associated WWTS discharge flow at the WWTS or applicable splitter structure.	Continuous Flow Monitoring	Continuous Flow Monitoring; Year-round	Monthly DMRs; Annual Report	Surface Water Discharge; Augmentation Flow	NPDES/SDS; Water Appropriation
(New Station)	SD006	Headwater Wetlands of Trimble Creek	Monitor discharge of treated effluent from the WWTS to the headwater wetlands of Trimble Creek for stream augmentation. Monitor associated WWTS discharge flow at the WWTS or applicable splitter structure.	Continuous Flow Monitoring	Continuous Flow Monitoring; Year-round	Monthly DMRs; Annual Report	Surface Water Discharge; Augmentation Flow	NPDES/SDS; Water Appropriation
(New Station)	SD007	Headwater Wetlands of Trimble Creek	Monitor discharge of treated effluent from the WWTS to the headwater wetlands of Trimble Creek for stream augmentation. Monitor associated WWTS discharge flow at the WWTS or applicable splitter structure.	Continuous Flow Monitoring	Continuous Flow Monitoring; Year-round	Monthly DMRs; Annual Report	Surface Water Discharge; Augmentation Flow	NPDES/SDS; Water Appropriation
(New Station)	SD008	Headwater Wetlands of Trimble Creek	Monitor discharge of treated effluent from the WWTS to the headwater wetlands of Trimble Creek for stream augmentation. Monitor associated WWTS discharge flow at the WWTS or applicable splitter structure.	Continuous Flow Monitoring	Continuous Flow Monitoring; Year-round	Monthly DMRs; Annual Report	Surface Water Discharge; Augmentation Flow	NPDES/SDS; Water Appropriation
(New Station)	SD009	Headwater Wetlands of Trimble Creek	Monitor discharge of treated effluent from the WWTS to the headwater wetlands of Trimble Creek for stream augmentation. Monitor associated WWTS discharge flow at the WWTS or applicable splitter structure.	Continuous Flow Monitoring	Continuous Flow Monitoring; Year-round	Monthly DMRs; Annual Report	Surface Water Discharge; Augmentation Flow	NPDES/SDS; Water Appropriation
(New Station)	SD010	Headwater Wetlands of Trimble Creek	Monitor discharge of treated effluent from the WWTS to the headwater wetlands of Trimble Creek for stream augmentation. Monitor associated WWTS discharge flow at the WWTS or applicable splitter structure.	Continuous Flow Monitoring	Continuous Flow Monitoring; Year-round	Monthly DMRs; Annual Report	Surface Water Discharge; Augmentation Flow	NPDES/SDS; Water Appropriation

Existing Station ID	Proposed Station ID	Water Body	Description	Parameter Group(s)	Frequency	Reporting	Monitoring Type	Permit(s)
(New Station)	SD011	Second Creek	Monitor discharge of treated effluent from WWTS to Second Creek for stream augmentation. Monitor associated WWTS discharge flow at the WWTS or applicable splitter structure.	Continuous Flow Monitoring	Continuous Flow Monitoring; Year-round	Monthly DMRs; Annual Report	Surface Water Discharge; Augmentation Flow	NPDES/SDS; Water Appropriation
Augmentation Flow								
(New Station)	SW050	Unnamed (Mud Lake) Creek	Monitor flow from drainage swale to headwaters area of Unnamed (Mud Lake) Creek.	Continuous Flow Monitoring	Continuous Flow Monitoring; Year-round	Annual Report	Augmentation Flow	Water Appropriation

Large Table 19 Plant Site Proposed Benchmark Stormwater Monitoring

Existing Station ID	Proposed Station ID	Water Body	Description	Parameter Group(s)	Frequency	Reporting	Monitoring Type	Permit(s)
Benchmark Stormwater Monitoring								
(New Station)	BML01	Second Creek	Monitor industrial stormwater discharge from the western portion of the Plant Site to show compliance with benchmark monitoring requirements.	Plant Site Benchmark Stormwater Parameter List	Quarterly during Storm Event; Year-round	Quarterly Stormwater Discharge Monitoring Reports (DMRs); Annual Report	Benchmark Stormwater	NPDES/SDS
(New Station)	BML02	Second Creek	Monitor industrial stormwater discharge from the east-central portion of the Plant Site to show compliance with benchmark monitoring requirements.	Plant Site Benchmark Stormwater Parameter List	Quarterly during Storm Event; Year-round	Quarterly Stormwater DMRs; Annual Report	Benchmark Stormwater	NPDES/SDS
(New Station)	BML03	Second Creek	Monitor industrial stormwater discharge from the east-central portion of the Plant Site to show compliance with benchmark monitoring requirements.	Plant Site Benchmark Stormwater Parameter List	Quarterly during Storm Event; Year-round	Quarterly Stormwater DMRs; Annual Report	Benchmark Stormwater	NPDES/SDS

Large Table 20 Plant Site Proposed Internal Waste Stream Monitoring

Existing Station ID	Proposed Station ID	Internal Stream	Description	Parameter Group(s)	Frequency	Reporting	Monitoring Type	Permit(s)
Monitor Only								
(New Station)	WS001	FTB Pond	Monitor waste stream into Flotation Tailings Basin (FTB) Pond (sampled at pond intake).	Internal Waste Stream Parameter List	Monthly; Year-round	Monthly Discharge Monitoring Reports (DMRs); Annual Report	Monitor Only	NPDES/SDS
(New Station)	WS002	FTB Seepage Containment System	Monitor waste stream from FTB Seepage Containment System (sampled at the Waste Water Treatment System (WWTS) intake).	Internal Waste Stream Parameter List	Monthly; Year-round	Monthly DMRs; Annual Report	Monitor Only	NPDES/SDS
(New Station)	WS003	FTB South Seepage Management System; Second Creek	Monitor waste stream from FTB South Seepage Management System (sampled at the WWTS intake). Monitor amount of seepage extracted from Second Creek watershed.	Internal Waste Stream Parameter List; Continuous Flow Monitoring	Monthly Water Quality; Continuous Flow Monitoring; Year-round	Monthly DMRs; Annual Report	Monitor Only; Seepage Flow	NPDES/SDS; Water Appropriation
(New Station)	WS004	HRF Pond	Monitor waste stream in Hydrometallurgical Residue Facility (HRF) Pond (sampled at pond intake).	Internal Waste Stream Parameter List; Continuous Flow Monitoring; Water Levels	Monthly Water Quality; Continuous Flow Monitoring; Daily Water Level; Year-round	Monthly DMRs; Annual Report	Monitor Only; Water Appropriation Source	NPDES/SDS; Water Appropriation
(New Station)	WS005	HRF Leachate	Monitor waste stream from HRF Leakage Collection System (underliner leakage).	Internal Waste Stream Parameter List	Monthly; Year-round	Monthly DMRs; Annual Report	Monitor Only	NPDES/SDS
(New Station)	WS006	Unnamed (Mud Lake) Creek	Monitor amount of seepage extracted from Unnamed (Mud Lake) Creek watershed.	Continuous Flow Monitoring	Continuous Flow Monitoring; Year-round	Annual Report	Seepage Flow	Water Appropriation
(New Station)	WS007	Trimble Creek	Monitor amount of seepage extracted from Trimble Creek watershed.	Continuous Flow Monitoring	Continuous Flow Monitoring; Year-round	Annual Report	Seepage Flow	Water Appropriation
(New Station)	WS008	Unnamed Creek	Monitor amount of seepage extracted from Unnamed Creek watershed.	Continuous Flow Monitoring	Continuous Flow Monitoring; Year-round	Annual Report	Seepage Flow	Water Appropriation
(New Station)	WS009	Sewage Treatment Stabilization Ponds	Monitor waste stream from the southeast corner of the Sewage Treatment Stabilization Ponds.	Internal Waste Stream Parameter List; Continuous Flow Monitoring; Water Level	Monthly Water Quality; Continuous Flow Monitoring during discharge periods; Daily Water Level; Ice-free Conditions	Monthly DMRs; Annual Report	Monitor Only; Water Appropriation Source	NPDES/SDS; Water Appropriation
(New Station)	WS010	FTB Cell 1E	Monitor pond water level in FTB Cell 1E.	Water Level	Daily Water Level; Ice-free Conditions	Monthly DMRs; Annual Report	Water Appropriation Source	Water Appropriation
(New Station)	WS011	FTB Cell 2E	Monitor pond water level in FTB Cell 2E.	Water Level	Daily Water Level; Ice-free Conditions	Monthly DMRs; Annual Report	Water Appropriation Source	Water Appropriation
(New Station)	WS012	Tailings Slurry Discharge	Monitor tailings slurry discharge to FTB.	Continuous Flow Monitoring	Continuous Flow Monitoring; Year-round	Annual Report	Internal Flow	Water Appropriation
(New Station)	WS013	FTB to Beneficiation Plant	Monitor total pumping from FTB to the Beneficiation Plant.	Continuous Flow Monitoring	Continuous Flow Monitoring; Year-round	Annual Report	Internal Flow	Water Appropriation
(New Station)	WS014	FTB Seepage Capture Systems	Monitor flow from the FTB Seepage Capture Systems to the FTB Pond.	Continuous Flow Monitoring	Continuous Flow Monitoring; Year-round	Annual Report	Internal Flow	Water Appropriation

Existing Station ID	Proposed Station ID	Internal Stream	Description	Parameter Group(s)	Frequency	Reporting	Monitoring Type	Permit(s)
(New Station)	WS015	FTB Seepage Capture Systems	Monitor waste stream into the WWTS, which includes the combined influent from FTB Seepage Containment System and FTB South Seepage Management System.	WWTS Influent Parameter List; Continuous Flow Monitoring	Weekly 24-hour Water Quality Composite; Continuous Flow Monitoring; Year-round	Monthly DMRs; Annual Report	Monitor Only; Internal Flow	NPDES/SDS; Water Appropriation
(New Station)	WS016	HRF Pond	Monitor pond water level in HRF Pond.	Water Level	Daily Water Level; Ice-free Conditions	Monthly DMRs; Annual Report	Water Appropriation Source	Water Appropriation
(New Station)	WS031	Plant Reservoir	Monitor precipitation collected in the Plant Reservoir.	Water Level	Daily Water Level; ice free conditions	Annual Report	Water Appropriation Source	Water Appropriation
(New Station)	WS051	WWTS Basin	Monitor precipitation collected in the WWTS Basin	Water Level	Daily Water Level; ice free conditions	Annual Report	Water Appropriation Source	Water Appropriation
(New Station)	WS061	WWTS to FTB Pond	Monitor total pumping from the WWTS to the FTB Pond.	Continuous Flow Monitoring	Continuous Flow Monitoring; Year-round	Annual Report	Internal Flow	Water Appropriation
(New Station)	WS062	WWTS to East Pit	Monitor flow from the WWTS to the East Pit during East Pit flushing.	Continuous Flow Monitoring	Continuous Flow Monitoring; Year-round	Annual Report	Internal Flow	Water Appropriation
(New Station)	WS063	WWTS to West Pit	Monitor flow from the WWTS to the West Pit during West Pit flooding.	Continuous Flow Monitoring	Continuous Flow Monitoring; Year-round	Annual Report	Internal Flow	Water Appropriation
(New Station)	WS071	WWTS Backwash and Cleaning Water	Monitor waste stream from WWTS, consisting of backwash from the Greensand Filter and CIP waste from the primary and secondary membranes.	WWTS Backwash and Cleaning Water Parameter List; Continuous Flow Monitoring	Weekly 24-hour Water Quality Composite; Continuous Flow Monitoring; Year-round	Monthly DMRs; Annual Report	Monitor Only	NPDES/SDS
(New Station)	WS072	Mine Water Chemical Precipitation Treatment Train	Monitor effluent from the mine water chemical precipitation treatment train.	WWTS Internal Waste Stream Parameter List; Continuous Flow Monitoring	Monthly Water Quality; Continuous Flow Monitoring; Year-round	Monthly DMRs; Annual Report	Monitor Only	NPDES/SDS
(New Station)	WS073	Mine Water Membrane Filtration Treatment Train	Monitor effluent from the mine water membrane filtration treatment train to the FTB Pond.	WWTS Internal Waste Stream Parameter List; Continuous Flow Monitoring	Monthly Water Quality; Continuous Flow Monitoring; Year-round	Monthly DMRs; Annual Report	Monitor Only	NPDES/SDS
(New Station)	WS074	Tailings Basin Seepage Treatment Train	Monitor blended effluents from the reverse osmosis and nanofiltration membranes of the tailings basin seepage treatment train, upstream of discharge stabilization.	Sulfate and Copper	Weekly; Year-round	Monthly DMRs; Annual Report	Internal Performance Monitoring	NPDES/SDS
(New Station)	WS081	Plant Reservoir	Monitor flow from Plant Reservoir to Beneficiation Plant.	Continuous Flow Monitoring	Continuous Flow Monitoring; Year-round	Annual Report	Internal Flow	Water Appropriation
(New Station)	WS082	Plant Reservoir	Monitor flow from Plant Reservoir to Hydrometallurgical Plant.	Continuous Flow Monitoring	Continuous Flow Monitoring; Year-round	Annual Report	Internal Flow	Water Appropriation
(New Station)	WS083	Plant Reservoir	Monitor flow from Plant Reservoir to FTB Pond.	Continuous Flow Monitoring	Continuous Flow Monitoring; Year-round	Annual Report	Internal Flow	Water Appropriation
(New Station)	WS084	Plant Reservoir	Monitor flow from Plant Reservoir to Potable Water Treatment Plant.	Continuous Flow Monitoring	Continuous Flow Monitoring; Year-round	Annual Report	Internal Flow	Water Appropriation
(New Station)	WS085	Plant Reservoir	Monitor flow from Plant Reservoir to Fire Water Systems.	Flow monitoring	When usage occurs	Annual Report	Internal Flow	Water Appropriation

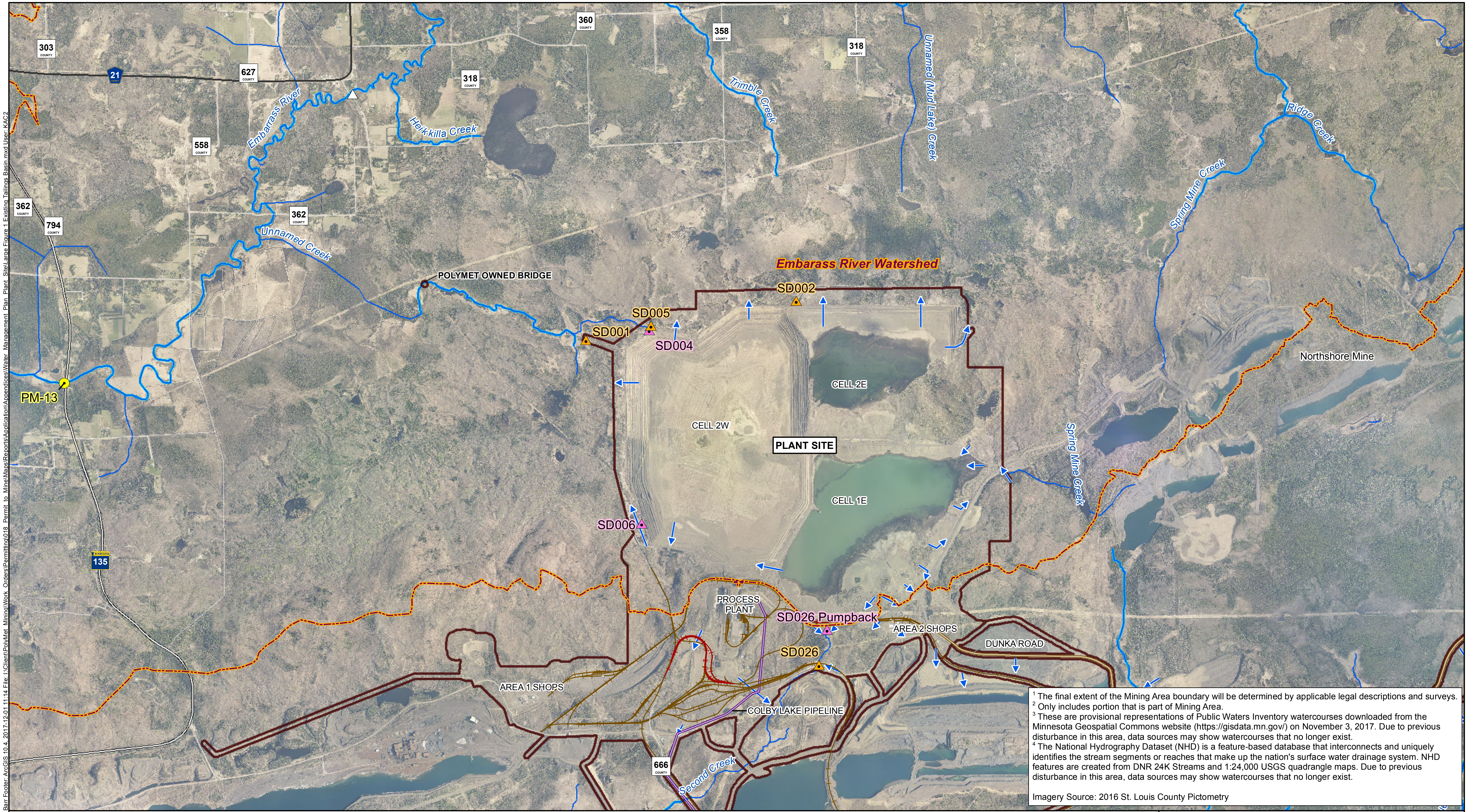
Existing Station ID	Proposed Station ID	Internal Stream	Description	Parameter Group(s)	Frequency	Reporting	Monitoring Type	Permit(s)
(New Station)	WS086	Plant Reservoir	Monitor flow from Plant Reservoir to air emission scrubber system.	Continuous Flow Monitoring	Continuous Flow Monitoring; Year-round	Annual Report	Internal Flow	Water Appropriation
(New Station)	WS087	Plant Reservoir	Monitor flow from Plant Reservoir to miscellaneous water needs.	Flow monitoring	When usage occurs	Annual Report	Internal Flow	Water Appropriation
(New Station)	WS088	Plant Reservoir	Monitor flow from Plant Reservoir to truck fill stations.	Flow monitoring	When usage occurs	Annual Report	Internal Flow	Water Appropriation
(New Station)	SW047	Colby Lake	Monitor the flow from Colby Lake.	Continuous Flow Monitoring	Continuous flow monitoring; Year-round	Annual Report	Water Appropriation Source	Water Appropriation

Large Table 21 Plant Site Proposed Parameter List

List Name	Parameters	
Plant Site Groundwater Quality Surficial Aquifer Parameter List	-Alkalinity -Aluminum -Arsenic -Barium -Chloride -Chromium -Copper -Fluoride	-Hardness -Lead -Manganese -pH -Specific Conductance -Sulfate -Total Dissolved Solids (TDS) -Zinc
Plant Site Groundwater Quality Bedrock Parameter List	-Alkalinity -Aluminum -Arsenic -Barium -Boron -Cadmium -Chloride -Chromium -Cobalt -Copper -Fluoride	-Hardness -Lead -Manganese -Nickel -pH -Phosphorus -Specific Conductance -Sulfate -TDS -Thallium -Zinc
Plant Site Surface Water Quality Parameter List	-Alkalinity -Aluminum -Antimony -Arsenic -Cadmium -Chloride -Cobalt -Copper -Hardness -Lead	-Mercury -Nickel -pH -Specific Conductance -Sulfate -TDS -Total Suspended Solids (TSS) -Temperature -Zinc
Surface Water Discharge Parameter List	<u>Metals/Inorganics</u> -Aluminum -Antimony -Arsenic -Barium -Beryllium -Boron -Cadmium -Chromium -Cobalt -Iron -Lead -Magnesium -Manganese -Mercury -Molybdenum -Nickel -Selenium -Silver -Strontium -Thallium -Tin -Vanadium -Zinc	<u>General Parameters</u> -Chloride -Fluoride -Hardness -Dissolved Oxygen -pH -TSS -Sodium (%) <u>Other</u> -WET testing
Plant Site Benchmark Stormwater Monitoring Parameter List (Industrial Stormwater Requirements for Sub-Sector G1)	-COD -Nitrite plus Nitrate-Nitrogen	-TSS
Internal Waste Stream Parameter List	-Arsenic -Cadmium -Copper -Lead	-Mercury -pH -TSS -Zinc
Waste Water Treatment System (WWTS) Influent Parameter List	<u>Metals/Inorganics</u> -Aluminum -Antimony -Arsenic -Barium -Beryllium -Boron -Cadmium -Chromium -Cobalt -Copper -Iron -Lead -Magnesium -Manganese -Mercury -Molybdenum -Nickel -Selenium -Silver -Strontium -Thallium -Tin -Vanadium -Zinc	<u>General Parameters</u> -Chloride -Fluoride -Hardness -Dissolved Oxygen -pH -TSS -Sodium (%) -Sulfate

List Name	Parameters	
Plant Site WWTS Backwash and Cleaning Water Parameter List	-Phosphorus -COD	-Sodium
WWTS Internal Waste Stream Parameter List	Metals/Inorganics -Aluminum -Antimony -Arsenic -Barium -Beryllium -Boron -Cadmium -Chromium -Cobalt -Copper -Iron -Lead -Manganese -Nickel -Selenium -Silver -Thallium -Zinc	General Parameters -Chloride -Fluoride -Hardness -Sodium (%) -Sulfate

Large Figures



[1] The final extent of the Mining Area boundary will be determined by applicable legal descriptions and surveys.
[2] Only includes portion that is part of Mining Area.
[3] These are provisional representations of Public Waters Inventory watercourses downloaded from the Minnesota Geospatial Commons website (https://gisdata.mn.gov/) on November 3, 2017. Due to previous disturbance in this area, data sources may show watercourses that no longer exist.
[4] The National Hydrography Dataset (NHD) is a feature-based database that interconnects and uniquely identifies the stream segments or reaches that make up the nation's surface water drainage system. NHD features are created from DNR 24K Streams and 1:24,000 USGS quadrangle maps. Due to previous disturbance in this area, data sources may show watercourses that no longer exist.

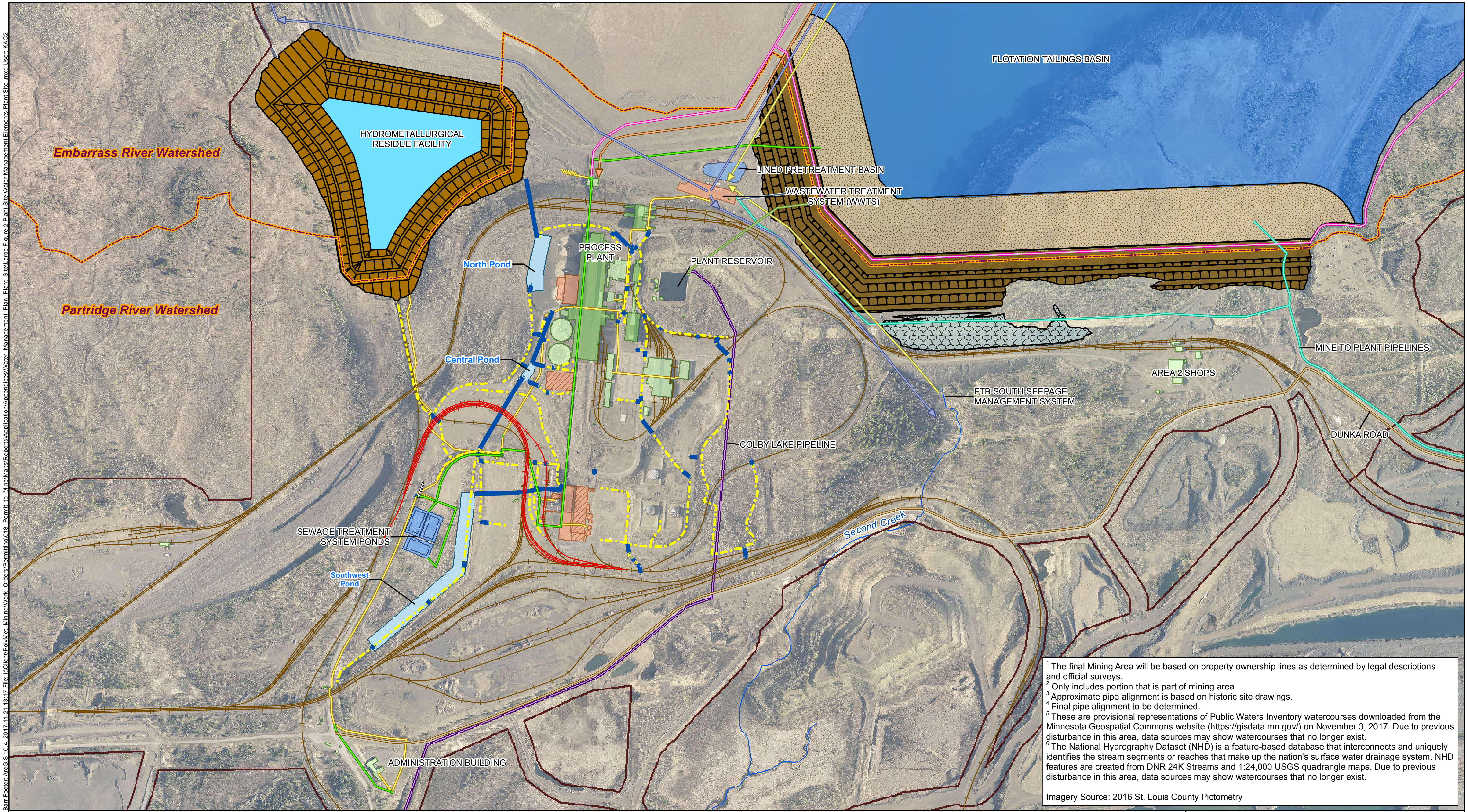
Imagery Source: 2016 St. Louis County Pictometry

Mining Area[1]
Dunka Road[2]
Existing Railroad
Proposed Railroad
Surface Water Evaluation Location
Existing Surface Discharge Station
Existing Surface Discharge Station and Temporary Pumpback System
USGS Gage
Stormwater Flow Lines
Colby Lake Pipeline
Watershed Divide
Public Waters Inventory (PWI) Watercourses[3]
National Hydrography Dataset (NHD) Rivers & Streams[4]

0 3,500 7,000
Feet

EXISTING TAILINGS BASIN
NorthMet Project
Poly Met Mining, Inc.

Large Figure 1
Water Management Plan – Plant



[1] The final Mining Area will be based on property ownership lines as determined by legal descriptions and official surveys.
[2] Only includes portion that is part of mining area.
[3] Approximate pipe alignment is based on historic site drawings.
[4] Final pipe alignment to be determined.
[5] These are provisional representations of Public Waters Inventory watercourses downloaded from the Minnesota Geospatial Commons website (https://gisdata.mn.gov/) on November 3, 2017. Due to previous disturbance in this area, data sources may show watercourses that no longer exist.
[6] The National Hydrography Dataset (NHD) is a feature-based database that interconnects and uniquely identifies the stream segments or reaches that make up the nation's surface water drainage system. NHD features are created from DNR 24K Streams and 1:24,000 USGS quadrangle maps. Due to previous disturbance in this area, data sources may show watercourses that no longer exist.

Imagery Source: 2016 St. Louis County Pictometry

Mining Area[1]
Dunka Road[2]
Existing Beneficiation Plant Building
Existing Other Plant Building
Proposed Beneficiation Plant Building
Proposed Hydrometallurgical Plant Building
Existing Railroads
Proposed Railroads
Proposed Access Road
Colby Lake Pipeline
Existing Sewer Pipe[3]
Proposed Sewer Pipe[4]
Mine to Plant Pipelines
FTB Water Return Pipe
FTB Tailings Discharge Pipe
Tailings Basin Seepage Collection Pipe
Plant Reservoir Overflow
Treated Water Pipe
Treated Mine Water Ppe
Stormwater Culvert
Stormwater Ditch

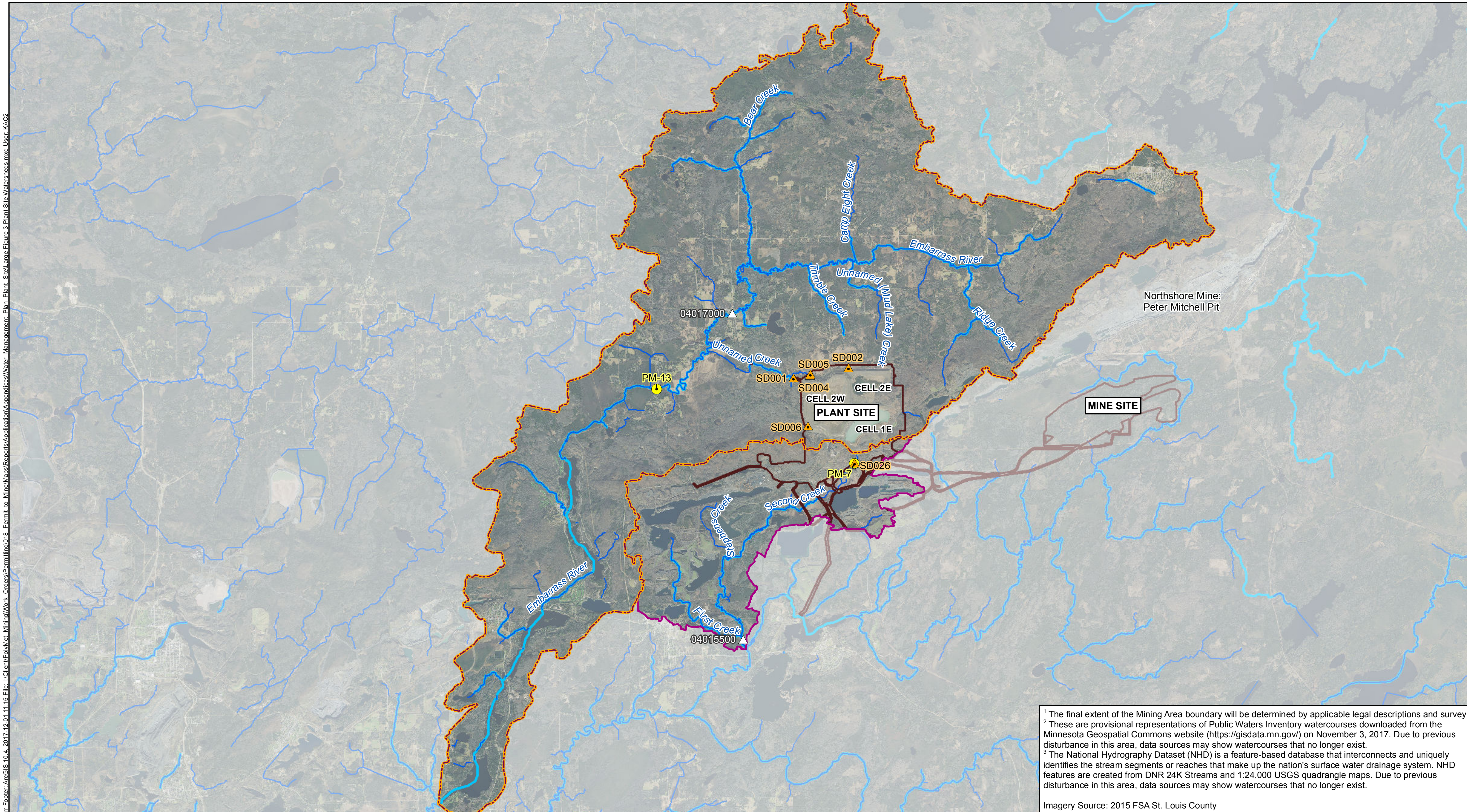
Mine Year 20 Footprints

Dam
Beach
South Buttress
HRF Pond
HRF Dam
Stormwater Ponds
Watershed Divide
National Hydrography Dataset (NHD) Rivers & Streams[5]

0 1,000 2,000
Feet

PLANT SITE WATER MANAGEMENT ELEMENTS
NorthMet Project
Poly Met Mining, Inc.

Large Figure 2
Water Management Plan – Plant



[1] The final extent of the Mining Area boundary will be determined by applicable legal descriptions and surveys.
[2] These are provisional representations of Public Waters Inventory watercourses downloaded from the Minnesota Geospatial Commons website (https://gisdata.mn.gov/) on November 3, 2017. Due to previous disturbance in this area, data sources may show watercourses that no longer exist.
[3] The National Hydrography Dataset (NHD) is a feature-based database that interconnects and uniquely identifies the stream segments or reaches that make up the nation's surface water drainage system. NHD features are created from DNR 24K Streams and 1:24,000 USGS quadrangle maps. Due to previous disturbance in this area, data sources may show watercourses that no longer exist.

Imagery Source: 2015 FSA St. Louis County

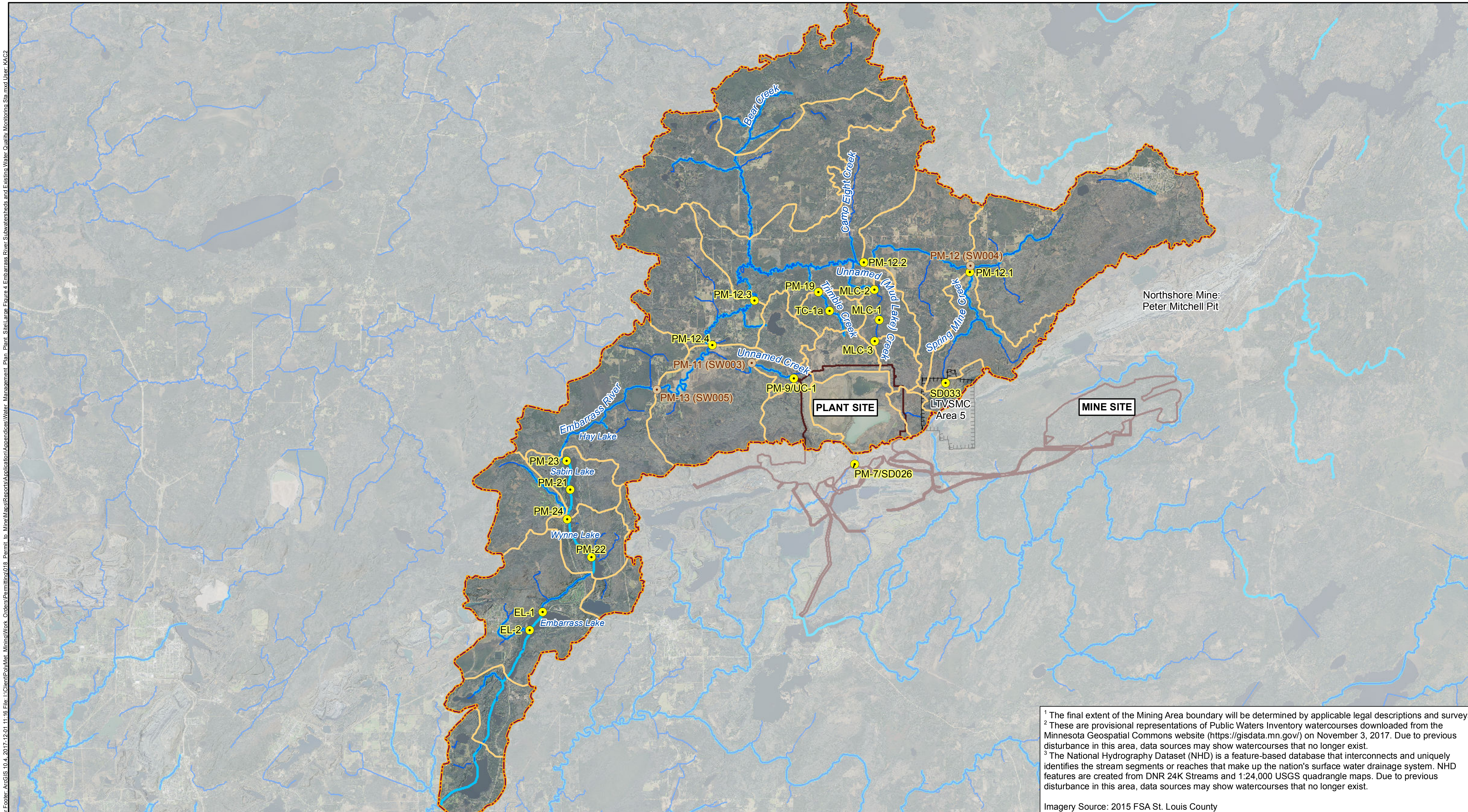
Mining Area[1]
Existing Surface Discharge Station
Surface Water Evaluation Location
USGS Gages
Embarrass River Watershed
Second Creek Watershed
Public Waters Inventory (PWI) Watercourses[2]
National Hydrography Dataset (NHD) Rivers & Streams[3]

Note: Surface water monitoring location PM-7/SD026 is a surface water monitoring location for the Plant Site in the Partridge River watershed.

0 1.25 2.5 5
Miles

PLANT SITE WATERSHEDS
NorthMet Project
Poly Met Mining, Inc.

Large Figure 3
Water Management Plan – Plant



[1] The final extent of the Mining Area boundary will be determined by applicable legal descriptions and surveys.
[2] These are provisional representations of Public Waters Inventory watercourses downloaded from the Minnesota Geospatial Commons website (https://gisdata.mn.gov/) on November 3, 2017. Due to previous disturbance in this area, data sources may show watercourses that no longer exist.
[3] The National Hydrography Dataset (NHD) is a feature-based database that interconnects and uniquely identifies the stream segments or reaches that make up the nation's surface water drainage system. NHD features are created from DNR 24K Streams and 1:24,000 USGS quadrangle maps. Due to previous disturbance in this area, data sources may show watercourses that no longer exist.

Imagery Source: 2015 FSA St. Louis County

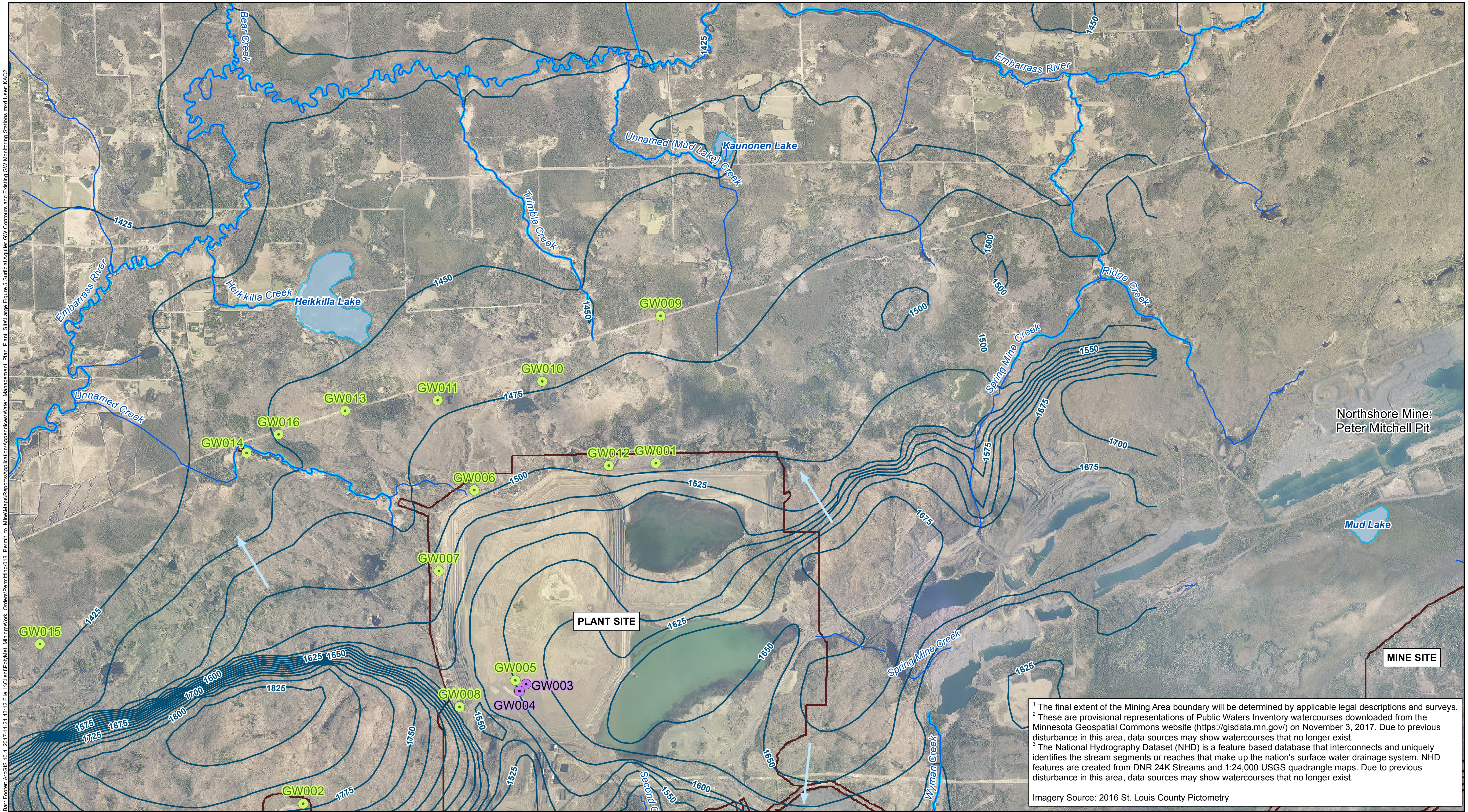
Mining Area[1]
Existing Surface Water Station
Surface Water Monitoring Station
Embarrass River Watershed
Embarrass River Subwatersheds
LTVSMC Area 5
Public Waters Inventory (PWI) Watercourses[2]
National Hydrography Dataset (NHD) Rivers & Streams[3]

Note: PM-7/SD026 is a surface water monitoring location on Second Creek, a tributary to the Partridge River. All other surface water monitoring locations and stations shown are within the Embarrass River watershed.

0 1.25 2.5 5
Miles

EMBARASS RIVER SUBWATERSHEDS AND EXISTING WATER QUALITY MONITORING STATIONS
NorthMet Project
Poly Met Mining, Inc.

Large Figure 4
Water Management Plan – Plant



[1] The final extent of the Mining Area boundary will be determined by applicable legal descriptions and surveys.
[2] These are provisional representations of Public Waters Inventory watercourses downloaded from the Minnesota Geospatial Commons website (https://gisdata.mn.gov/) on November 3, 2017. Due to previous disturbance in this area, data sources may show watercourses that no longer exist.
[3] The National Hydrography Dataset (NHD) is a feature-based database that interconnects and uniquely identifies the stream segments or reaches that make up the nation's surface water drainage system. NHD features are created from DNR 24K Streams and 1:24,000 USGS quadrangle maps. Due to previous disturbance in this area, data sources may show watercourses that no longer exist.

Imagery Source: 2016 St. Louis County Pictometry

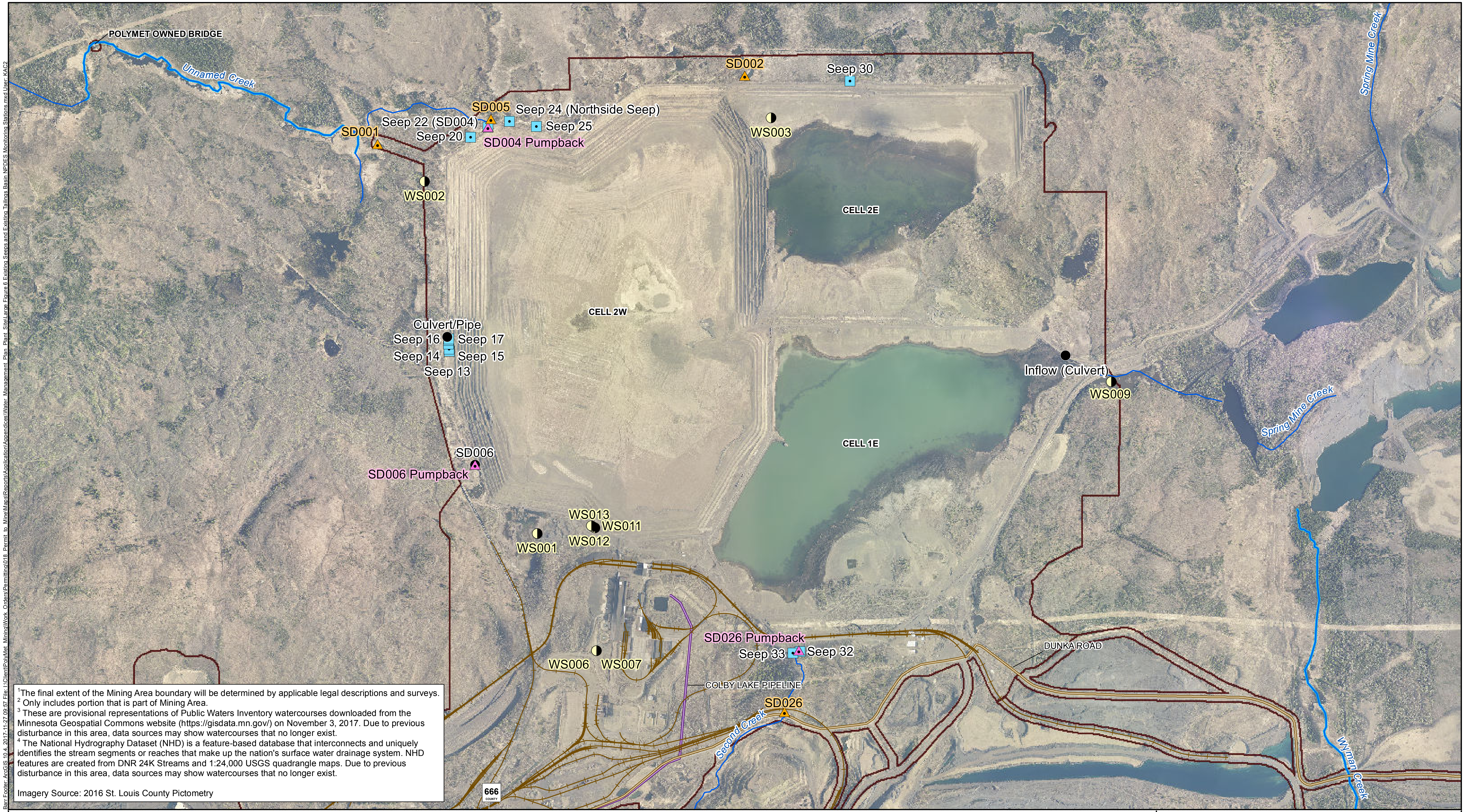
Mining Area[1]
Groundwater Monitoring Wells
Groundwater Monitoring Wells - Intermittent Sampling (Dry)
Surficial Aquifer Groundwater Contours - Inferred
Groundwater Flow Direction
Public Waters Inventory Basins
Public Waters Inventory (PWI) Watercourses[2]
National Hydrography Dataset (NHD) Rivers & Streams[3]

N

0 3,500 7,000
Feet

SURFICIAL AQUIFER GROUNDWATER CONTOURS AND EXISTING GROUNDWATER MONITORING STATIONS
NorthMet Project
Poly Met Mining, Inc.

Large Figure 5
Water Management Plan – Plant



[1]The final extent of the Mining Area boundary will be determined by applicable legal descriptions and surveys.
[2] Only includes portion that is part of Mining Area.
[3] These are provisional representations of Public Waters Inventory watercourses downloaded from the Minnesota Geospatial Commons website (https://gisdata.mn.gov/) on November 3, 2017. Due to previous disturbance in this area, data sources may show watercourses that no longer exist.
[4] The National Hydrography Dataset (NHD) is a feature-based database that interconnects and uniquely identifies the stream segments or reaches that make up the nation's surface water drainage system. NHD features are created from DNR 24K Streams and 1:24,000 USGS quadrangle maps. Due to previous disturbance in this area, data sources may show watercourses that no longer exist.

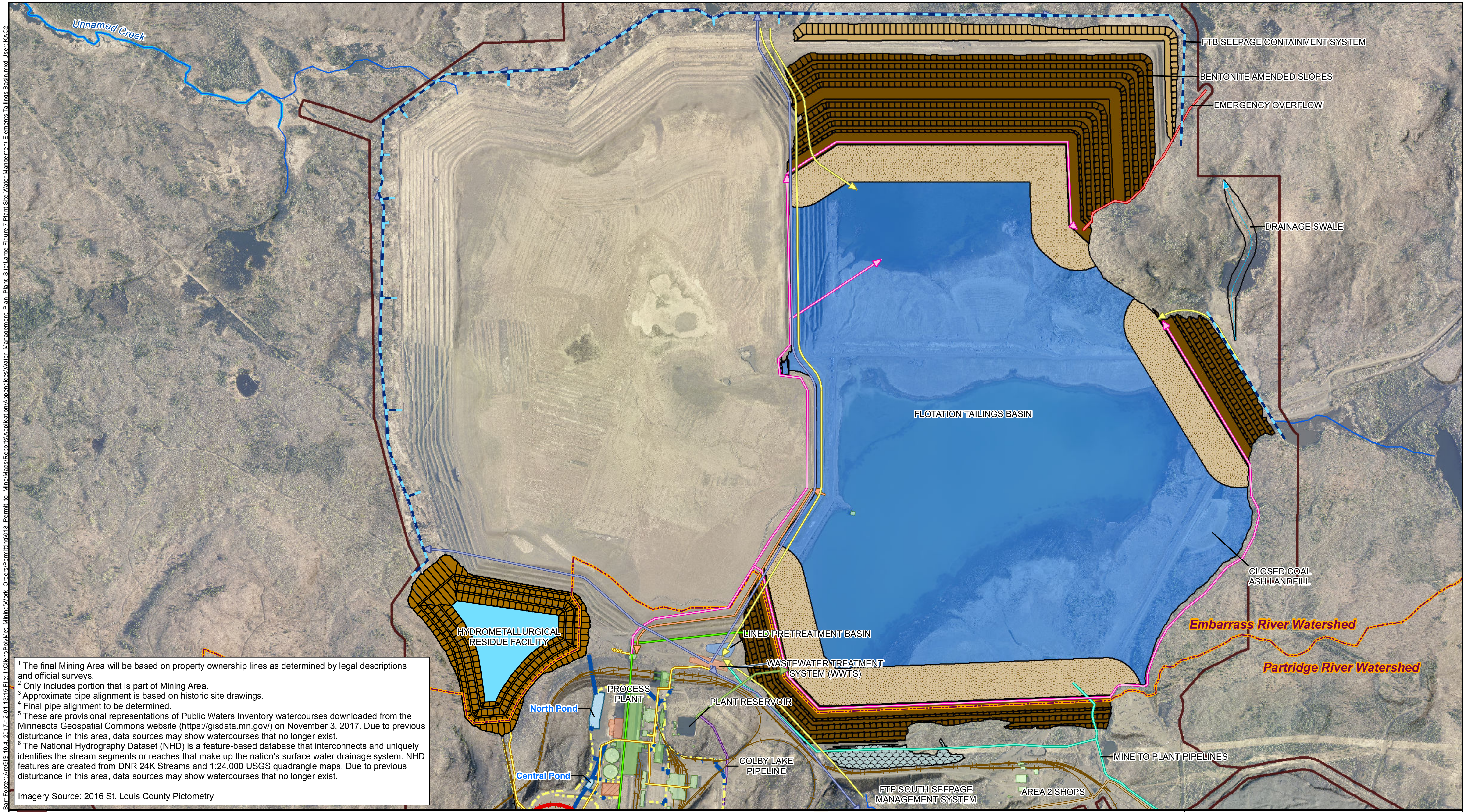
Imagery Source: 2016 St. Louis County Pictometry

- Mining Area[1]
- Dunka Road[2]
- Existing Railroad
- Existing Surface Discharge Station
- Seep Temporary Pumpback System
- Existing Waste Stream Station
- Culvert
- Seeps
- Colby Lake Pipeline
- Public Waters Inventory Basins
- Public Waters Inventory (PWI) Watercourses[3]
- National Hydrography Dataset (NHD) Rivers & Streams[4]

0 2,000 4,000
Feet

EXISTING SEEPS AND EXISTING TAILINGS BASIN NPDES MONITORING STATIONS
NorthMet Project
Poly Met Mining, Inc.

Large Figure 6
Water Management Plan – Plant



[1] The final Mining Area will be based on property ownership lines as determined by legal descriptions and official surveys.
[2] Only includes portion that is part of Mining Area.
[3] Approximate pipe alignment is based on historic site drawings.
[4] Final pipe alignment to be determined.
[5] These are provisional representations of Public Waters Inventory watercourses downloaded from the Minnesota Geospatial Commons website (https://gisdata.mn.gov/) on November 3, 2017. Due to previous disturbance in this area, data sources may show watercourses that no longer exist.
[6] The National Hydrography Dataset (NHD) is a feature-based database that interconnects and uniquely identifies the stream segments or reaches that make up the nation's surface water drainage system. NHD features are created from DNR 24K Streams and 1:24,000 USGS quadrangle maps. Due to previous disturbance in this area, data sources may show watercourses that no longer exist.

Imagery Source: 2016 St. Louis County Pictometry

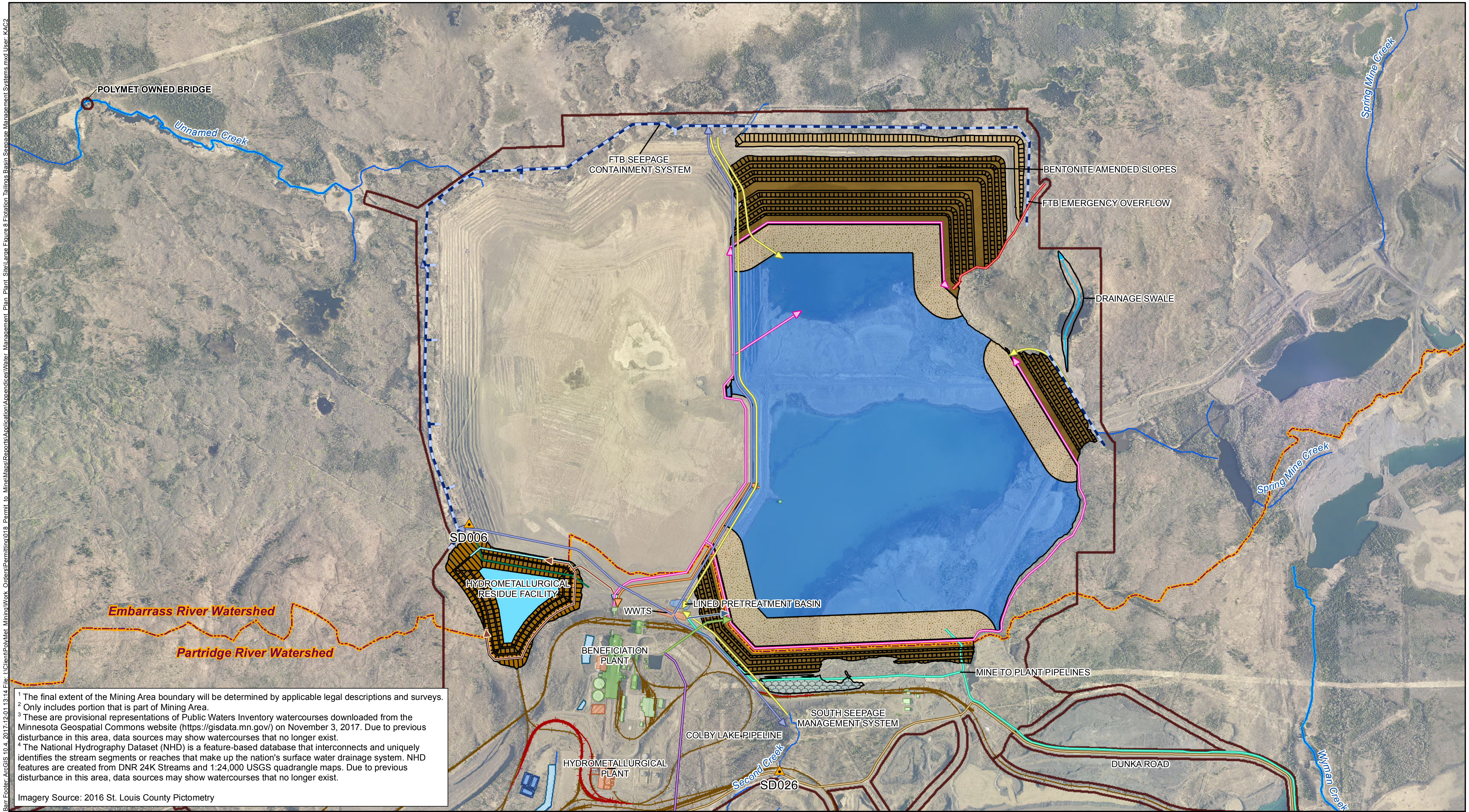
- Mining Area[1]
- Dunka Road[2]
- Existing Beneficiation Plant Building
- Existing Other Plant Building
- Proposed Beneficiation Plant Building
- Proposed Hydrometallurgical Plant Building
- Existing Railroads
- Proposed Railroad
- Colby Lake Pipeline
- Existing Sewer Pipe[3]
- Proposed Sewer Pipe[4]
- Mine to Plant Pipelines
- FTB Seepage Containment System
- FTB Water Return Pipe
- FTB Tailings Discharge Pipe
- Plant Reservoir Overflow
- Tailings Basin Seepage Collection Pipe
- Treated Water Pipe
- Treated Mine Water Ppe
- Stormwater Culvert
- Stormwater Ditch
- Stormwater Ponds

Mine Year 20 Footprints
- Dam
- Beach
- North Buttress
- South Buttress
- HRF Pond
- HRF Dam
- Watershed Divide
- Public Waters Inventory (PWI) Watercourses[5]
- National Hydrography Dataset (NHD) Rivers & Streams[6]

0 1,500 3,000
Feet

PLANT SITE WATER MANAGEMENT ELEMENTS TAILINGS BASIN
NorthMet Project
Poly Met Mining, Inc.

Large Figure 7
Water Management Plan – Plant



[1] The final extent of the Mining Area boundary will be determined by applicable legal descriptions and surveys.
[2] Only includes portion that is part of Mining Area.
[3] These are provisional representations of Public Waters Inventory watercourses downloaded from the Minnesota Geospatial Commons website (https://gisdata.mn.gov/) on November 3, 2017. Due to previous disturbance in this area, data sources may show watercourses that no longer exist.
[4] The National Hydrography Dataset (NHD) is a feature-based database that interconnects and uniquely identifies the stream segments or reaches that make up the nation's surface water drainage system. NHD features are created from DNR 24K Streams and 1:24,000 USGS quadrangle maps. Due to previous disturbance in this area, data sources may show watercourses that no longer exist.

Imagery Source: 2016 St. Louis County Pictometry

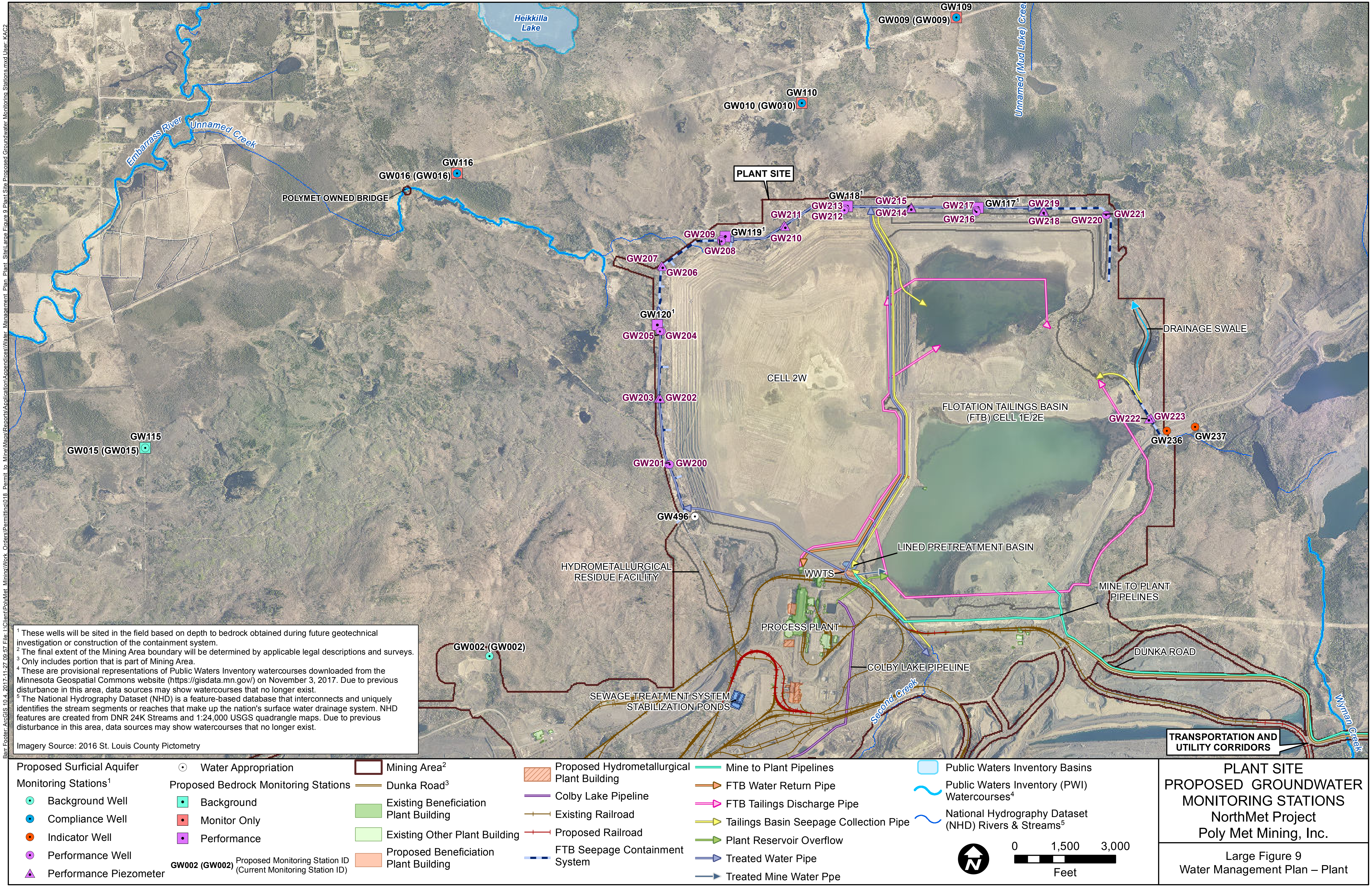
Mining Area[1]
Dunka Road[2]
Colby Lake Pipeline
Existing Railroad
Proposed Railroad
Existing NPDES Discharge Stations
FTB Seepage Containment System
FTB Water Return Pipe
FTB Tailings Discharge Pipe
Tailings Basin Seepage Collection Pipe
Plant Reservoir Overflow
Treated Water Pipe
Treated Mine Water Ppe
FTB Seepage Collection Drain (under HRF)
Return Water Pipe
Residue Discharge Pipe
Mine to Plant Pipelines

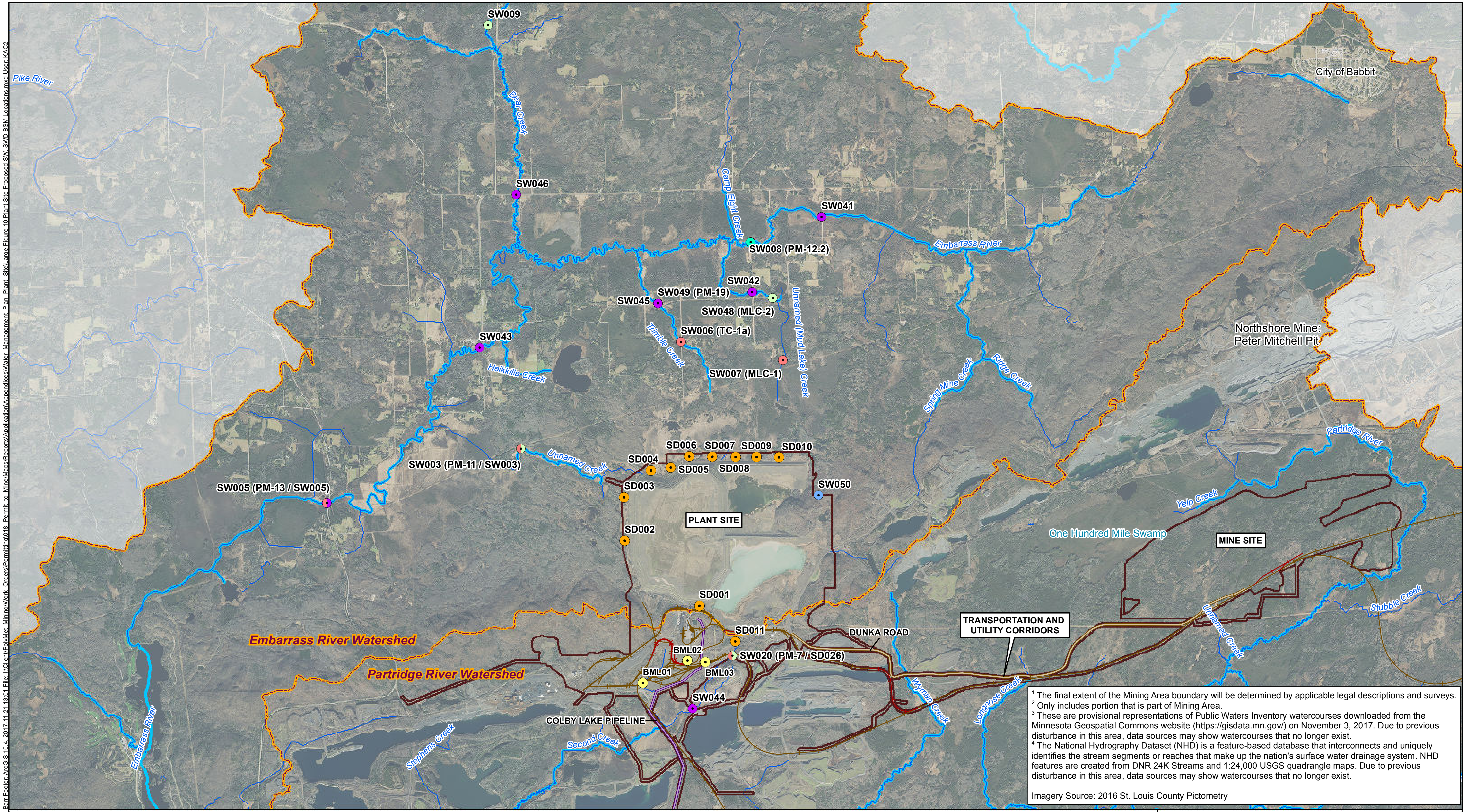
Mine Year 20 Footprints
Dam
Beach
North Buttress
South Buttress
HRF Pond
HRF Dam
Stormwater Ponds
Watershed Divide
Public Waters Inventory (PWI) Watercourses[3]
National Hydrography Dataset (NHD) Rivers & Streams[4]

0 1,000 2,000
Feet

FLOTATION TAILINGS BASIN
SEEPAGE CAPTURE SYSTEMS
NorthMet Project
Poly Met Mining, Inc.

Large Figure 8
Water Management Plan – Plant


Heikkila Lake
GW109
GW009 (GW009)
Unnamed (Mud Lake) Creek
GW110
GW010 (GW010)
Embarrass River
Unnamed Creek
GW116
GW016 (GW016)
POLYMET OWNED BRIDGE
PLANT SITE
GW118[1]
GW213
GW212
GW211
GW215
GW214
GW217
GW216
GW117[1]
GW219
GW218
GW220
GW221
GW209
GW119[1]
GW208
GW210
GW207
GW206
GW120[1]
GW205
GW204
CELL 2W
DRAINAGE SWALE
FLOTATION TAILINGS BASIN
(FTB) CELL 1E/2E
GW203
GW202
GW222
GW223
GW236
GW237
GW115
GW015 (GW015)
GW201
GW200
GW496
LINED PRETREATMENT BASIN
HYDROMETALLURGICAL
RESIDUE FACILITY
WWTS
MINE TO PLANT
PIPELINES
PROCESS PLANT
GW002 (GW002)
DUNKA ROAD
COLBY LAKE PIPELINE
SEWAGE TREATMENT SYSTEM
STABILIZATION PONDS
Second Creek
Wyman Creek
TRANSPORTATION AND
UTILITY CORRIDORS
[1] These wells will be sited in the field based on depth to bedrock obtained during future geotechnical investigation or construction of the containment system.
[2] The final extent of the Mining Area boundary will be determined by applicable legal descriptions and surveys.
[3] Only includes portion that is part of Mining Area.
[4] These are provisional representations of Public Waters Inventory watercourses downloaded from the Minnesota Geospatial Commons website (https://gisdata.mn.gov/) on November 3, 2017. Due to previous disturbance in this area, data sources may show watercourses that no longer exist.
[5] The National Hydrography Dataset (NHD) is a feature-based database that interconnects and uniquely identifies the stream segments or reaches that make up the nation's surface water drainage system. NHD features are created from DNR 24K Streams and 1:24,000 USGS quadrangle maps. Due to previous disturbance in this area, data sources may show watercourses that no longer exist.
Imagery Source: 2016 St. Louis County Pictometry
Proposed Surficial Aquifer Monitoring Stations[1]
Background Well
Compliance Well
Indicator Well
Performance Well
Performance Piezometer
Water Appropriation
Proposed Bedrock Monitoring Stations
Background
Monitor Only
Performance
GW002 (GW002) Proposed Monitoring Station ID (Current Monitoring Station ID)
Mining Area[2]
Dunka Road[3]
Existing Beneficiation Plant Building
Existing Other Plant Building
Proposed Beneficiation Plant Building
Proposed Hydrometallurgical Plant Building
Colby Lake Pipeline
Existing Railroad
Proposed Railroad
FTB Seepage Containment System
Mine to Plant Pipelines
FTB Water Return Pipe
FTB Tailings Discharge Pipe
Tailings Basin Seepage Collection Pipe
Plant Reservoir Overflow
Treated Water Pipe
Treated Mine Water Ppe
Public Waters Inventory Basins
Public Waters Inventory (PWI) Watercourses[4]
National Hydrography Dataset (NHD) Rivers & Streams[5]
0 1,500 3,000
Feet
PLANT SITE
PROPOSED GROUNDWATER
MONITORING STATIONS
NorthMet Project
Poly Met Mining, Inc.
Large Figure 9
Water Management Plan – Plant



[1] The final extent of the Mining Area boundary will be determined by applicable legal descriptions and surveys.
[2] Only includes portion that is part of Mining Area.
[3] These are provisional representations of Public Waters Inventory watercourses downloaded from the Minnesota Geospatial Commons website (https://gisdata.mn.gov/) on November 3, 2017. Due to previous disturbance in this area, data sources may show watercourses that no longer exist.
[4] The National Hydrography Dataset (NHD) is a feature-based database that interconnects and uniquely identifies the stream segments or reaches that make up the nation's surface water drainage system. NHD features are created from DNR 24K Streams and 1:24,000 USGS quadrangle maps. Due to previous disturbance in this area, data sources may show watercourses that no longer exist.

Imagery Source: 2016 St. Louis County Pictometry

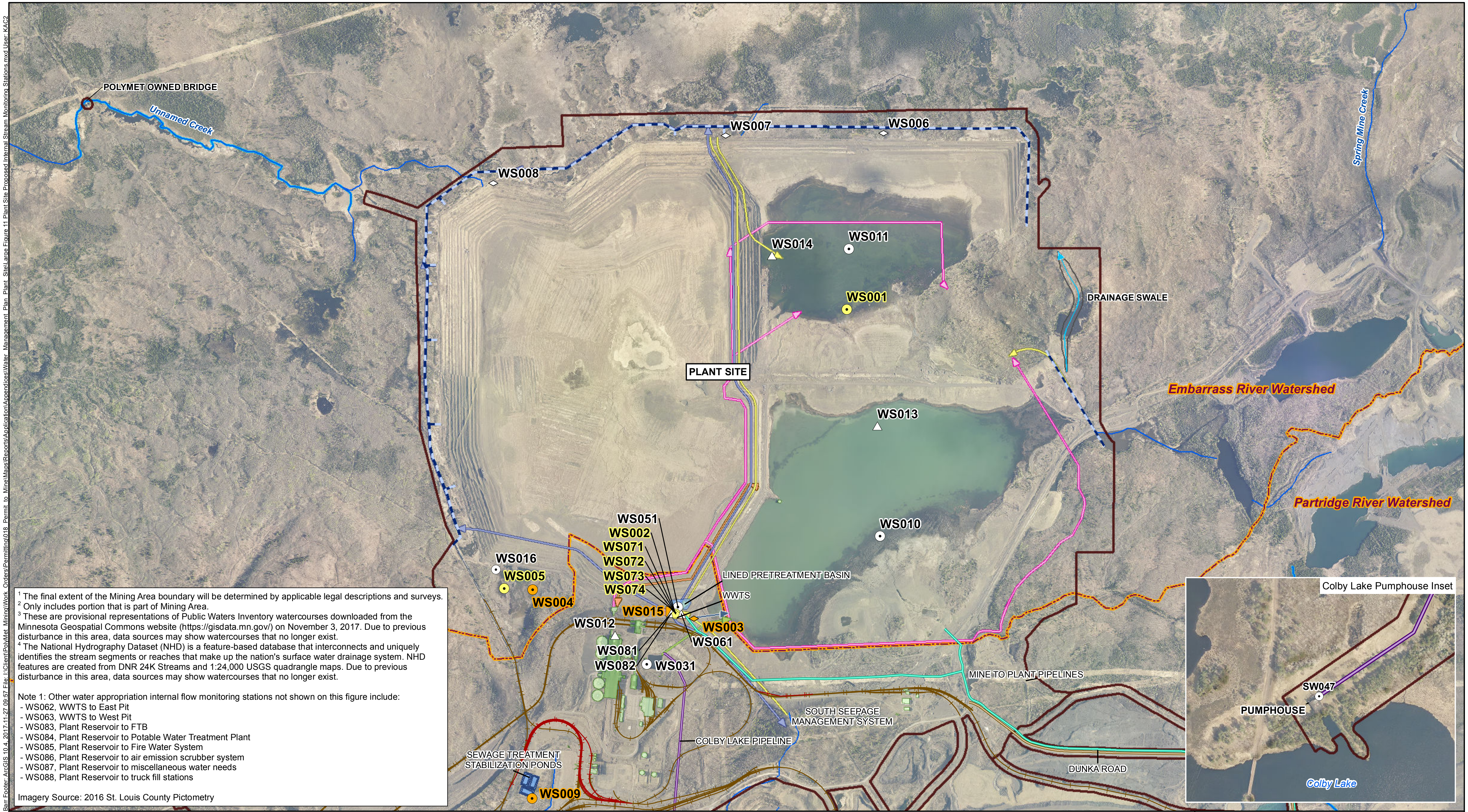
Proposed Surface Water Monitoring Stations
- Background
- Monitor Only
- Augmentation Flow
- Stream Flow
- Aquatic Biota
- Monitor Only/Aquatic Biota
- Monitor Only/Stream Flow
- Benchmark Stormwater Monitoring Location
- Surface Water Discharge
- Mining Area[1]
- Dunka Road[2]
- Existing Railroad
- Proposed Railroad
- Colby Lake Pipeline
- Watershed Divide
- Public Waters Inventory (PWI) Watercourses[3]
- National Hydrography Dataset (NHD) Rivers & Streams[4]

SW402 (SW002) Proposed NPDES/SDS Monitoring Station ID (Current Monitoring Station ID)

0 0.5 1 2
Miles

PLANT SITE PROPOSED SURFACE WATER AND SURFACE WATER DISCHARGE PROPOSED BENCHMARK STORMWATER MONITORING LOCATIONS
NorthMet Project
Poly Met Mining, Inc.

Large Figure 10
Water Management Plan – Plant



[1] The final extent of the Mining Area boundary will be determined by applicable legal descriptions and surveys.
[2] Only includes portion that is part of Mining Area.
[3] These are provisional representations of Public Waters Inventory watercourses downloaded from the Minnesota Geospatial Commons website (https://gisdata.mn.gov/) on November 3, 2017. Due to previous disturbance in this area, data sources may show watercourses that no longer exist.
[4] The National Hydrography Dataset (NHD) is a feature-based database that interconnects and uniquely identifies the stream segments or reaches that make up the nation's surface water drainage system. NHD features are created from DNR 24K Streams and 1:24,000 USGS quadrangle maps. Due to previous disturbance in this area, data sources may show watercourses that no longer exist.

Note 1: Other water appropriation internal flow monitoring stations not shown on this figure include:
- WS062, WWTS to East Pit
- WS063, WWTS to West Pit
- WS083, Plant Reservoir to FTB
- WS084, Plant Reservoir to Potable Water Treatment Plant
- WS085, Plant Reservoir to Fire Water System
- WS086, Plant Reservoir to air emission scrubber system
- WS087, Plant Reservoir to miscellaneous water needs
- WS088, Plant Reservoir to truck fill stations

Imagery Source: 2016 St. Louis County Pictometry

NPDES/SDS Only, Internal Waste Stream Monitor Only
NPDES/SDS Only, Internal Performance Monitoring
Water Appropriation Only, Appropriation Source Monitoring
Water Appropriation Only, Seepage Flow Monitoring
Water Appropriation Only, Internal Flow Monitoring
NPDES/SDS Monitor Only and Water Appropriation Source
NPDES/SDS Monitor Only and Water Appropriation Seepage Flow
NPDES/SDS Monitor Only and Water Appropriation Internal Flow
Mining Area[1]
Dunka Road[2]
Existing Railroad
Proposed Railroad
Colby Lake Pipeline
Mine to Plant Pipelines
FTB Seepage Containment System
FTB Water Return Pipe
FTB Tailings Discharge Pipe
Tailings Basin Seepage Collection Pipe
Plant Reservoir Overflow
Treated Water Pipe
Treated Mine Water Ppe
Watershed Divide
Public Waters Inventory (PWI) Watercourses[3]
National Hydrography Dataset (NHD) Rivers & Streams[4]

0 1,000 2,000
Feet

PLANT SITE PROPOSED INTERNAL STREAM MONITORING STATIONS
NorthMet Project
Poly Met Mining, Inc.

Large Figure 11
Water Management Plan – Plant

Attachments

Attachment A WWTS Terminology Changes

Some terminology associated with the WWTS has changed since the FEIS. Changes are associated with the relocation of the mine water treatment trains that were previously at the Mine Site WWTF to the Plant Site WWTS, and the relocation of the Mine Site equalization basins to south of Dunka Road. To aid review of documents prepared for the FEIS which are referenced in this plan, the following table explains WWTS terminology changes.

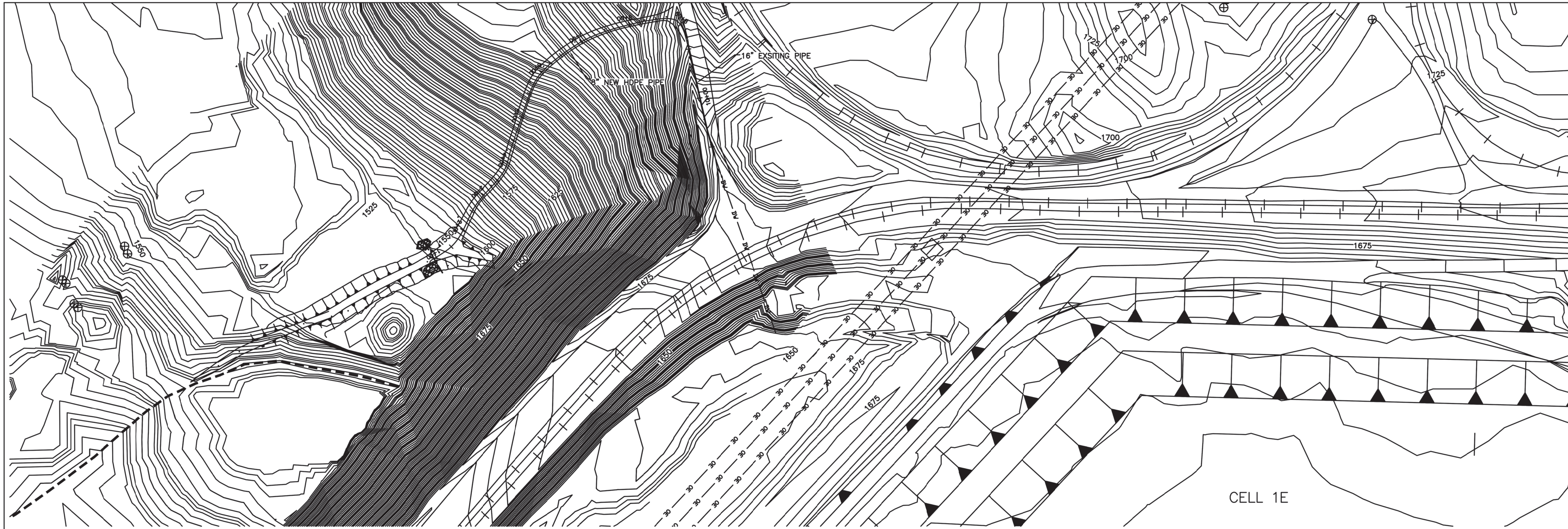
Former name	New name
Waste Water Treatment Plant (WWTP) and Waste Water Treatment Facility (WWTF)	Waste Water Treatment System (WWTS)[1]
Treated Water Pipeline	As a whole: • Mine to Plant Pipelines (MPP) Three individual pipes: • Construction Mine Water Pipeline • Low Concentration Mine Water Pipeline • High Concentration Mine Water Pipeline
Construction Mine Water Basin	Construction Mine Water Basin
West Equalization Basin	High Concentration Equalization Basin (HCEQ Basin)
East Equalization Basin 1	Low Concentration Equalization Basin 1 (LCEQ Basin 1)
East Equalization Basin 2	Low Concentration Equalization Basin 2 (LCEQ Basin 2)
WWTP effluent (discharged to receiving waters)	WWTS discharge
WWTF effluent (sent to the FTB via the Central Pumping Station)	Treated mine water[2] (WWTS stream pumped to the FTB)
Treated mine water[3]	Treated mine water[2]
Central Pumping Station	Central Pumping Station
--	Equalization Basin Area[4]
Splitter Structure	This structure will be integrated into the Central Pumping Station.
Central Pumping Station or “CPS” Pond	This pond no longer exists.

1. The two sets of treatment trains that were previously at two locations will now be housed under one roof at the Plant Site.
2. Formerly “treated mine water”, which included WWTF effluent, OSLA runoff, and construction mine water. With reconfiguration, that mixture no longer exists, and the “treated mine water” consists of effluent from the chemical precipitation and membrane filtration portion of the WWTS.
3. “Treated mine water” formerly included WWTF effluent, OSLA runoff, and construction mine water. With reconfiguration, that mixture no longer exists, but these flows still report to the FTB.
4. New term describing pond area south of Dunka Road

Attachment B

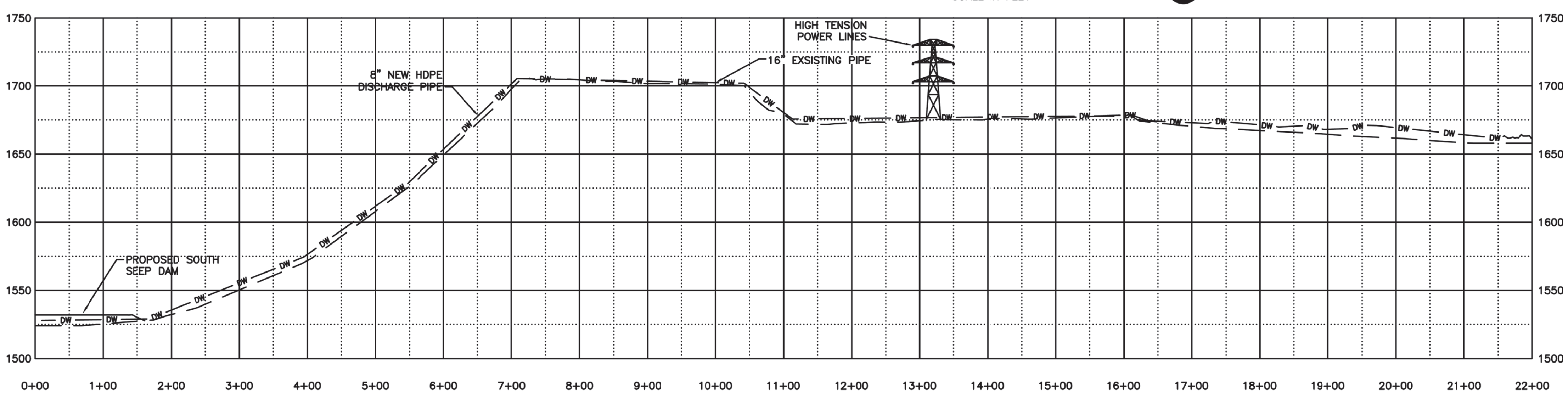
Seepage Management System Design Drawings

These drawings reflect the current SD026 seepage pumpback system, which pumps seepage back to the Tailings Basin. This plan set does not include the proposed tie-in to the proposed WWTS. These drawings will be revised for final design to show the proposed design changes for the NorthMet Project.



1 PLAN: CELL 1E SEEP PIPE ALIGNMENT

0 100 200
SCALE IN FEET



2 ELEVATION: CELL 1E SEEP PIPE PROFILE

0 100 200
HORZ. SCALE IN FEET

0 50 100
VERT. SCALE IN FEET

POLYMET DRAWING REVIEW
- ☐ APPROVED
- ☐ APPROVED AS NOTED
- ☐ REVISE AND RESUBMIT

BY: DATE:

LEGEND:

- EXISTING 25' MAJOR CONTOUR
- EXISTING 5' MINOR CONTOUR
- EXISTING RAILROAD TRACKS
- EXISTING ROADWAY
- EXISTING TRAIL
- EXISTING POWER POLES
- DE — EXISTING POWER LINES
- DW — SEEPAGE DISCHARGE PIPELINE
- PROPOSED DIKE ALIGNMENT

REV NO	DATE	REVISIONS	BY	CHKR
1	1/2013	SUMP LOCATION	DWH	_
–	–	–	–	–
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–	–	–	–	–
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–	–	–	–	–
–	–	–	–	–

DRAWING STATUS				
ISSUED	REV	DATE	SDE	PEM
PRELIMINARY	–	–	–	–
APPROVED FOR CONSTRUCTION	–	–	–	–

NOT APPROVED FOR CONSTRUCTION UNLESS SIGNED AND DATED. DESTROY ALL PRINTS BEARING EARLIER DATE AND/OR REV.NO.

I HEREBY CERTIFY THAT THIS PLAN, SPECIFICATION, OR REPORT WAS PREPARED BY ME OR UNDER MY DIRECT SUPERVISION AND THAT I AM A DULY LICENSED PROFESSIONAL ENGINEER UNDER THE LAWS OF THE STATE OF MINNESOTA.

SIGNATURE
PRINTED NAME
DATE REG. NO.

DRAWN: DH	DATE: 8/4/10
CHECKED: PB	DATE: 8/510
SCALE: –	
SHEET 1 OF 3	

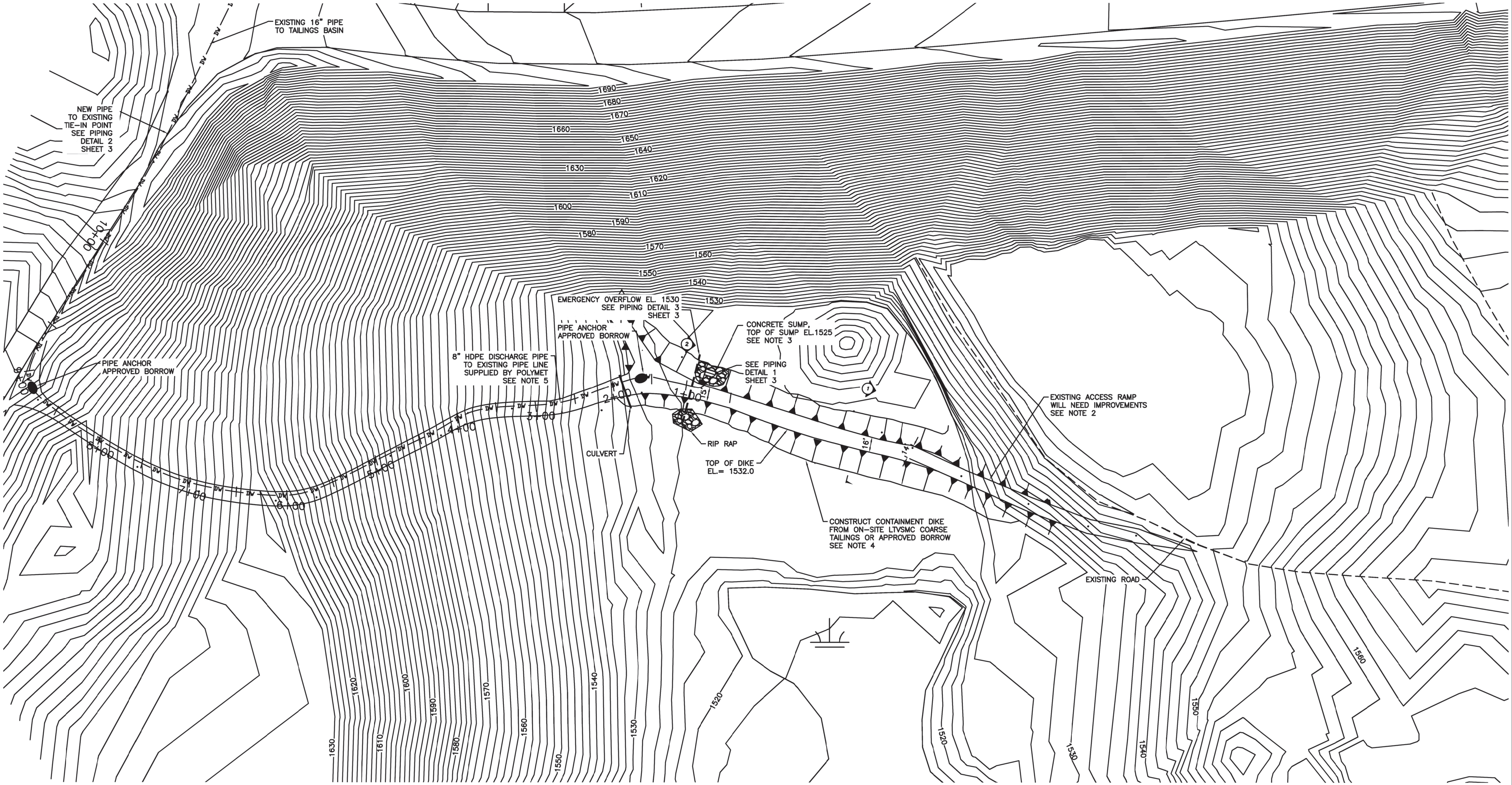
TAILINGS BASIN CONSENT DCREE
TEMPORARY SEEPAGE COLLECTION SYSTEM
CELL 1E SEEP 026 – PLAN AND PROFILE

POLYMET MINING

POLYMET MINING INC.
NORTHMET PROJECT
HOYT LAKES, MINNESOTA

DWG. NO. TJ–2–001 REV 1

INCHES 1 2



PLAN: CELL 1E SEEP AREA DIKE LAYOUT

0 50 100
SCALE IN FEET

NOTE:
1) ALL MECHANICAL HARDWARE, PIPING, AND ELECTRICAL COMPONENTS SUPPLIED BY POLYMET.
2) EXISTING ROAD AND RAMP HAS BEEN IMPROVED.
3) CONCRETE SUMP SUPPLIED BY POLYMET 2000 GAL. 156" X 81"X 60" DEEP
4) EXCAVATION REQUIRED TO LOCATE SUITABLE GROUND FROM WHICH TO BUILD DIKE.
5) 8" HDPE PIPE MUST HAVE A CONTIUOUS SLOPE OF ⅛" PER 12" TO ASSURE PROPER DRAINAGE.

LEGEND:

EXISTING 10' MAJOR CONTOUR
EXISTING 2' MINOR CONTOUR
EXISTING ROAD
DW — NEW SEEPAGE DISCHARGE PIPELINE
DW — EXISTING SEEPAGE DISCHARGE LINE

POLYMET DRAWING REVIEW
☐ APPROVED
☐ APPROVED AS NOTED
☐ REVISE AND RESUBMIT
BY: DATE:

REV NO	DATE	REVISIONS	BY	CHKR
1	1/2013	SUMP LOCATION AND DETAIL	DWH	_
–	–	–	–	–
–	–	–	–	–
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–	–	–	–	–

DRAWING STATUS				
ISSUED	REV	DATE	SDE	PEM
PRELIMINARY	–	–	–	–
APPROVED FOR CONSTRUCTION	–	–	–	–

NOT APPROVED FOR CONSTRUCTION UNLESS SIGNED AND DATED. DESTROY ALL PRINTS BEARING EARLIER DATE AND/OR REV.NO.

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PRINTED NAME ________
DATE ________ REG. NO. ________

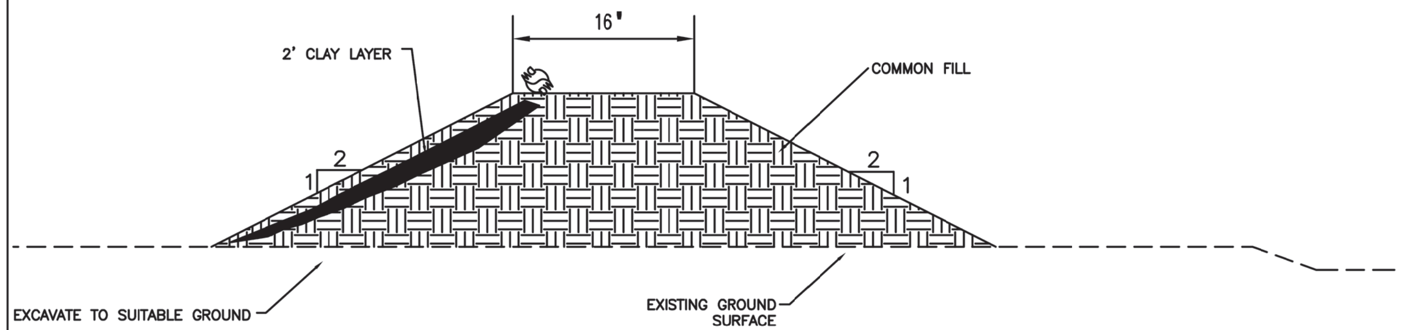
DRAWN: DH	DATE: 8/4/2010
CHECKED: PB	DATE: 8/5/2010
SCALE: –	
SHEET 2 OF 3	

TAILINGS BASIN CONSENT DECREE
TEMPORARY SEEPAGE COLLECTION SYSTEM
CELL 1E SEEP 026– DIKE LAYOUT

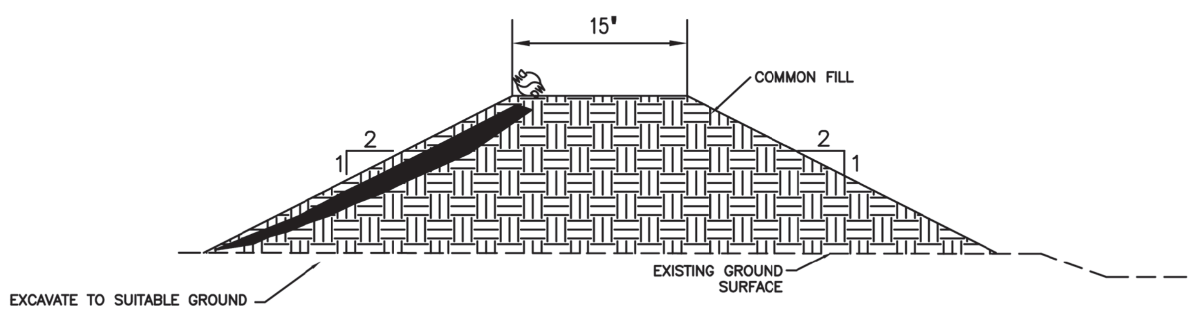
POLYMET MINING

POLYMET MINING INC.
NORTHMET PROJECT
HOYT LAKES, MINNESOTA

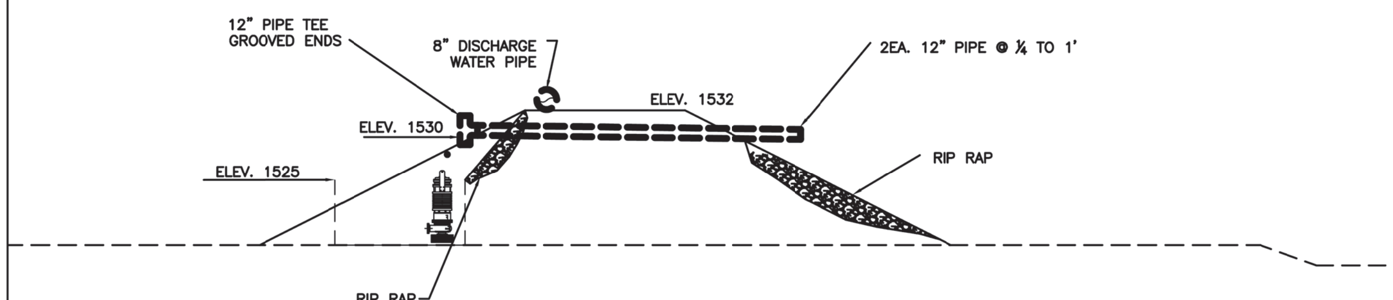
DWG. NO. TJ–2–001 REV 1



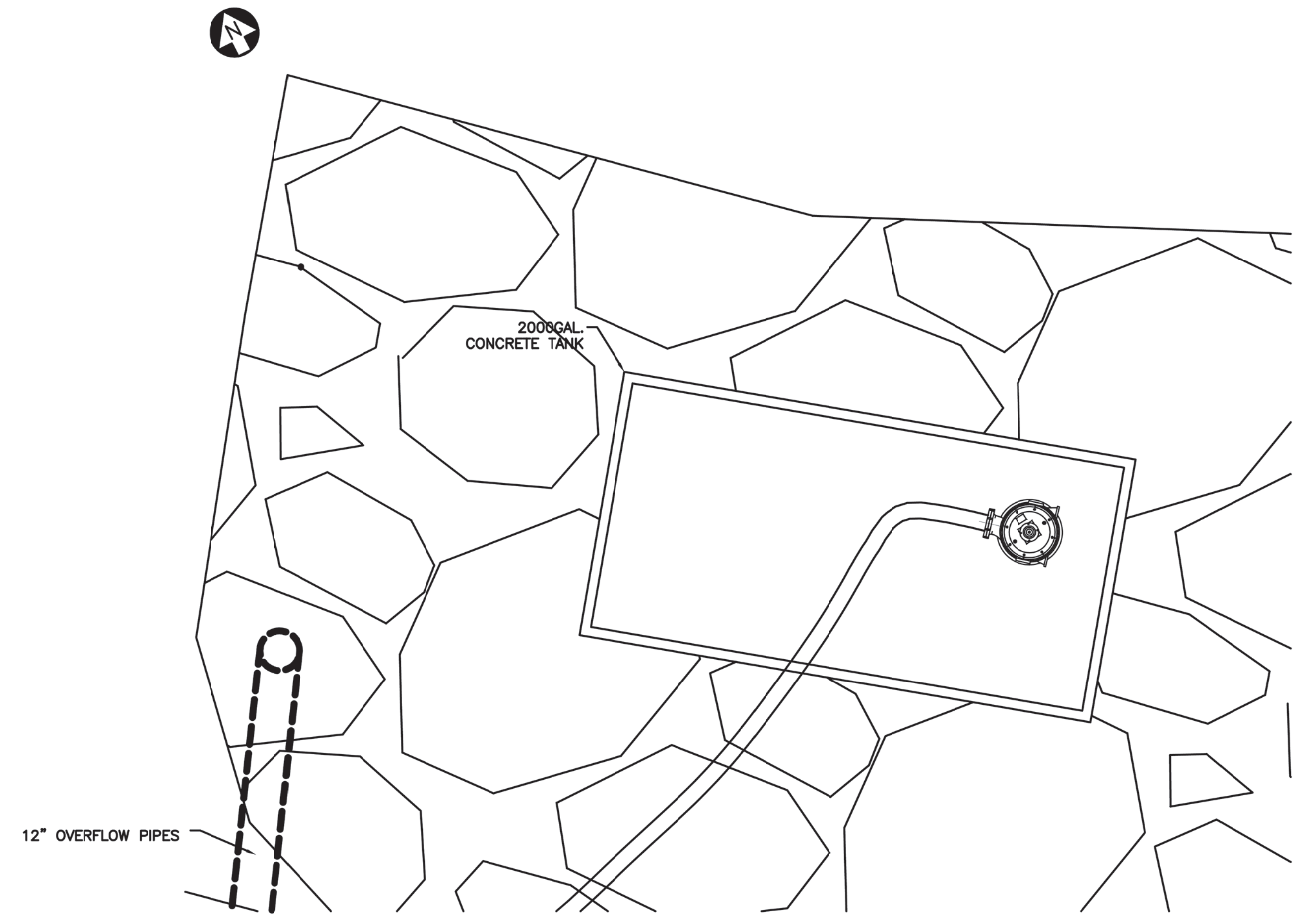
1 SH2 SECTION: DIKE



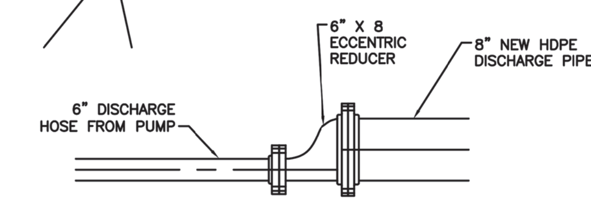
2 SH2 SECTION: DIKE



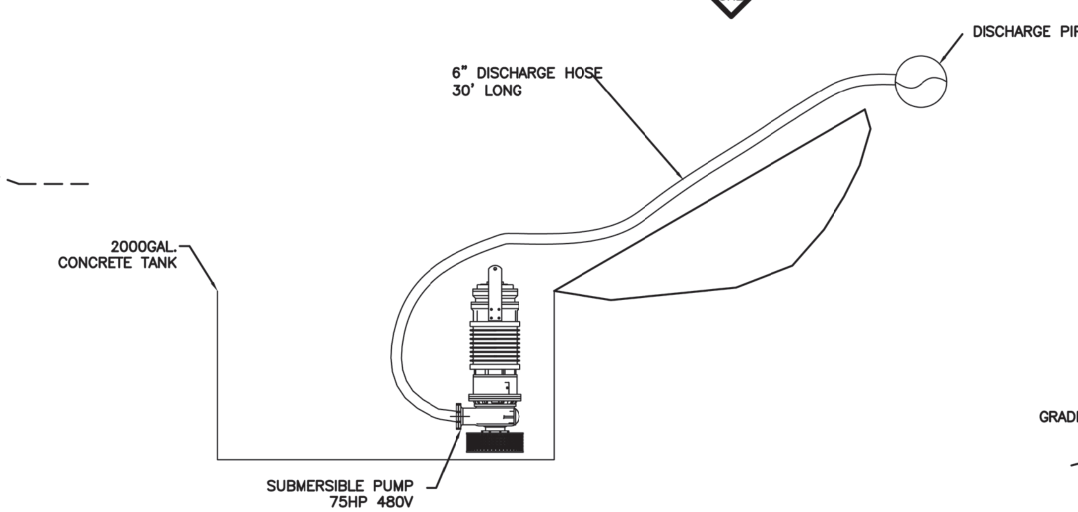
3 SH2 OVER FLOW DETAIL



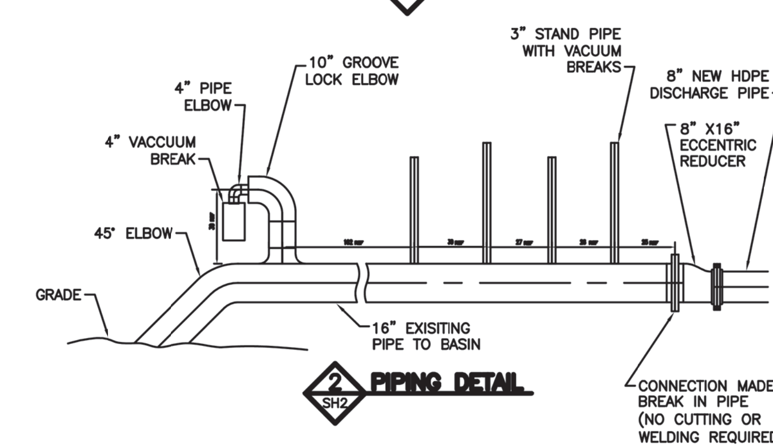
1 SH2 PIPING & SUMP DETAIL PLAN VIEW



1 SH2 PIPING DETAIL



1 SH2 PIPING & SUMP DETAIL ELEVATION VIEW



2 SH2 PIPING DETAIL

POLYMET DRAWING REVIEW
☐ APPROVED
☐ APPROVED AS NOTED
☐ REVISE AND RESUBMIT
BY: DATE:

REV NO	DATE	REVISIONS	BY	CHKR
1	1/2013	SUMP DETAIL	DWH	_
_	_	_	_	_
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DRAWING STATUS				
ISSUED	REV	DATE	SDE	PEM
PRELIMINARY	_	_	_	_
APPROVED FOR CONSTRUCTION	_	_	_	_

NOT APPROVED FOR CONSTRUCTION UNLESS SIGNED AND DATED. DESTROY ALL PRINTS BEARING EARLIER DATE AND/OR REV.NO.

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SIGNATURE ____
PRINTED NAME ____
DATE ____ REG. NO. ____

DRAWN: DH	DATE: 8/4/2010
CHECKED: PB	DATE: 8/5/2010
SCALE: _	
SHEET 3 OF 3	

TAILINGS BASIN CONSENT DCREE
TEMPORARY SEEPAGE COLLECTION SYSTEM
CELL 1E SEEP 026 – DETAILS

POLYMET MINING

POLYMET MINING INC.
NORTHMET PROJECT
HOYT LAKES, MINNESOTA

DWG. NO. TJ–2–001 REV 1

INCHES 1 2

Attachment C

FTB Seepage Containment and Stream Augmentation Systems Permit Application Support Drawings

Drawings are located in Appendix 6 of the Permit to Mine application and are not duplicated here.

Attachment D

Groundwater Modeling of the NorthMet Flotation Tailings Basin Seepage Containment System

Groundwater Modeling of the NorthMet Flotation Tailings Basin Containment System

Supporting Document for Water Management Plan – Plant

Prepared for
PolyMet Mining Inc.

January 2015

4700 West 77th Street
Minneapolis, MN 55435-4803
Phone: 952.832.2600
Fax: 952.832.2601

Groundwater Modeling of the NorthMet Flotation Tailings Basin Containment System

January 2015

Contents

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List of Figures

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1.0 Introduction

This report describes the technical approach, rationale, and scope for the two-dimensional (i.e., flow path) groundwater modeling that was conducted to support the design of the Flotation Tailings Basin (FTB) Containment System at the PolyMet NorthMet Project (Project) Plant Site and to support the assumptions made in the GoldSim water quality model regarding FTB Containment System capture effectiveness (Reference (1)). Groundwater modeling objectives, methods, and results are presented. The modeling was based on the current understanding of the Plant Site conditions and the Project description (Reference (2)) developed for the Final Environmental Impact Statement (FEIS).

In this report, the FTB is the newly constructed NorthMet Flotation Tailings impoundment, and the Tailings Basin is the existing LTV Steel Mining Company (LTVSMC) Tailings Basin as well as the combined LTVSMC Tailings Basin and the FTB.

Groundwater flow path models were used to assess the effectiveness of the FTB Containment System along the north, northwest, and west flow paths defined in the GoldSim water quality model (Section 5.1.1.2 of Reference (1)). The flow path models originate at the toe of the North, Northwest, and West FTB Dams and terminate at the Embarrass River. Each model simulates groundwater flow along one of these three paths, representing a narrow, cross-sectional slice of aquifer spanning the length of a groundwater flow path. The locations of the flow-path models are shown on Figure 1-1.

Groundwater flow path models for tailings basin seepage to the south and east were not developed. Eastern and southern groundwater flow paths were not modeled in GoldSim (Section 5.1.1.2 of Reference (1)) because the modeling assumes complete capture for these portions of the FTB Containment System (i.e., all water from the FTB that reports to these portions of the FTB Containment System, both surface and/or groundwater, is captured). This assumption for complete capture of seepage to the east was based on the existing topography, inward hydraulic gradients during current conditions and long-term closure, and the design of the FTB Containment System and the swale to control unimpacted water (Section 3.4 of Reference (3)). For seepage to the south, the capture assumption is also based on the existing topography, which causes seepage in this direction to emerge as surface seepage within a short distance of the dam toe rather than being transported via subsurface flow. PolyMet has also committed to collect essentially all seepage to the south (Section 4.4 of Reference (3)).

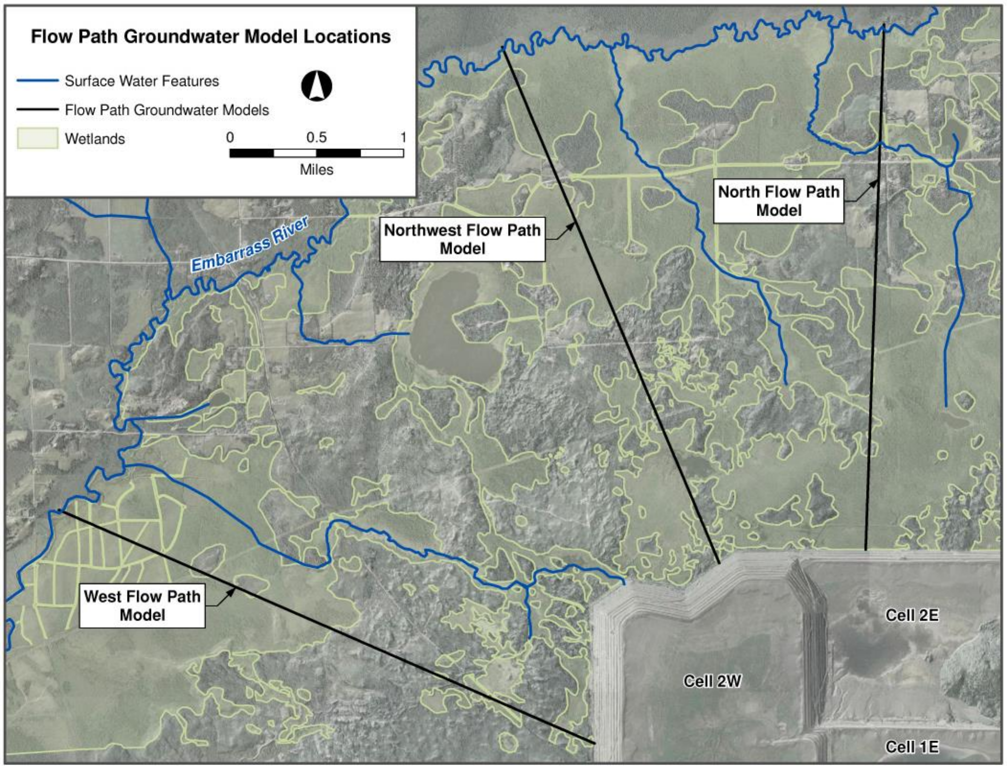

Figure 1-1 Locations of Flow Path Models Used to Evaluate the FTB Containment System

1.1 Objectives

The rate of groundwater seepage from the Tailings Basin was estimated by the Plant Site groundwater flow model (Section 4.2.1 in Attachment A of Reference (1)). The fate of that seepage was then evaluated using the Plant Site GoldSim model (Reference (1)), which assumed capture efficiencies for the FTB Containment System of: 100% of surface water and 90% of groundwater. The flow path models described in this report were developed to support the simplifying assumption that 90% of groundwater will be captured by the FTB Containment System. The objective of the flow path models was to estimate the rate of seepage from the Tailings Basin that will pass beyond the FTB Containment System.

1.2 Background

Estimates of tailings basin seepage entering each of the groundwater flow paths under operations and long-term closure conditions from the three-dimensional Plant Site models were used as input to the flow path models. The three-dimensional Plant Site models were first developed during the Draft Environmental Impact Statement (DEIS) process (Attachment A-6 of Reference (4), Attachment A-6 of Reference (5)). The DEIS versions of the model calibrations were steady-state and did not simulate changes in water levels within the basin. As part of the modeling effort for the Supplemental Draft Environmental Impact Statement (SDEIS), the calibration of the groundwater model was updated to represent transient conditions following LTVSMC closure until present. For the FEIS modeling effort, the groundwater models were updated to incorporate groundwater elevation data collected through 2013 and changes as recommended by the Co-lead Agencies (Attachment A of Reference (1)). The flow path models were updated using results from the FEIS version of the three-dimensional Plant Site models, and this report documents the current version of the flow path models developed for the FEIS.

1.2.1 Containment System Overview

A containment system, comprising a collection trench, drain pipe, and low-permeability cutoff wall, will be installed to capture seepage leaving the northern, northwestern, western and eastern sides of the Tailings Basin (Section 2.1.4 of Reference (6)). This containment system was not included in the three-dimensional Plant Site models, because the three-dimensional Plant Site model was developed to understand the fate and the transport of water that enters the footprint of the Tailings Basin. While the area outside the Tailings Basin (including where the containment system will be installed) was included in the three-dimensional model for continuity, the model was not developed to evaluate transport of the seepage outside the footprint of the Tailings Basin.

By intercepting seepage from the Tailings Basin and returning captured water for reuse or treatment, the system is designed to reduce the constituent load from the Tailings Basin entering the downgradient surface and groundwater system. The cutoff wall will extend through the full thickness of unconsolidated deposits (approximately 10 to 30 feet thick) to the top of bedrock, and will direct groundwater flow toward the collection trench and drain pipe. The collection trench will be installed immediately upgradient of the cutoff wall, i.e., on the side nearest the Tailings Basin, and will be backfilled with granular, transmissive material. A drain pipe will be placed at the base of the collection trench at a depth of approximately five to eight feet below grade.

The FTB Containment System will decrease flows to tributaries of the Upper Embarrass River and to Second Creek (also known locally as Knox Creek), a tributary to the lower Partridge River. The Project will implement stream augmentation measures to prevent potential hydrologic impacts to Unnamed Creek, Mud Lake Creek, Trimble Creek, and Second Creek. Stream flow in Trimble Creek, Unnamed Creek, and Second Creek will be augmented with treated effluent from the WWTP. Stream flow in Mud Lake Creek will be augmented with non-contact stormwater runoff diverted via the drainage swale constructed east of the FTB East Dam. WWTP effluent discharge for stream augmentation will be directed downstream of the FTB seepage capture systems.

1.3 Report Organization

This report is organized into five sections, including this introduction. Section 2.0 presents the conceptual model used to develop the flow path groundwater flow models. Section 3.0 describes the construction of the flow path models, and Section 4.0 presents model results. Summary and conclusions are presented in Section 5.0.

2.0 Conceptual Model

A *hydrogeologic conceptual model* is a schematic description of how water enters, flows through, and leaves the groundwater system. Its purpose is to describe the major sources and sinks of water, the grouping or division of hydrostratigraphic units into aquifers and aquitards, the direction of groundwater flow, the interflow of groundwater between aquifers, and the interflow of water between surface waters and groundwater. The hydrogeologic conceptual model is both scale-dependent (e.g., local conditions may not be identical to regional conditions) and dependent upon the objectives. It is important when developing a conceptual model to strive for an effective balance: the model should be kept as simple as possible while still adequately representing the system to analyze the objectives at hand.

2.1 Geologic Units

This section provides an overview of the Plant Site geology and the hydraulic properties of each geologic unit, particularly as they pertain to the development of the groundwater flow models. A more detailed summary of the current understanding of bedrock structure and hydrogeology at the Mine Site and the Plant Site, and description of the regional and local bedrock geology and hydrogeology, including the nature of fractured bedrock, can be found in Reference (7).

2.1.1 Surficial Deposits

The native unconsolidated deposits in the vicinity of Plant Site are a relatively thin mantle of Quaternary-age glacial till and associated reworked sediments, most of which were deposited and reworked by the retreating Rainy Lobe during the last glacial period in association with the development of the Vermillion moraine complex (Reference (8)). Near the Tailings Basin, unconsolidated deposits have been characterized based on soil borings and monitoring wells, which have been completed to the north and west of the Tailings Basin. The unconsolidated deposits generally consist of discontinuous lenses of silty sand to poorly graded sand with silt, to poorly graded sand with gravel. Very little silt or clay has been encountered, with the exception of the soil boring drilled near monitoring well GW006, where several feet of silt is interbedded with silty sand (Reference (9)). In places, the till is overlain by organic peat deposits. Depth to bedrock in the area surrounding the Tailings Basin is generally less than 50 feet. The unconsolidated deposits generally thicken in a northerly direction toward the Embarrass River. Wetland areas also become more common to the north, off the northern flank of the Giant's Range, the granite outcrops located adjacent to the Tailings Basin. These wetland areas are underlain by thin glacial drift and lacustrine deposits, which were deposited by the retreating Rainy Lobe and associated lakes that were trapped between the retreating ice margin and the Giant's Range.

Siegel and Ericson (Reference (10)) indicate that the till of the Rainy Lobe has an estimated hydraulic conductivity range of 0.1 to 30 feet/day. In-situ pumping tests were conducted at monitoring wells GW001, GW006, GW007, GW009, GW010, GW011, and GW012 to estimate hydraulic conductivity, as described in detail in Attachment F of Reference (11). The data collected during the tests was used to estimate the hydraulic conductivity of the unconsolidated deposits using three different methods; the Moench solution (Reference (12)), the Theis solution (Reference (13)), and using specific capacity data (Reference (14)). The hydraulic conductivity estimates from each solution are different at each location.

Not only is there spatial variability, shown by differences between wells, but there is uncertainty in the hydraulic conductivity at any given well, shown by the differences in the estimates at each well. Table 2-1 shows the estimates of hydraulic conductivity at each well (Reference (9)). GW009 generally has the lowest estimates of hydraulic conductivity (around 0.5 feet/day) and GW010 generally has the highest estimates of hydraulic conductivity (around 50 feet/day). The arithmetic and geometric means of the average hydraulic conductivity estimates at the test locations are approximately 13 feet/day and 5 feet/day, respectively.

Table 2-1 Hydraulic Conductivity Measured During Single-Well Pumping Tests in Unconsolidated Materials

Monitoring Well	Moench Solution[(1)] (feet/day)	Theis Solution[(2)] (feet/day)	Specific Capacity (feet/day)
GW001	1.3	1.8	1.6
GW006	9.6	5.7	10.7
GW007	11.5	30.4	14.8
GW009	0.4	0.5	0.6
GW010	52.0	31.9	64.8
GW011	8.6	15.9	11.4
GW012	0.7	2.4	0.7

(1) Reference (12)
(2) Reference (13)

Additional characterization of hydraulic properties of the unconsolidated deposits was conducted as part of a geotechnical investigation during 2014 (Attachment F of Reference (11)). Slug tests were conducted in ten standpipe piezometers and two monitoring wells screened in the native unconsolidated deposits: R14-04, R14-06, R14-08, R14-12, R14-13, R14-15, R14-16, R14-26, R14-27, R14-28, GW001, and GW012. Hydraulic conductivity estimates from the slug tests ranged from 0.15 to 132 feet/day. The results of those analyses are shown in Table 2-2.

Table 2-2 Hydraulic Conductivity Measured in Unconsolidated Materials Using Slug Tests

Well	Test	K feet/day
R14-04	test 3 - in	2.86
	test 3 - out	3.57
R14-06	test 2 - out	131.76
	test 3 - out	88.13
R14-08	test 1 - in	1.19
	test 2 - out	1.42
R14-12	test 1 - out	0.15
	test 2 - out	0.16
R14-13	test 2 - out	2.12
	test 3 - in	1.53
R14-15	test 1 - in	20.84
	test 2 - out	31.04
R14-16	test 2 - out	18.52
	test 3 - in	16.77
R14-26	test 2 - out	51.65
	test 3 - in	24.45
R14-27	test 2 - out	114.65
	test 3 - out	104.54
R14-28	test 1 - in	0.38
	test 2 - out	0.77
GW001	test 1 - in	0.99
	test 3 - out	1.24
GW012	test 1 - in	0.44
	test 2 - in	0.33

2.1.2 Bedrock

The uppermost bedrock at the Plant Site consists of quartz monzonite and monzodiorite of the Neoarchean Giant's Range batholith. These pink to dark-greenish gray, hornblende-bearing, coarse-grained rocks are referred to collectively as the "Giant's Range granite". The granite locally outcrops as a northeast-southwest trending ridge and drainage divide that makes up the highest topography in the area; the Giant's Range. The Giant's Range granite has been scoured by glaciers, creating local depressions and linear valleys. In this report, "bedrock hills" is used to describe the Giant's Range granite outcrops located adjacent to the Tailings Basin.

Groundwater flow within the bedrock is primarily through fractures and other secondary porosity features, as the rock has low primary hydraulic conductivity. The upper portions of the rock are more likely than rock at depth to contain a fracture network capable of transmitting water. The literature-based assessment of the upper fractured zone suggests that groundwater flow in the Giants Range granite likely occurs mostly in the upper 300 feet of the bedrock; however, the site-specific fracture data indicate that the amount of fracturing decreases significantly in the upper 20 feet of the bedrock surface (Reference (7)).

Siegel and Ericson (Reference (10)) measured specific capacity in one well in the upper 200 feet of the Giant's Range granite and measured hydraulic conductivity of 2.6 x 10^{-2} feet/day. This well was located less than 1 mile to the east of the Plant Site. Specific capacity data from a residential well located north of the Plant Site suggests that the hydraulic conductivity of the upper 47 feet of the granite at that location is approximately 42 feet/day. The log for this well indicates that the top of bedrock is at 18 feet below grade, and the casing also extends to 18 feet below grade. Because the well casing apparently does not extend into bedrock, it is possible that the higher hydraulic conductivity estimate at this well may reflect some degree of hydraulic connection with the unconsolidated deposits.

Packer testing was conducted at five boreholes in the uppermost portions (<20 feet) of the Giant's Range granite during a 2014 geotechnical investigation in the Plant Site area (Attachment F of Reference (11)). The results from that testing are shown on Table 2-3. Hydraulic conductivity values for the upper portion of the Giant's Range granite at the Plant Site range from effectively zero (i.e., no water was produced in three of the packer test intervals) to 3 feet/day, with a geometric mean of 0.14 feet/day (for the purposes of calculating a geometric mean, the lowest hydraulic conductivity value measured during the investigation was used for the three intervals that did not produce water).

Table 2-3 Hydraulic conductivity measured in bedrock during packer tests

Boring	Test Interval (feet)	Kr feet/day
B14- 36	14 - 18.5	<0.00411
	20.5 - 26.5	0.0041
B14-55	37 - 41.5	3.1
	41.5 - 46.5	<0.00411
	46 - 50.5	<0.00411
B14-44	34 - 42	0.11
	42 - 46	0.23
B14-65	24 - 30	0.15
	27.5 - 33.5	0.65
B14-76	37 - 42	0.29

(1) For packer test results where zero inflow was observed during testing, permeability values were selected based on inference from lowest packer test result obtained.

2.2 Sources and Sinks for Water

The Tailings Basin receives water from direct precipitation and runoff from watershed areas to the east. Water falling within the tailings basin watershed collects in the ponds in Cell 1E and Cell 2E or infiltrates through dams and beaches. The ponds lose water to evaporation from the water surface and to seepage through the pond bottom. Most groundwater in the Plant Site vicinity flows to the north and northwest toward the Embarrass River; however, some portion of the water entering the Tailings Basin flows south and discharges to Second Creek, a tributary of the Partridge River.

2.3 Local Flow System

Regionally, groundwater flows primarily northward, from the bedrock hills to the Embarrass River (Reference (10)). Groundwater elevations in the network of monitoring wells located around the Tailings Basin indicate that groundwater in the unconsolidated deposits flows primarily to the north and northwest, toward the Embarrass River. Groundwater flow to the south and east is constricted by bedrock outcrops of the Giant's Range granite (Reference (15)). However, a gap in the bedrock hills near the southern end of the Tailings Basin allows some water to flow southward (south seeps), forming the headwaters of Second Creek, a tributary to the lower Partridge River. A second gap in the bedrock hills is present near the eastern side of the Tailings Basin. Under current conditions, seepage does not flow from the Tailings Basin to the east, because the Cell 1E pond is topographically lower than the surface water features to the east. Groundwater in the native unconsolidated material currently flows to the northwest toward the Tailings Basin. Following the completion of the FTB East Dam, groundwater within the unconsolidated deposits is generally expected to continue to flow from the east toward the Tailings Basin. The presence of the FTB Pond will not alter the existing regional groundwater flow direction, but may result in radial flow away from the Tailings Basin area on a local scale. Some water could seep through the unconsolidated material below the East Dam. Based on topography and the inferred groundwater divides to the area east of the Tailings Basin, this seepage would likely discharge near the toe of the East Dam, and it is not anticipated to flow east toward the Area 5NW pit or Spring Mine Lake (Reference (16)). The eastern segment of the FTB Containment System will be constructed in this area to capture any seepage that would discharge in this area (Reference (6)).

As the Tailings Basin was built up over time, a groundwater mound formed beneath the basin due to seepage from the basin ponds, altering local flow directions and rates. Therefore, the Tailings Basin determines patterns of runoff and infiltration at the Plant Site. Under current conditions, water that infiltrates through the Tailings Basin (from precipitation and seepage from the existing ponds) seeps downward to the native unconsolidated deposits.

Beneath the unconsolidated deposits, low-permeability crystalline bedrock impedes further downward groundwater flow; based on the contrast in hydraulic conductivity between the unconsolidated deposits and bedrock described above, groundwater flow through the bedrock is likely negligible relative to flow through the unconsolidated deposits. Because the unconsolidated deposits are thin and have relatively low hydraulic conductivity, and because the water table is close to the ground surface (which effectively limits the hydraulic gradient), the unconsolidated deposits have a limited capacity to transport Tailings Basin seepage. Therefore, a large portion of that seepage discharges to wetland areas near the Tailings Basin dams, while a small portion remains in the unconsolidated deposits and flows away from the basin laterally as groundwater.

2.4 Hydrologic Model Selection

The flow path models were developed using MODFLOW-NWT (Reference (17)), a formulation of the industry-standard finite-difference groundwater modeling code MODFLOW (Reference (18); Reference (19); Reference (20)). MODFLOW solves the following three-dimensional, differential equation of groundwater flow for saturated steady-state and transient conditions Equation 2-1:

$$\frac{\partial}{\partial x}\left(K_{xx}\frac{\partial h}{\partial x}\right)+\frac{\partial}{\partial y}\left(K_{yy}\frac{\partial h}{\partial y}\right)+\frac{\partial}{\partial z}\left(K_{zz}\frac{\partial h}{\partial z}\right)-W=S_s\frac{\partial h}{\partial t}$$

Equation 2-1

Where K_{xx}, K_{yy}, and K_{zz} are the three principal directions of the hydraulic conductivity tensor, W represents sources and sinks, S_s represents specific storage, h is hydraulic head, and t is time. MODFLOW was developed by the U.S. Geological Survey and is in the public domain. MODFLOW-NWT was selected over other MODFLOW formulations because it is more stable for nonlinear hydrogeologic conditions, such as the drying of model cells near the FTB Containment System drain. Due to the way the models were set up (using ground surface as the top of the model) and the vertical discretization used, it was anticipated that some cells would be located near or above the water table and may be dry during some simulations. MODFLOW-NWT accommodates drying and rewetting by using the Newton method for solving nonlinear equations (described in Reference (17)). Hereinafter, MODFLOW-NWT will be referred to as MODFLOW.

The particle-tracking code MODPATH (Reference (21)) was used to estimate the rate of seepage bypassing the FTB Containment System. MODPATH uses output files from MODFLOW simulations to compute three-dimensional flow paths by tracking particles throughout the model domain until they reach a boundary, enter an internal source or sink, or are terminated in a process specified by the modeler. MODPATH also keeps track of the time-of-travel for simulated particles as they move though the model domain.

The models were developed using the graphical user interface Groundwater Vistas (Version 6; Reference (22)).

3.0 Model Construction

For each of the three groundwater flow path models, six simulations were completed. Each flow path was simulated under two seepage conditions (operations and long-term closure), using three assumed values for the thickness of the upper fractured zone in the granite bedrock (25, 50, and 100 feet) as shown on Figure 3-1.

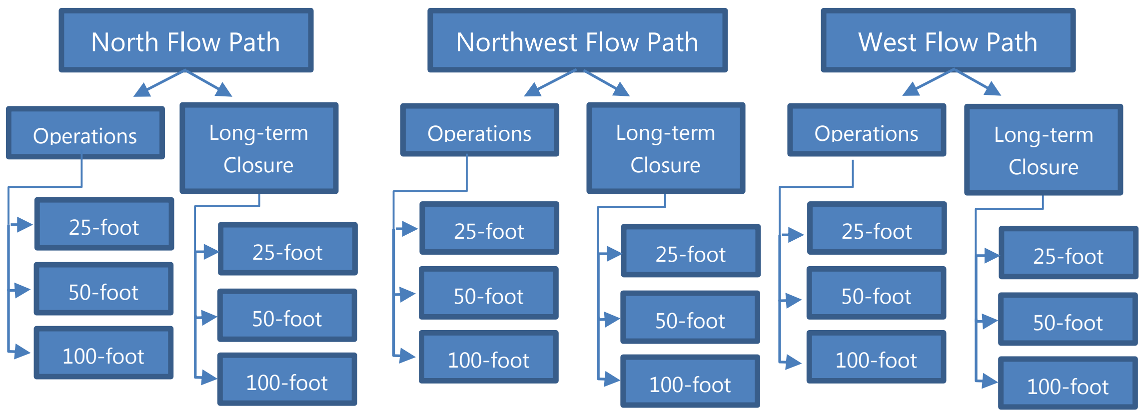

Figure 3-1 Model Simulations for the Flow Path Groundwater Models for Two Different Flow Conditions and Three Different Bedrock Thicknesses

Cross-sectional diagrams of the three flow paths, detailing model discretization and key model parameter values are shown in Large Figure 1 through Large Figure 3. In each figure, the model cells are shown in gray outline, and individual cells are colored to indicate either a boundary condition or hydraulic conductivity zone. The figures each depict three surfaces for the bottom of the model: one surface corresponding to the model with a bedrock thickness of 25 feet, one for the model with a bedrock thickness of 50 feet, and one for the model with a bedrock thickness of 100 feet. Model discretization is discussed in detail in Section 3.1, boundary conditions in Section 3.2, model parameters in Section 3.3, and simulated components of the FTB Containment System in Section 3.4.

3.1 Model Domain and Discretization

Each flow-path model grid consists of a single row, oriented approximately parallel to groundwater flow in one of the three flow paths defined in the GoldSim model (Reference (1)). The origin of each grid is located at the toe of the Tailings Basin dam, and the last column of each model intersects the Embarrass River; see Section 3.2 for a discussion of the boundary conditions used to represent these endpoints. Column spacing varies over the length of each model. A two-foot spacing is used in the primary area of interest, i.e., the 500 feet nearest the Tailings Basin; this is followed by a gradual transition over 50 cells to a 150-foot spacing, which is used over the remaining distance to the Embarrass River. Each model's single row is one foot wide.

The domain of each model is bounded at the top by the ground surface and at the bottom by a specified depth below the bedrock surface. Several GIS datasets were used to define the ground and bedrock surfaces. A LiDAR-based, three-meter resolution Digital Elevation Model (DEM), available through the Minnesota Elevation Mapping Project (Reference (23)), was used to calculate ground elevations. Bedrock elevations were calculated using a combined bedrock dataset, derived from a regional, 30-meter resolution Minnesota Geological Survey (MGS) bedrock surface (Reference (24)), into which local bedrock data were incorporated. Groundwater wells and borings completed in the vicinity of the Tailings Basin, for which estimated bedrock elevations were available, were buffered a distance of 3,280.4 feet (or 1,000 meters). The area within the buffer was then clipped from the MGS bedrock surface. Finally, the coordinates of each well, its associated bedrock elevation and the remaining regional grid data were provided as input to a new surface interpolation. The resulting surface matches the regional grid outside the 1,000-meter buffer and within, smoothly transitions to match the field-measured site data.

To calculate the ground surface and bedrock surface elevation in each column, centerlines spanning each model's single row were generated and divided into segments corresponding to model columns. These centerlines were then intersected with ground and bedrock raster datasets; in the process, the one or more cells in each raster dataset coincident with each column segment were identified. Length-weighted average elevations for each model column were calculated by applying Equation 3-1 to the intersected ground and bedrock datasets in turn:

$$E_a = \sum_{i=1}^{n} \frac{E_i \times L_i}{L_t}$$ **Equation 3-1**

Where E_i is the elevation of a given coincident raster cell, L_i is the length of the column segment within that raster cell, L_t is the total length of the column segment and E_a is the average elevation of the column segment.

The upper portion of each flow path model representing the unconsolidated deposits was discretized vertically into layers of equal thickness, evenly subdividing the thickness of unconsolidated deposits. During the SDEIS modeling, the number of layers was selected such that layers were approximately two feet thick at the end of the model nearest the Tailings Basin. This target thickness matched the two-foot column spacing used within the first 500 feet and resulted in regular grid geometry over this area of primary interest. For the FEIS modeling, the depth to bedrock was updated, resulting in thinner model layers for the northwest flow path. The average thickness of unconsolidated deposits between the Tailings Basin and the FTB Containment System cutoff wall, as well as vertical discretization of the unconsolidated deposits, are summarized in Table 3-1.

Table 3-1 Vertical Discretization of Unconsolidated Deposits between the Tailings Basin and the FTB Containment System

Flow Path Model	Average Thickness of Unconsolidated Deposits between Tailings Basin and FTB Containment System Cutoff Wall	Number of Model Layers Representing Unconsolidated Deposits	Average Thickness of Layers Representing Unconsolidated Deposits between Tailings Basin and FTB Containment System Cutoff Wall
North	21.2 Feet	10	2.1 Feet
Northwest	16.5 Feet	14	1.2 Feet
West	14.4 Feet	7	2.1 Feet

The bedrock was divided into layers of equal thickness, each approximately 2 feet thick, for each flow-path model set. The number of layers was selected to match the target bedrock thickness with layers approximately two feet thick at the end of the model nearest the Tailings Basin. This target thickness matched the two-foot column spacing used within the first 500 feet and resulted in regular grid geometry over this area of primary interest. Vertical discretization of bedrock is summarized in Table 3-2.

Table 3-2 Number of Model Layers Representing Bedrock

Bedrock Thickness	North	Northwest	West
25 feet	10	11	13
50 feet	20	22	26
100 feet	40	44	52

3.2 Boundary Conditions

Seepage from the Tailings Basin and distributed meteoric recharge, described in Sections 3.2.1 and 3.2.2, respectively, are the primary groundwater sources in each flow path model. Groundwater is allowed to leave the modeled system via wetlands, described in Section 3.2.3, and the containment system drain pipe, described in Section 3.4. The Embarrass River, described in Section 3.2.4, comprises the downgradient flow boundary in the flow path models.

3.2.1 Representation of Tailings Basin Seepage

Specified-flux cells were used to represent tailings basin seepage; this boundary condition is implemented using Well Package in MODFLOW, used to inject or extract water from a model at a specified rate (Reference (18)). The first column of each model is coincident with the toe of a tailings basin dam; therefore, one specified-flux cell was placed in each layer of the first column, as shown in Large Figure 1 through Large Figure 3.

The rate of seepage from the Tailings Basin at each flow path was estimated using the Plant Site groundwater model (Attachment A of Reference (1)). The seepage rates used in operations simulations represent Mine Year 7 conditions; these rates were selected in order to evaluate the performance of the FTB Containment System under conditions during which the maximum seepage is expected. The seepage rates used in long-term closure simulations represent conditions after the reclamation of the Tailings Basin. These rates are lower due to the planned application of the FTB cover system, cessation of tailings deposition on the FTB beaches, and gradual dissipation of the groundwater mound beneath the Tailings Basin. Output from the Plant Site model which was used as input to the flow-path models consisted of a seepage rate from the Tailings Basin in units of cubic length per time, i.e., gpm, which corresponds to a length along the perimeter of the Tailings Basin. Because the flow-path models represent a one-foot-wide segment of the flow path, the seepage rate was divided by the flow path width (i.e., the corresponding length along the perimeter of the Tailings Basin) to obtain the rate per linear foot, which was the total seepage rate used as input in the model. Seepage rates used in each model are summarized in Table 3-3.

Table 3-3 Seepage Estimates under Operations and Long-Term Closure Conditions

Flow Path	Flow Path Width (Feet)	Seepage from Tailings Basin Dam (GPM)		Seepage from Tailings Basin Dam (GPM / Linear Foot of Dam)	
		Operations (Mine Year 7)	Long-term Closure	Operations (Mine Year 7)	Long-term Closure
North	8460	1600	570	0.19	0.067
Northwest	5415	580	410	0.11	0.076
West	11065	960	690	0.087	0.062

Seepage rates applied in the model were scaled to reflect the differences in hydraulic conductivity and thickness of the unconsolidated deposits and bedrock. To calculate the scaled seepage rate in the unconsolidated deposits, Equation 3-2 was applied:

$$q_s = q_{total} \frac{K_s t_s}{(K_s t_s + K_b t_b)}$$

Equation 3-2

Where q_s is the scaled seepage rate in the unconsolidated deposits, q_{total} is the total seepage rate, K_s is the hydraulic conductivity of the unconsolidated deposits, t_s is the thickness of the unconsolidated deposits, K_b is the hydraulic conductivity of the bedrock, and t_b is the thickness of the bedrock. The same equation, with the bedrock and surficial values reversed, is used to calculate the scaled seepage rate in bedrock. These rates were then divided by the number of layers (unconsolidated or bedrock) to obtain the rate assigned to each specified-flux cell in the model. The scaled seepage rates applied in the model are shown on Table 3-4.

Table 3-4 Seepage Estimates Applied to the North, Northwest, and West Flow Paths, Scaled by Transmissivity

Flow Path Model	Bedrock Thickness (feet)	Unconsolidated Deposits Scaled Seepage Rate gpm/linear ft		Bedrock Scaled Seepage Rate gpm/linear ft	
		Operations (Mine Year 7)	Long-term Closure	Operations (Mine Year 7)	Long-term Closure
North	25	0.187	0.0667	0.002	0.0007
	50	0.185	0.0660	0.004	0.0014
	100	0.181	0.0646	0.008	0.0028
Northwest	25	0.106	0.0750	0.001	0.0007
	50	0.105	0.0743	0.002	0.0015
	100	0.103	0.0729	0.004	0.0029
West	25	0.0854	0.0614	0.0014	0.0010
	50	0.0841	0.0604	0.0027	0.0020
	100	0.0815	0.0586	0.0053	0.0038

3.2.2 Recharge

Distributed recharge was applied uniformly across the top of each model via the Recharge Package in MODFLOW (Reference (18)); the median recharge rate of 0.61 inches/year, which was calculated based on the watershed area and baseflow in the Embarrass River (Reference (1)), was used for both operations and long-term closure simulations.

3.2.3 Representation of Wetlands

Wetland areas were represented in the MODFLOW models using river cells downgradient of the FTB Containment System and drain cells upgradient of the system (i.e., between the Tailings Basin and the FTB Containment System). A river cell, implemented via the River Package in MODFLOW, is a head-dependent boundary condition. If the modeled hydraulic head in the aquifer is higher than the river cell control elevation, the cell removes water from the aquifer. Conversely, if the head in the aquifer is lower than the control elevation, the cell contributes water to the aquifer. This flux is regulated by the river cell conductance, a function of the hydraulic conductivity, area and thickness of the riverbed deposits represented by the boundary condition (Reference (18)). A drain cell, implemented via the Drain Package in MODFLOW, functions similarly to a river cell but cannot contribute water to the aquifer (Reference (18)). Because the containment system drain pipe induces a strong downward hydraulic gradient, drain cells were selected to represent wetlands between the Tailings Basin and the FTB Containment System; this prevented the modeled wetlands from contributing more water to the FTB Containment System than would actually be available in the wetlands.

Wetland locations in each MODFLOW model were determined using a combined wetlands dataset, derived from National Wetlands Inventory data (Reference (25)), into which site wetland delineations were incorporated. Model centerlines (described in Section 3.1) were used to determine wetland placement in the models; the centerlines were intersected with the wetlands dataset, and the length of each column segment within wetland areas was calculated. A river or drain cell was placed in the top model layer in columns fully or partly coincident with wetlands, with the exception of model cells downgradient of the FTB Containment System for the northwest flow path. Though delineated wetlands are not present there, river cells were added from the cutoff wall to 50 feet downgradient of the wall to represent the head control that will be realized from flow augmentation downgradient of the FTB Containment System. Delineated wetlands are present downgradient of the FTB Containment System for the north and west flow paths, and additional boundary conditions were not necessary to represent the head control that will be realized from flow augmentation in these locations.

To calculate each cell's conductance, the length of overlap between column segment and wetland was used in Equation 3-3:

$$C = K\frac{LW}{M}$$ **Equation 3-3**

Where K is the hydraulic conductivity of the riverbed or drain material, L is length of the cell within wetland areas, W is the cell width and M is the thickness of the riverbed or drain material. A constant value was specified for all variables other than length: a hydraulic conductivity of 49.2 feet/day (representative of relatively conductive material) and a width and thickness of one foot were used. Groundwater flux to or from the aquifer is regulated by this conductance and is dependent on the difference between the hydraulic head in the aquifer and the river or drain control elevation; to represent wetland areas, control elevations were set to the ground surface elevation of each river or drain cell.

3.2.4 Representation of the Embarrass River

Specified-head cells were used to represent the Embarrass River in the MODFLOW models. The location of the river was determined using the National Hydrography Dataset (Reference (26)), and each model was extended from the Tailings Basin such that the last model column intersected the river. Specified-head cells were placed in all model layers in the last column; these cells maintain a specific hydraulic head in the aquifer below the river (Reference (18)). In each model, the ground surface elevation of the last column, representative of the stage of the Embarrass River, was used to set the boundary's hydraulic head. The distance from the Tailings Basin to the river, and the river stage used in each model, are listed in Table 3-5.

Table 3-5 Embarrass River Parameters

Model	Distance from Tailings Basin to Embarrass River (Feet)	Embarrass River Elevation (Feet Mean Sea Level)
North	15,820	1428.3
Northwest	16,870	1425.6
West	17,620	1411.9

3.2.5 No-Flow Boundaries

The bottoms of the flow path models, as well as the long sides of each model's single row, are no-flow boundaries. While these boundaries constrain and simplify the modeled groundwater flow fields, they conceptually represent general flow conditions. The long sides of each model's single row are parallel to the flow paths, and the bottom model boundary conceptually represents the depth at which the bedrock can be considered impermeable, as it has significantly lower hydraulic conductivity than the unconsolidated deposits and the more shallow portions of the bedrock. . Simulation of three different bedrock thicknesses was completed to capture the uncertainty in the range at which this depth may be encountered.

3.3 Hydraulic Conductivity and Porosity

Hydraulic conductivity and porosity (needed for particle tracking simulations) in the unconsolidated deposits and the bedrock, were simulated in the model as two homogeneous zones: one zone representing the unconsolidated deposits, and one zone representing bedrock. At the direction of the co-lead agencies, a horizontal hydraulic conductivity value of 13 feet per day, the representative average value from single-well pumping tests near the perimeter of the Tailings Basin (Reference (9)), and an assumed porosity value of 0.3 was assigned to the unconsolidated deposits in the model. The ratio of horizontal to vertical hydraulic conductivity was assumed to be 2.5:1, which is consistent with Freeze and Cherry (Reference (27)). A horizontal hydraulic conductivity value of 0.14 feet per day, the geometric mean value from packer tests conducted in borings near the Tailings Basin (Reference (11)), and an assumed porosity value of 0.05 was assigned to bedrock in the model. Because bedrock in the model represents the upper, fractured portion of bedrock, it was assumed to be isotropic. For the model realizations with bedrock thicknesses of 50 and 100 feet, applying the geometric mean hydraulic conductivity throughout the bedrock interval is a conservative assumption. In reality, the hydraulic conductivity of the bedrock likely decreases significantly with depth. RQD data from the bedrock that underlies the area to the north and west of the Plant Site indicate the influence of the upper fractured bedrock: average RQD increases from about 60% to 85% from the bedrock surface to 20 feet below the top of bedrock (Reference (7)).

3.4 Representation of the Containment System

Three primary components of the FTB Containment System were explicitly represented in the MODFLOW models: the cutoff wall, the drain pipe and the collection trench containing the drain pipe. The cutoff wall was implemented in each model via the Horizontal-Flow Barrier (HFB) Package in MODFLOW, used to simulate thin, vertical features with low hydraulic conductivity. Consistent with the FTB Containment System design, the wall was extended through model layers representing the unconsolidated deposits, from the ground surface to the bedrock; the hydraulic conductivity of the wall was set to 0.0028 feet/day, and a thickness of one foot was specified.

The distance between the Tailings Basin and the cutoff wall in each model was based on the proposed barrier alignment and is listed in Table 3-6. These distances may be longer than the direct distance between the perimeter of the Tailings Basin and the FTB Containment System, as they represent measurements along the groundwater flow paths, which are not necessarily orthogonal to the Tailings Basin.

Table 3-6 FTB Containment System Parameters

Model	Cutoff Wall Depth (Feet)	Distance from Tailings Basin to Cutoff Wall (Feet)	Drain Pipe Depth (Feet)
North	21.3	262	8
Northwest	15.0	334	8
West	11.7	364	5

The FTB Containment System drain pipe was represented in each flow-path model using a single drain cell, with a control elevation set five to eight feet below the ground surface; drain depths, listed in Table 3-6 are consistent with the FTB Containment System design, intended to prevent the system from freezing in winter (Reference (6)). Because the unconsolidated deposits are generally thinner in the vicinity of the FTB Containment System along the western groundwater flow path, the drain was placed closer to the ground surface in the west flow path model. In each model, the drain cell was positioned immediately inside the cutoff wall, in the model layer corresponding to the control elevation. The drain cell was assigned a hydraulic conductivity of 567 feet/day, which was used to calculate the drain cell conductance. The cells immediately above the drain were assigned a hydraulic conductivity of 284 feet/day, representative of the gravel backfill material to be used in the collection trench.

4.0 Results

Two simulations were conducted for each set of flow path models using MODFLOW: one representative of groundwater flow conditions during operations and one of conditions during long-term closure. The seepage rates were determined using the Plant Site groundwater model, as described in Attachment A of Reference (1) The models were run in steady-state.

Following the MODFLOW simulation, particle tracking was completed with MODPATH. One particle was started in the first column of each model layer in each model, where seepage is specified, and tracked forward through the modeled groundwater flow fields. In all simulations, the particles that originated in the model layers representing the unconsolidated deposits were captured by the FTB Containment System. The seepage from the Tailings Basin to bedrock was divided equally between the model layers representing bedrock. To calculate the seepage rate bypassing the FTB Containment System, the number of bedrock particles that bypassed the FTB Containment System were counted. The number of particles bypassing was then divided by the total number of bedrock particles and this proportion was multiplied by the total seepage from the Tailings Basin to bedrock to obtain the flow bypassing the FTB Containment System. Because the models were run in steady-state, the MODPATH results represent the long-term conditions; in reality, operations conditions may not be maintained for long enough for the system to reach steady-state. Particle tracking results under operations conditions are shown in Large Figure 4 through Large Figure 6; results under long-term closure conditions are shown in Large Figure 7 through Large Figure 9.

The results of the modeling indicate nearly all seepage from the Tailings Basin is captured by the FTB Containment System, as summarized in Table 4-1.

Table 4-1 Tailings Basin Seepage in GPM Bypassing the Containment System

Bedrock Fracture Zone Thickness	North Flow Path		Northwest Flow Path		West Flow Path	
	Operations (Mine Year 7)	Long-Term Closure	Operations (Mine Year 7)	Long-term Closure	Operations (Mine Year 7)	Long-Term Closure
25 feet	0	0	0	0	0	0
50 feet	0	0	0	0	0	0
100 feet	0	0	0	0	8	7

5.0 Summary and Conclusions

Groundwater modeling of groundwater seepage from the Tailings Basin to the north, northwest, and west flow paths was conducted to support the GoldSim water quantity and quality modeling. The objective of the flow-path models was to estimate the rate of seepage from the Tailings Basin that will pass beyond the FTB Containment System, thereby determining the effectiveness of the capture system.

Three MODFLOW flow path models, north, northwest, and west, corresponding to groundwater flow paths defined in the GoldSim model, were constructed. The flow path models originate at the toe of the tailings basin dams and terminate at the Embarrass River. Each model simulates groundwater flow along one of these three paths, representing a narrow, cross-sectional slice of aquifer spanning the length of a groundwater flow path. Model parameters and boundary conditions were set using data from onsite investigations and Project description; seepage from the Tailings Basin to each flow path was determined using the Plant Site model (Attachment A of Reference (1)).

Steady-state model simulations were completed for each flow path under operations and long-term closure conditions and for each of three assumed thicknesses of the more permeable fractured zone at the top of the bedrock. In total, 18 model simulations were completed. Model results indicated that all seepage from the Tailings Basin will be captured from the north and northwest flow paths under all assumptions of bedrock fracture zone thickness. From the west flow path all seepage is captured for bedrock fracture zone thicknesses of 25 feet and 50 feet; however, when the bedrock fracture zone thicknesses is assumed to be 100 feet, the model estimates that 8 gpm of seepage bypasses the FTB Containment System under operations conditions, and 7 gpm of seepage bypasses the FTB Containment System under long-term closure conditions. These flow rates correspond to 0.8% and 1% of total seepage toward the west flow path for operations and long-term closure conditions, respectively. Relative to the average aquifer capacity of the west flow path (110 gpm; Reference (1)), the rate of bypassing seepage is approximately 7% and 6% for operations and closure, respectively.

These results indicate that the Plant Site GoldSim model assumption (that seepage equal to 10% of the aquifer capacity bypasses the FTB Containment System) (Section 5.2.2. of Reference (1)) is conservative. The modeling shows that, at most, seepage equal to 7% of the aquifer capacity bypasses the system.

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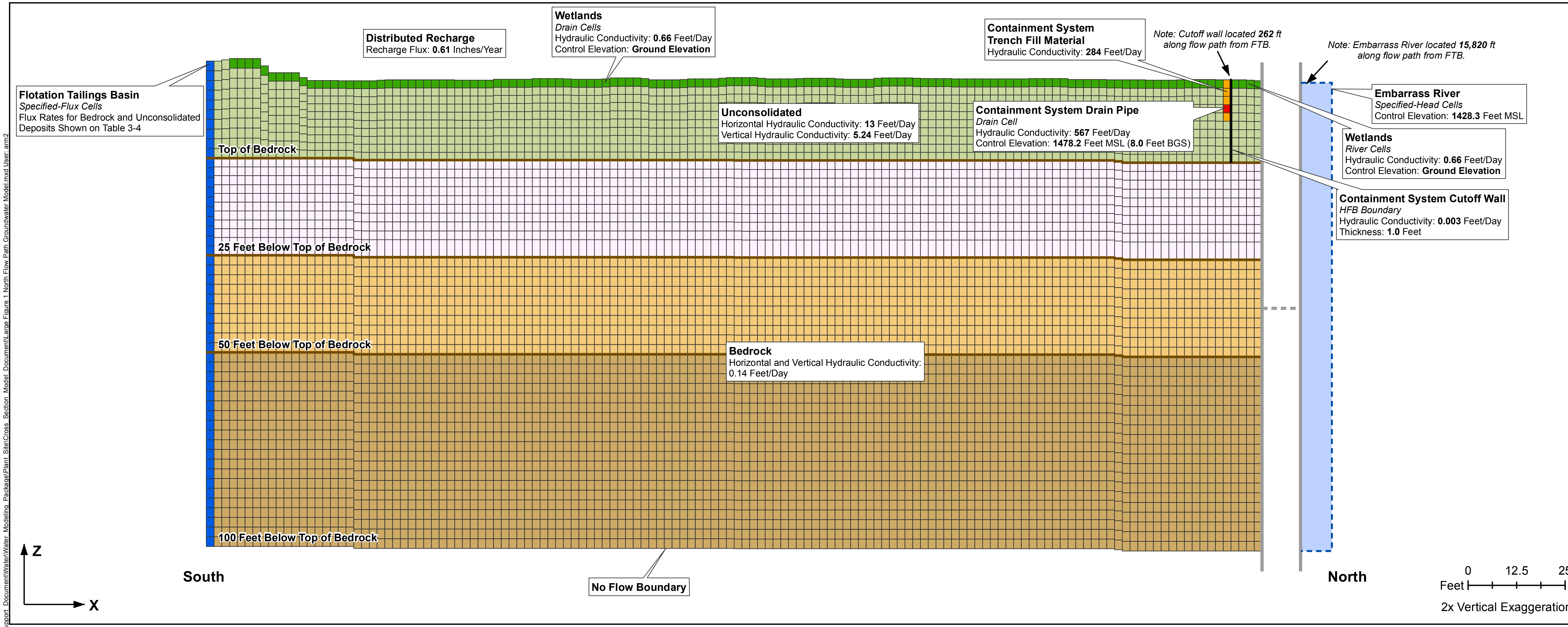
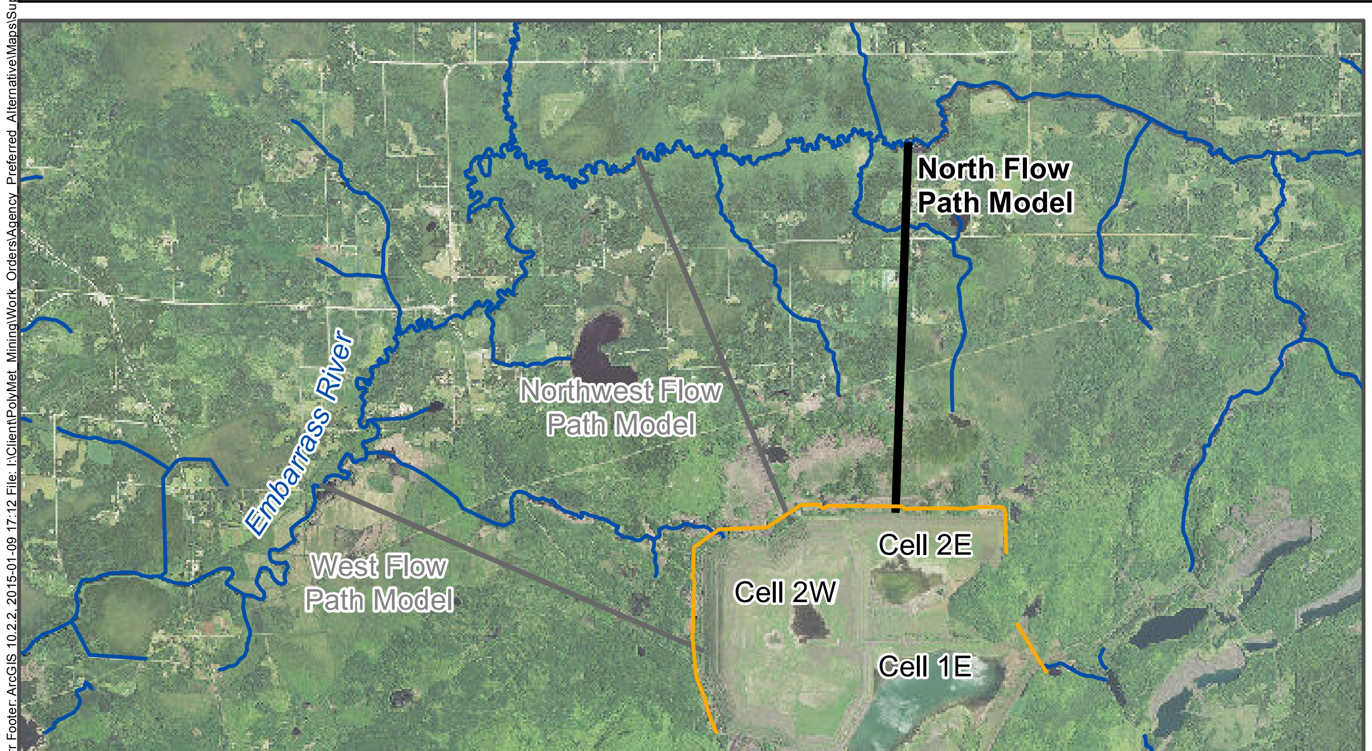
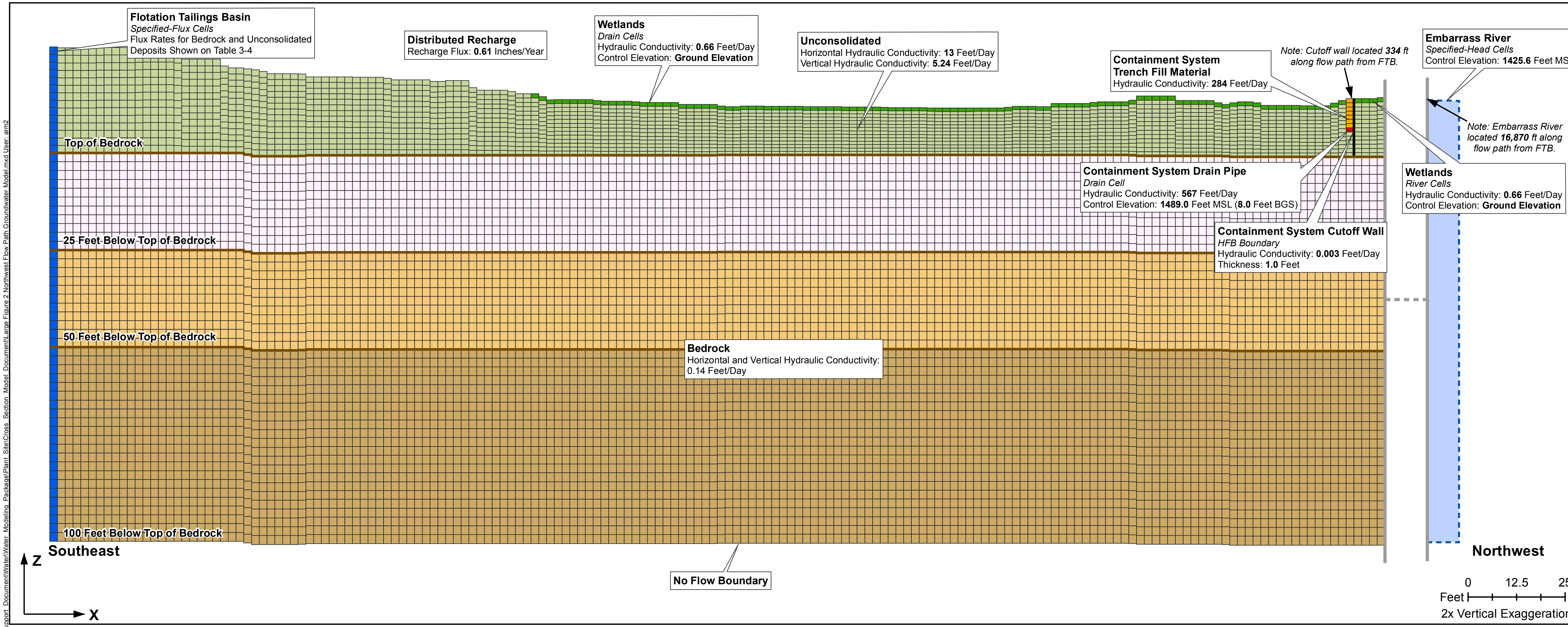
Large Figures

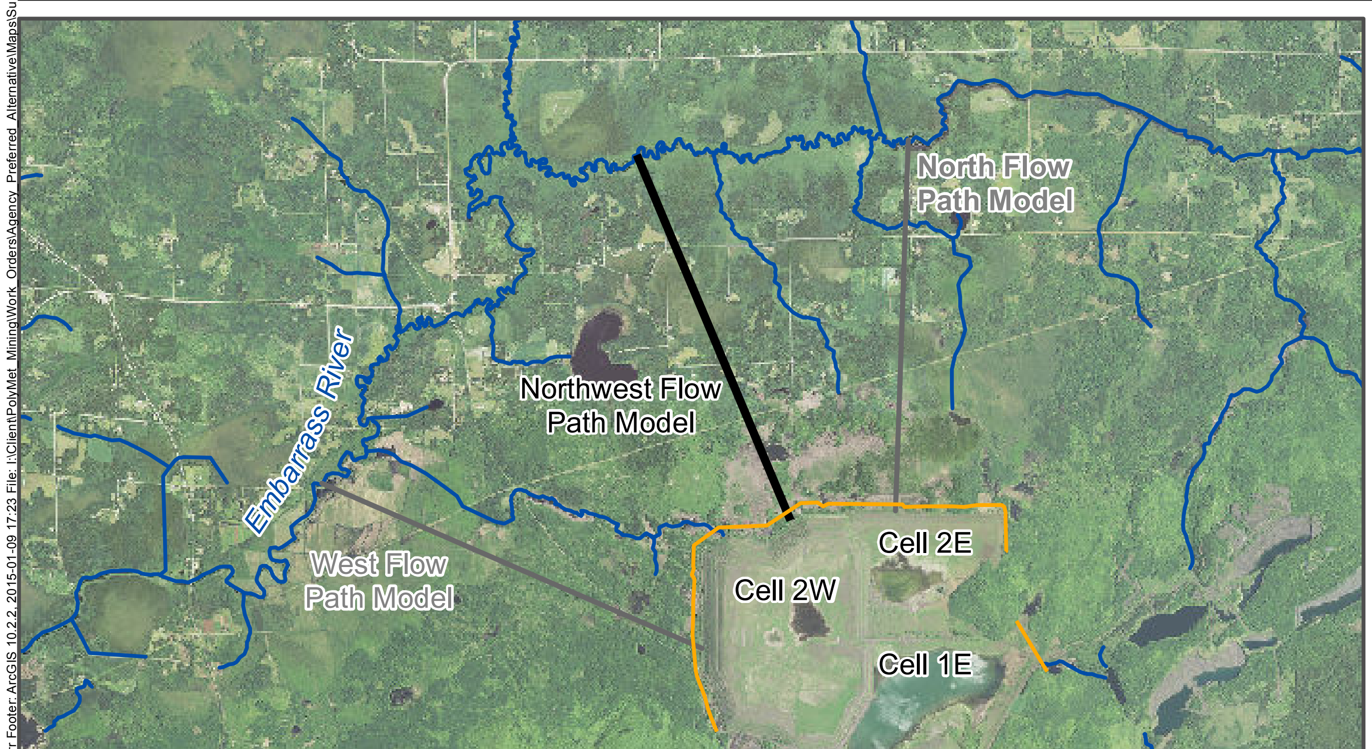


Note: North Flow Path Models included the top 25, 50, or 100 feet of bedrock. The total depth shown represents 100 feet of bedrock with the 25- and 50-foot depth intervals shown.



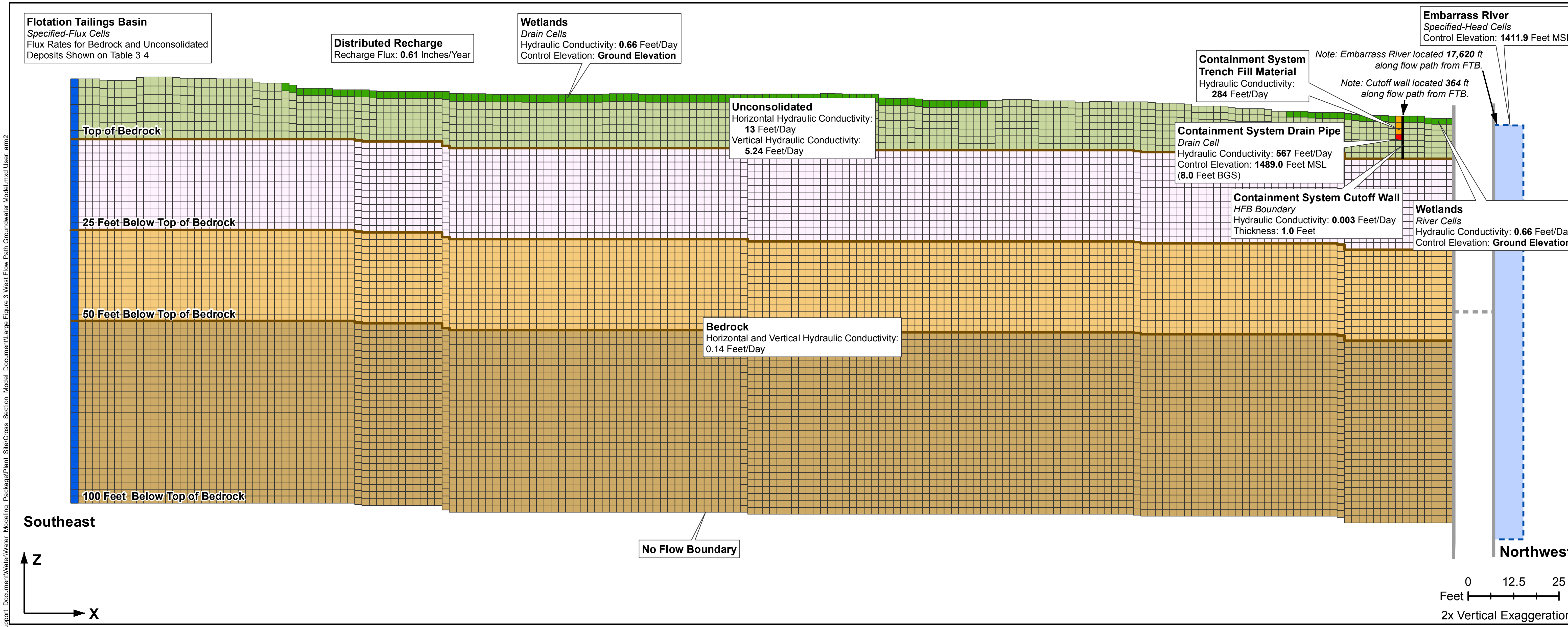
Large Figure 1
NORTH FLOW PATH
GROUNDWATER MODEL
NorthMet Project
Poly Met Mining, Inc.
Hoyt Lakes, MN

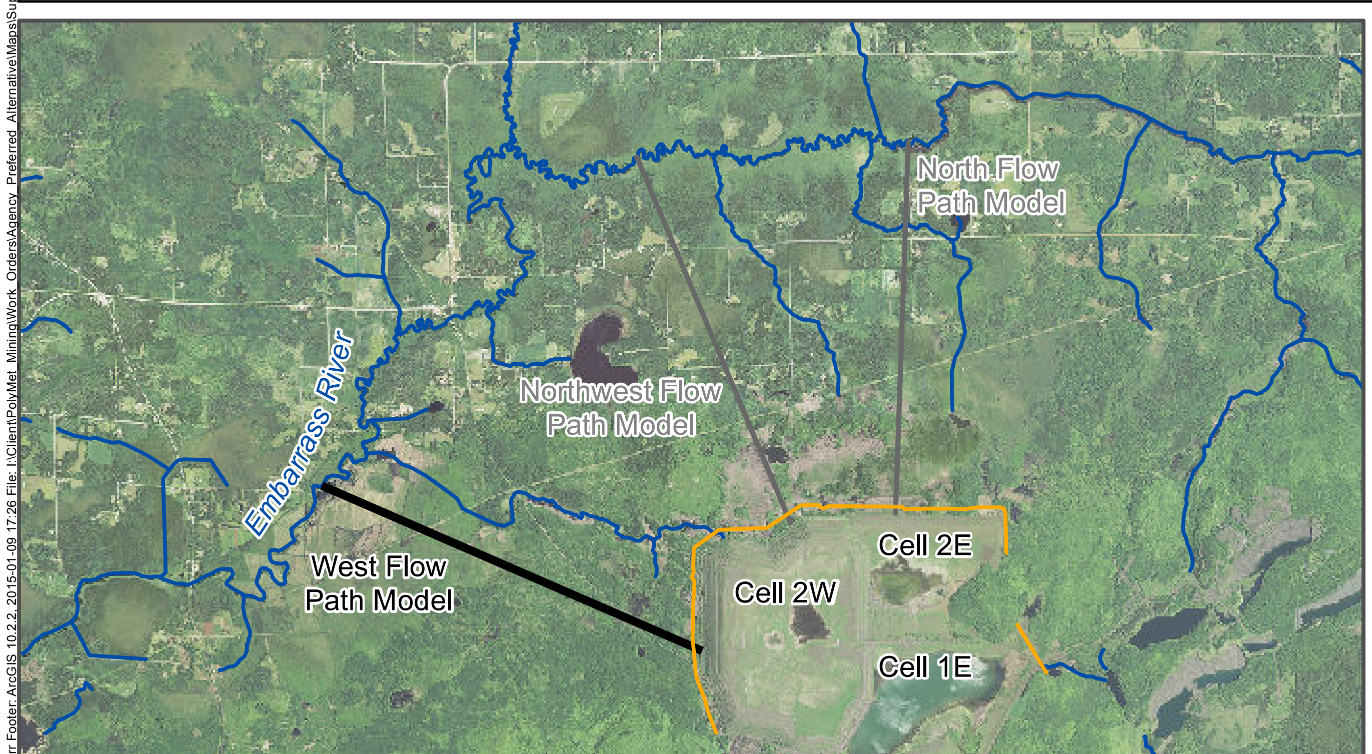




Note: Northwest Flow Path Models included the top 25, 50, or 100 feet of bedrock. The total depth shown represents 100 feet of bedrock with the 25- and 50-foot depth intervals shown.

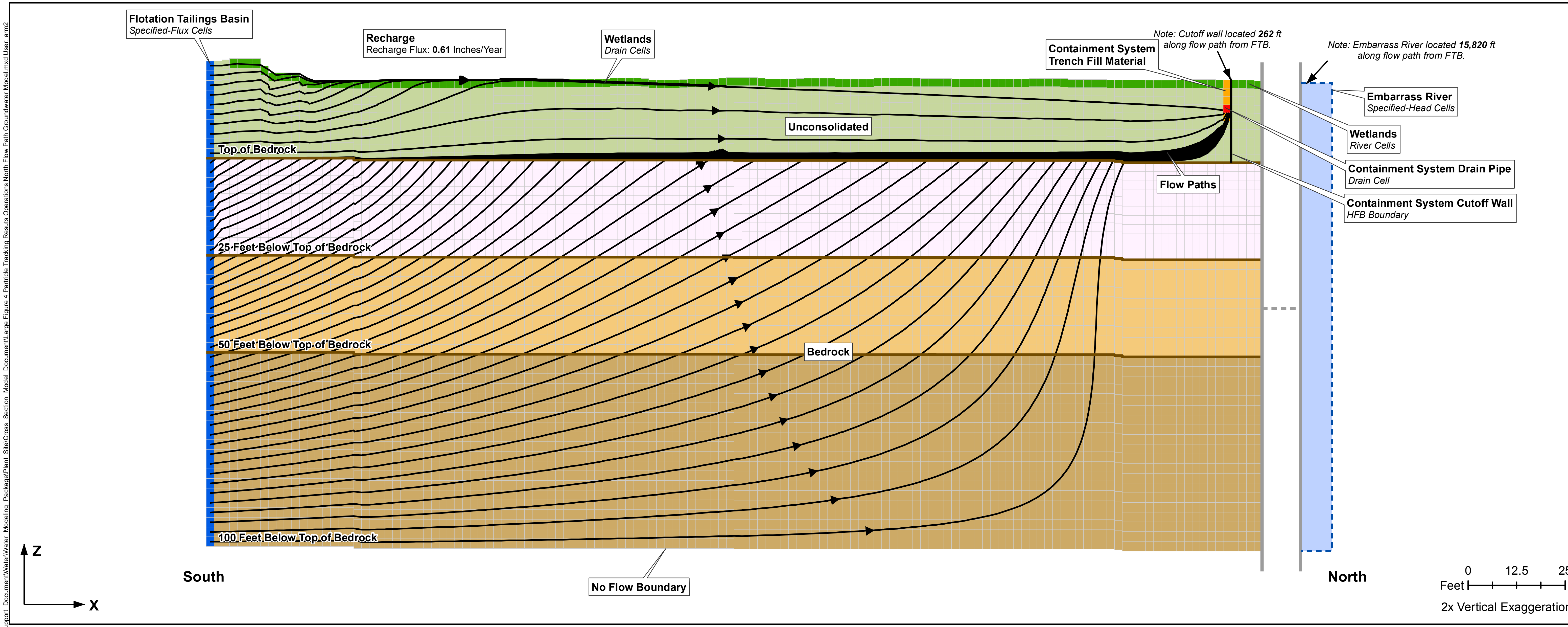
Large Figure 2
NORTHWEST FLOW PATH GROUNDWATER MODEL
NorthMet Project
Poly Met Mining, Inc.
Hoyt Lakes, MN

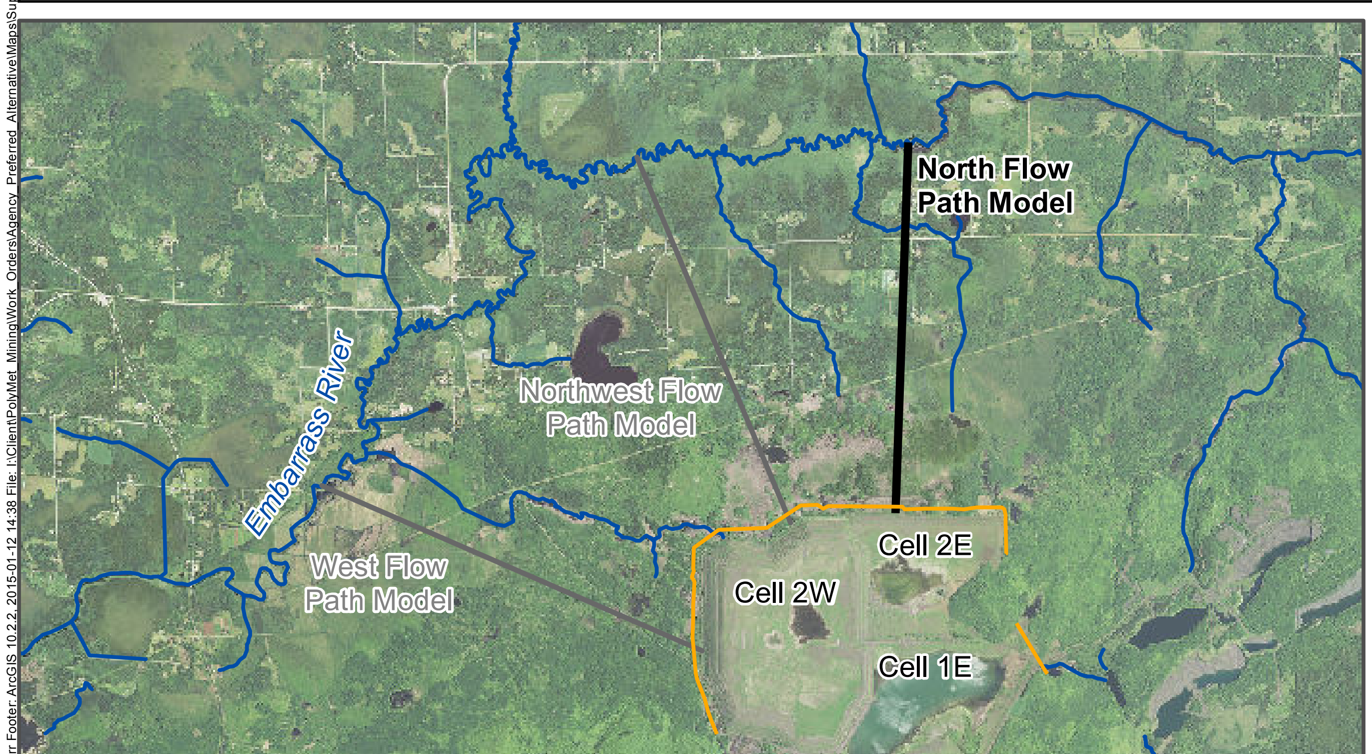




Note: West Flow Path Models included the top 25, 50, or 100 feet of bedrock. The total depth shown represents 100 feet of bedrock with the 25- and 50-foot depth intervals indicated.

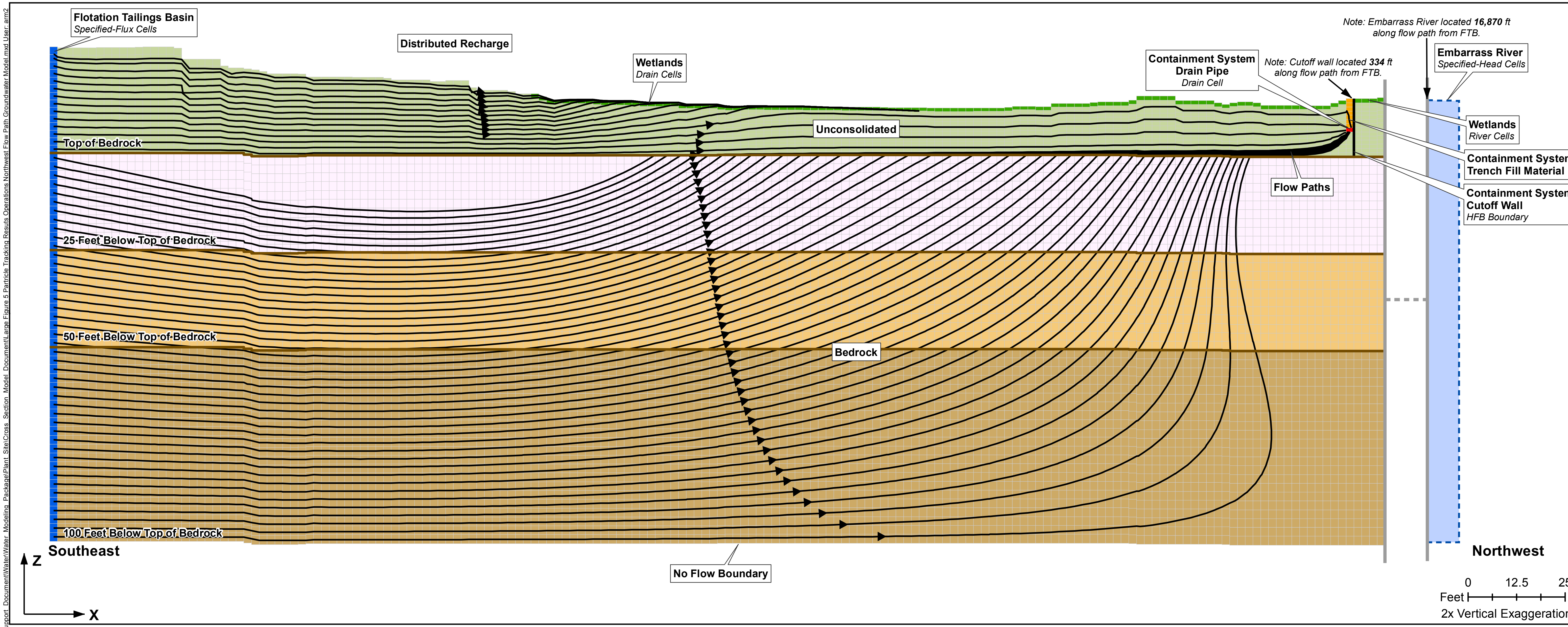
Large Figure 3
WEST FLOW PATH
GROUNDWATER MODEL
NorthMet Project
Poly Met Mining Inc.
Hoyt Lakes, MN

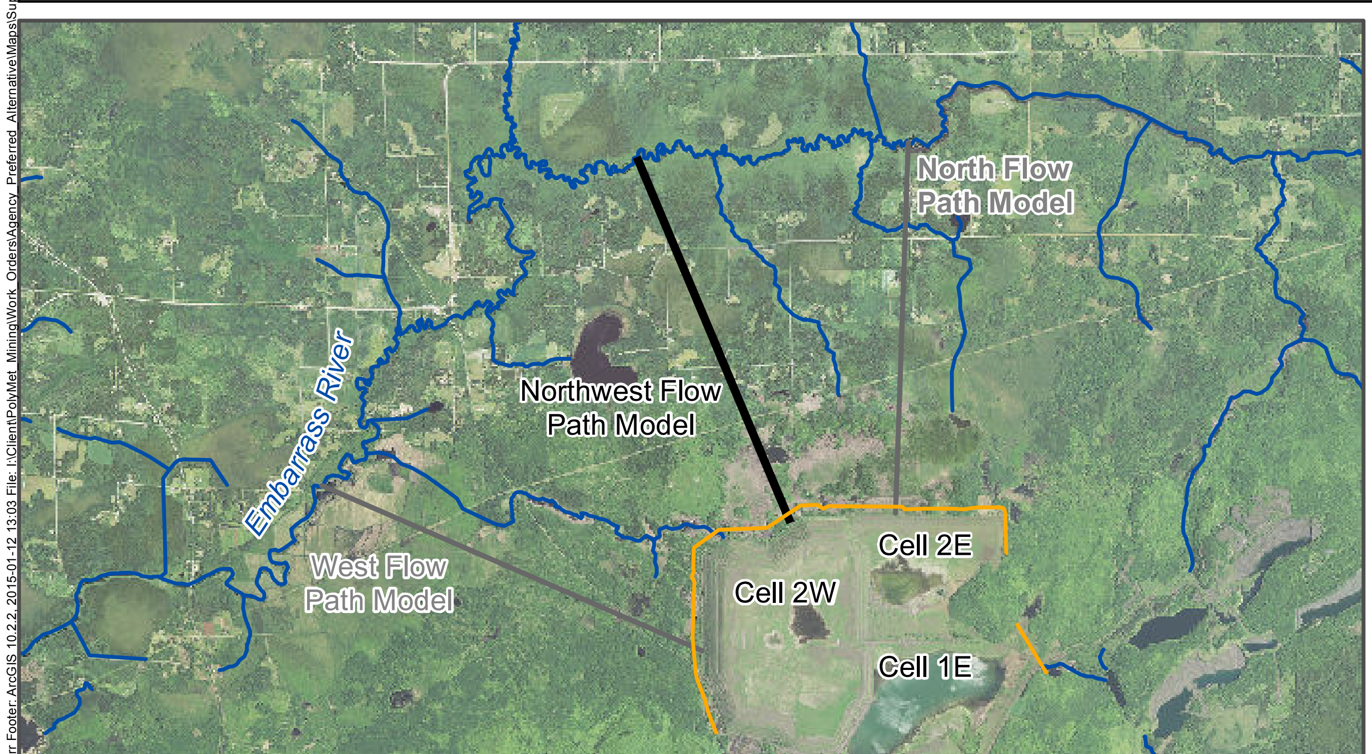




Note: North Flow Path Models included the top 25, 50, or 100 feet of bedrock. The total depth shown represents 100 feet of bedrock with the 25- and 50-foot depth intervals indicated. Particle tracking results are only shown for the simulation with 100 feet of bedrock.

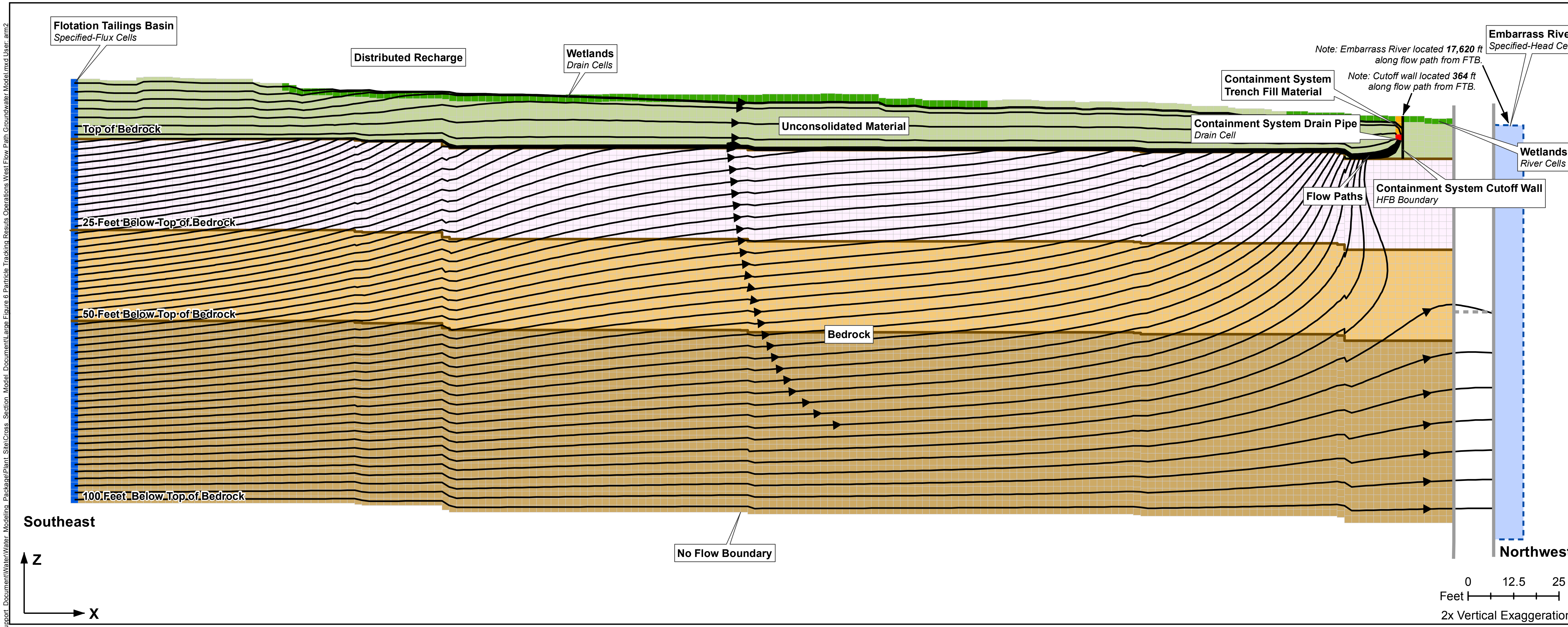
Large Figure 4
PARTICLE TRACKING RESULTS, OPERATIONS
NORTH FLOW PATH GROUNDWATER MODEL
NorthMet Project
Poly Met Mining, Inc.
Hoyt Lakes, MN

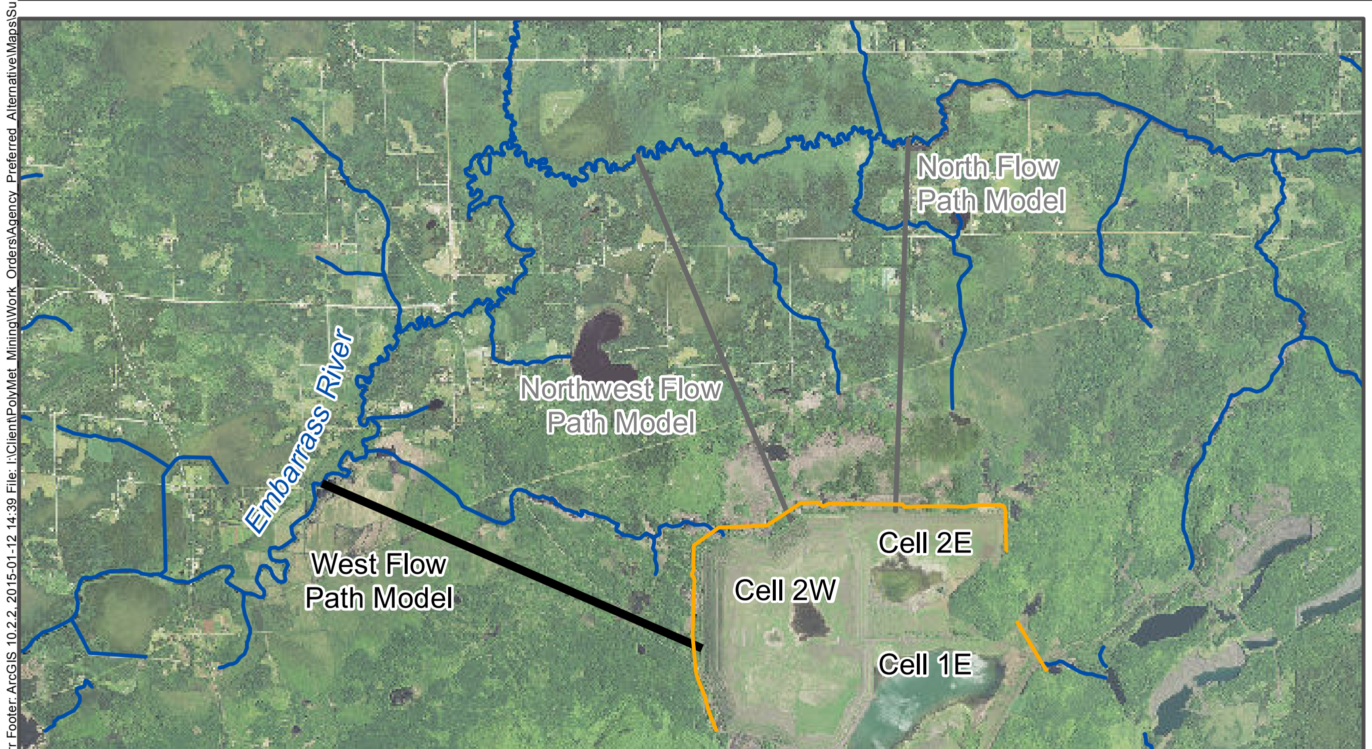




Note: Northwest Flow Path Models included the top 25, 50, or 100 feet of bedrock. The total depth shown represents 100 feet of bedrock with the 25- and 50-foot depth intervals indicated. Particle tracking results are only shown for the simulation with 100 feet of bedrock.

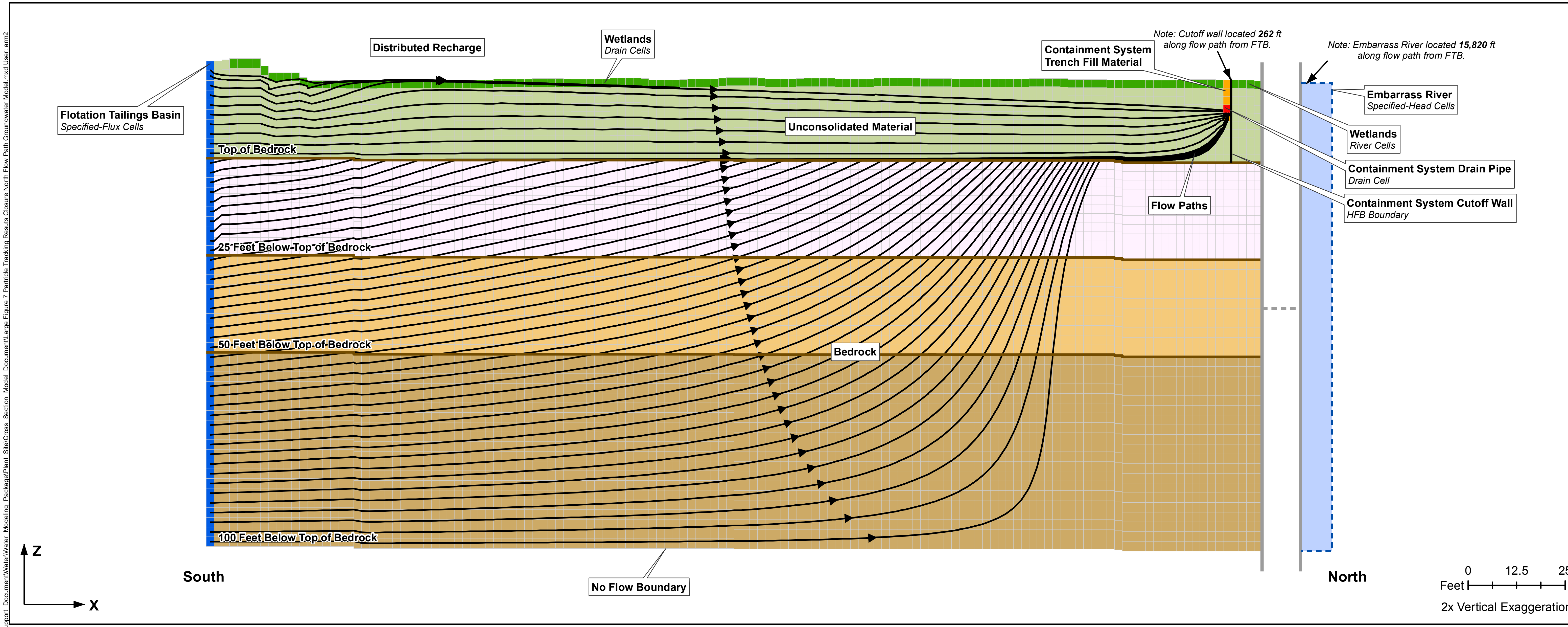
Large Figure 5
PARTICLE TRACKING RESULTS, OPERATIONS
NORTHWEST FLOW PATH GROUNDWATER MODEL
NorthMet Project
Poly Met Mining, Inc.
Hoyt Lakes, MN

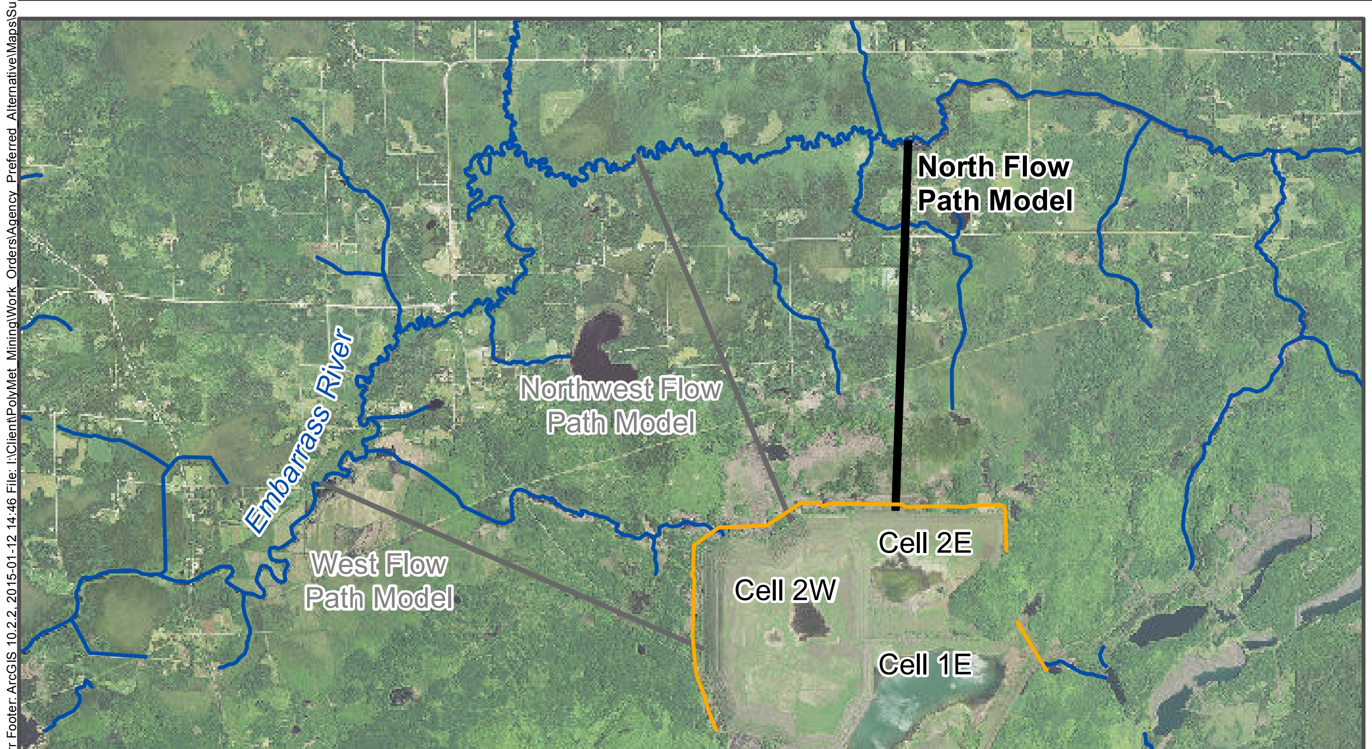




Note: West Flow Path Models included the top 25, 50, or 100 feet of bedrock. The total depth shown represents 100 feet of bedrock with the 25- and 50-foot depth intervals indicated. Particle tracking results are only shown for the simulation with 100 feet of bedrock.

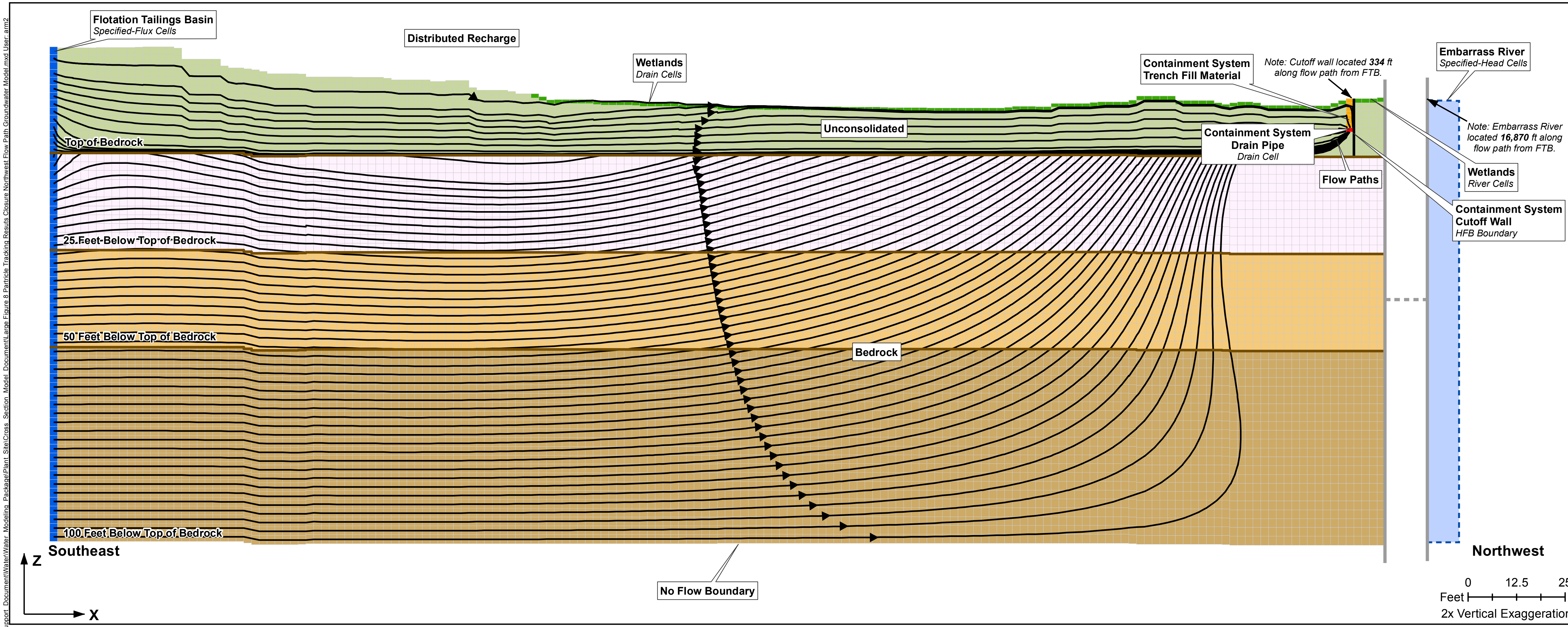
Large Figure 6
PARTICLE TRACKING RESULTS, OPERATIONS
WEST FLOW PATH GROUNDWATER MODEL
NorthMet Project
Poly Met Mining Inc.
Hoyt Lakes, MN

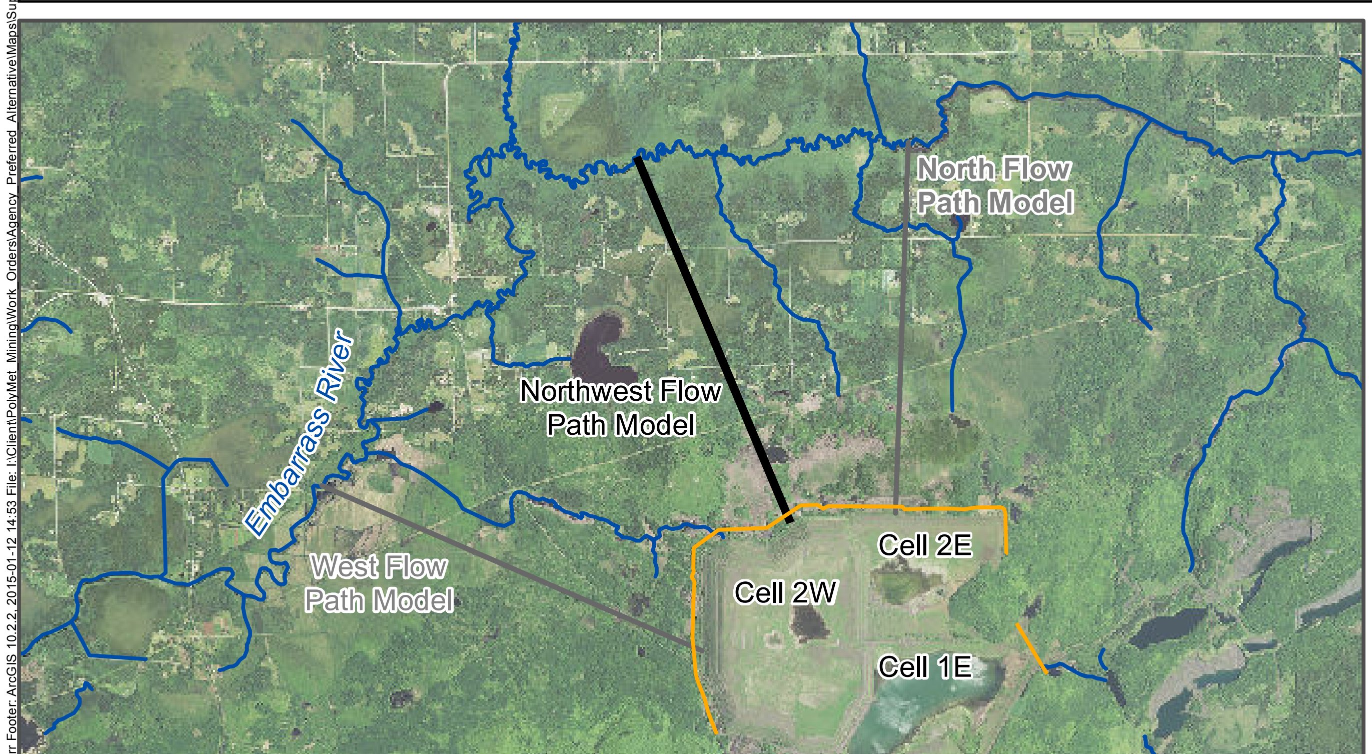




Note: North Flow Path Models included the top 25, 50, or 100 feet of bedrock. The total depth shown represents 100 feet of bedrock with the 25- and 50-foot depth intervals indicated. Particle tracking results are only shown for the simulation with 100 feet of bedrock.

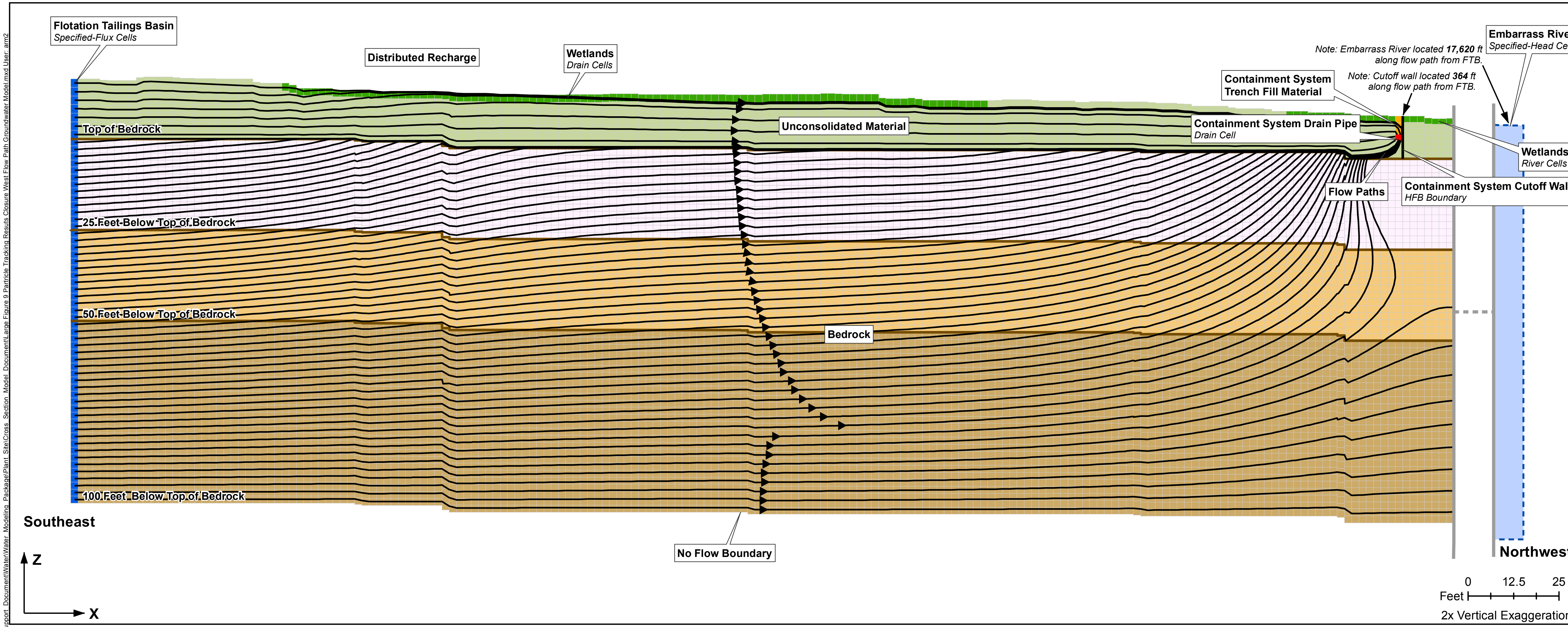
Large Figure 7
PARTICLE TRACKING RESULTS, CLOSURE
NORTH FLOW PATH GROUNDWATER MODEL
NorthMet Project
Poly Met Mining, Inc.
Hoyt Lakes, MN

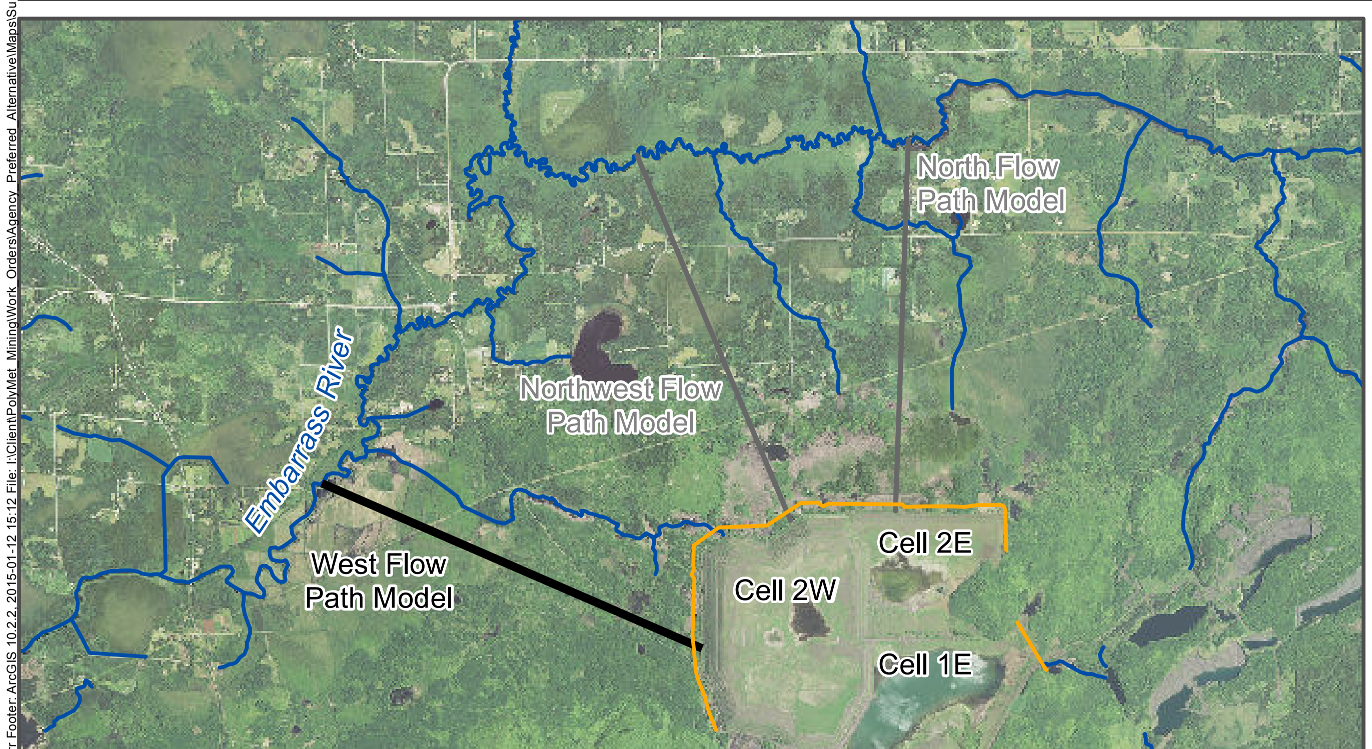




Note: Northwest Flow Path Models included the top 25, 50, or 100 feet of bedrock. The total depth shown represents 100 feet of bedrock with the 25- and 50-foot depth intervals indicated. Particle tracking results are only shown for the simulation with 100 feet of bedrock.

Large Figure 8
PARTICLE TRACKING RESULTS, CLOSURE
NORTHWEST FLOW PATH GROUNDWATER MODEL
NorthMet Project
Poly Met Mining, Inc.
Hoyt Lakes, MN





Note: West Flow Path Models included the top 25, 50, or 100 feet of bedrock. The total depth shown represents 100 feet of bedrock with the 25- and 50-foot depth intervals shown. Particle tracking results are only shown for the simulation with 100 feet of bedrock.

Large Figure 9
PARTICLE TRACKING RESULTS, CLOSURE
WEST FLOW PATH GROUNDWATER MODEL
NorthMet Project
Poly Met Mining Inc.
Hoyt Lakes, MN

Attachment E

Preliminary Sewage Treatment System Facility Plan

Drawings are located in Appendix 9 of the Permit to Mine application and are not duplicated here.

Attachment F

Design Basis for Plant Site Stormwater System

resourceful. naturally.
engineering and environmental consultants

I hereby certify that this plan, specification, or report was prepared by me or under my direct supervision, and that I am a duly Licensed Professional Engineer under the laws of the state of Minnesota.

Signature:
Name: Brian K. LeMon
Date: April 28, 2016
License # 20789   Expires: 06/30/2016

Technical Memorandum

To: Jim Tieberg
From: Brian LeMon, P.E.
Subject: Preliminary Design Basis Report for Plant Site Stormwater
Date: April 28, 2016
Project: NorthMet Project – Mine Site and Tailings Basin – Plant Site Stormwater Design

1.0 Introduction

This memo presents the design basis for the NorthMet Project (Project) Plant Site Stormwater (PSSW) system which will be owned and operated by Poly Met Mining Inc. (PolyMet). Ore extracted from the nearby mine will be processed at a plant historically used as the Erie Mining Company and LTV Steel Mining Company (LTVSMC) processing plant. This design basis memo covers two areas. The first is the main processing plant shown in Large Figure 1 and Large Figure 2 which includes the main processing facilities and surrounding rail yard. The limits of the analysis for this area are the subwatersheds that contain the plant site which are shown in purple on Large Figure 2. The second area is related to a new section of railroad track that will be constructed to connect the mine to the plant site. This site is shown on Large Figure 3. The design basis presented in this memo will be used to guide design of stormwater systems for these two areas.

The primary objectives guiding the design of the stormwater systems include:

- Support the NPDES/SDS Permit Application for the Project, which will be submitted to the MPCA.
- Route runoff created by rainfall and snow melt away from the sites in a way that allows uninterrupted plant and rail operation up to a selected design event.
- Provide the volume of runoff storage on site needed to meet regulatory requirements.
- Provide treatment of runoff prior to release into the environment to meet regulatory requirements.

Stormwater refers to runoff which will be managed as construction and industrial stormwater. Based on preliminary discussions with the Minnesota Pollution Control Agency (MPCA), it is expected that stormwater features at the Plant Site will need to meet the requirements of the Industrial Stormwater Multi-Sector General Permit (ISW Permit - Reference (1)) during operations and the Construction Stormwater General Permit (CSW Permit - Reference (2)) during construction.

The PSSW must take into account 1) existing infrastructure to remain in place, 2) changes to the existing structures 3) facilities needed to accommodate new processes, 4) the impacts of structures to be removed and 5) the construction of new buildings and facilities at the Plant Site. The PSSW design is based on record/historical drawings of the infrastructure for the Plant Site which were provided by PolyMet. Additional knowledge of the existing stormwater infrastructure at the Plant Site was gained through discussions with PolyMet staff, site visits and site surveys. Some existing Plant Site stormwater features on site from the previous operations are either no longer functional or are in poor condition. A larger capacity system than originally designed will be necessary to convey stormwater across the site due to the change of roof drains being routed externally rather than being collected internally.

Information for the proposed site was also obtained from PolyMet and those working on Plant Site design. Certain aspects of the proposed site are still to be determined (e.g., precise building footprints). The design will be updated as the Project progresses towards final design. Because of this the PSSW is shown schematically in this memo. Final detailed design of PSSW features will not occur until the proposed site is fully planned out. The PSSW design presented here has been documented through a series of three memos that describe the design as well as options to address challenges, assumptions, and further work that is necessary before final design can be completed (Reference (3), Reference (4), Reference (5)).

This introductory section provides background and basic understanding of the purpose of the design. Section 2 Site Characteristics, provides a review of overall Plant Site information applicable to the design. Section 3 Permit Design Calculations, provides details on the ISW Permit, CSW Permit and water quality sampling that is in progress at the Plant Site. Section 4 Stormwater Modeling, describes the water quantity and quality modeling that was used to design the stormwater system. Section 5 Stormwater System Preliminary Design, includes the preliminary design information for the PSSW that will be used to convey stormwater at the Plant Site to discharge off site.

2.0 Site Characteristics

The Plant Site is located approximately eight miles west of the Mine Site near the city of Hoyt Lakes, Minnesota and is shown on Large Figure 1. Construction of a new section of railroad track that will connect the mine to the Plant Site is included in this design basis and is shown on Large Figure 3.

2.1 Design Storm Event

The runoff event chosen by PolyMet which will be used to guide the design of the PSSW system is the Atlas 14 10-year 24-hour storm event, which is 3.55 inches for this location (Reference (6)), this is consistent with the stormwater design at the Mine Site. This storm was used in the water quality and quantity models, discussed in Section 4.0, to determine the size of PSSW infrastructure, including ditches, culverts, pipes, and ponds. Infrastructure will be sized to handle this event and route stormwater away from the site in a way that should result in little or no disruption of activities at the site. Ponding will be restricted to stormwater features designed for containing water.

The model was also used to test the Atlas 14 50-year and 100-year, 24-hour storm events in order to assess the impacts to buildings and other critical infrastructure. The rainfall depth for both of these storms is shown in Table 2-1. The maximum depth of flooding within the two inundated flat areas for the 50-year and 100-year storm events is also listed, along with the likelihood of the 50-year and 100-year storm events occurring over a 20-year and 50-year life of the mine.

The model also predicted that for the 100-year 24-hour storm, there will be flow outside of the ditches and culverts that will cause some localized inundation over railroads, roads and fields where there currently are no other structures. The ditch closest to the proposed Sewage Treatment Ponds, Alignment Z as shown on drawing PSSW-008 (Attachment A), will overflow during this storm but the existing site grading is directed away from the Sewage Treatment Pond area towards the Southwest Stormwater Pond. Therefore, based on this modeling, impacts to the Sewage Treatment Ponds from runoff events up to and including the 100-year storm event are not expected. However, it should be pointed out that flows in the sanitary system can be impacted by infiltration and inflow. For example, floor drains connected to the sanitary system and sanitary manholes can be inundated in some runoff events causing significant additional flow to the proposed Sewage Treatment Ponds via the sanitary system. It is beyond the scope of this effort to identify the location and likelihood of such inundation.

Table 2-1 Summary of 100-Year, 24-Hour and 50-Year, 24-Hour Storm Events

Storm Event (24-hour)	Storm Size (inches)	Peak depth of flooding over given area(1)		Probability of at least one event occurring over plant operations	
		East of Concentrator	Near Hydrometallurgical Plant	20 Years	50 Years
100-year	5.71	6 inches	12 inches	18%	39%
50-year	5.01	5 inches	11 inches	33%	64%

(1) The depth of flooding provided is the peak depth over the given areas by applying the model water elevations with designed ditches to the existing Plant Site topography (using LiDAR data). The flood elevations provided in this table should be taken as an estimate. Certain locations have deeper inundations than listed, but were excluded as they are local flooding in existing depressions across the generally flat areas.

2.2 Site Topography, Watersheds and Soils

The Plant Site is constructed on multiple flat terraces that are separated by steep grade changes. Significant changes will occur in some areas after the Plant Site is modified to accommodate all future construction. Watershed divides of the future Plant Site after proposed construction were determined based on existing topography from LiDAR data that was verified by onsite field observations and proposed Project designs.

There are two main watersheds at the existing Plant site that dissect the area from north to south; the East Plant watershed and the West Plant watershed as shown on Large Figure 1. After the plant site is developed, the area north and west of the West Plant watershed with the south boundary being the railroad that accesses the Coarse Crusher from the west, will be cut off from its current flow path to the northwest due to the development of the Hydrometallurgical Residue Facility (HRF) in the existing Emergency Basin. The development of the HRF will sub-divide this area creating the West Plant HRF – Subwatershed 1 and Subwatershed 2, as shown on Large Figure 2.

2.2.1 East Plant Watershed

Development in the East Plant watershed includes construction of proposed new buildings needed for mineral processing at the Plant Site, as shown on Large Figure 1. These buildings will be built on the footprint of buildings that have been removed or through repurposing of existing buildings, which means there is no increase in the impervious footprint in the East Plant watershed. A combination of new and existing infrastructure will be utilized to convey water across the site. The analysis contained in this memo assumes that existing drainage infrastructure is fully functional. During on site observations it was noted that many culverts and ditches were filled with sediment or otherwise compromised and not functioning at full capacity. In some cases they were not functioning at all. Existing culverts that are to be reused must be cleaned out and assessed for condition. Damaged culverts must be repaired or replaced. In addition to this, ditches must cleaned out, regraded and/or re-established to provide increased drainage capacity as noted in the plans.

There are currently two locations where stormwater leaves the East Plant watershed via culverts, hereafter referred to as the East Plant #1 and East Plant #2 discharges at the locations shown on Large Figure 1. Barr recommends that both of these locations be maintained as discharge points during and following Plant Site development. Due to the similarities between the two discharge areas, only one of these points will likely require industrial stormwater monitoring for the purpose of ISW Permit compliance.

2.2.2 West Plant Watershed

Most of the planned new construction (new buildings and rail modifications [Reference (7)]) occur within the West Plant watershed. Site modeling for this watershed, as discussed in Section 4, shows that the existing system is not adequate to contain a significant storm event. Similar to the East Plant watershed, a combination of new and existing infrastructure will be utilized to convey water across the site. In general, stormwater will be routed through a series of ditches, culverts, pipes, drop structures, manholes, catch basins and stormwater ponds to the southwest corner of the Plant Site. The most downstream pond will discharge off-site through an existing culvert at the West Plant discharge location, as shown on Large Figure 2.

2.2.3 West Plant – HRF Subwatershed 1

The West Plant – HRF Subwatershed 1 is located north of the West Plant watershed. This subwatershed will be bound by new Flotation Tailings Basin (FTB) dam construction to the east, the existing tailings basin to the north, the new HRF construction to the west and the rail road grade to the south. This watershed will include the new construction for the Waste Water Treatment Plant. The HRF dam will cut off the current flow path to the northwest; drainage from this subwatershed will be re-directed to a proposed pond that will include an overflow pipe to the south under the railroad tracks into the West Plant watershed, as shown on Large Figure 2.

2.2.4 West Plant – HRF Subwatershed 2

The West Plant – HRF Subwatershed 2 is located west of the West Plant watershed. This subwatershed will include the new dam for the HRF but no additional construction is planned within the subwatershed. The HRF dam will cut off the current flow path to the northwest; drainage from this subwatershed will be re-directed to the south in a new ditch that will replace existing rail tracks as shown on Large Figure 2.

2.2.5 Watershed Soils and impervious Surfaces

Soils at the Plant Site have been classified into hydrologic soil types, which indicate the rate of infiltration that will occur after prolonged wetting. The hydrologic soil ratings for the Plant Site were developed based on data from the Gridded Soil Survey Geographic Database for Minnesota published by the United

States Department of Agriculture, Natural Resources Conservation Service. The majority of the site is classified as hydrologic soil group C, which has low infiltration rates when thoroughly wetted and consists of soils with restrictive layers that impede infiltration. Some soils were not in the database and were assigned hydraulic groups based on site observations. This includes loamy Udorthents (cut and fill land) and iron mine dumps, which were assigned hydrologic groups C and A respectively.

Impervious areas across the Plant Site were calculated based on the 2013 aerial imagery of the site with the addition of the buildings and rail construction (Reference (7)). All existing impervious surfaces were assumed to remain impervious in the future, which was verified based on the conceptual layout for the Project.

The existing Plant Site building roof drains will be modified thereby increasing the runoff rate and quantity. Historically, most of the roof drains were routed into the underground sump and tunnel network for use in the iron ore process. Many of these roof drains were combined with floor drains. Any existing roof drains that are not currently directed to the stormwater system will be modified to do so, and new buildings will be designed to direct their roof drainage to the stormwater system.

2.3 Site Visit and Evaluation of Existing Stormwater Infrastructure

Three site visits were completed by Barr staff to verify watershed delineations, conduct a survey and evaluate existing stormwater infrastructure. The site visits also included discussions with PolyMet staff and record drawing reviews.

Surveyed elevation data collected on existing stormwater infrastructure and surrounding ground areas was compared to the elevation data compiled from LiDAR and record drawings to create the stormwater model of future Plant Site conditions. Where feature inverts could not be surveyed, elevation information from record drawings and/or LiDAR were referenced to determine a reasonable assumption for the feature elevation.

2.3.1 Condition of Existing Stormwater Infrastructure

In general, the existing stormwater infrastructure is in poor condition from minimal maintenance and activities that blocked the stormwater conveyance paths that have occurred since LTVSMC ceased taconite production in 2001. Future stormwater infrastructure (including labeled structure names) is shown on Large Figure 2 and in the stormwater permit level drawing set included as Attachment A.

2.3.1.1 Culverts

Based on the condition of the exposed stormwater culverts it should be expected that the majority will need to be removed and replaced. Existing culverts have sediment buildup, crushed ends and, in some cases, are entirely collapsed. Culverts to be reused will need to be cleaned out and inspected for damage.

2.3.1.2 Ditches

Most of the ditches around the site are filled with sediment and will need to be re-established to restore their original planned capacity. In many cases they will need to be excavated deeper and/or wider than their original planned cross-section to increase capacity. This excavation will be limited by the existing topography, bedrock and infrastructure.

2.3.1.3 Drop Structures

The two existing drop structures west of the Concentrator and north of the proposed Oxygen Plant will continue to be utilized for stormwater conveyance. They are shown as 40-inch and 36-inch drop structures on drawings PSSW-005 and PSSW-006, respectively (Attachment A). These structures must be cleaned out, inspected and replaced if necessary. The potential re-use of these structures is discussed in Section 5.2.

2.3.1.4 Catch Basins and Manholes

The existing catch basins and manholes show signs of disrepair. All structures and connecting pipes that will be re-used in the stormwater design must be cleaned out inspected and evaluated for refurbishment or replacement. Specific existing structures are described below.

- Catch basin (CB #1), manholes (MH #13 through 17) and associated pipe connections convey water from near the future location of the Hydrometallurgical Plant and related buildings to the Southwest Stormwater Pond. These structures and associate piping are shown on Large Figure 2 and on drawings PSSW-008 and PSSW-009 (Attachment A). Discussions with PolyMet confirmed that this system was sealed by LTVSMC in closure by filling manhole #13 with concrete. This stormwater conveyance route will need to be re-established and is discussed in Section 5.2.

- Catch basin #2 south of the Central Stormwater Pond is shown on drawing PSSW-006 (Attachment A). Based on discussions with PolyMet, it is assumed that this catch basin is connected to an underground pipe that routes water from the Central Stormwater Pond to an existing ditch north of the existing Sewage Treatment Plant building. This structure will be replaced and is discussed in Section 5.2.

- Manhole #3, as shown on Large Figure 2, is shown in record drawings to collect drainage from the railroad trestles near the Coarse Crusher. This manhole currently collects water from the roof drains of the Coarse Crusher building. Field review of this manhole found that, in addition to the roof drains, there are two additional pipes that could not be identified on record drawings. Further review of flows from this area will be necessary to verify that the water collected in these drains and in Manhole #3 can be classified as stormwater (as opposed to floor drainage from the Coarse Crusher) and discharged to the surface.

- Existing manholes to the east of the Hydrometallurgical Plant and related buildings, as shown on drawing PSSW-009 and as identified through record drawings, have been taken offline and are not planned to be utilized for conveyance. These structures are still in place underground.

- Record drawings show floor drains collecting in manholes that discharge to the surface from the General Shop and Rebuild Garage buildings; see Large Figure 1 for building locations. These manholes are not planned to be utilized for stormwater conveyance. Floor drains from any building planned for use in the future must be disconnected from the PSSW system and redirected to a facility that can treat the water as needed to meet quality requirements or directed back to the process for reuse. The main point is that floor drains must NOT be discharged as stormwater.

3.0 Permit Design Calculations

3.1 Permits

PolyMet and Barr are in the process of developing an application for an individual NPDES/SDS permit for discharges from the Project. Based on preliminary discussions with the MPCA, it is expected that the language in this permit for stormwater discharges from the Plant Site during operations will be based on the ISW Permit (Reference (1)). Therefore, stormwater features at the Plant Site will need to meet the minimum requirements of the ISW Permit during operations and CSW Permit (Reference (2)) during construction.

3.2 Water Quality

The ISW Permit sets the benchmark monitoring values for Total Suspended Solids (TSS) for metal mine sites as 100 mg/L. This limit will be further discussed, along with the modeling software for TSS, in section 4.2 of this report.

Floor drains will be collected and not discharged to stormwater. This is critical, as the ISW Permit specifically does not allow floor drains from process areas to be discharged as stormwater (Part B.1.b of Reference (1)). Any existing floor drains that are currently being routed to the stormwater system will need to be redesigned and rerouted during Plant refurbishment for collection and sent to the FTB, WWTP or captured for use in the process.

Other water sources that are not explicitly excluded from being discharged to the stormwater system may be combined and discharged with stormwater as discussed in Section 5. This will only occur after water quality sampling and design is complete to confirm that the water will meet water quality standards set by the permit and that the water will not come into contact with process water. This effort is ongoing and will be determined through the final design process.

4.0 Stormwater Modeling

Two computer models of the proposed future Plant Site were developed to represent the area during rainfall events. The stormwater quantity model includes ditches, culverts, and ponds in order to estimate the necessary capacity of each component in the system. This model is used to size the stormwater features to reduce, to the extent reasonable, the likelihood of flooding under the selected design event identified earlier in this memo. The TSS model represents the water quality in the runoff and as it is conveyed. This model is used to determine the necessary detention time and related capacity in the stormwater ponds to meet stormwater quality standards.

It should be mentioned that uncertainty is inherent to models involving complex systems, such as this stormwater system, and many assumptions must be made during model design. Given the available information, it is believed that the simplifications made for this model are reasonable and result in a model that is suitable for the intended purpose. However, differences between the conceptual model and the actual system may result in outcomes that are different than those estimated by the model. Appropriate safety factors are applied during design to account for this uncertainty.

4.1 Stormwater Quantity Modeling

An XP-SWMM stormwater model was developed to evaluate the current design of the system and identify areas where additional features are needed or where the capacity of the existing features will not be sufficient to achieve the goals of the Project. Information from record drawings, surveys, site visits, LiDAR, and knowledge gained from experience at similar sites was used to develop the model of the facility. Through this process, attempts were made to minimize the number of changes to the original infrastructure that will need to be made. However, as has already been noted, not all of the infrastructure modeled was located, and much of what was located was in poor to very poor condition and will need to be repaired or replaced.

The model was used to analyze the 10-year, 50-year and 100-year, 24-hour storm events, as discussed in Section 2.1. These storm events were applied to the proposed Plant Site watershed areas discussed in Section 2.2, and routed through existing and proposed stormwater infrastructure. The design storm chosen by PolyMet is the Atlas 14 10-year 24-hour storm event, consistent with the stormwater design at the Mine Site, which is 3.55 inches for this site (Reference (6)). This storm was used in the model to estimate the size of the infrastructure, including ditches, culverts, pipes, and ponds needed to convey and/or store the design event. This information was then used to complete permit level design, which is discussed in Section 3.0. Infrastructure sized to handle this event will route stormwater away from the site in a way that should result in little to no disruption of activities at the site. Planning of PSSW infrastructure is intended to restrict ponding during this event to stormwater features designed for containing water. Note that the design event is used to size PSSW infrastructure and is not the same as flood protection. Please refer to the Phase 2 memo (Reference 4) for information related to how much of the site is inundated under greater runoff events.

The Plant Site stormwater evaluation and model is based on the following assumptions:

- Grading within each of the Plant Site watersheds will be minimal, limited to grading around new buildings or features; therefore there will be minimal impact to the current stormwater features and flow directions. The exception to this is the grading for the HRF and FTB.
- The following features will be incorporated into the stormwater design, as shown in Large Figure 1:
    - The dam of the HRF
    - The dam of the FTB
    - Several new buildings
- No additional roads or railroads other than those shown on Large Figure 1 will be constructed; if additional roads and railroads are required, they will need to be added to this stormwater evaluation.

- Roof drains will be directed to the stormwater system. Historically, most of the roof drains were routed into the underground sump and tunnel network for use in the process. Many of these roof drains were combined with floor drains. Any existing roof drains that are not currently directed to the stormwater system will be modified to do so, and new buildings will be designed to direct their roof drainage to the stormwater system.

- Floor drains must be disconnected from the PSSW system. This is critical, as the ISW Permit specifically does not allow floor drains from process areas to be discharged as stormwater (Part B.1.b of Reference (1)). Any existing floor drains that are currently being routed to the PSSW will need to be redesigned during Plant refurbishment for collection and sent to the FTB, Waste Water Treatment Plant (WWTP) or for use in the process.

- The MPCA in Reference (1) includes "foundation or footing drains where flows are not contaminated" as an authorized (non-stormwater) discharge (Part A.2.i). The water quality of groundwater flows from the french drain systems in place across the Plant Site will be compared to surface water quality standards to determine if it can be routed to the stormwater system or if it needs to be collected and treated based on this permit language. This pertains to the groundwater flows from the Concentrator foundation drains.

The model includes inflows from two sources that are not direct results of stormwater runoff: flows from the concentrator foundation drains and effluent from the sewage treatment ponds based on MPCA discharge guidance (Reference (8)). Both of these flows are still being evaluated for where they will discharge and if they can be discharged with stormwater. They were included in the model to account for the quantity of water that may be in the system when the storm occurs.

4.2 Total Suspended Solids (TSS) Modeling

Water quality modeling for the West Plant watershed was developed using Version 3.4 of the P8 water quality model (Program for Predicting Polluting Particle Passage thru Pits, Puddles, and Ponds). P8 is a model used for estimating the generation and transport of stormwater runoff pollutants in developed watersheds. The model tracks the movement of particulate matter (fine sand, dust, soil particles, etc.) as it is carried by stormwater runoff. Particle deposition in ponds is tracked in order to estimate the amount of pollutants carried by the particles that eventually reach a water body.

The P8 model requires a variety of inputs beyond the watershed characteristics and pollutant removal device (ponds, etc.) characteristics. P8 also requires hourly precipitation data for either a single storm event or for a long-term climatic period. Pollutant characteristic information is also required. The default pollutant and particle information, contained in the P8 NURP50 particle file, was used as a starting point for the water quality components of the stormwater runoff. The NURP50 particle file was developed as part of the Nationwide Urban Runoff Program (NURP), a research program conducted by the U.S. Environmental Protection Agency, and provides default parameters for several water quality components, based upon calibration to median, event-mean concentrations reported by NURP (Reference (9)). Pervious curve numbers were determined for each subwatershed in P8 based on area-weighting the curve numbers for the respective proposed land cover (assuming fair or 50 to 75% ground cover) and soil type combination, as published in Soil Conservation Service guidance (Reference (10)).

TSS concentrations were only evaluated at the West Plant discharge because the majority of the site changes and new impervious areas are located in the West Plant watershed. The East Plant watershed will primarily remain the same, with very little change to existing infrastructure or imperviousness. The evaluation of the base case was conducted using literature values for inputs to estimate the expected TSS concentrations in runoff generated at the site with no best management practices (BMPs) in place (Reference (11)). The modeled overall average TSS concentration for simulation of the 10-year, Type II storm event was compared with the available literature for various industrial runoff source areas (paved parking, storage and driveway areas), which generally will be expected to correspond with an average runoff concentration of 281 mg/L TSS from the literature (Reference (12)).

Literature sources are used as standard practice to compare to the expected TSS runoff concentrations because site-specific data is frequently not available. The initial simulation of the average West Plant watershed runoff TSS concentration was 50% lower than the literature estimate, therefore the P8 Model water quality components scale factor was increased from 1.0 to 1.5 in the base model, which increased the predicted average runoff concentration to the expected levels noted above. The remaining default P8 water quality parameters were maintained in the model without further adjustment.

The P8 model was then used to estimate the reduction in TSS achieved by the addition of various BMPs as part of the design. The ISW Permit sets the benchmark monitoring values for TSS for metal mine sites as 100 mg/L. BMPs were added to the model to achieve the goals of an outflow TSS concentration of less than 100 mg/L and to reach a 70% reduction in inflow TSS, based on the TSS evaluation and commitments made for the Project. The model results showed that the installation of three overflow weirs along the Southwest Stormwater Pond meets the permit requirements during the Atlas 14 10-year 24-hour storm. The overflow weir elevations were set so that the 10-year storm event passes through a 30-inch culvert and larger storms overflow the weir. These three culverts and weirs were placed at two existing invert changes along the pond and at the outlet to the existing stormwater ditch. This design is shown on permit-level drawings PSSW-010 and 024 (Attachment A). By routing the 10-year storm through the three stormwater ponds, the P8 model predicts that the 10-year stormwater is treated to 99 mg/L of TSS at the discharge for a 64% overall TSS removal. During final design an appropriate factor of safety will be included in the design of ponds where regulatory permit sampling will occur.

Other design options were identified for potential evaluation through final design. Further modeling and evaluation of the capacity in the Southwest Pond Area is necessary to verify that the alternatives will work with other planned infrastructure changes and improve treatment for TSS. These options can be evaluated in final design to determine the configuration that will best meet the site and permit constraints.

5.0 Stormwater System Preliminary Design

The preliminary PSSW design drawings are included in Attachment A. The PSSW design includes stormwater ponds, ditches, culverts, drop structures, catch basins, manholes and pipes as discussed in the following sections.

5.1 Stormwater Ponds

The stormwater ponds are needed in the site design in order to reduce the suspended solids in the runoff water and contain stormwater to minimize flooding at the Plant Site during the 10-year storm event. The dimensions of the ponds were limited by the existing infrastructure in the area, as shown on drawings PSSW-005, PSSW-006, PSSW-008 and PSSW-010 (Attachment A). Large Table 1 lists the design assumptions and peak water elevations during the 10- and 100-year storm events for each stormwater pond. Water levels for the Southwest Stormwater Pond may be dependent on downstream ditch and culvert capacities, which have not yet been determined and will be analyzed as part of final design.

The areas for stormwater pond development were evaluated during the site visits and are shown on Large Figure 2. There are currently no plans for construction of a stormwater pond in the East Plant watershed, and no anticipated need for it in the future. If a pond is determined to be necessary due to industrial stormwater monitoring results, there is room available to develop a pond upstream of the East Plant #2 discharge location. There is limited space near the East Plant #1 discharge location, but there is room for future stormwater pond development a short distance upstream, if one is deemed necessary during final design.

5.1.1 Southwest Stormwater Pond

The Southwest Stormwater Pond is the furthest downstream pond in the West Plant watershed before discharging offsite, as shown on Large Figure 2. It will be located at the southwest corner of the Plant Site where there currently is a long wide ditch. The ditch will be graded and widened to the west to obtain additional capacity. A series of culvert and overflow weirs will be constructed perpendicular to the flow of the pond to reduce the velocity of water and restrict particle movement through the pond. The pond discharges into an existing ditch to the south, through a culvert under a railroad grade, and eventually flows into Second Creek.

5.1.2 Central Stormwater Pond

The Central Stormwater Pond will be constructed west of the future Oxygen Plant, as shown on Large Figure 2. Currently there is a small depression that holds water in this area. Expansion of this depression will be limited by the slope to the east and roads on the other three sides. This depression has an outlet pipe that drains southwest toward the Southwest Stormwater Pond.

5.1.3 North Stormwater Pond

The North Stormwater Pond will be constructed west of the Concentrator, as shown on Large Figure 2. Currently this area is large, relatively flat, and covered in tailings. PolyMet staff have indicated that bedrock is located close to the surface near the Concentrator, but drops off sharply in the direction of the pond. The pond discharges through a culvert, for flows up to the 10-year storm, and tops the overflow weir during larger storms; water then drains through a series of ditches and culverts before entering the Central Stormwater Pond.

5.1.4 HRF Stormwater Pond

The HRF Stormwater Pond design will be included as part of the final design of the HRF. The HRF Stormwater Pond will be designed and constructed to provide retention of runoff from this area prior to routing it through the railroad embankment to the North Stormwater Pond in the West Plant watershed as shown on drawing PSSW-005 (Attachment A). The water retention capacity in the HRF Stormwater Pond after a storm event will be important to delay the runoff from this large subwatershed area and remove TSS prior to being routed to the West Plant watershed stormwater system through the proposed overflow pipe.

5.2 Stormwater Structures

Refer to Large Table 2, Large Table 3 and Large Table 4 for a list of each structure in the West Plant stormwater system along with design assumptions and locations. Sizes and details of all new structures will be determined in final design.

All existing drop structures and manholes that are to be reused in this preliminary design must be cleaned out, inspected, and evaluated for re-use. If the structure is found insufficient it will either be refurbished or removed and replaced.

5.2.1 Drop Structures

The two existing drop structures west of the Concentrator and north of the future Oxygen Plant will continue to be utilized for stormwater conveyance. They are shown as 40 inch and 36 inch drop structures on drawings PSSW-005 and PSSW-006, respectively (Attachment A). These structures will be cleaned out, inspected and replaced if necessary. One new 48 inch drop structure will be located southwest of the future Oxygen Plant on Stormwater Alignment M, as shown on drawing PSSW-006 (Attachment A). This structure is necessary to collect water from ditches and direct it to the Central Stormwater Pond.

5.2.2 Catch Basins

Two new catch basins are needed to replace existing structures. This is necessary due to changes in invert elevations and sizes of the pipes connecting to the structures. This includes Catch Basin (CB) #1 shown on drawing PSSW-009 and CB #2 shown on drawing PSSW-006 (Attachment A).

5.2.3 Manholes

Downstream from CB #1 manholes MH #13 through #17 and associated pipe connections convey water from near the future location of the Hydrometallurgical Plant and related buildings to the Southwest Stormwater Pond as shown on Large Figure 2 and on drawings PSSW-008 and PSSW-009 (Attachment A). Manhole #13 was filled with concrete during closure activities of LTVSMC and will need to be replaced. Manholes #14, 15 and 16 will be inspected and based on the inspection it will be determined if they can be refurbished or should be replaced. Manhole #17 will be removed.

Two additional new manholes will be added to the system. The first MH #1A will be added along the East Plant watershed drainage system near the Rebuild Garage to transition from multiple smaller pipes under a railroad to one larger pipe for the remaining underground length, as shown on drawing PSSW-012 (Attachment A). The second new manhole MH #1B will be added to allow access for cleaning out the two pipes downstream of CB #2 on Stormwater Alignment P, as shown on drawings PSSW-006 and PSSW-020 (Attachment A).

5.2.4 Sediment Trap

A sediment trap will be installed at the west side of the Limestone storage yard prior to combining stormwater runoff from this area with other stormwater flows. This will help reduce the TSS in the runoff from the limestone stockpiles. The sediment trap location is shown on drawing PSSW-008 (Alignment W near station 1+30) and details are shown on PSSW-032 (Attachment A).

5.3 Ditches

Ditches will be expanded, constructed or cleaned out as necessary and as space allows across the Plant Site. Ditches are designed to convey water across the site to the three discharge locations (West Plant, East Plant #1 and East Plant #2). Riprap along ditches is currently included on steep ditch slopes; location and size will be further evaluated in final design.

The new ditch that serves as the outlet for HRF – Subwatershed 2 directs water along Stormwater Alignment PP, as shown on drawing PSSW-007 and PSSW-030 (Attachment A). Stormwater Alignment PP routes water to the Southwest Stormwater pond.

Two locations have been identified with potential design constraints that will be worked through in final design. These are described in the following sections.

5.3.1 Ditch or Pipe North of the Concentrator

The ditch that flows to the west, north of the Concentrator (Stormwater Alignment E), is typically dry at one location a short distance northwest of the Concentrator. After visiting the site it appears that this ditch is infiltrating through the railroad embankment and flowing to the Emergency Basin, which is planned as the future location of the HRF. The design of this ditch has constraints including expected shallow depths to bedrock and steep slopes resulting in high velocities. Drawings PSSW-004, 005, and 017 (Attachment A), show grading for an unlined ditch at this location with the note that the ditch will be replaced with a pipe. The details of this design will be determined in final design.

5.3.2 Existing Infrastructure Inhibiting Ditch Modifications

Two of the ditches east of the Concentrator are unable to be designed with the modeled capacity due to existing adjacent infrastructure. One ditch (Stormwater Alignment B) directs water from the south to the north between the road and the railroad track east of the Concentrator. The second ditch (Stormwater Alignment CC) routes water between the toe of the rock wall from the Plant Reservoir and a railroad. These ditches are shown as Stormwater Alignments B and CC on drawings PSSW-004, 011, 012, 016, 025, and 026 (Attachment A). Additional ditches that feed into these ditches also are unable to be designed with the required capacity as estimated in the model due to adjacent infrastructure. These ditches include a note in the drawings that the ditch will be cleaned out and details will be determined in final design.

Currently the top side slopes of the inhibited ditches are directly at the rail tracks. The rail tracks should be removed or for rail safety, ditches should be offset from the rail tracks. In some locations the ditch may be designed to fit in the space available but with much steeper side slopes and greater depth than is typical for rail designs and could make the existing section of track unstable.

Two options for these ditches are being evaluated. The first option is to conduct maintenance on the existing ditches and utilize them to the greatest extent possible. This will involve cleaning the ditches out, grading in select spots to maintain drainage, and replacing culverts to maintain flow and access to buildings. The size of the culverts will be based on the depths of the existing ditches and maintaining cover over the culverts rather than conveying the 10-year design storm. Model results show that flooding will result outside of the ditches over the area east of the Concentrator but the exact extent of the flooding is unknown. The second option is to remove these two sections of track inhibiting the ditches or potentially relocate them. This will allow for the full capacity ditch to be constructed and contain the 10-year event. This evaluation will be completed during final design.

5.4 Pipes and Culverts

The drawings in Attachment A make a distinction between pipes and culverts. Culverts are typically open on either end and are used to convey water under an obstruction in the flow path, such as an access road. Pipes on the other hand connect to other structures, as seen on drawing PSSW-022 (Attachment A), Alignment V where a series of pipes are connected by manholes. Large Table 5 and Large Table 6 give the design assumptions and the estimated 10 and 100 year velocity and flow rates for each culvert and pipe at the site, respectively.

All existing pipes that are planned for re-use will be inspected and evaluated for refurbishment or replacement. This includes the pipes connecting CB #1 and MHs #13 through #17. With the removal of MH #17 the pipe downstream of the manhole will need to be removed or abandoned in place as well, as seen on drawing PSSW-008 (Attachment A). Other new pipes will be needed at the discharges of the Central Stormwater Pond and connecting to the drop structures located east of the Central Stormwater Pond, as seen on drawings PSSW-005, 006 and 008 (Attachment A).

During one of the site visits a location was identified where water currently flows through the railroad ballast without a culvert. This is shown on Stormwater Alignment CC near station 34+00 on drawings PSSW-015 and 026 (Attachment A). With the improvements upstream of this location along the same alignment, adding a culvert at this location should be evaluated in final design for the stability of the railroad.

5.4.1 Outlet Culverts

The outlet culverts for the three Plant Site discharges are all located outside of PolyMet's Project Area Boundary as shown on Large Figure 1. Two of the outlet culverts are sufficiently sized to convey the 10-year storm from the site, and one outlet culvert is not. Further evaluation is needed to verify that downstream infrastructure will not be impacted by the Plant Site Improvements. Each discharge location is discussed further below.

Based on the modeling, the West Plant watershed discharge culvert is already of adequate size with the addition of the control structures planned for the Southwest Stormwater Pond. This analysis did not include further evaluation of the downstream ditch, including the portion that flows behind the Administration Building.

The East Plant watershed #1 discharge culvert and additional culverts immediately downstream were determined to not be sufficient to convey the 10-year storm. New culverts sized for the 10-year storm are included in the recommended design, although this series of culverts is south of PolyMet's current Project Area Boundary. The model shows that not making these improvements results in flooding upstream and over the road at this discharge location during the 10-year design event. This area of the Plant Site is topographically flat so the flooding in this location could quickly spread to areas near the Hydrometallurgical Plant. The design of East Plant watershed #1 discharge is shown on drawing PSSW-013 and 029 (Attachment A) as Stormwater Alignment NN. The ditch immediately upstream of this outlet is also located just outside of the Project Area Boundary. This ditch needs grading improvements as shown on drawing PSSW-013 (Attachment A).

The East Plant watershed #2 discharge conveys water through a series of culverts under railroad tracks. The stormwater model currently shows stormwater for the 10-year design storm adequately passing through the first culvert at its current size. The design is shown on drawing PSSW-015 and 026 (Attachment A) as Stormwater Alignment CC. The watershed areas and infrastructure downstream of the discharge culvert were not included in the model, so the stormwater impacts beyond this location could not be sufficiently evaluated. Barr recommends further analysis of this discharge route in final design to verify that the design storm does not adversely impact the rail yard immediately downstream.

5.5 Other Design Features

In addition to the conveyance of stormwater across the Plant Site two additional design features related to the stormwater are discussed in the following sections. This includes water flowing into the Emergency Drainage Tunnel Manhole from the Concentrator footing drains and the stormwater along the Connection Track.

5.5.1 Emergency Drainage Tunnel Manhole

Currently water is routed from the Concentrator to the Emergency Basin through the Emergency Drainage Tunnel Manhole located just west of the Concentrator building. The design of the HRF requires that the Emergency Drainage Tunnel be blocked off at the discharge location near the HRF. The end of this tunnel at the Emergency Drainage Tunnel Manhole will be blocked as part of the PSSW design thus trapping the water draining from the Concentrator foundation drains in the manhole. One option for routing this water from the manhole is to drain it by gravity to the surface and discharge it with the stormwater. The location of the manhole and the design of this option is shown on drawing PSSW-005, and a plan for blocking off this tunnel is shown on drawing PSSW-033 (Attachment A).

Discharge of this Concentrator foundation drain water to the stormwater system is dependent on the results of further water quality testing of the water draining to the Emergency Drainage Tunnel Manhole and site design relating to the removal of the thickeners. These factors will dictate if and how the water can be discharged to the stormwater system.

5.5.2 Connection Track Stormwater

Krech Ojard & Associates (KOA) designed the connection track located southeast of PolyMet's Plant Site. This design includes ditches along the railroad embankment and one planned stormwater discharge location at the southeast end of the rail connection. The ditch and approximate location of the planned stormwater discharge, shown on Large Figure 3, are based on the design drawings for this alignment (Reference (13)) and subsequent 2016 modifications for the Construction SWPPP process (Reference (14)).

Stormwater controls along the connection track need to meet the requirements of the CSW Permit. One specific requirement of the CSW Permit that is applicable to the connection track is the need for collection and treatment of runoff when 1 or more acres of new impervious surface is created.

Approximately the first half of the connection track, from Station 11+00 (the beginning of the new track) to approximately Station 45+00, will be built along the existing impervious road. South of Station 45+00, a new embankment will be built to extend the railroad to connect with the Cliffs Mainline Track at approximately Station 66+63. This new track will be considered new impervious area. As shown on Large Figure 3, three infiltration basins along the connection track are planned to infiltrate stormwater and meet the CSW permit requirement related to treatment of runoff from new impervious areas. Two of the infiltration basins are located west and east of the Connection Track at approximately Station 32+00. The third infiltration basin is located north of the Connection Track near where it connects to the Cliffs Mainline Track at approximately Station 66+00.

The CSW Permit requires that the first 1 inch of runoff from the new impervious surface created by the Project be retained on-site through infiltration, unless the area will not allow infiltration, such as with shallow bedrock, hydrologic class D soils, or high groundwater (Part III.D. of the CSW Permit). According to the CSW Permit, if there is an impediment to infiltration, other treatment methods, such as wet sedimentation ponds, can be used prior to the discharge of this stormwater to surface waters.

A site visit was made to evaluate the southern discharge location. A few scattered small rocks and a few very large boulders were observed along the alignment in the vicinity of Station 66+00. The drainage in this area is to the east into a large wetland, which is an indication of high groundwater in this area. This discharge location is along a portion of the connection track alignment that will require a large cut. Additional cut will be needed for a stormwater feature in this location. In final design a geotechnical investigation will be necessary to determine the depth to bedrock and confirmation of the depth to the water table prior to final design determination on the stormwater feature (infiltration basin, wet sedimentation pond, swale, or other methods).

6.0 References

1. **Minnesota Pollution Control Agency.** Authorization to Discharge Stormwater Associated with Industrial Activity under the National Pollutant Discharge Elimination System (NPDES)/State Disposal System (SDS) Permit Program. Expiration Date: April 5, 2020. *Minnesota Pollution Control Agency / Water / Water types and programs / Stormwater / Industrial Stormwater.* [Online] April 5, 2015. https://www.pca.state.mn.us/sites/default/files/wq-strm3-67a.pdf.

2. —. General Permit Authorization to Discharge Stormwater Associated with Construction Activity under the National Pollutant Discharge Elimination System/State Disposal System Permit Program. Expiration Date: August 1, 2018. *Minnesota Pollution Control Agency / Water / Water types and programs / Stormwater / Construction Stormwater.* [Online] August 1, 2013. https://www.pca.state.mn.us/sites/default/files/wq-strm2-68a.pdf.

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5. —. Additional Changes to the PolyMet Plant Site Stormwater Modeling and Permit Level Design Technical Memorandum to Jennifer Saran, Paul Brunfelt, and Jim Tieberg, Poly Met Mining Inc. April 23, 2015.

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7. **Krech Ojard & Associates, P.A.** New Rail Construction for Plant Site Rail Drawings. Prepared for PolyMet Mining Corporation - NorthMet Project. 2013.

8. **Minnesota Pollution Control Agency.** Stabilization Pond Discharge Guidance. *Minnesota Pollution Control Agency.* [Online] July 2009. https://www.pca.state.mn.us/sites/default/files/wq-wwtp7-06.pdf.

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10. **U.S. Department of Agriculture; National Resource Conservation Service; Conservation Engineering Division.** Urban Hydrology for Small Watersheds (Technical Release 55). June 1986.

11. **Kim, J. Y. and Sansalone, J. J.** Event-based size distributions of particulate matter transported during urban rainfall-runoff events. *Water Research.* May 2008, Vol. 42, 10-11, pp. 2756-2768.

12. **Pitt, Robert, et al.** Sources of Pollutants in Urban Areas (Part 2) - Recent Sheetflow Monitoring. [ed.] William James, et al. *Effective Modeling of Urban Water Systems, Monograph 13.* Ontario : CHI, Guelph, 2004, pp. 485-506.

13. **Krech Ojard & Associates, P.A.** New Rail Construction from PolyMet Connection Track to Cliffs Erie Mainline Drawings. Prepared for PolyMet Mining Corporation - Northmet Project. 2013.

14. —. Connection Track Proposed Track Improvements Plan & Profile Drawings. Prepare for PolyMet Mining Corporation - NorthMet Project. 2013.

Large Tables

Large Table 1 Table of Infrastructure - Ponds

ID	Bottom Elevation	Normal Water Elevation	Overflow Elevation	10 Year Peak Water Elevation	100 Year Peak Water Elevation	Side Slopes
North stormwater pond	1608	1609	1615.5	1614.1	1616.3	3:1
Central stormwater pond	1569	1571.5	1585.5	1577.9	1582.7	3:1
Southwest stormwater pond	TBD	TBD	TBD	TBD	TBD	3:1

Large Table 2 Table of Infrastructure - Drop Structure

Stormwater Alignment	Nominal Drop Shaft Diameter (in)	Name	Top Elevation	Bottom Elevation	Drawing Number
J	40	DS J	1614	1594	PSSW-018
K	36	DS K	1612	1586	PSSW-018
M	48	DS M	1616	1593	PSSW-018

Large Table 3 Table of Infrastructure - Catch Basins

Stormwater Alignment	Approximate Station	Name	Rim Elevation	Invert Elevation	Existing/ Proposed	Drawing Number
S	11+40	CB #1	1578.85	1573.85	Proposed	PSSW-009
P	2+00	CB #2	1578.40	1569.24	Proposed	PSSW-006

Large Table 4 Table of Infrastructure - Manholes

Stormwater Alignment	Approximate Station	Name	Rim Elevation	Invert Elevation	Existing/ Proposed	Drawing Number
CC	14+40	MH #1A	1711.45	1707.60	Proposed	PSSW-012
P	5+40	MH #1B	1581.00	1567.10	Proposed	PSSW-006
V	0+60	MH #13	1581.35	1574.53	Proposed	PSSW-009
V	2+40	MH #14	1581.35	1559.35	Existing	PSSW-009
V	5+10	MH #15	1565.26	1536.55	Existing	PSSW-009
V	5+80	MH #16	1542.30	1533.47	Existing	PSSW-009
V	10+20	MH #17	N/A	N/A	Existing	PSSW-008

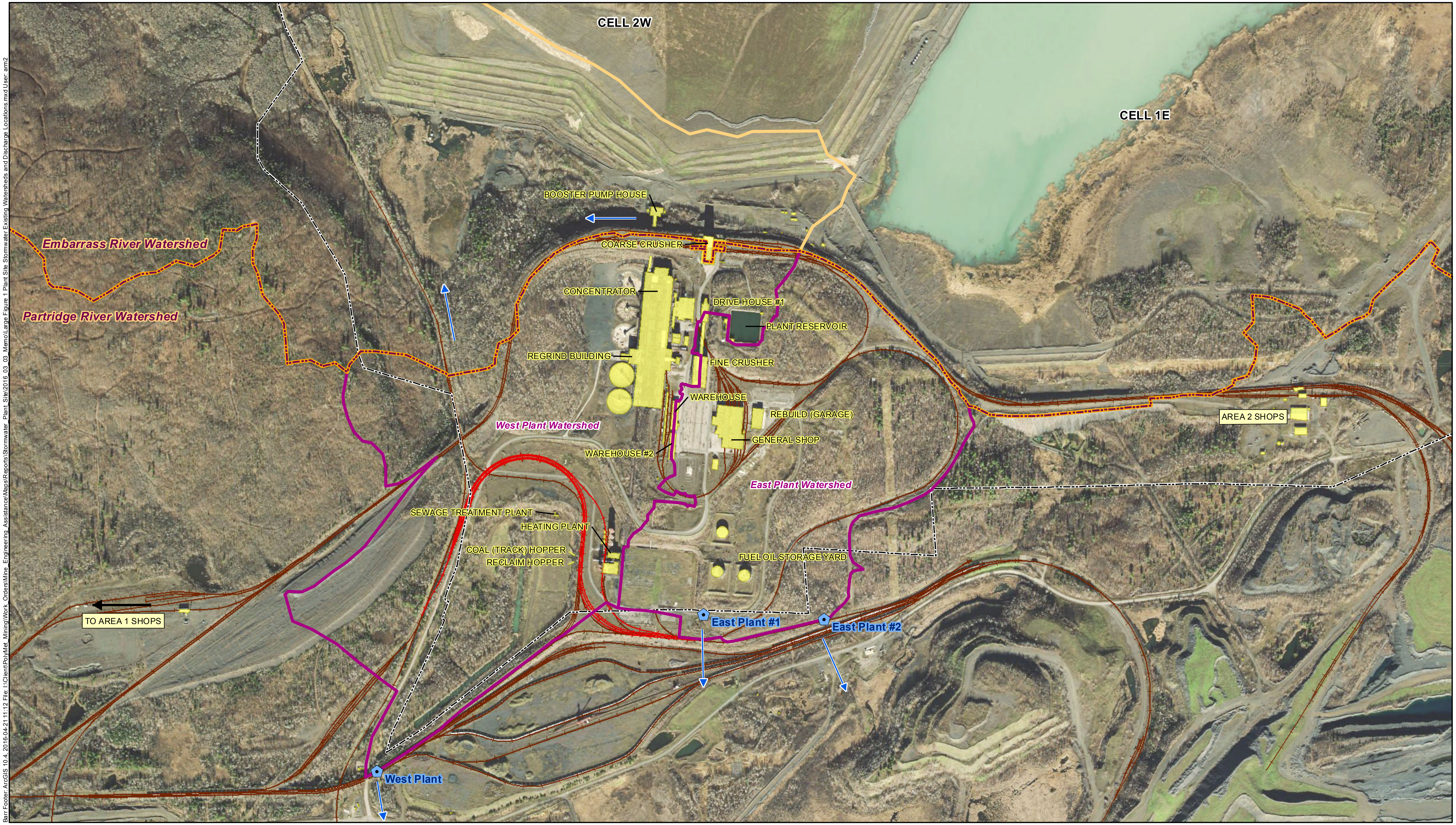
Large Table 5 Table of Infrastructure - Culverts

Stormwater Alignment	Approximate Upstream Station	Function	Length (ft)	Slope %	Nominal Pipe Size (in)	Upstream Invert Elevation	Downstream Invert Elevation	Drawing Number	Max Flow Rate 10 Year (cfs)	Max Velocity 10 Year (ft/s)	Max Flow Rate 100 Year (cfs)	Max Velocity 100 Year (ft/s)
A	1+50	Under existing road grade	48	-3.81	12	1707.50	1705.69	PSSW-016	1	6.2	1	6.5
B	0+50	N/A	42	TBD	TBD	TBD	TBD	PSSW-004	4	1.0	5	1.1
B	4+10	N/A	45	TBD	TBD	TBD	TBD	PSSW-004	8	2.4	12	3.9
B	8+40	N/A	55	TBD	TBD	TBD	TBD	PSSW-004	15	2.4	24	3.3
C	1+00	N/A	49	TBD	TBD	TBD	TBD	PSSW-004	4	4.4	4	3.7
D	0+40	Under existing road grade	67	-0.73	24	1707.50	1707.00	PSSW-016	21	6.7	21	6.7
E	1+80	Under existing road grade	45	-0.27	30	1706.21	1706.10	PSSW-017	26	5.2	27	5.5
E	2+20	Under existing railroad grade	24	-1.25	36	1706.10	1705.80	PSSW-017	36	5.1	43	6.1
E	2+60	Under existing ground	25	-0.40	36	1705.80	1705.70	PSSW-017	39	5.3	45	6.3
E	3+00	Under existing road grade	213	-0.33	42	1705.70	1705.00	PSSW-017	39	4.9	45	5.2
F	0+00	Outlet from north stormwater pond	80	-4.59	12	1609.00	1605.33	PSSW-018	9	2.4	47	4.1
F	9+05	Under existing road grade	81	-1.59	24	1580.27	1579.00	PSSW-018	25	8.1	29	9.3
H	0+00	Under existing road grade	95	-0.20	12	1585.69	1585.50	PSSW-018	6	6.9	6	7.0
I	0+00	N/A	N/A	-44.73	36	1611.43	1599.76	PSSW-018	21	16.2	33	17.2
K	2+20	Under proposed road grade	21	-0.61	27	1612.43	1612.31	PSSW-019	28	7.3	32	8.1
M	2+40	Under proposed road grade	30	-0.48	24	1617.18	1617.04	PSSW-019	4	2.8	7	3.0
N	7+60	Under existing road grade	30	-2.22	30	1575.91	1575.24	PSSW-020	31	0.5	113	0.5
P	9+70	Under existing road grade	44	-5.00	2-36	1541.58	1539.42	PSSW-020	79	6.5	120	9.9
T	8+60	Under existing road grade	42	-0.33	18	1577.75	1577.61	PSSW-022	6	3.3	5	2.9
T	9+80	Under proposed railroad grade	32	-0.16	27	1577.50	1577.45	PSSW-022	6	2.4	6	2.4
U	4+10	Under existing access road	36	-0.11	12	1577.99	1577.95	PSSW-022	3	4.2	3	4.4
W	1+40	Under existing road grade	47	-0.84	30	1536.16	1535.76	PSSW-023	21	4.4	32	6.7
Y	2+20	Under existing road grade	95	-0.26	21	1538.00	1537.75	PSSW-023	7	3.3	11	4.8
BB	3+90	Under existing road grade	41	-3.13	24	1537.82	1536.53	PSSW-023	11	6.3	22	-6.9
SP	12+00	Overflow weir	44	-2.27	30	1531.00	1530.00	PSSW-024	49	9.9	52	10.4
SP	18+00	Overflow weir	47	-2.13	30	1526.00	1525.00	PSSW-024	53	11.1	68	13.8
SP	26+00	Overflow weir	44	-2.27	30	1525.00	1524.00	PSSW-024	59	3.4	251	4.1
SP	32+00	N/A	N/A	N/A	60	N/A	N/A	PSSW-024	N/A	N/A	N/A	N/A
CC	13+60	Under existing railroad grade	72	-0.42	3-24	1707.89	1707.59	PSSW-025	12	3.8	13	4.0
CC	14+40	Under existing road/railroad grade	180	-0.96	36	1707.72	1706.00	PSSW-025	37	6.8	30	4.3
CC	16+60	Under existing road grade	40	-1.25	36	1705.50	1705.00	PSSW-025	22	3.8	8	6.4
CC	18+00	Under existing road grade	35	-1.44	36	1704.00	1703.50	PSSW-025	1	2.2	1	2.7
CC	27+40	Under existing road grade	82	-2.12	48	1643.00	1641.28	PSSW-025	49	6.9	67	6.9
CC	44+20	Under existing road/railroad grade	N/A	-1.56	42	N/A	N/A	PSSW-026	231	29.9	367	38.7
DD	0+20	N/A	60	TBD	TBD	TBD	TBD	PSSW-026	6	3.7	7	3.9
DD	5+00	N/A	45	TBD	TBD	TBD	TBD	PSSW-026	11	2.4	13	2.6
EE	0+20	N/A	50	TBD	TBD	TBD	TBD	PSSW-026	13	3.9	7	3.2
FF	0+00	N/A	20	TBD	TBD	TBD	TBD	PSSW-026	17	6.0	59	6.1
GG	0+00	N/A	40	TBD	TBD	TBD	TBD	PSSW-027	12	14.2	10	9.9
II	0+00	Under existing railroad grade	N/A	-2.29	18	N/A	N/A	PSSW-027	8	8.5	9	8.5
JJ	2+40	Under existing railroad grade	54	-0.95	24	1707.50	1707.00	PSSW-028	13	3.9	19	6.1
JJ	5+10	Under existing railroad grade	180	-7.77	36	1705.92	1692.00	PSSW-028	22	13.0	25	13.0
JJ	12+40	Under proposed access road	100	-0.66	24	1641.07	1640.41	PSSW-028	22	8.0	25	8.3
KK	2+10	Under existing road grade	45	-0.53	36	1707.24	1707.00	PSSW-029	10	2.9	18	2.8
NN	9+00	Under existing road grade	96	-0.72	30	1576.07	1574.88	PSSW-029	39	25.6	39	16.4
NN	10+80	Under existing ground	32	-1.27	30	1574.20	1573.80	PSSW-029	38	7.6	39	7.8
NN	11+60	Under existing road grade	30	-3.98	30	1572.74	1571.54	PSSW-029	38	7.7	39	8.0
NN	12+00	Under existing railroad grade	60	-0.66	30	1571.40	1571.00	PSSW-029	39	7.9	42	8.6

Large Table 6 Table of Infrastructure - Pipes

Stormwater Alignment	Approximate Upstream Station	Length (ft)	Slope %	Nominal Pipe Size (in)	Upstream Invert Elevation	Downstream Invert Elevation	Drawing Number	Max Flow Rate 10 Year (cfs)	Max Velocity 10 Year (ft/s)	Max Flow Rate 100 Year (cfs)	Max Velocity 100 Year (ft/s)
J	0+30	78	-12.80	18	1594.00	1584.00	PSSW-019	22	14.5	34	17.9
K	3+20	125	-4.02	15	1585.00	1580.00	PSSW-019	28	2.6	41	2.9
M	4+00	114	-2.65	18	1593.00	1590.00	PSSW-019	18	10.6	30	16.6
P	0+00	204	-0.64	2-30	1570.54	1569.24	PSSW-020	36	7.3	44	8.8
P	2+00	346	-0.62	2-30	1569.24	1567.10	PSSW-020	41	8.3	49	9.9
P	5+40	376	-0.62	2-30	1567.10	1564.79	PSSW-020	41	8.3	49	9.9
V	0+00	67	-0.36	15	1575.85	1575.61	PSSW-022	8	6.4	9	6.9
V	0+60	173	-0.31	2-12	1575.53	1575.00	PSSW-022	4	5.1	4	5.5
V	2+40	273	-2.23	18	1560.35	1554.27	PSSW-022	8	8.1	9	8.2
V	5+10	75	-3.46	18	1537.55	1534.97	PSSW-022	8	8.5	9	8.5
V	5+90	423	-0.93	24	1534.47	1530.47	PSSW-022	8	5.7	9	5.3

Large Figures



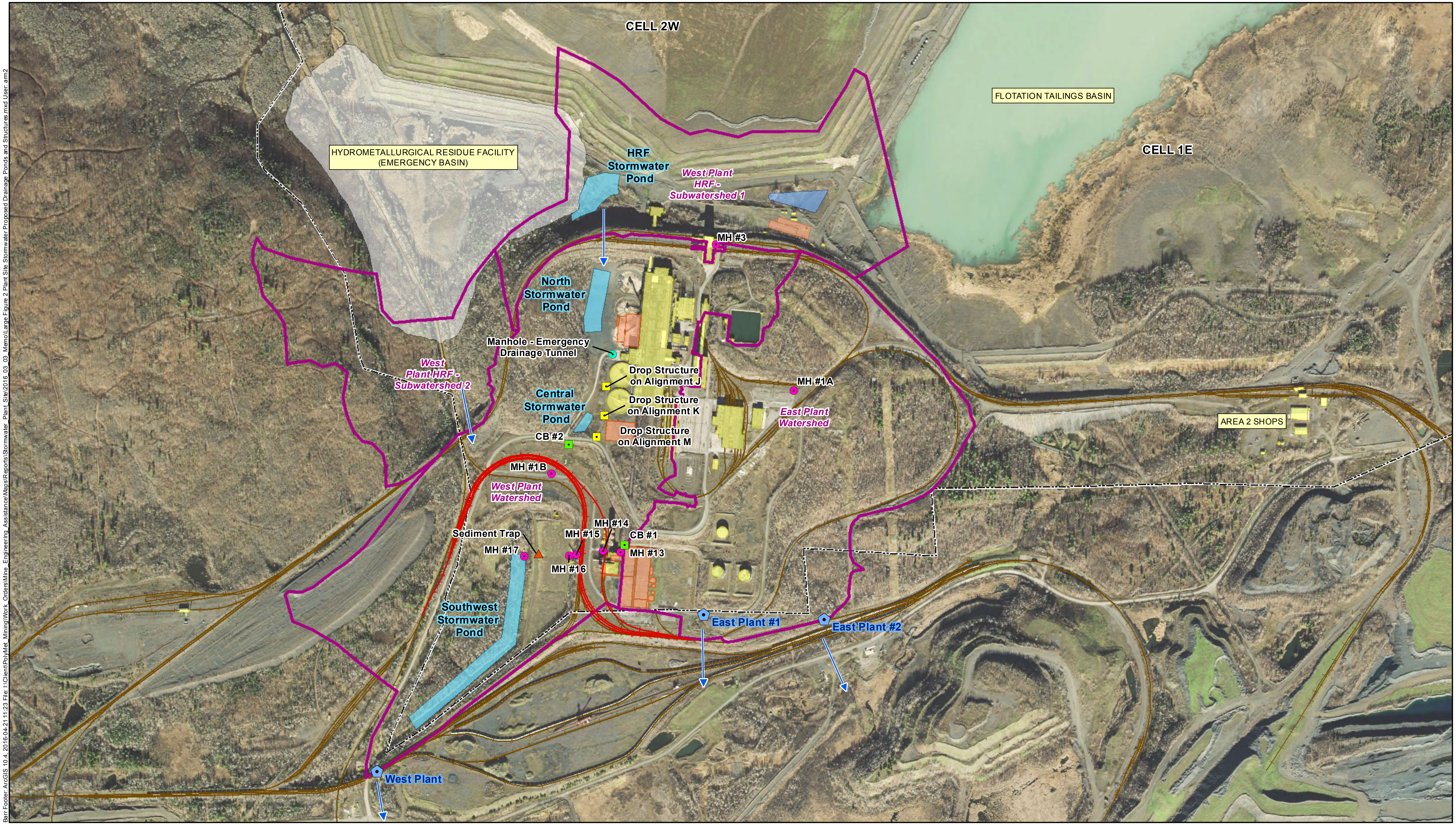
Project Area
Plant Site Watersheds
Embarrass River Subwatersheds
Watershed Divide
Existing Building

Plant Site Stormwater Discharge Location
Existing Outflows
Proposed Railroad
Existing Railroad

Note: Only the area within the Plant Site watershed boundaries has been included in this stormwater evaluation.

0 450 900 1,800
Feet

Large Figure 1
PLANT SITE STORMWATER
EXISTING WATERSHEDS AND DISCHARGE LOCATIONS
NorthMet Project
Poly Met Mining, Inc.
Hoyt Lakes, Minnesota



Project Area
Partridge River Subwatersheds
Proposed Building
Existing Building
Existing Railroads
Proposed Railroads
Plant Site Stormwater Discharge Location
Catch Basin
Manhole
Manhole - Emergency Drainage Tunnel
Sediment Trap
Drop Structure
Proposed Outflows
Proposed Stormwater Pond

0 450 900 1,800
Feet

Large Figure 2
PLANT SITE STORMWATER
PROPOSED DRAINAGE, PONDS, AND STRUCTURES
NorthMet Project
Poly Met Mining, Inc.
Hoyt Lakes, Minnesota

- Connection Track Stationing
- Connection Track
- Dunka Road
- Treated Water Pipeline
- Existing Culvert
- Culvert Extension
- Connection Track Culvert
- Connection Track Ditch
- Infiltration Basin
- Wetland
- Approximate Connection Track Discharge Point
- Approximate Discharge Direction

0 200 400 800

Feet

Large Figure 3
CONNECTION TRACK STORMWATER
NorthMet Project
Poly Met Mining, Inc.
Hoyt Lakes, Minnesota

Attachment G

Plant Site Stormwater Permit Application Support Drawings

Drawings are located in Appendix 10 of the Permit to Mine application and are not duplicated here.