POLYMET
MINING

NorthMet Project

Water Management Plan - Plant

Version 4

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

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Acronyms, Abbreviations, and Units

Acronym	Stands For
BMP	Best Management Practice
Cliffs Erie	Cliffs Erie, LLC
FTB	Flotation Tailings Basin
gpm	gallons per minute
HRF	Hydrometallurgical Residue Facility
LTVSMC	LTV Steel Mining Company
MDNR	Minnesota Department of Natural Resources
MPCA	Minnesota Pollution Control Agency
NA	Not Available
N/A	Not Applicable
NPDES	National Pollutant Discharge Elimination System
PTM	Permit to Mine
SAP	Sampling and Analysis Plan
SDS	State Disposal System
SPCC	Spill Prevention Control and Countermeasures
SWPPP	Storm Water Pollution Prevention Plan
TBD	to be determined
TWP	Treated Water Pipeline
USGS	U.S. Geological Survey
WWTP	Plant Site Waste Water Treatment Plant

1.0 Introduction

This document presents the Water Management Plan - Plant for Poly Met Mining Inc.'s (PolyMet) NorthMet Project (Project) and describes the management of process water and stormwater at the Plant Site. 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)
- the existing former LTV Steel Mining Company (LTVSMC) tailings basin (Tailings Basin), with a new Flotation Tailings Basin (FTB) constructed atop
- an FTB South Seepage Management System and an FTB Containment System to manage seepage from the Tailings Basin
- a Waste Water Treatment Plant (WWTP)
- 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, an FTB Cover System on the FTB beaches and pond bottom, to manage seepage and oxygen infiltration

This document describes the design and operation of process water and stormwater infrastructure associated with the Plant Site. It presents the estimated quantity of process water to be pumped from the FTB Containment System and the FTB South Seepage Management System (collectively referred to as the FTB seepage capture systems) and the estimated water quality at the appropriate water compliance points. It also presents operating plans, water quality and quantity monitoring plans, reporting requirements, and adaptive management approaches. Information from this report will become part of the Minnesota Department of Natural Resources (MDNR) Permit to Mine (PTM) application, the MDNR Water Appropriation Permit application, and Minnesota Pollution Control Agency (MPCA) National Pollutant Discharge Elimination System (NPDES) / State Disposal System (SDS) Permit application and is summarized in the NorthMet Project Description (Reference (1)). This and all other Management Plans will evolve through the environmental review, permitting, operating, reclamation, and long-term closure 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 existing former LTVSMC tailings basin, as well as the combined 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 21 in Reference (1). The area that contains the Beneficiation Plant, the Hydrometallurgical Plant, the WWTP, and the Plant Reservoir is collectively referred to as the Process Plant Area and is shown on Large Figure 22 in Reference (1).

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 (2)) and the quantity of water that will be discharged from the WWTP in operations, reclamation, and long-term closure, as modeled in Reference (2).

Several other Management Plans contain information that relates to the water management at the Plant Site. The NorthMet Project Flotation Tailings Management Plan (Reference (3)) includes design details for the FTB. The NorthMet Project Residue Management Plan (Reference (4)) includes design details for the HRF. The NorthMet Project Adaptive Water Management Plan (Reference (5)) contains details of adaptive engineering controls (WWTP and FTB Cover System) that will ensure compliance with applicable water quality standards at appropriate evaluation points.

Detailed reclamation plans for the process water and stormwater management systems are described in this document. The overall reclamation plan is described in the NorthMet Project Reclamation Plan (Reference (6)).

1.1 Objective

The objective of the Water Management Plan - Plant is to provide a safe and reliable system of 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 water appropriations and withdrawal limits. Compliance is demonstrated by modeling outcomes discussed in Reference (2).

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 2.0	Description of the process water systems at the Plant Site associated with the Beneficiation Plant, Hydrometallurgical Plant, and WWTP, stormwater systems, and stream augmentation needs

Section 3.0	Description of key outcomes, including quantity of water required to be appropriated from Colby Lake and water quality at compliance points
Section 4.0	Description of operational management plans for process water, stormwater, spills, and overflows
Section 5.0	Description of water quantity and quality monitoring, including process water internal to the Project, stormwater from the Plant Site, Project surface discharges, external surface water, and groundwater. The specifics of monitoring, including specific locations, nomenclature, frequency, and parameters will be finalized during the NPDES/SDS and Water Appropriation permitting processes.
Section 6.0	Description of reporting and annual reporting requirements including comparison to modeled outcomes and compliance, adaptive management plans, and available mitigations
Section 7.0	Description of the reclamation and long-term closure plans for the Plant Site water management systems including the Contingency Reclamation Plan (assumes closure in the upcoming year) for Mine Years 0 and 1

Because this document is intended to evolve through the environmental review, permitting (NPDES/SDS, Water Appropriations, and PTM), operating, reclamation, and long-term closure phases of the Project, some of the attachments are included as placeholders and are so identified. It will be reviewed and updated as necessary in conjunction with changes that occur and for future permitting needs. 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, as described in Reference (1) and shown on Large Figure 21 of Reference (1). Several water management components have been acquired from LTVSMC for use on this Project, including:

- buildings and infrastructure at the Process Plant Area, including the Plant Reservoir
- the Colby Lake Pumphouse and water supply line from Colby Lake to the Plant Reservoir
- the inter-pit pipeline from the Plant Reservoir to the Area 1 Shops and Area 2 Shops
- the Tailings Basin and associated water management systems
- the Emergency Basin

Existing drainage patterns at the Plant Site are shown on Large Figure 1. Most of the drainage leaving the Process Plant Area and the Area 1 Shops and Area 2 Shops flows south to Second Creek. Second Creek is also known locally as Knox Creek, but for the purpose of this Project, it will be referred to as Second Creek.

The 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 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 Tailings Basin operations were shut down in January 2001 and have been inactive since then except for reclamation activities consistent with an MDNR-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 Tailings Basin. In 2011, temporary pumpback systems were installed near (upstream of) surface discharge stations SD004, SD006, and SD026 to return seepage to the 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 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 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 (2) 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 Reference (2).

1.4.1 Surface Water Baseline Data

As described in Section 4 of Reference (2), the Plant Site is primarily located within the Embarrass River watershed, upstream of the Embarrass River chain of lakes (Large Figure 2). Approximately 20% of the Plant Site, including the SD026 discharge from the 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 2).

Upstream of the U.S. Geological Survey (USGS) gaging station 04017000 (Large Figure 2), 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 drainage 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) 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 3). Section 4.4 of Reference (2) provides additional detail on the Embarrass River watershed, and Section 4.5 of Reference (2) and Section 4.4 of Reference (7) 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 (2). 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 2); 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 3 and include five monitoring locations on the Embarrass River above the chain of lakes, two locations along Spring Mine Creek, three locations along 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 (2). Baseline monitoring data from water collected in Wynne Lake, Sabin Lake, and Embarrass Lake is presented in Large Table 6 of Reference (2). 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 2) in the Second Creek watershed in 2004, 2006, and 2007. Cliffs Erie continues to monitor this location as part of their ongoing NPDES monitoring requirements; this site is identified as surface discharge station SD026 for NPDES monitoring (Section 1.4.5). Data collected at PM-7 and SD026 is presented in Large Table 5 of Reference (2).

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 4. 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 (2)). 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 permit for the existing Tailings Basin. The groundwater monitoring well network also includes four wells installed in 2009 specifically for evaluation of baseline conditions for this Project, and four additional wells installed as part of the Cliffs Erie Consent Decree. Groundwater monitoring data collected from monitoring wells in the surficial deposits are summarized in Large Table 3 in Reference (2). The locations of the groundwater monitoring wells are shown on Large Figure 4.

1.4.3 Tailings Basin Surface Seepage

Surface seepage from the 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 Tailings Basin where flow has been observed in the last eight years (2007-2014) are shown on Large Figure 5 and listed in Table 1-1.

Table 1-1 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)
Seeps 13-17(2)	1	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
SD006(3)	303	383	710	618	722	Not Applicable (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
Seep 22 (SD004)	2	3	3	4	3	N/A	N/A	N/A	N/A
Seep 24	26	7	10	12	11	9	9	10	8.5
Seep 25	11	27	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
Seeps 32 & 33 (upstream of SD026)(4)	490	195	600	781	1379	N/A	N/A	N/A	N/A
Inflow (culvert)(5)	745	Not Available (NA)	80	116	NA	No Flow	39	69	21

(1) See Large Figure 5
(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 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 drainage flowing into the Tailings Basin (Cell 1E) from the northeast. There is no seepage from the Tailings Basin included in this flow.

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

The existing NPDES permit for the Tailings Basin (MN0054089) includes 12 waste stream stations, summarized in Table 1-2 and shown on Large Figure 5 (with the exception of WS008, WS014, and WS015, which are waste streams for chemical dust suppressants that do not have a specific location). Only waste stream station WS009 is expected to be included in future permit requirements for this Project (Section 5.1.4).

Table 1-2 Existing NPDES Permit MN0054089 Waste Stream Stations

Station	Local Name	Status
WS001	NW side of Emergency Basin	Will be inactivated following construction of the HRF; permit requirements not anticipated to continue during operations, reclamation or long-term closure
WS002	NW Seepage Collection Return Pumping to TB	No longer active; permit requirements not anticipated to continue during operations, reclamation or long-term closure
WS003	NE Seepage Collection Return Pumping to TB	No longer active; permit requirements not anticipated to continue during operations, reclamation or long-term closure
WS006	Biosolids transferred to POTW	No longer active; permit requirements not anticipated to continue during operations, reclamation or long-term closure
WS007	Treated Sewage to Emergency Basin	No longer active; permit requirements not anticipated to continue during operations, reclamation or long-term closure
WS008	Ligninsulfonate applied for Dust Control	No specific location; dependent on location of application. No longer active; permit requirements not anticipated to continue during operations, reclamation or long-term closure
WS009	Culvert under RR grade, NE side of Cell 1E	Monitoring of flow and water quality; permit requirements anticipated to continue during operations until East Dam cuts off this inflow as discussed in Section 5.1.4
WS011	Tailings Basin Seep 1	Seep currently dry; location will be disturbed by construction of HRF; permit requirements not anticipated to continue during operations, reclamation or long-term closure
WS012	Tailings Basin Seep 2	Seep currently dry; location will be disturbed by construction of HRF; permit requirements not anticipated to continue during operations, reclamation or long-term closure
WS013	Tailings Basin Seep 3	Seep currently dry; location will be disturbed by construction of HRF; permit requirements not anticipated to continue during operations, reclamation or long-term closure
WS014	Coherex applied for Dust Control	No specific location; dependent on location of application. No longer active; permit requirements not anticipated to continue during operations, reclamation or long-term closure
WS015	Nalco Dust-Bas 8803 for Dust Control	No specific location; dependent on location of application. No longer active; permit requirements not anticipated to continue during operations, reclamation or long-term closure

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

The existing NPDES permit for the Tailings Basin (MN0054089) includes five surface discharge stations, summarized in Table 1-3. The existing NPDES permit for the Hoyt Lakes Mining Area (MN0042536) includes one surface discharge station relevant to the Project, summarized in Table 1-4. All six of these stations are shown on Large Figure 5. Three of these existing surface discharge stations (SD004, SD005, and SD006) will be combined into an internal waste stream of FTB seepage collected by the FTB Containment System, which will be monitored as discussed in Section 5.1.2. Only surface discharge station SD026, or a location near it, is expected to be included in future permit requirements as a surface discharge station for this Project (Section 5.3.1).

Table 1-3 Existing NPDES Permit MN0054089 Surface Discharge Stations

Station	Local Name	Status
SD001	Northwest Seepage Collection Ditch	This location will no longer be considered a surface discharge station; permit requirements not anticipated to continue during operations, reclamation or long-term closure.
SD002	Northeast Seepage Collection Ditch	This location will no longer be considered a surface discharge station; permit requirements not anticipated to continue during operations, reclamation or long-term closure.
SD004	Tailings Basin Cell 2W Seep A	Seepage at this location will be collected by the FTB Containment System and will be part of a new internal waste stream included in Project monitoring (Section 5.1.2).
SD005	Tailings Basin Cell 2W Seep B	Seepage at this location will be collected by the FTB Containment System and will be part of a new internal waste stream included in Project monitoring (Section 5.1.2).
SD006	Power Line Access Road Culvert	Seepage at this location will be collected by the FTB Containment System and will be part of a new internal waste stream (Section 5.1.2). The stream near SD006 (outside the FTB Containment System) will be a surface discharge station for the WWTP and is discussed in Section 5.3.1.

Table 1-4 Existing NPDES Permit MN0042536 Surface Discharge Stations

Station	Local Name	Status
SD026	Second Creek (aka Knox 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 (Section 5.1.2). Second Creek, near SD026, will be a surface discharge station for the WWTP and is discussed in Section 5.3.1.

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

Existing NPDES Permit MN0054089 has three surface water stations, summarized in Table 1-5 and shown on Large Figure 3. These monitoring stations are expected to be included in Project monitoring (Section 5.0).

Table 1-5 Existing MN0054089 Surface Water Monitoring Locations

Station	Local Name	Status
SW003	Unnamed Creek tributary to Embarrass River	This location is the same as PM-11 and is included in the monitoring proposed in Section 5.4.1
SW004	Embarrass River at CR620	This location is the same as PM-12 and is included in the monitoring proposed in Section 5.4.1
SW005	Embarrass River at Hwy 135 Bridge	This location is the same as PM-13 and is included in the monitoring proposed in Section 5.4.1

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 offsite water resources. Process 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 and around the FTB and within the HRF will be collected for use as process water. Stormwater within the Process Plant Area, Area 1 Shops, and Area 2 Shops will be kept separate from process 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. Make-up water required by the Beneficiation Plant and the Hydrometallurgical Plant will primarily be drawn from the FTB Pond and the HRF Pond, respectively, with excess water pumped from the Plant Reservoir, as needed.

The FTB will serve as the primary reservoir for Project process water. In addition to receiving process water from the Beneficiation Plant in the Flotation Tailings slurry, it will also receive process water from the Mine Site. 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; water will be treated at the WWTP 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 treatment plant that feeds the Potable Water 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, and other applications that require clean water – after use, this water reports to the Beneficiation or Hydrometallurgical Plant process water systems
- fire water – only used in an emergency

The following sections describe the major components of the Plant Site water management systems, including process water, stormwater, and stream augmentation.

2.1 Process Water – Beneficiation Plant

Within the Beneficiation Plant, 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 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 (2) and summarized below. Most of the water used in the Beneficiation process is decanted water from the FTB Pond. This water supply includes water that is piped to the FTB through the Treated Water Pipeline (TWP) from the Mine Site (Reference (8)). 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

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]
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 (2). 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 water. The Flotation Tailings settle out in the FTB, and the excess water is returned to the Beneficiation Plant for reuse. The FTB also receives water from the Mine Site via the TWP (Section 2.1 of Reference (8)). The FTB is fully described in Reference (3).

2.1.3 Flotation Tailings Basin (FTB) South Seepage Management System

The FTB South Seepage Management System will collect 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 all existing 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, the 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 5 and Section 1.4.5). The pumpback system consists of a cutoff berm 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 WWTP. Drawings in Attachment A show the current design of the SD026 seepage pumpback system, with the location shown on Large Figure 6. PolyMet and Cliffs Erie are currently working together to assess the effectiveness 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) Containment System

The FTB Containment System will collect seepage along the north, northwest, west, and east toes of the Tailings Basin Dams, as shown on Large Figure 6. The FTB Containment System is designed to intercept the seepage that emerges as surface water near the toe (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. Seepage to the south of the Tailings Basin will be collected by the FTB South Seepage Management System described in Section 2.1.3.

The FTB Containment System consists of a cutoff wall (a low permeability hydraulic barrier) placed into the existing surficial deposits, with a drainage 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, collected water will be returned to the FTB Pond for reuse to the extent possible with excess water treated via the WWTP prior to discharge (Section 2.3). Water collected on the western and northern sides of the Tailings Basin will be conveyed to one of two main pump stations through a control valve station, centrally located on the northern side of the Tailings Basin. From there it will be routed back to the FTB Pond, or to the WWTP for treatment and discharge, 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. All 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. The containment system will continue to operate during reclamation and through long-term closure.

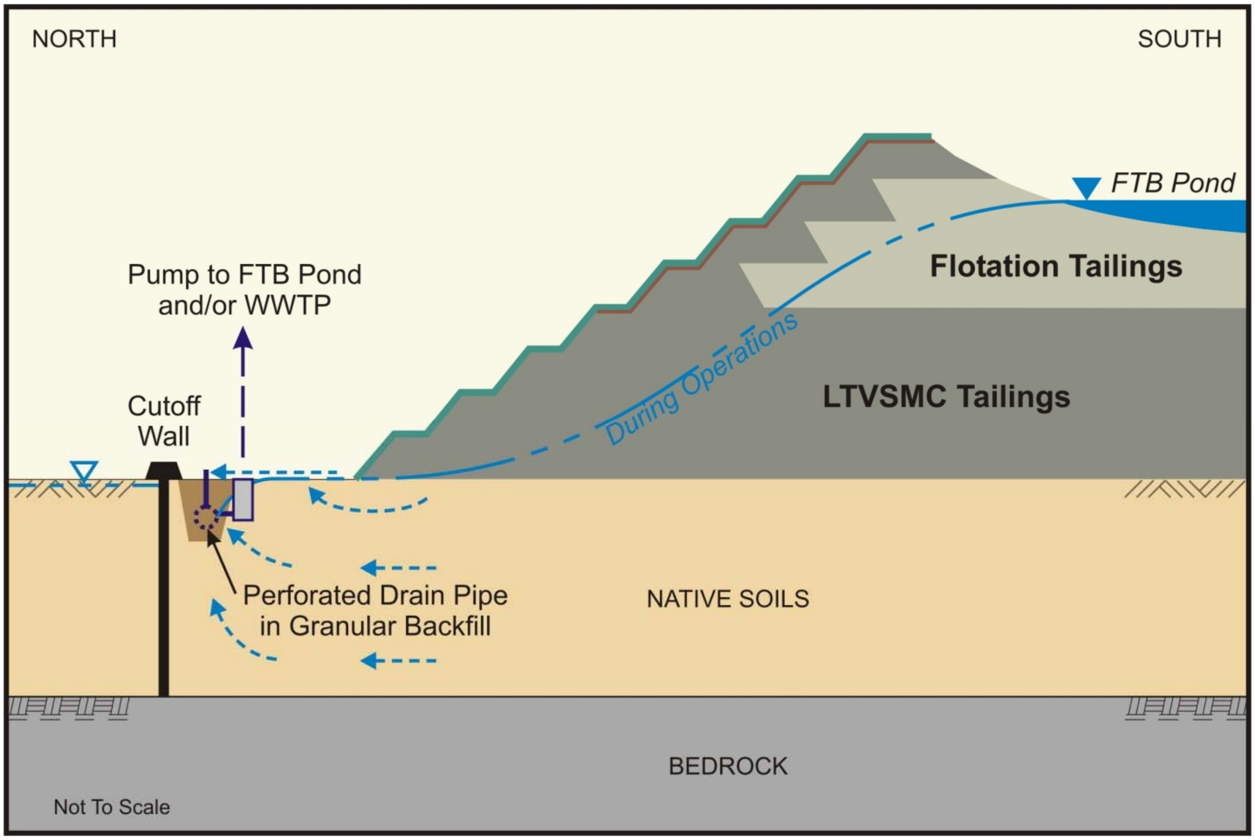

Figure 2-1 **Conceptual Cross-Section: FTB Containment System**

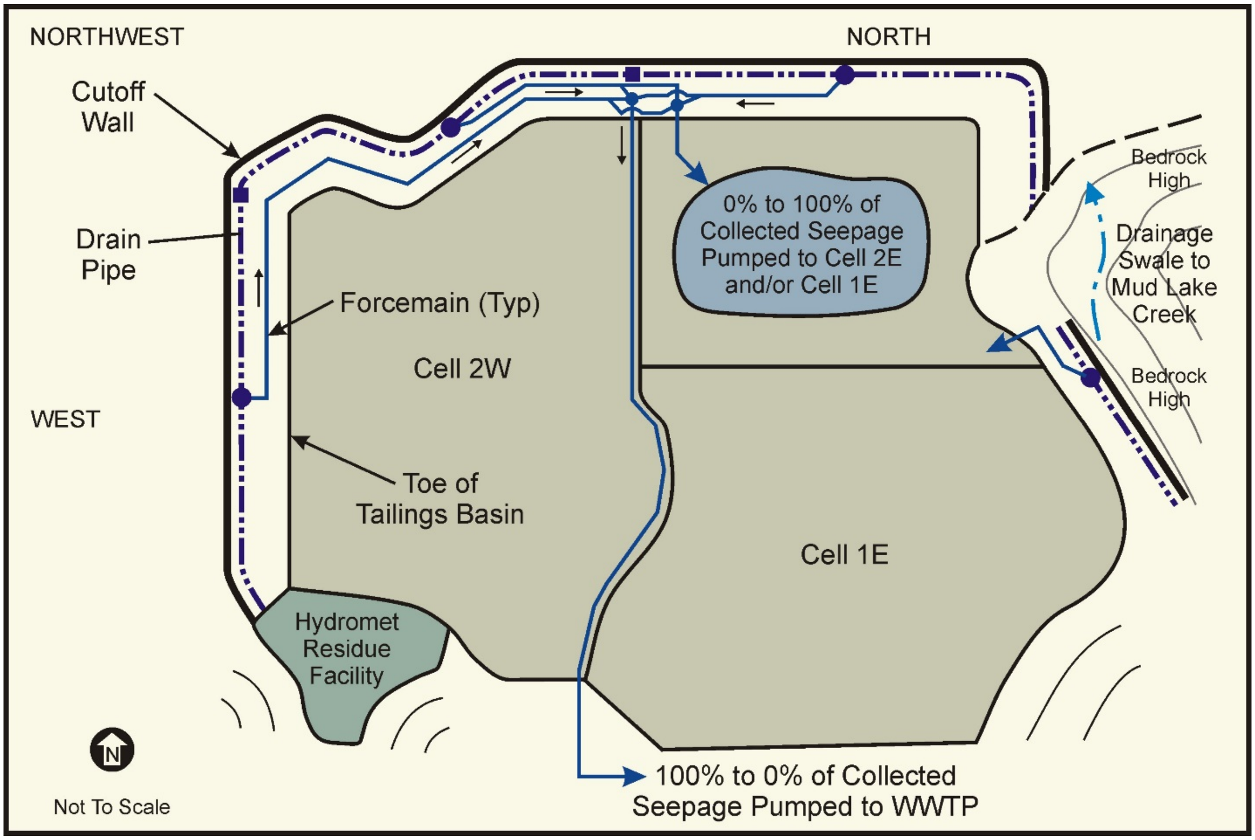

Figure 2-2 Conceptual Plan View: Flotation Tailings Basin Containment System

The containment system will collect the FTB 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 Containment System and downgradient of the FTB Containment System, as documented in Reference (9), Section 5.1.5 (direct wetland impacts) and Section 5.2 (indirect wetland impacts).

Attachment B contains the Permit Support Drawings for the FTB Containment System. 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 Permit Support Drawings

(Attachment B), 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 and temporary dewatering will be required. This water, which normally percolates to the ground surface and discharges away from the Tailings Basin as surface water, will be pumped to a sedimentation basin to facilitate sediment removal prior to being discharged from the site.

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 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 (10). 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 C). 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 (2)). Capture efficiency depends on how much flow enters the bedrock, so the groundwater flow modeling, described in Attachment C, 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. Effectiveness 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 (11)), 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 effectiveness of the eastern section of the FTB 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 2.5). 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 Containment System is expected to have a capture efficiency of 100%.

2.2 Process Water – 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.

2.2.1 Hydrometallurgical Plant Water Balance

The water used in the Hydrometallurgical process consists mainly of decanted water from the HRF 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 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 (2).

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 Beneficiation 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 (2). 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 includes gland water and water in reagents; each of which result in minor individual flows.
(6) Other outflows includes 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 water. The solids settle out into the HRF, and the 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 HRF is described in Reference (4) with details about water management within the HRF provided in Section 4 of Reference (4).

2.3 Waste Water Treatment Plant (WWTP)

Water collected in the FTB Containment System will be pumped to the FTB or the WWTP as necessary to prevent any overflow from the FTB Pond. The WWTP will treat this water to meet applicable surface water discharge limits. During operations and reclamation, reject concentrate from the WWTP will be sent to the Mine Site Waste Water Treatment Facility (WWTF) for further solute removal. During long-term closure, the concentrate will be evaporated and crystallized. The flow to the WWTP will vary significantly over the life of the Project. To address this variability, the WWTP can be expanded or treatment capabilities modified if required to meet water resource objectives. The details of the adaptive design are presented in Section 4 of Reference (5). The WWTP will be located near the FTB as shown on Large Figure 7.

After treatment, water from the WWTP 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 (2). The WWTP will discharge to Unnamed Creek near SD006 (outside the FTB Containment System) and to Second Creek near SD026. The exact location to which the WWTP will discharge within the Trimble Creek watershed and the number of locations is not yet determined. 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 of the basin. The effluent from the WWTP will be distributed to these tributaries in proportion to the flow required to prevent significant hydrologic impacts. See Section 2.5 for more details on stream augmentation.

2.4 Stormwater Management

Over most of the Process Plant Area, Area 1 Shops, and Area 2 Shops (Large Figure 1), stormwater will be separated from process water using dikes, ditches, and storm sewers. The stormwater management infrastructure will be operated in accordance with the Construction Storm Water Pollution Prevention Plan (SWPPP), which is included as Attachment D (to be developed prior to construction), and the Industrial SWPPP, which is included as Attachment E (to be developed prior to the start of operations). These SWPPPs have been developed 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. The Industrial SWPPP contains the Plant Site drainage areas and directions of stormwater runoff, discharge outfalls from the site with name and location of receiving waters, locations of storm sewer inlets, and an indication of which, if any, structures have floor drains or loading dock drains that are connected to storm sewers. Both of these SWPPPs describe best management practices (BMPs) to be used at the Plant Site to reduce or eliminate pollutants to stormwater.

Stormwater falling within the tributary area to the FTB will be collected, either within the pond where it becomes process water or by the FTB Containment System. Stormwater management for the FTB is described in Section 2.5 of Reference (3).

Stormwater falling within the tributary area to the HRF pond will become process water. Stormwater management for the HRF is described in Section 2.5 of Reference (4).

2.5 Stream Augmentation

Construction of the FTB 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, Mud Lake Creek, and Second Creek. As described in Section 5.2.2.9.1 and 6.6 of Reference (2), flow to Unnamed Creek, Trimble Creek, and Second Creek will be augmented by WWTP effluent to offset potential hydrologic impacts to these creeks.

Flow to 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. A drainage swale will be constructed near the East Dam to reroute this watershed north to the Mud Lake Creek watershed. The drainage swale will prevent water from pooling at the toe of the East Dam and augment streamflow in Mud Lake Creek. The additional flow expected to Mud Lake Creek from the diverted watershed is approximately 300 gpm on an average annual basis, which will mitigate about 80% of the captured seepage flow by the FTB Containment System from this watershed. With this augmentation, the Mud Lake Creek flows will result in approximately 90% of its pre-Project average annual flow. The drainage swale will be constructed in Mine Year 0, which is a change in the Project timing as described in the Supplemental Draft Environmental Impact Statement plan, which was to construct the drainage swale in Mine Year 7 (Section 5.2.2.3.3 of Reference (12)).

Table 2-3 shows the minimum flow that must be discharged on an average annual basis to each of the three streams that require augmentation from the WWTP.

Table 2-3 WWTP Flow Requirements for Stream Augmentation

Description	Trimble Creek (gpm)	Unnamed Creek (gpm)	Second Creek (gpm)
Minimum Requirement from WWTP	1,178	336	184
Maximum Allowable from WWTP	2,066	836	276
Expected Flows from WWTP -Operations (Mine Years 0 to 21)	1,190 – 1,890	340 – 540	185 – 295(1)
Expected Flows from WWTP -Reclamation (Mine Years 21 to 31)	1180	336	184
Expected Flows from WWTP -Long-Term Closure	1485	423	232

(1) Note the highest modeled flows to Second Creek did exceed the maximum allowable by about 20 gpm due to the simplified distribution of WWTP effluent in the modeling and the tight target flow range at SD026. However, the high flow rate (295 gpm) is within the observed flows at SD026 from July 1999 to September 2014 (range is from less than 10 gpm to nearly 2,500 gpm).

In long-term closure, it is expected that stream augmentation will continue to be needed from the WWTP. See Section 5.2.2.9.1 and 6.6 of Reference (2) for more details.

3.0 Key Outcomes

Water modeling (detailed in Section 5 of Reference (2)) 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 WWTP, as described in Section 2.0.

Key outcomes of the water quantity modeling described in Reference (2) related to Project makeup water demand are summarized in Table 3-1. Additional groundwater appropriation will be needed for groundwater collected during construction at the Plant Site. Dewatering may be necessary during construction of the FTB Containment System, Plant Site stormwater infrastructure, Plant Site buildings and infrastructure, and Plant Site Sewage Treatment System. Estimated water appropriation flows for these groundwater needs will be provided in permitting. Water collected by the FTB seepage capture systems is already appropriated from other sources; therefore it will not likely require a water appropriations permit.

Table 3-1 Water Appropriation for the Plant Site

Water Source Location	Source Water	90th Percentile Maximum Estimated Daily Volumes (Million Gallons per Day)(1)	90th Percentile Maximum Estimated Annual Volume (Million Gallons per Year)(1)
Operations Phase			
Colby Lake	Surface Water	15.1 MGD (Mine Year 1)	1,300 MGY (Mine Year 1)
HRF Wick Drain System(2)	Groundwater	TBD in permitting	TBD in permitting

(1) Source of data: Section 6.1.4 of Reference (7); this table lists the peak water need and year of the peak need
(2) The HRF wick drain system is an optional feature of the HRF and, if required, would tie into the FTB Containment System for collection. Appropriation quantities for the wick drain system will be determined in permitting, if required.

3.2 Water Quality

Key outcomes of the water quality modeling described in Reference (2) are provided as Large Tables:

- estimated FTB Pond water quality in Large Table 1

- estimated Tailings Basin seepage water quality in Large Table 2 to Large Table 5 from the north, northwest, west, south, and east toes, respectively
- estimated water quality in Large Table 6 to Large Table 8 along the north, northwest, and west groundwater flow paths downstream of the Plant Site
- estimated water quality in Large Table 9 to Large Table 14 at three surface water locations along the Embarrass River and three surface water locations along the three tributaries (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 WWTP, 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 operational phase of the Project. Section 7.0 describes the management of water during reclamation and long-term closure.

4.1 Process Water

Process water at the Plant Site will be primarily contained within the FTB Pond and HRF Pond. Pond water will be maintained at safe operating elevations within these ponds. Process water collected in the FTB seepage capture systems helps to maintain the water level in the FTB Pond. Any water collected by the FTB seepage capture systems in excess of the pond capacity will be treated by the WWTP before being discharged.

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 (3).

The FTB Pond had 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 water sent to the pond from the FTB seepage capture systems and the amount of 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, as described in Section 4.1.1. HRF pond level management is detailed in Section 4 of Reference (4).

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 Water System 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.

Water collected by the FTB South Seepage Management System will be routed from the system pump station through pipes to the WWTP or FTB Pond for reuse, depending on operational requirements. The preferred discharge point will be to the FTB Pond. Water level controls at the FTB Pond and real time water balance data will dictate whether a portion or all of the collected water must be diverted to the WWTP for treatment and discharge. The pumps in the seepage management system will be operated using level sensors so that a desired water level is maintained in the sumps and lift stations.

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) Containment System

The FTB 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 (5). The eastern segment of the FTB 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.

Water collected by the FTB 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 WWTP for treatment. The preferred discharge point will be to the FTB Pond. Water level controls at the FTB Pond and real time water balance data will dictate whether a portion or all of the collected water must be diverted to the WWTP for treatment and discharge. Water collected by the segment of the FTB 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 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 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 will be conducted once every 5 years unless monitoring of 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 would be reconstructed as needed, and if pipe collapse were to occur, pipe design specifications and construction methods would be reviewed and pipes replaced as necessary. For a system of this type, pipe collapse would not be 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 Plant (WWTP)

During operations, the WWTP will treat excess water from the FTB seepage capture systems, beyond the quantity needed to maintain the desired FTB pond level, and discharge the effluent to augment stream flows, as described in Section 2.5. WWTP systems will treat the excess water to meet the appropriate discharge limits. The WWTP may also provide water for reuse in certain process steps in the Beneficiation Plant or the Hydrometallurgical Plant. The operation of the WWTP is further discussed in Section 4.2 of Reference (5).

4.2 Stormwater

The stormwater management infrastructure will be managed in accordance with the Construction SWPPP (Attachment D, to be developed prior to construction) and the Industrial SWPPP (Attachment E, to be developed prior to the start of operations), as described in Section 2.4. The intent of these SWPPPs is to protect water quality by preventing pollution of stormwater associated with construction and industrial activities at the Plant Site. These SWPPPs will identify and describe controls and BMPs to be used at the Plant to minimize the discharge of potential pollutants in stormwater runoff. The SWPPP will be updated as necessary to meet the requirements of the project permitting. A SWPPP is a “living” document that changes as the site changes. 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

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.

4.3 Spills

This section is a summary of the Plant Site Spill Prevention Control and Countermeasures (SPCC) Plan which is included as Attachment F (to be developed prior to start of operations). The SPCC 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 are further described in Attachment F. 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 process water features. 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 from process water areas may ultimately overflow into the Plant Site stormwater system and off-site. Actual location of discharge will depend on the location of the overflow, with drainage divides shown in Large Figure 2 and Large Figure 3.

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 (3)). No water will be released through overflow or outlet structures during operations. Precipitation falling within the FTB will flow to the FTB Pond. All precipitation that falls within the FTB perimeter will be contained by freeboard, including the precipitation from up to the 72-hour Probable Maximum Precipitation (PMP) event. 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 it is usually assumed by hydrologists to be on the order of 100 million to 10 billion years. Based on an extrapolation of the 72-hour rainfall depth data from the U.S. Weather Bureau-Office of Hydrology Technical Paper TP 49 and the assumed return period of 100 million years, a 1/3 PMP event could occur roughly once in 1,000 years and a 2/3 PMP could occur once in 500,000 years. On this basis, there is a low likelihood of overflow; however, it is standard practice in dam design to accommodate even low probability overflows in a manner that protects the integrity of the dams. 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 (3).

During long-term closure when there will be a positive water balance in the FTB, water will be pumped from the FTB Pond to the WWTP to prevent overflow from the FTB Pond. An emergency overflow embedded in bedrock east of Cell 2E will be established during reclamation. The location and layout of the emergency overflow is provided on Drawings FTB-

015 to FTB-018 in Attachment A of Reference (3). If pumping systems shut down due to a power outage simultaneous with a significant precipitation event, this overflow structure will prevent the washout of dams in the unlikely case of the water rising to elevations near the final dam elevation. Embedding the channel into bedrock will also minimize or eliminate any long-term maintenance requirements for the channel.

4.4.2 Hydrometallurgical Residue Facility (HRF)

Similar to the FTB, the HRF will function as a closed system, with the pond level managed to remain at the design level (Section 4 of Reference (4)). 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 (4). 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 (4). 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. 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 (4).

4.4.3 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 surface and shallow groundwater flow seeping from the FTB along the south side of the FTB. The current design, shown in Attachment A, includes an impoundment to block the seepage and a small sump with a submersible pumps. An emergency overflow is designed into the system, as shown in Attachment A, at an elevation of 1530 feet, which is approximate 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, water 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).

4.4.4 Flotation Tailings Basin (FTB) Containment System

Similar to the FTB South Seepage Management System, the FTB Containment System is a system in place to collect surface and shallow groundwater flow seeping from the FTB as described in Section 2.1.4 and Section 4.1.4. The current design, shown in Attachment B, 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. If the pumps in these sumps are shut down due to a power outage, water draining in these pipes will back up and an overflow may occur from the two lift stations. Excess water not contained will flow off-site at the existing surface discharge station SD002 (Section 1.4.5).

4.4.5 Waste Water Treatment Plant (WWTP)

The WWTP overflow locations will be determined based on the final location of the WWTP. The water level in the WWTP Equalization Basins will be controlled by the upstream pumps pumping water to the WWTP and the rate of treatment. If there is a loss of power at the Plant, the upstream pumping systems will also likely be shut down due to this power outage. If the upstream pumping systems continued to pump while the WWTP was shut down, there may be an overflow from the WWTP Equalization Basins. If the water level in the WWTP Equalization Basins are nearing overflow, the upstream pumps will need to be shut off to prevent an overflow from occurring. If an overflow does occur, this drainage would either go through the Plant Site stormwater system or to the FTB Pond, depending on the location and timing of the overflow (with relation to the FTB South Dam construction).

4.4.6 Process Plants

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.

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, which will be finalized in 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 ensure short-term and long-term compliance. The proposed water monitoring plans that PolyMet expects to be required by the various permits and regulations applicable to processing plant operations are summarized in Table 5-1 and described in Sections 5.1 to 5.5. The specifics of monitoring for the Project, including the specific locations, nomenclature, frequency, and parameters, will be outlined in the permit applications, and finalized during the permitting process.

Table 5-1 Overview of Water Monitoring Plans at Plant Site

Monitoring Plan Component		Purpose	Summary	General Locations
Internal Streams	FTB Pond (Section 5.1.1)	Monitor pond water levels and trends in basin pond water characteristics over time	Daily water level (WL) monitoring and monthly water quality (WQ) monitoring	WL monitoring location TBD; WQ monitoring at pond barge
	FTB Seepage (Section 5.1.2)	Evaluate seepage rate and trends in water quality characteristics over time	Continuous flow monitoring and monthly WQ samples from FTB seepage capture systems	FTB Containment System lift stations and FTB South Seepage Management System pump station
	HRF Pond (Section 5.1.1)	Monitor water level to prevent overtopping the HRF dam and monitor water quality trends over time	Daily WL monitoring and monthly WQ monitoring	WL monitoring location TBD; WQ monitoring at pond barge
	HRF Leachate (Section 5.1.3)	Evaluate leachate quantity and characteristics over time	Continuous flow monitoring and monthly or quarterly monitoring of leachate quality	Underdrain
	Continued Existing Waste Streams (Section 5.1.4)	Continue existing NPDES monitoring requirements as appropriate	Quarterly monitoring of flow and WQ during non-frozen conditions (April, July, and October)	Seep into Cell 1E

Monitoring Plan Component		Purpose	Summary	General Locations
Stormwater	Stormwater (Section 5.2)	Monitor stormwater quality and quantity	Monthly (during non-frozen conditions, April – October) flow rate and WQ monitoring	Stormwater control features
Surface Discharges	Waste Water Treatment Plant (Section 5.3.1)	Demonstrate acceptable effluent characteristics	Continuous flow monitoring on WWTP effluent and monthly effluent WQ monitoring, monthly total flow monitoring at discharge locations	WWTP Effluent
Surface Water	Embarrass River and Tributaries (Section 5.4.1)	Evaluate trends in surface water quality and flow	Monthly sampling of flow and water quality	Embarrass River, Mud Lake Creek, Trimble Creek, and Unnamed Creek
	Second Creek (Section 5.4.2)	Evaluate trends in surface water quality and flow	Monthly sampling of flow and water quality	Second Creek downstream of seepage barrier
	Colby Lake Intake (Section 5.4.3)	Evaluate water quantity use over time for plant use	Continuous flow monitoring at intake	Colby Lake intake
Groundwater	General (Section 5.5)	Evaluate groundwater quality and water level trends over time	Monitoring wells sampled quarterly during non-frozen conditions (April, July, and October)	Existing monitoring wells installed around the Tailings Basin
Wetlands	Wetlands (Section 5.6)	Evaluate potential effects of processing plant operations on wetlands and determine if the potential indirect impacts from these operations have occurred or if additional mitigation is needed.	Number of piezometers and sampling frequency yet to be determined	Continuation of the baseline monitoring program

Additional detail on each monitoring plan is presented in Large Table 15 to Large Table 19. For each monitoring plan, the tables specify the following:

- Media to be monitored
    - GW = groundwater
    - SW = surface water
    - S = seepage
    - PS = process stream (internal waste stream)
    - TW = treated water
- Status of Monitoring System:
    - E = existing
    - P = proposed
- Station ID: monitoring station nomenclature as shown in Large Table 15 to Large Table 19
- Location Map: Large Figure 7 to Large Figure 11 provide locations of monitoring stations
- Frequency: the frequency of monitoring
- Parameter Groups(s): Reference to the lists of monitoring parameters for each program (PLACEHOLDER, to be provided in permitting)
- Reporting Requirements: the frequency of monitoring report submittal

These monitoring plan components will be detailed in Sampling and Analysis Plans (SAP) that will be prepared as part of the permit application process 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 (SOP) specific to the various activities to be performed. The QAPP will detail the data quality objectives for the monitoring program, summarize 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 U.S. Environmental Protection Agency 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.

5.1 Internal Streams

Key internal waters will be monitored for water quality and flow rate or level. Large Table 15 and Large Figure 7 show the details of internal monitoring.

5.1.1 Flotation Tailings Basin (FTB) and Hydrometallurgical Residue Facility (HRF) Ponds

The pond water level in the FTB and HRF will be monitored daily.

The pond water quality in the FTB and HRF will be monitored monthly.

Monitoring within the FTB will occur in each cell (Cell 1E and Cell 2E) until the cells merge at which point there will only be one cell for monitoring (Cell 1/2E).

5.1.2 Flotation Tailings Basin (FTB) Seepage

The quantity of FTB seepage recovered from the FTB South Seepage Management System will be monitored continuously based on pump run hours with use of pump curves or with flow meters.

The quality of the FTB seepage recovered from the FTB South Seepage Management System will be monitored monthly.

The quantity of FTB seepage collected by the FTB Containment System will be monitored continuously based on pump run hours with use of pump curves or with flow meters.

The quality of the FTB seepage collected by the FTB Containment System will be monitored monthly.

The quantity of FTB seepage that is recycled to the FTB Pond and the quantity that is pumped to the WWTP will be monitored daily.

5.1.3 Hydrometallurgical Residue Facility (HRF) Leachate

The quantity of HRF Leachate will be monitored continuously based on pump run hours with use of pump curves or with flow meters.

The quality of the HRF Leachate will be monitored monthly to start and modified to quarterly once the quality has been verified as consistent.

5.1.4 Continued Existing Waste Streams

As described in Section 1.4.4, waste stream station WS009 is expected to be included in future permit requirements until the construction of the East Dam cuts off this inflow.

The quantity of flow at WS009 will be monitored quarterly during non-frozen conditions (approximately April, July, and October).

The quality of flow at WS009 will be monitored quarterly during non-frozen conditions (approximately April, July, and October).

5.2 Stormwater

The quantity of stormwater flowing from the Plant Site will be monitored at the perimeter stormwater pond outlets on a monthly basis during non-frozen conditions (approximately April to October).

The quality of the stormwater flowing from the site will be monitored on a monthly basis during non-frozen conditions (approximately April to October) at each stormwater outlet.
Large Table 16 and Large Figure 8 show the details of stormwater monitoring.

5.3 Surface Discharges

Surface discharges will be monitored. Large Table 17 and Large Figure 9 show the details of surface discharge monitoring.

5.3.1 Waste Water Treatment Plant (WWTP) Surface Discharges

The WWTP will discharge water to Unnamed Creek near existing surface discharge station SD006, Second Creek near existing surface discharge station SD026, and to new locations within the Trimble Creek watersheds as described in Section 2.3.

The quality of the WWTP effluent will be monitored on a monthly basis.

A flow meter will be installed on the WWTP effluent for continuous flow monitoring.

The total flow to each discharge location will be monitored monthly.

5.4 Surface Water

Key surface waters will be monitored. Large Table 18 and Large Figure 10 show the details of surface water monitoring.

5.4.1 Embarrass River and Tributaries

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 (Mud Lake Creek, Trimble Creek, and Unnamed Creek). Project impacts to these surface water bodies will be monitored and compared to surface water quality standards at Mud Lake Creek (MLC-2), Trimble Creek (TC-1) and Unnamed Creek (PM-11, which is existing SW003), as shown on Large Figure 10.

The Embarrass River flow upstream and downstream of the Project will be monitored monthly during non-frozen conditions (approximately April to October). This includes the continuation of monitoring at two locations along the Embarrass River (PM-12, which is existing NPDES Station SW004, and PM-13, which is existing NPDES Station SW005) that are currently monitored under the NPDES permit as discussed in Section 1.4.6 and another monitoring location at PM-12.2 that has been monitored for baseline conditions in 2010 through 2013.

Flow in Embarrass River, Mud Lake Creek, Trimble Creek and Unnamed Creek downstream of the Project will be monitored monthly during non-frozen conditions (approximately April to October).

Water quality in Embarrass River, Mud Lake Creek, Trimble Creek, and Unnamed Creek downstream of the Project will be monitored monthly during non-frozen conditions (approximately April to October).

5.4.2 Second Creek

Approximately 20% of the Plant Site is located in the Second Creek watershed. This includes the Process Plant Area, Area 1 Shops, Area 2 Shops, and the south side of the FTB, including the FTB South Seepage Management System. Project impacts to Second Creek will be monitored.

The Second Creek flow downstream of the Project will be monitored on a monthly basis during non-frozen conditions (approximately April to October).

Water quality in Second Creek downstream of the Project will be monitored monthly during non-frozen conditions (approximately April to October).

5.4.3 Colby Lake

Water will be appropriated from Colby Lake for use in the Beneficiation Plant and the Hydrometallurgical Plant.

Flow quantities pumped from Colby Lake will be monitored continuously based on pump run hours with a flow meter.

Water quality monitoring for Colby Lake as it relates to potential impacts from the Mine Site is discussed in Section 5.0 of Reference (8).

5.5 Groundwater

Groundwater in the surficial aquifer will be monitored for potential impacts from the Project. Groundwater at the Plant Site generally flows to the north and northwest. Groundwater quality and groundwater elevations will be monitored quarterly during non-frozen conditions (approximately April, July, and October) at monitoring wells within the FTB, near the toe of the FTB, and near the northern and western property boundaries (Large Figure 11).

Large Table 19 shows the details of groundwater monitoring.

5.6 Wetlands

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 4 of Reference (13) and Large Table 6.

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 to 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 be developed through the Environmental Review process, permitting, and during operations, reclamation, and long-term closure to define when changes are needed to the proposed water management systems.

A key component of adaptive management for water is the Adaptive Water Management Plan (Reference (5)) 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 Monthly Reporting

The NPDES/SDS permit and the Water Appropriations permit will require and define routine water quality and quantity reporting and annual reporting requirements. The content required for those reports will be defined in those permits.

Routine water quality reports will be submitted to the MPCA, and monthly water quantity reports will be submitted to the MDNR. In addition to water quantity and quality monitoring described in Section 5.0, PolyMet anticipates that routine reports will include:

- sulfur content of Flotation Tailings
- monthly precipitation
- water flow and water quality parameters of water from the Mine Site
- identification and explanation of variations from permit requirements, if any

6.2 Annual Reporting

An Annual NPDES/SDS Report will be submitted to the MPCA. PolyMet anticipates that it will include:

- a comparison of actual seepage, leachate, and pond water chemistry to the water chemistry estimated by the Project water model from start of operations through the past year

- the total gallons of water pumped between the FTB and Beneficiation Plant, from the FTB Containment System, from the FTB South Seepage Management System, and to the FTB from the Mine Site for the past year
- identification of any changes made to the FTB Containment System, the HRF leakage collection system, or the FTB South Seepage Management System during the last year
- a summary of any previously reported variations from permit requirements during the past year if any
- identification of any changes planned for the FTB Containment System, the HRF leakage collection system, or the FTB South Seepage Management System during the coming year

An Annual PTM Report will be submitted to the MDNR. PolyMet anticipates that it will include:

- the total tons of Flotation Tailings placed in the FTB from the start of operations through the past year and remaining planned capacity, including the estimated breakdown of Flotation Tailings composition of fines and slimes
- 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
- an update of the Flotation Tailings waste characterization program
- an update of the Residue waste characterization program
- an update on any pilot-testing or monitoring for development of non-mechanical treatment systems, as described in Section 6 of Reference (5)

- an update of any Special Performance Monitoring defined in Reference (5)
- an update on the results of any Test Projects defined in Reference (5)

An Annual Appropriations Report will be submitted to the MDNR. It is anticipated that it will include the monitoring data collected in accordance with the permit including:

- monthly records of the amount of water appropriated or used for each appropriation
- total amount appropriated for the year

6.3 Annual Comparison to Model

Annual reports will include comparison of actual water quantity and quality to the quantity and quality estimated by the Project water quality model updated with the most recent monitoring data for the conditions existing at the time of the report.

6.4 Model Refinements

The Project water model developed in Reference (2) is an integrated model that includes all aspects of the Project. If the annual comparison to model shows differences that can be logically explained as being caused by modeling assumptions that have been demonstrated to be incorrect, the model will be refined.

The adjusted model will be used to update the Project water quantity and quality estimates. If the update indicates that outcomes will not be acceptable, adaptive management will be initiated.

6.5 Adaptive Management

There are adaptive management actions that could be implemented if there is an exceedance of a surface or groundwater standard detected as part of water quality monitoring or if the water model projects a future exceedance of surface or groundwater standards given observed conditions. In general the steps will be:

1. Initiate any field studies that may be necessary to determine the root cause of the exceedance.
2. Once the root cause is identified, implement any adjustments that can be made to the adaptive engineering controls described in Reference (5) that will remedy the root cause. Adjustments to the adaptive engineering controls include changing the scale or type of control and/or its design.
3. If the exceedances persist, implement contingency mitigation (Section 6.6) that will remedy the root cause and include that contingency mitigation as an adaptive engineering control in Reference (5).

4. Monitor and model effects to the environment with new or adjusted engineering control. If issue persists begin Step 1 again.

6.6 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 (5). These mitigations would be developed and designed if needed and coordinated with the MDNR and MPCA as appropriate.

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

    i. The FTB Containment System or the FTB South Seepage Management 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 Mine Site WWTF 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 WWTP for treatment before being returned to the FTB Pond.

    iii. Pond water could be sent to the WWTP 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 Containment System.

Several of the potential mitigation options discussed above include additional treatment of water at the WWTP. The WWTP is, by design, adaptive, as described in Section 4.2 of Reference (5). The WWTP treatment capacity can be expanded by adding additional parallel treatment trains to accommodate additional flow.

7.0 Incremental and Final Reclamation

Reclamation information included in this document is for the Plant Site water management systems only. This includes incremental reclamation, final reclamation, and long-term closure activities. Reclamation information for the FTB is in Reference (3). Reclamation information for the HRF is in Reference (4). Reclamation information for other Plant Site infrastructure is included in Reference (6).

7.1 Incremental Reclamation

No incremental reclamation of water management systems is anticipated at this time.

7.2 Final Reclamation

The FTB seepage capture systems and WWTP will continue to operate through reclamation and long-term closure periods. During reclamation, water from the FTB seepage capture systems and WWTP will be pumped through the TWP to the Mine Site for use in flooding the West Pit. The treatment objective for the WWTP during reclamation will be to provide a source of clean water for stream augmentation and to the West Pit as it is flooded with water. The operation of the WWTP during reclamation is discussed in Section 4.2 in Reference (5).

HRF drainage water will be sent to the WWTP for treatment and discharge. Details of closure of the HRF are described in Section 7 of Reference (4).

7.3 Long-Term Closure

Monitoring, reporting, and water treatment will continue during long-term closure, until release from these activities is granted by MDNR via the PTM and the MPCA via the NPDES/SDS permit. If any of the monitoring data shows that additional work is needed, a plan will be created and implemented to further improve water quality.

During long-term closure, the water level in the FTB will be maintained to prevent overflows, and water from the FTB seepage capture systems will continue to be collected and pumped to the WWTP for treatment to meet the appropriate water discharge limits as described in Section 4 of Reference (5). The ultimate objective is to transition from the mechanical treatment provided by the WWTP to a non-mechanical treatment system once the non-mechanical treatment system has been demonstrated to provide the required water treatment. Options for non-mechanical water treatment at the Plant Site during long-term closure are described in Section 6 of Reference (5).

7.3.1 Monitoring

The monitoring and reporting described in Section 5.0 and 6.0 will continue until MDNR releases the company from doing so under the PTM and the MPCA releases the company under the NPDES/SDS permit.

7.3.2 Flotation Tailings Basin (FTB) South Seepage Management

The FTB South Seepage Management System will operate during long-term closure until the seeps stop or water resource objectives are achieved without mechanical treatment.

7.3.3 Flotation Tailings Basin (FTB) Containment System

The FTB Containment System will operate during long-term closure until water resource objectives are achieved without mechanical treatment or until non-mechanical treatment has been proven, as described in Section 6 of Reference (5).

7.3.4 Water Treatment

The WWTP will continue to operate through reclamation and long-term closure, until non-mechanical treatment is proven as described in Section 6 of Reference (5). During long-term closure, the primary treatment objective for the WWTP will be to meet the appropriate discharge limits for any excess water that needs to be discharged to the environment. The WWTP will continue to treat water collected from the FTB seepage capture systems, and HRF drainage water, along with water from the FTB Pond as needed to prevent any overflow. The WWTP will be maintained operable until MDNR releases the company from active water treatment requirements under the PTM and the MPCA releases the company under the NPDES/SDS permit. Operation of the WWTP during long-term closure is discussed in Section 4.2 of Reference (5).

7.4 Contingency Reclamation Estimates

The following section provides an overview of the contingency reclamation plan for Mine Year 0 and Mine Year 1. For more specific details on reclamation and the associated cost estimates, see the permit-level version of the Reclamation Plan with the contingency reclamation estimates that will be part of the PTM application.

7.4.1 Contingency Reclamation Plan (Mine Years 0 and 1)

7.4.1.1 Mine Year 0 (end of construction/development)

If closure were to occur at the end of Mine Year 0, the activities described in Section 7.2 and 7.3 will be implemented. No Flotation Tailings will have been deposited in the FTB.

The WWTP will not have to be operated.

This plan is used to develop the Mine Year 0 Contingency Reclamation Estimate that will be the basis for financial assurance required by Minnesota Rules, part 6132.1200, which is required before a PTM can be granted.

7.4.1.2 Mine Year 1 (end of first year of operations)

If closure were to occur at the end of Mine Year 1, the activities described in Sections 7.2 and 7.3 will be implemented. The FTB will contain approximately 11 million tons of Flotation Tailings, and the FTB Pond will contain approximately 950 million gallons of water at elevation 1580 feet.

Water treatment by the WWTP is expected to continue until other non-mechanical methods can be proven and implemented to treat seepage from the Tailings Basin.

This plan will be used to develop the contingency reclamation estimate that will be the basis for financial assurance required by Minnesota Rules, part 6132.1200 the first or second calendar year (depending on construction progress) after the issuance of the PTM. The Reclamation Plan and contingency reclamation estimate will be updated annually to include contingency reclamation for the site conditions representative of the end of the upcoming year of operation.

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 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.

References

1. **Poly Met Mining Inc.** NorthMet Project Project Description (v9). February 2015.

2. —. NorthMet Project Water Modeling Data Package Volume 2 - Plant Site (v11). March 2015.

3. —. NorthMet Project Flotation Tailings Management Plan (v5). February 2015.

4. —. NorthMet Project Residue Management Plan (v4). December 2014.

5. —. NorthMet Project Adaptive Water Management Plan (v7). February 2015.

6. —. NorthMet Project Reclamation Plan (v5). January 2015.

7. —. NorthMet Project Water Modeling Data Package Volume 1 - Mine Site (v14). February 2015.

8. —. NorthMet Project Water Management Plan - Mine Site (v4). February 2015.

9. —. NorthMet Project Wetland Data Package (v10). February 2015.

10. —. NorthMet Project Rock and Overburden Management Plan (v7). January 2015.

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

12. **Minnesota Department of Natural Resources, United States Army Corps of Engineers, United States Forest Service.** Supplemental Draft Environmental Impact Statement - NorthMet Mining Project and Land Exchange. November 2013.

13. **Poly Met Mining Inc.** NorthMet Project Wetland Management Plan (v7). January 2015.

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Large Table 1 Estimated FTB Pond Water Quality

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	0.20	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
SO4 (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 (2).

Large Table 2 Estimated Tailings Basin Seepage Water Quality from the North Toe

Constituent	Mine Year / Percentile / Units	Mine Year 5 Average P10(1)	Mine Year 5 Average P50(1)	Mine Year 5 Average P90(1)	Mine Year 20 Average P10(1)	Mine Year 20 Average P50(1)	Mine Year 20 Average P90(1)	Mine Year 30 Average P10(1)	Mine Year 30 Average P50(1)	Mine Year 30 Average P90(1)	Mine Year 60 Average P10(1)	Mine Year 60 Average P50(1)	Mine Year 60 Average P90(1)	Mine Year 100 Average P10(1)	Mine Year 100 Average P50(1)	Mine Year 100 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
SO4 (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 (2).

Large Table 3 Estimated Tailings Basin Seepage Water Quality from the Northwest 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	0.10	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
SO4 (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 (2).

Large Table 4 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
SO4 (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 (2).

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

Constituent	Mine Year / Percentile / Units	Mine Year 5 Average P10[1]	Mine Year 5 Average P50[1]	Mine Year 5 Average P90[1]	Mine Year 20 Average P10[1]	Mine Year 20 Average P50[1]	Mine Year 20 Average P90[1]	Mine Year 30 Average P10[1]	Mine Year 30 Average P50[1]	Mine Year 30 Average P90[1]	Mine Year 60 Average P10[1]	Mine Year 60 Average P50[1]	Mine Year 60 Average P90[1]	Mine Year 100 Average P10[1]	Mine Year 100 Average P50[1]	Mine Year 100 Average P90[1]
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
SO4 (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 (2).

Large Table 6 Estimated Water Quality along the North 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	0.10	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
SO4 (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 (7).
(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 7 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
SO4 (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 (7).
(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 West 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	0.11	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
SO4 (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 (7).
(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 Surface Water Quality for the Embarrass River at PM-12 (Existing NPDES Station SW004)

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	0.09	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
SO4 (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 (7).
(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 (7).

Large Table 10 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
SO4 (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 (7).
(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 (7).

Large Table 11 Estimated Surface Water Quality for the Embarrass River at PM-13 (Existing NPDES Station SW005)

	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)
Constituent	Units																
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
SO4 (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 (7).

(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 (7).

Large Table 12 Estimated Surface Water Quality for Mud Lake Creek at MLC-2

Constituent	Mine Year	Water Quality Standard	Mine Year 2			Mine Year 13			Mine Year 25			Mine Year 40			Mine Year 100(2)		
	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	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	ion0.13	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
SO4 (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 (7).
(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 (7).

Large Table 13 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
SO4 (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 (7).
(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 (7).

Large Table 14 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
SO4 (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 (7).
(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 (7).

Large Table 15 Monitoring Plan – Internal Streams – NorthMet Plant Site

Monitoring Plan	Media	Status	Station ID (Nomenclature)	Location	Parameter Group(s)	Frequency	Reporting Requirements	Additional Information
Flotation Tailings Basin (FTB) Pond	PS	P	Cell 1E Cell 2E Cell 1/2E	Large Figure 7	Water Level	Daily	Annual Monitoring Report	Monitoring of pond water levels
					Water Quality (TBD)	Monthly	Water Quality Monitoring Report • Annual • Quarterly	Monitoring of in-pond water quality trends
FTB Seepage	S	P	WS126	Large Figure 7	Flow rate	Continuous	Annual Monitoring Report	Monitoring of flow from the FTB South Seepage Management System recycled to the FTB Ponds and pumped to the WWTP
					Water Quality (TBD)	Monthly	Water Quality Monitoring Report • Annual • Quarterly	Monitoring of trends in water quality of recovered surface seeps
	S	P	FTB Containment System	Large Figure 7	Flow rate	Continuous	Annual Monitoring Report	Monitoring of flow from the FTB Containment System recycled to the FTB Ponds and pumped to the WWTP
					Water Quality (TBD)	Monthly	Water Quality Monitoring Report • Annual • Quarterly	Monitoring of trends in water quality of FTB Containment System
Hydrometallurgical Residue Facility	PS	P	HRF Pond	Large Figure 7	Water Level	Daily	Annual Monitoring Report	Monitoring of pond water levels
					Water Quality (TBD)	Monthly	Water Quality Monitoring Report • Annual • Quarterly	Monitoring of in-pond water quality trends
	PS	P	HRF Leachate	Large Figure 7	Flow rate	Continuous	Annual Monitoring Report	Monitoring the quantity of leachate collected by the drainage layer.
					Water Quality (TBD)	Monthly or Quarterly	Water Quality Monitoring Report • Annual • Quarterly	Monitoring of leachate water quality.
Continued Existing Waste Streams	SW	P	WS009	Large Figure 7	Flow Rate	Quarterly during non-frozen conditions (Apr, Jul, Oct)	Annual Monitoring Report	Monitoring the quantity of water that enters the Tailings Basin from the east. Monitoring will cease once the East Dam is constructed in this area, which will cut off this flow.
					Water Quality (TBD)	Quarterly during non-frozen conditions (Apr, Jul, Oct)	Water Quality Monitoring Report • Annual • Quarterly	Monitoring of water entering the Tailings Basin from the east. Monitoring will cease once the East Dam is constructed in this area, which will cut off this flow.

Large Table 16 Monitoring Plan – Stormwater – NorthMet Plant Site

Monitoring Plan	Media	Status	Station ID (Nomenclature)	Location	Parameter Group(s)	Frequency	Reporting Requirements	Additional Information
Stormwater	SW	P	TBD	Large Figure 8	Flow rate	Monthly during non-frozen conditions (approximately April to October)	Annual Monitoring Report	Monitor volume of stormwater outflows from the Plant Site
					Water Quality (TBD)	Monthly during non-frozen conditions (approximately April to October)	Water Quality Monitoring Report • Annual • Quarterly	Monitor quality of stormwater outflows from the Plant Site

Large Table 17 Monitoring Plan – Surface Discharges – NorthMet Plant Site

Monitoring Plan	Media	Status	Station ID (Nomenclature)	Location	Parameter Group(s)	Frequency	Reporting Requirements	Additional Information
WWTP Effluent	TW	P	TBD	Large Figure 9	Flow rate	Continuous	Annual Monitoring Report	Monitoring effluent quantity
					Water Quality (TBD)	Monthly	Water Quality Monitoring Report • Annual • Monthly	Monitoring effluent characteristics to document water quality prior to discharge
	SW	P	TBD (Unnamed Creek, near SD006)	Large Figure 9	Total Flow	Monthly	Annual Monitoring Report	Monitoring of WWTP discharge volume to Unnamed Creek
	SW	P	TBD (Trimble Creek)	Large Figure 9	Total Flow	Monthly	Annual Monitoring Report	Monitoring of WWTP discharge volume to Trimble Creek
	SW	P	TBD (Mud Lake Creek)	Large Figure 9	Total Flow	Monthly	Annual Monitoring Report	Monitoring of WWTP discharge volume to Mud Lake Creek
	SW	P	SD026 (Second Creek)	Large Figure 9	Total Flow	Monthly	Annual Monitoring Report	Monitoring of WWTP discharge volume to Second Creek

Large Table 18 Monitoring Plan – Surface Water – NorthMet Plant Site

Monitoring Plan	Media	Status	Station ID (Nomenclature)	Location	Parameter Group(s)	Frequency	Reporting Requirements	Additional Information
Embarrass River and Tributaries	SW	E	PM-12 (existing NPDES station SW004) PM-12.2 PM-13 (existing NPDES station SW005) MLC-2 PM-19 PM-11 (existing NPDES station SW003)	Large Figure 10	Flow rate	Monthly during non-frozen conditions (April to October)	Annual Monitoring Report	Monitoring streamflow in the Embarrass River.
					Water Quality (TBD)	Monthly during non-frozen conditions (April to October)	Water Quality Monitoring Report • Annual • Quarterly	Monitoring water quality in the Embarrass River and tributaries.
Second Creek	SW	P	PM-7	Large Figure 10	Flow rate	Monthly during non-frozen conditions (April to October)	Annual Monitoring Report	Monitoring streamflow in Second Creek downstream of the FTB South Seepage Management System and downstream of the WWTP discharge
					Water Quality (TBD)	Monthly during non-frozen conditions (April to October)	Water Quality Monitoring Report • Annual • Quarterly	Monitoring of Second Creek downstream of the FTB South Seepage Management System and downstream of the WWTP discharge
Colby Lake Intake	SW	P	TBD (Colby Lake)	See Large Figure 102 of Reference (8)	Flow rate	Continuous	Water Quantity Monitoring Report • Annual • Monthly	Monitoring of the Colby Lake intake (existing location)
	SW	P	TBD (Unnamed Creek)	Large Figure 10	Total Flow	Monthly	Annual Monitoring Report	Monitoring of transfer of Colby Lake water for augmentation of Unnamed Creek.
	SW	P	TBD (Trimble Creek)	Large Figure 10	Total Flow	Monthly	Annual Monitoring Report	Monitoring of transfer of Colby Lake water for augmentation of Trimble Creek.
	SW	P	TBD (Mud Lake Creek)	Large Figure 10	Total Flow	Monthly	Annual Monitoring Report	Monitoring of transfer of Colby Lake water for augmentation in Mud Lake Creek.
	SW	P	TBD (Second Creek)	Large Figure 10	Total Flow	Monthly	Annual Monitoring Report	Monitoring of transfer of Colby Lake water for augmentation in Second Creek.

Large Table 19 Monitoring Plan – Groundwater – NorthMet Plant Site

Monitoring Plan	Media	Status	Station ID (Nomenclature)	Location	Parameter Group(s)	Frequency	Reporting Requirements	Additional Information
Groundwater	GW	E	GW001 GW002 GW003(1) GW004(1) GW005 GW006 GW007 GW008 GW009 GW010 GW011 GW012 GW013 GW014 GW015 GW016	Large Figure 11	Groundwater Elevations	Quarterly during non-frozen conditions (April, July October)	Water Quality Monitoring Report • Annual • Quarterly	Monitoring groundwater levels
					Water Quality (TBD)	Quarterly during non-frozen conditions (April, July, October)	Water Quality Monitoring Report • Annual • Quarterly	Monitor groundwater quality trends through time

(1) Monitoring wells GW003 and GW004 are currently dry and have been dry for a number of years. These wells will be checked during each monitoring event. If they are found to contain water, groundwater elevations will be measured and the feasibility of obtaining groundwater quality samples will be evaluated.

Large Table 20 Monitoring Plan – Wetland Hydrology – NorthMet Plant Site

Monitoring Plan	Media	Status	Station ID (Nomenclature)	Location	Parameter Group(s)	Frequency	Reporting Requirements	Additional Information
Wetlands – Baseline Monitoring								
Baseline Wetlands for the Plant Site	GW	E	Well TB1 through TB14 and TB1M through TB7M Ref TB1, Ref TB8, and Ref TB8M	Large Figure 8 in Reference (13)	Elevation – relative to ground surface	In progress Began in 2010 Ranging from monthly to continuous during non-freezing months	Varies	Provide sufficient hydrology information to allow identification of potential indirect hydrologic impacts to wetlands. There are currently 24 wetland hydrology monitoring wells at the Plant Site; see Section 4.3 of the Wetland Management Plan (Reference (13))
Wetlands – Operations Monitoring								
Plant Site Wetlands	GW	E P	TBD in permitting TBD in permitting	Large Figure 8 in Reference (13)	Elevation – relative to ground surface	TBD in permitting	TBD in permitting	This program will provide the necessary information to determine whether indirect hydrologic impacts have occurred and to assess required mitigation measures. Additional information is available in Section 4.4 of the Wetland Management Plan (Reference (13)) Final number of wells is TBD in permitting

Large Figures

Surface Water Evaluation Location PM-13

Project Areas

Existing Surface Discharge Station

Existing Surface Discharge Station and Temporary Pumpback System

USGS Gage

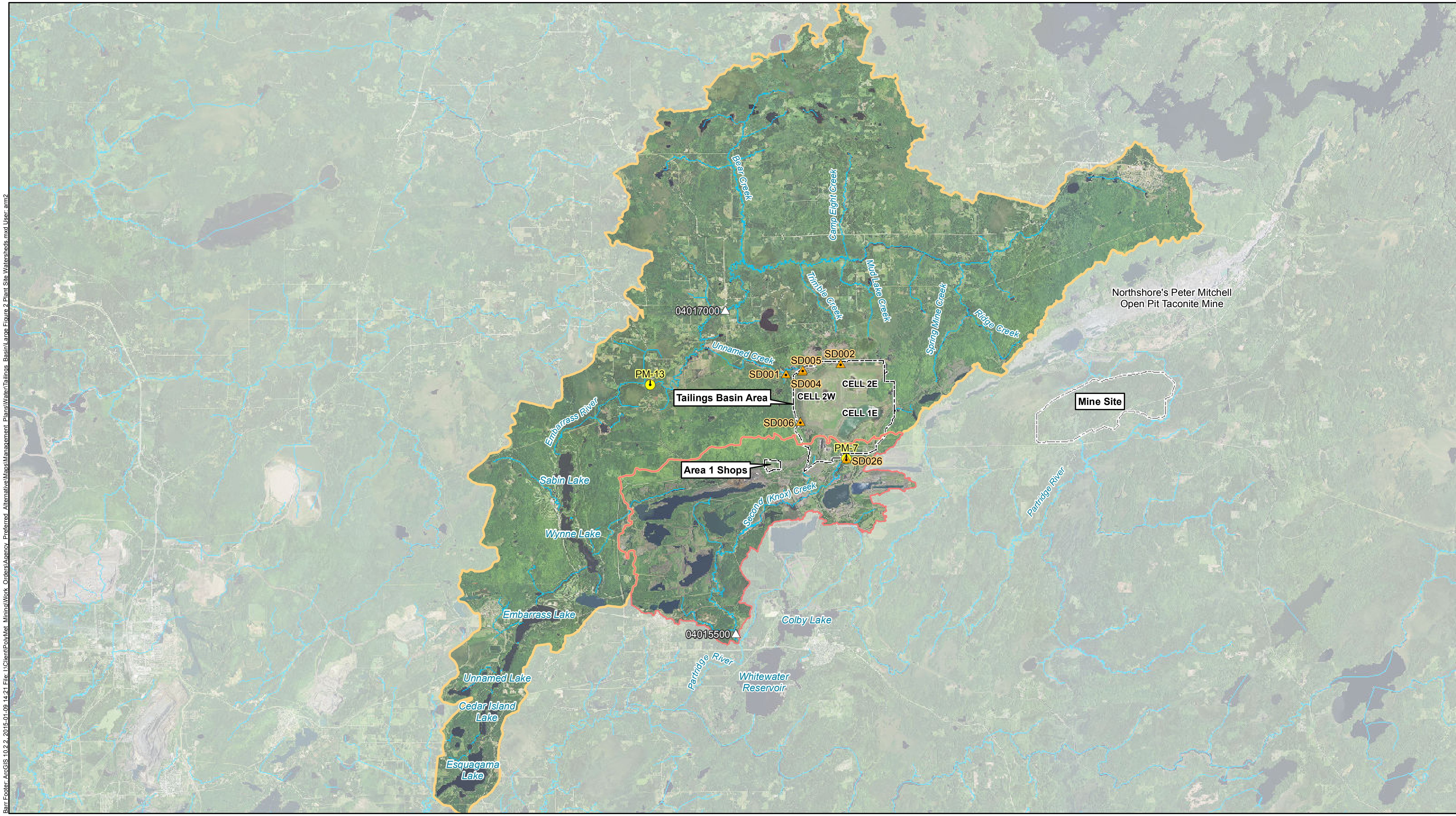
Stormwater Flow Lines

Streams and Rivers

0 1,750 3,500 7,000

Feet

Large Figure 1
EXISTING TAILINGS BASIN
NorthMet Project
Poly Met Mining, Inc.
Hoyt Lakes, MN

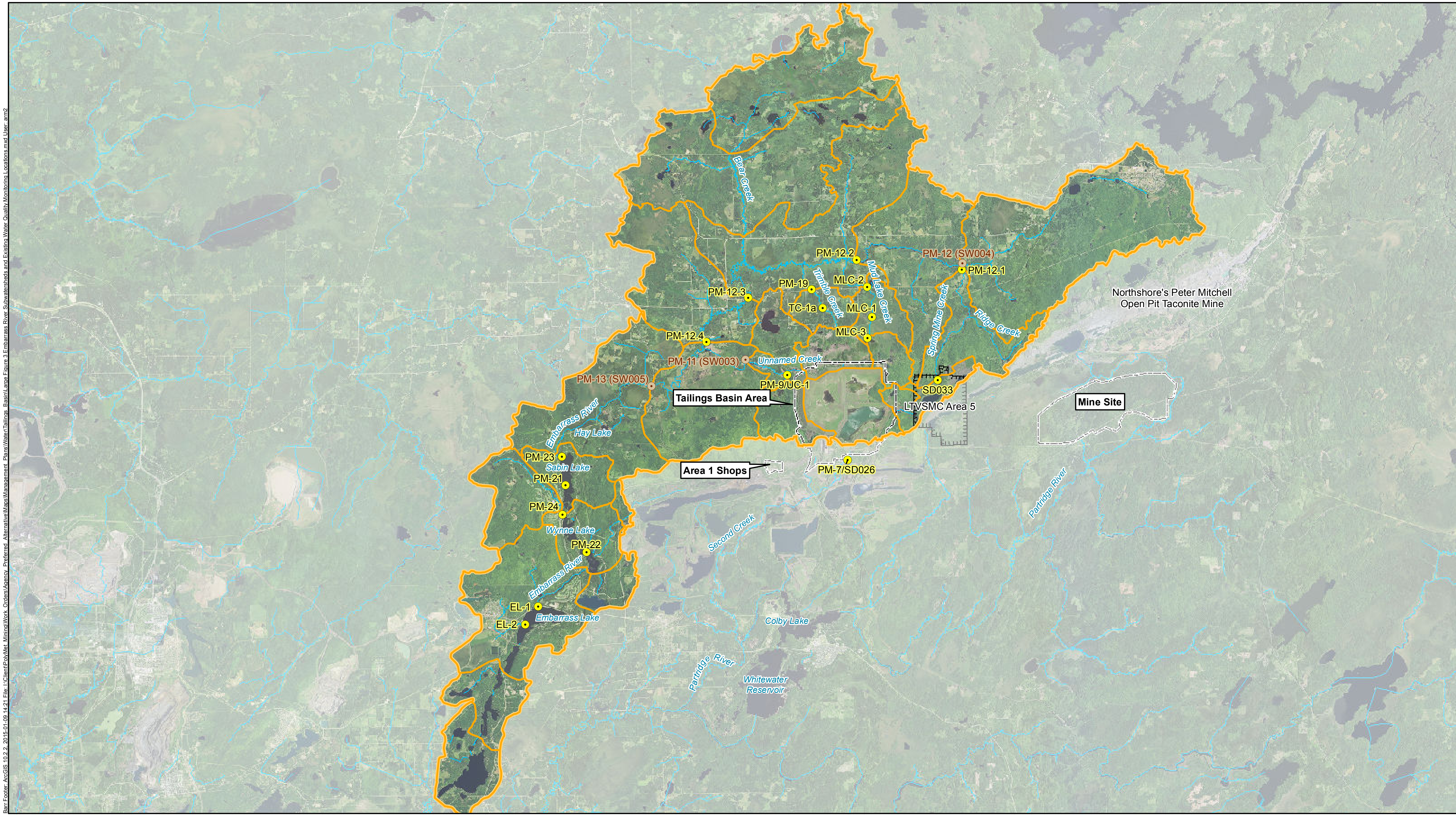


Existing Surface Discharge Station
Surface Water Evaluation Location
USGS Gages
Second Creek Watershed
Embarrass River Watershed
Project Areas
Streams/Rivers

0 1.25 2.5 5
Miles

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

Large Figure 2
PLANT SITE WATERSHEDS
NorthMet Project
Poly Met Mining, Inc.
Hoyt Lakes, MN



Existing Surface Water Stations

Surface Water Monitoring Locations

Embarrass River Subwatersheds

Embarrass River Watershed

LTVSMC Area 5

Project Area

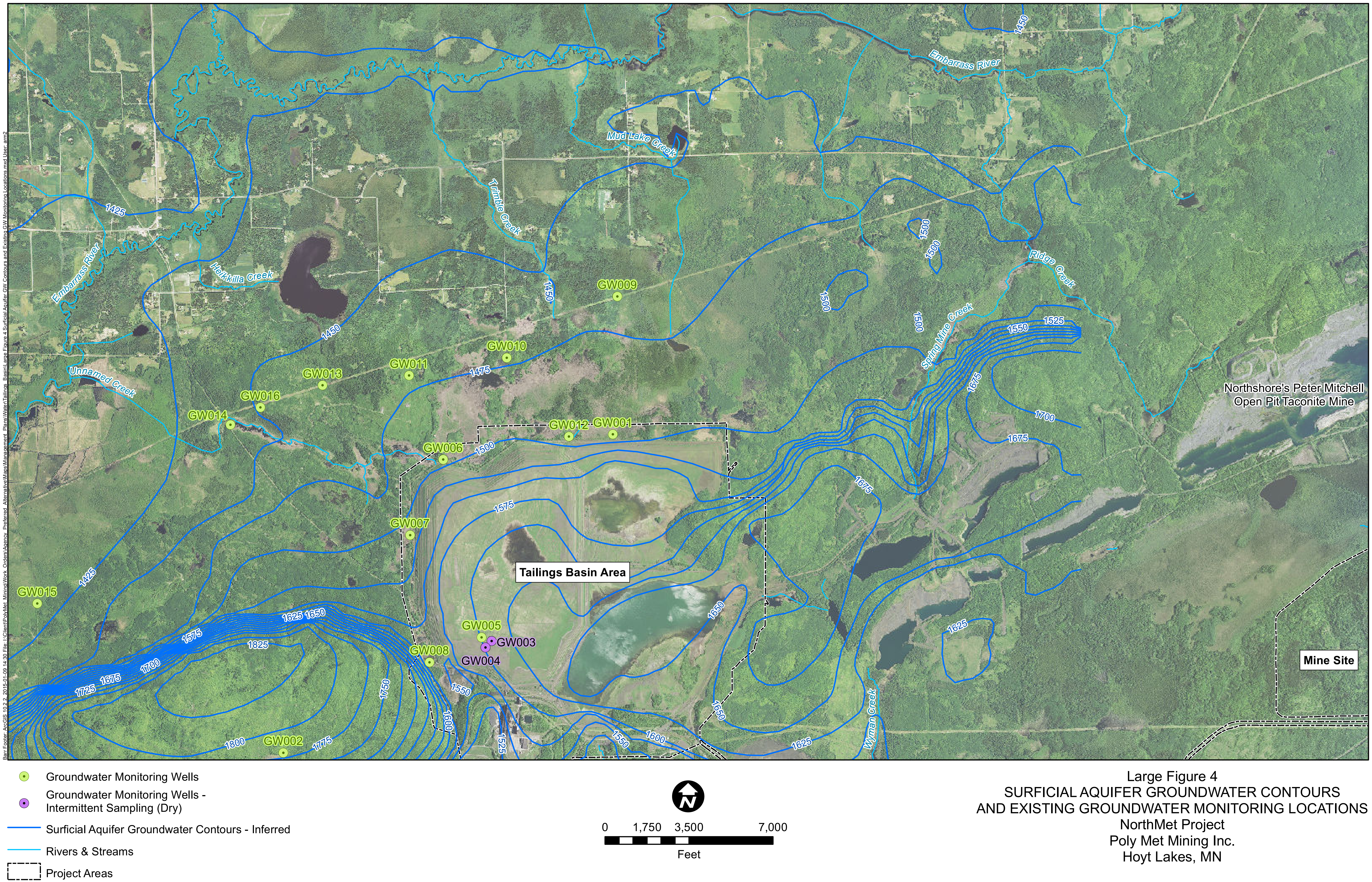
Streams and Rivers

0 1.25 2.5 5

Miles

Large Figure 3
EMBARRASS RIVER SUBWATERSHEDS AND
EXISTING WATER QUALITY MONITORING LOCATIONS
NorthMet Project
Poly Met Mining, Inc.
Hoyt Lakes, MN

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.



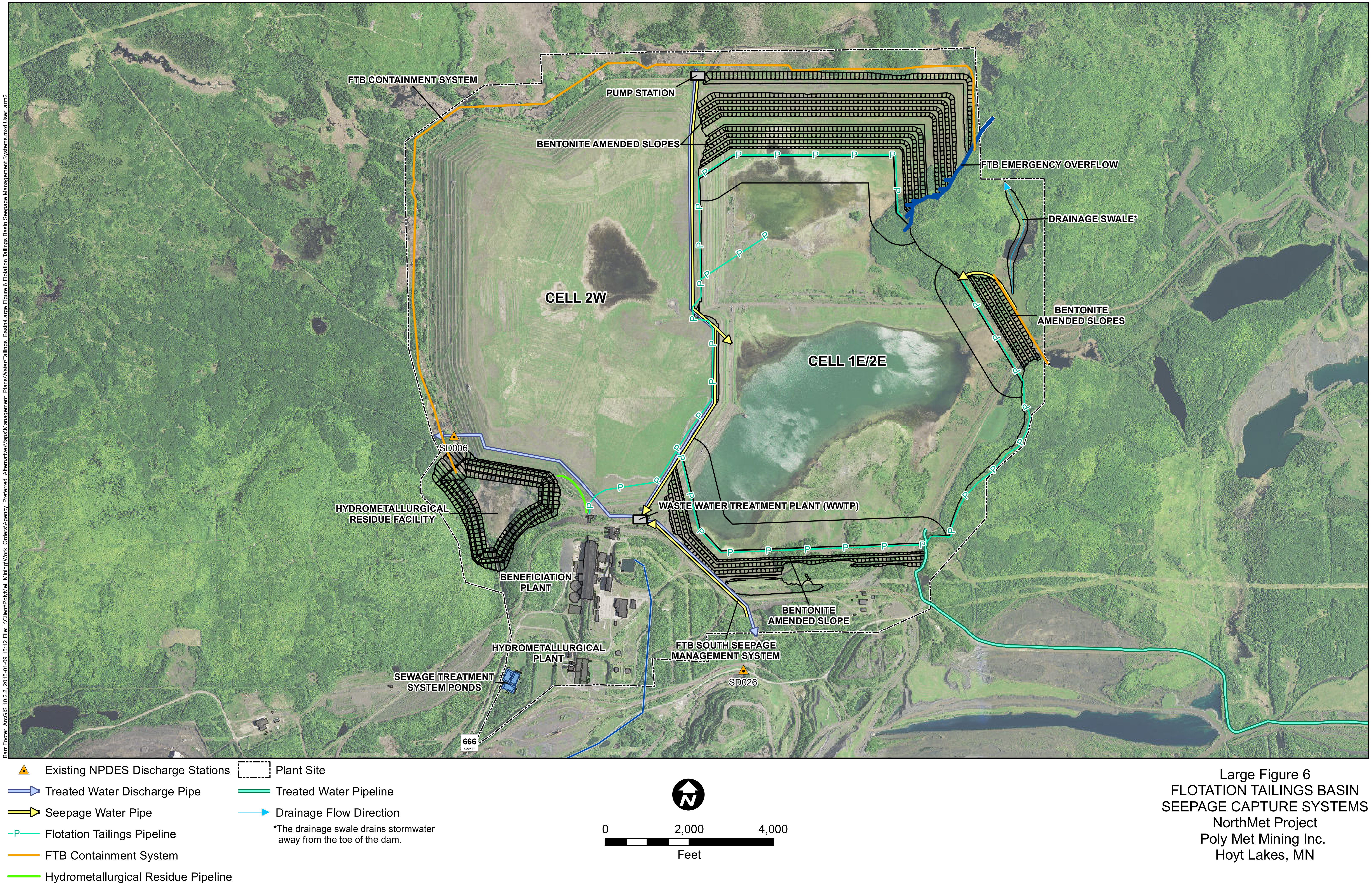
Large Figure 4
SURFICIAL AQUIFER GROUNDWATER CONTOURS
AND EXISTING GROUNDWATER MONITORING LOCATIONS
NorthMet Project
Poly Met Mining Inc.
Hoyt Lakes, MN

Barr Footer: ArcGIS 10.2.2, 2015-01-09 14:59 File: I:\Client\PolyMet_Mining\Work_Orders\Agency_Preferred_Alternative\Maps\Management_Plans\Water\Tailings_Basin\Large Figure 5 Existing Seeps and Existing Tailings Basin NPDES Monitoring Stations.mxd User: arm2

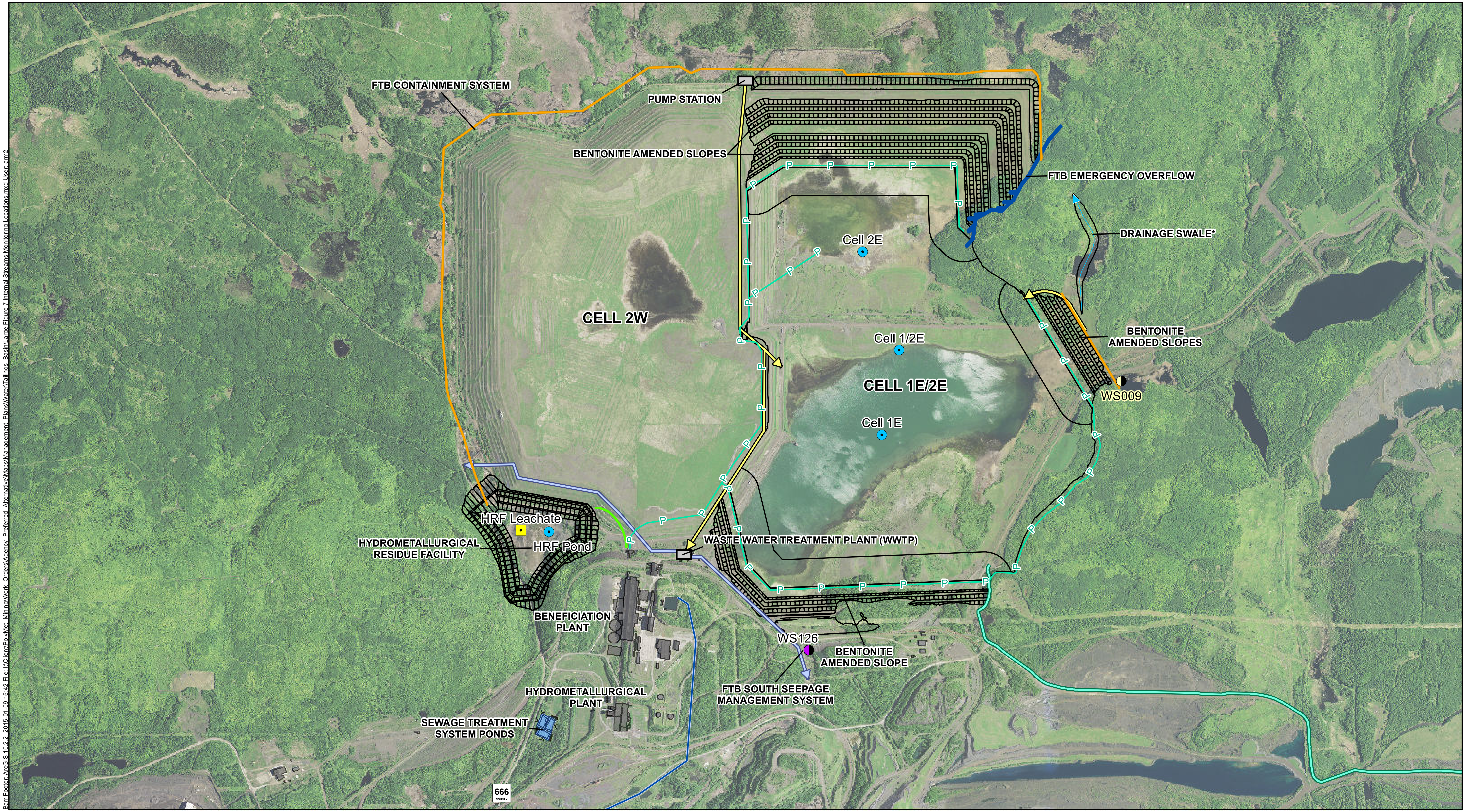
- Existing Surface Discharge Station
- Seep Temporary Pumpback System
- Existing Waste Stream Station
- Culvert
- Seeps
- Rivers & Streams
- Railroads

0 2,000 4,000
Feet

Large Figure 5
EXISTING SEEPS AND EXISTING TAILINGS BASIN NPDES MONITORING STATIONS
NorthMet Project
Poly Met Mining Inc.
Hoyt Lakes, MN



Large Figure 6
FLOTATION TAILINGS BASIN
SEEPAGE CAPTURE SYSTEMS
NorthMet Project
Poly Met Mining Inc.
Hoyt Lakes, MN



Additional Waste Stream Stations TBD

- Future Internal Waste Stream
- Existing Internal Waste Stream
- Pond Monitoring Location[1]
- HRF Drainage Layer Monitoring Location[1]

[1]Actual locations to be determined

- Treated Water Discharge Pipe
- Seepage Water Pipe
- Flotation Tailings Pipeline
- FTB Containment System
- Hydrometallurgical Residue Pipeline
- Treated Water Pipeline
- Drainage Flow Direction

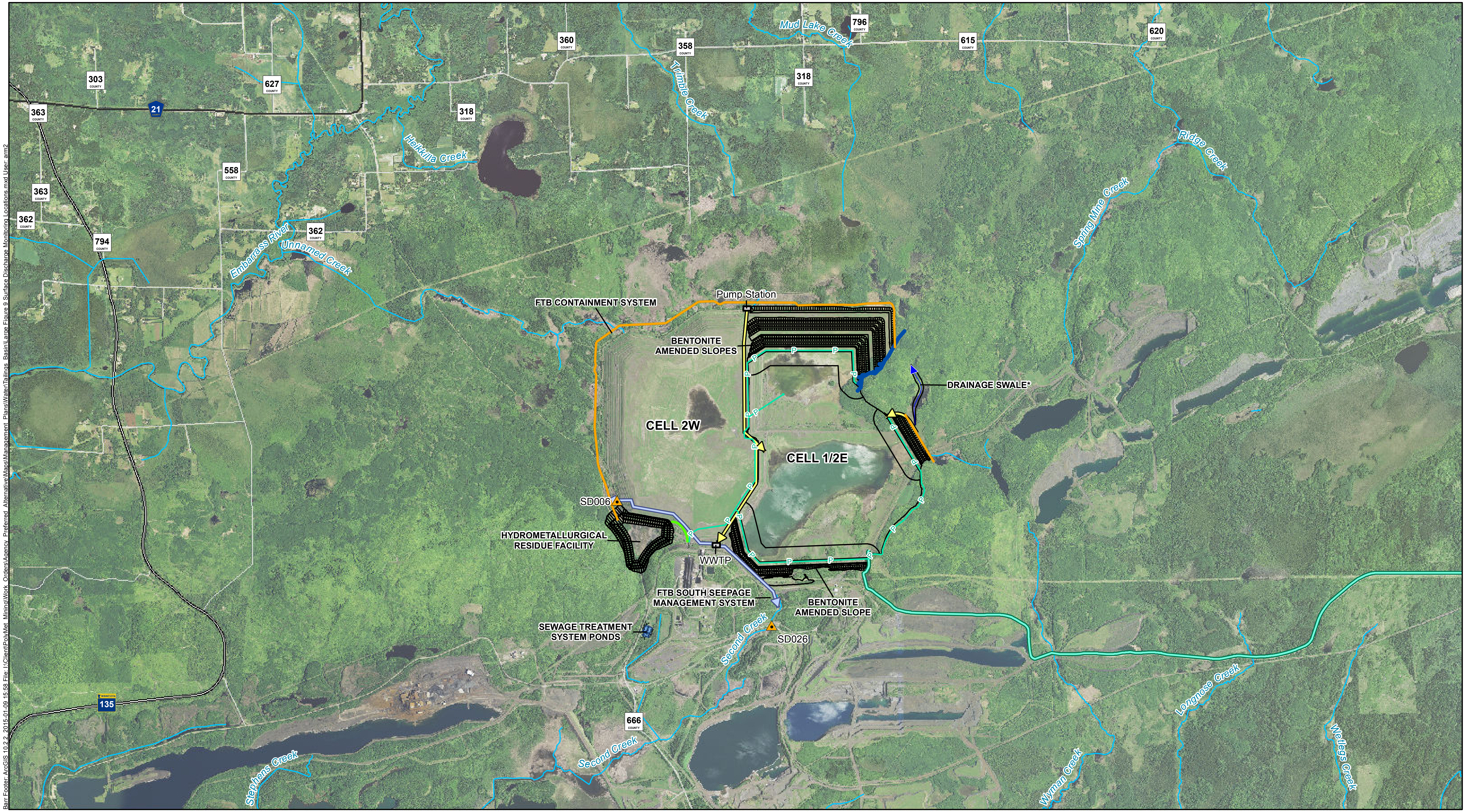
*The drainage swale drains stormwater away from the toe of the dam.

0 2,000 4,000
Feet

Large Figure 7
INTERNAL STREAMS MONITORING LOCATIONS
NorthMet Project
Poly Met Mining Inc.
Hoyt Lakes, MN

Barr Footer: ArcGIS 10.2.2, 2015-01-09 15:42 File: I:\Client\PolyMet_Mining\Work_Orders\Agency_Preferred_Alternative\Maps\Management_Plans\Water\Tailings_Basin\Large Figure 7 Internal Streams Monitoring Locations.mxd User: arm2

Large Figure 8 Stormwater Monitoring Locations – PLACEHOLDER



Barr Footer: ArcGIS 10.2.2, 2015-01-09 15:58 File: I:\Client\PolyMet_Mining\Work_Orders\Agency_Preferred_Alternative\Maps\Management_Plans\Water\Tailings_Basin\Large Figure 9 Surface Discharge Monitoring Locations.mxd User: arm2

Additional Surface Discharge Stations TBD

- Surface Discharge Station
- FTB Containment System
- Treated Water Discharge Pipe
- Seepage Water Pipe
- Flotation Tailings Pipeline
- Hydrometallurgical Residue Pipeline
- Treated Water Pipeline
- Streams and Rivers
- Drainage Flow Direction

*The drainage swale drains stormwater away from the toe of the dam.

0 4,000 8,000
Feet

Large Figure 9
SURFACE DISCHARGE MONITORING LOCATIONS
NorthMet Project
Poly Met Mining Inc.
Hoyt Lakes, MN

Additional Surface Monitoring Locations TBD

Surface Water Monitoring Locations

Rivers & Streams

Project Areas

0 4,000 8,000

Feet

Large Figure 10
SURFACE WATER
MONITORING LOCATIONS
NorthMet Project
Poly Met Mining Inc.
Hoyt Lakes, MN

Groundwater Monitoring Wells

Groundwater Monitoring Wells - Intermittent Sampling (Dry)

Rivers & Streams

PolyMet Property Boundary

0 3,000 6,000

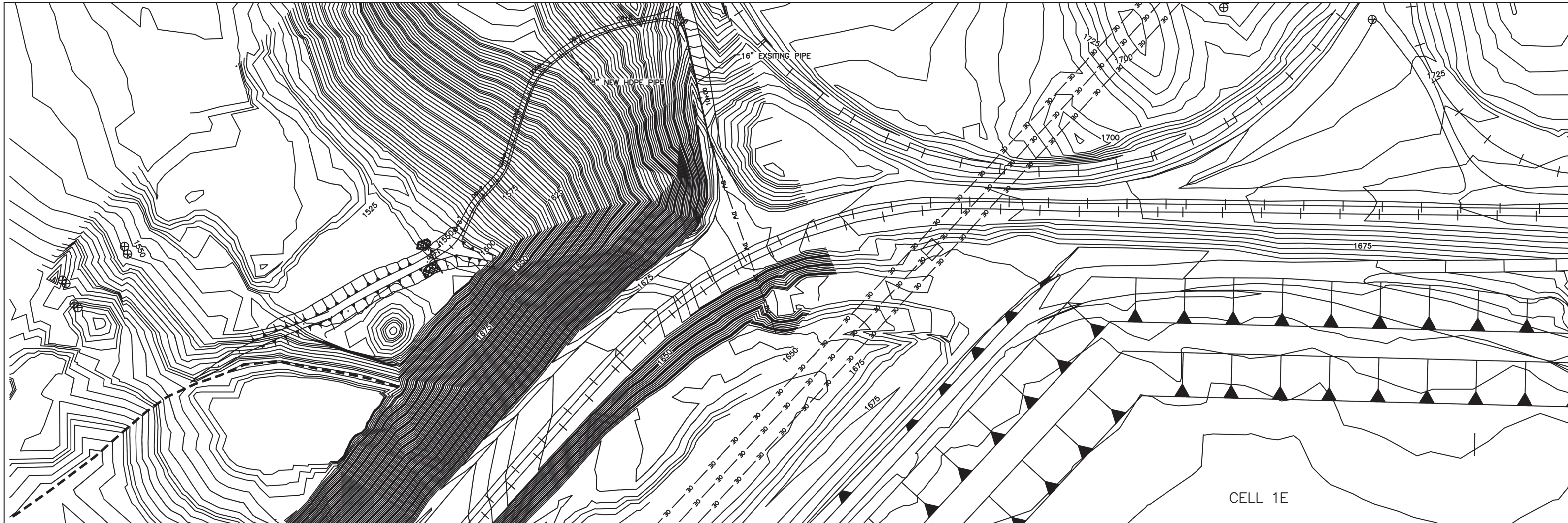
Feet

Large Figure 11
GROUNDWATER
MONITORING LOCATIONS
NorthMet Project
Poly Met Mining Inc.
Hoyt Lakes, MN

Attachments

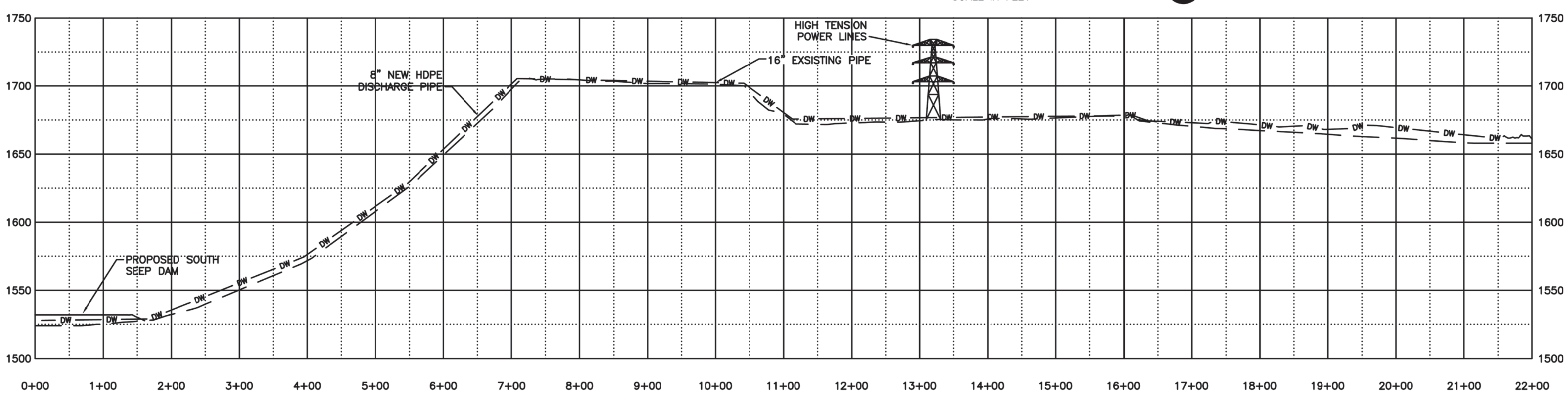
Attachment A

Seepage Management System Design Drawings



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

Note: These drawings reflect the current design of the 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 WWTP. These drawings will be revised for permitting to show these proposed design changes for the NorthMet Project.

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

BY: DATE:

LEGEND:

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

REV NO	DATE	REVISIONS	BY	CHKR
1	1/2013	SUMP LOCATION	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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DATE ______ REG. NO. ______

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

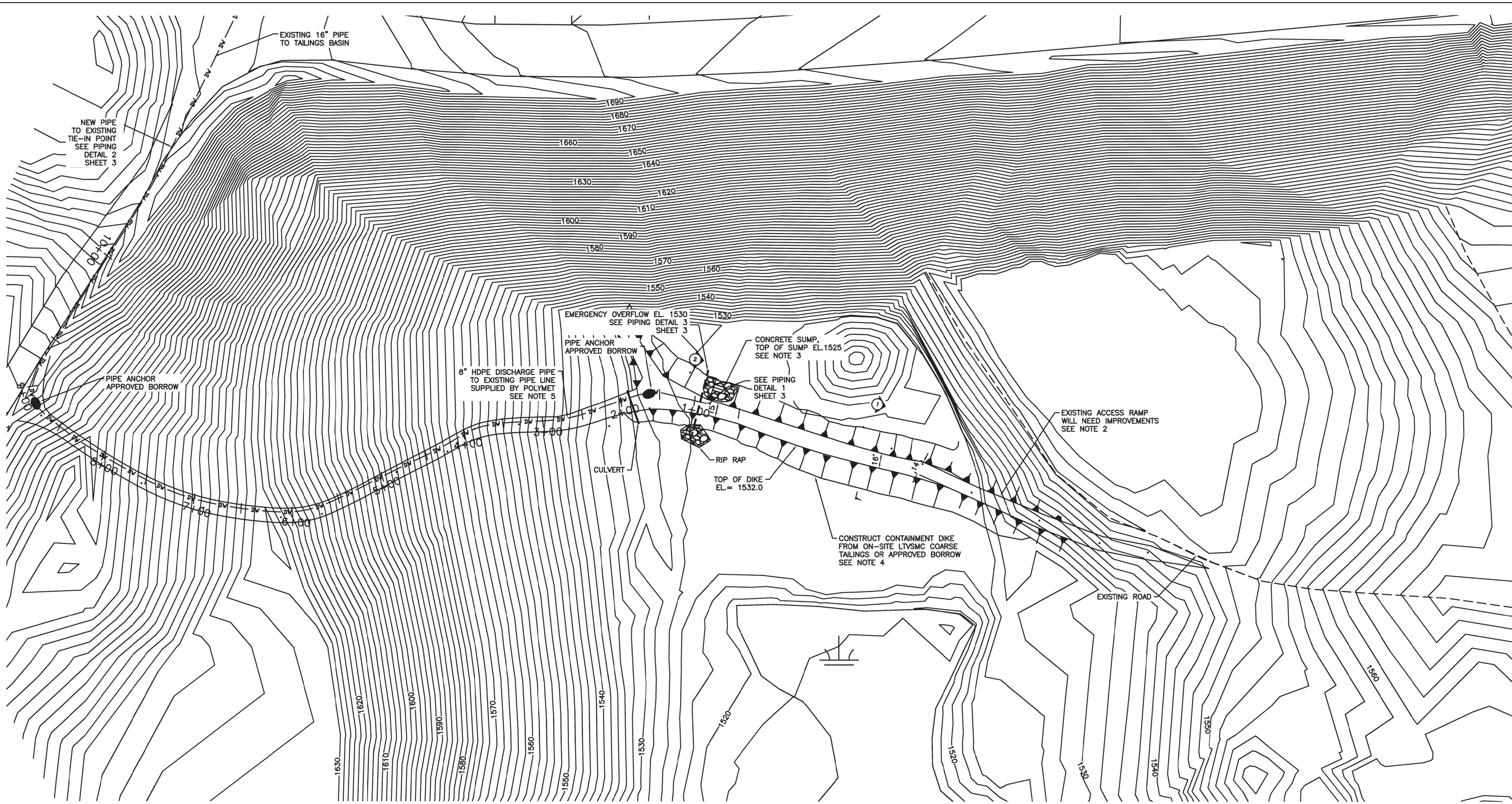
TAILINGS BASIN CONSENT DCREE
TEMPORARY SEEPAGE COLLECTION SYSTEM
CELL 1E SEEP 026 – PLAN AND PROFILE

POLYMET MINING INC.
NORTHMET PROJECT
HOYT LAKES, MINNESOTA

POLYMET MINING

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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PRELIMINARY	–	–	–	–
APPROVED FOR CONSTRUCTION	–	–	–	–

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DATE ______ REG. NO. ______

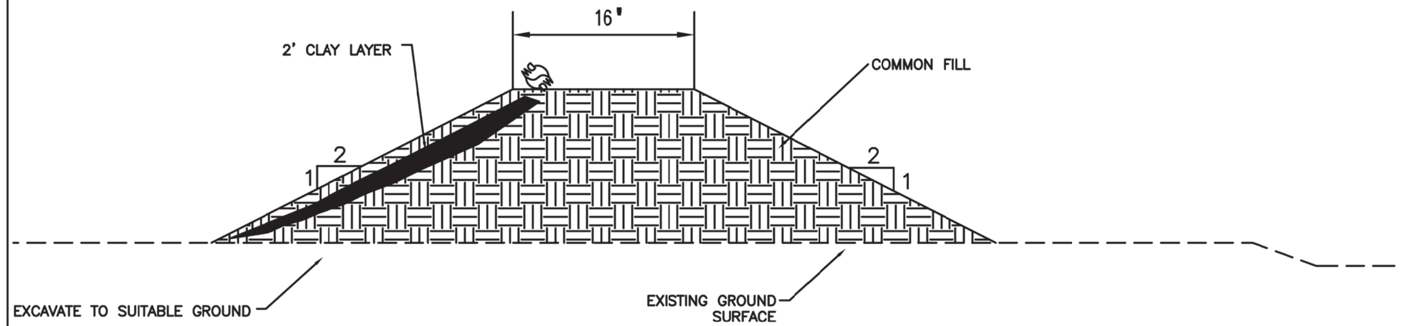
DRAWN: DH	DATE: 8/4/2010
CHECKED: PB	DATE: 8/5/2010
SCALE: –	
SHEET 2 OF 3	

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

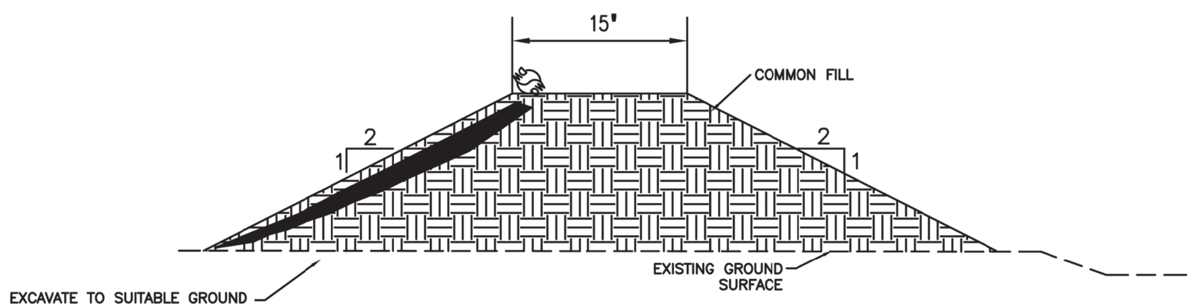
POLYMET MINING
POLYMET MINING INC.
NORTHMET PROJECT
HOYT LAKES, MINNESOTA

DWG. NO. TJ–2–001 REV 1

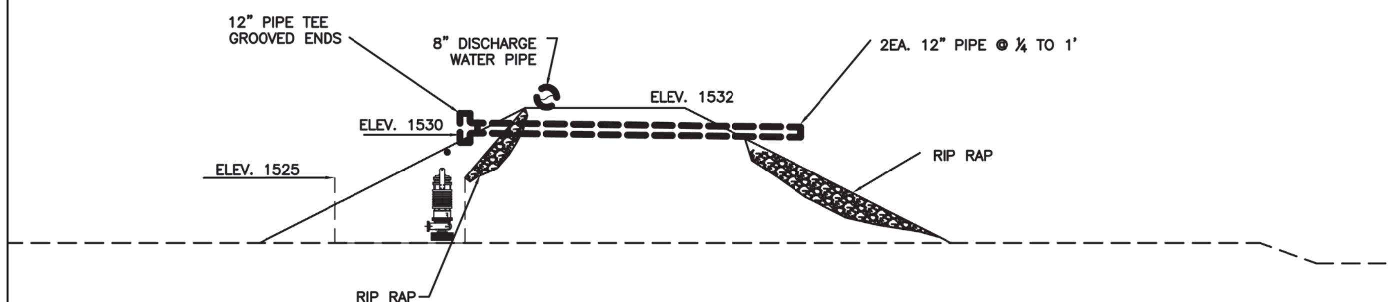
INCHES 1 2



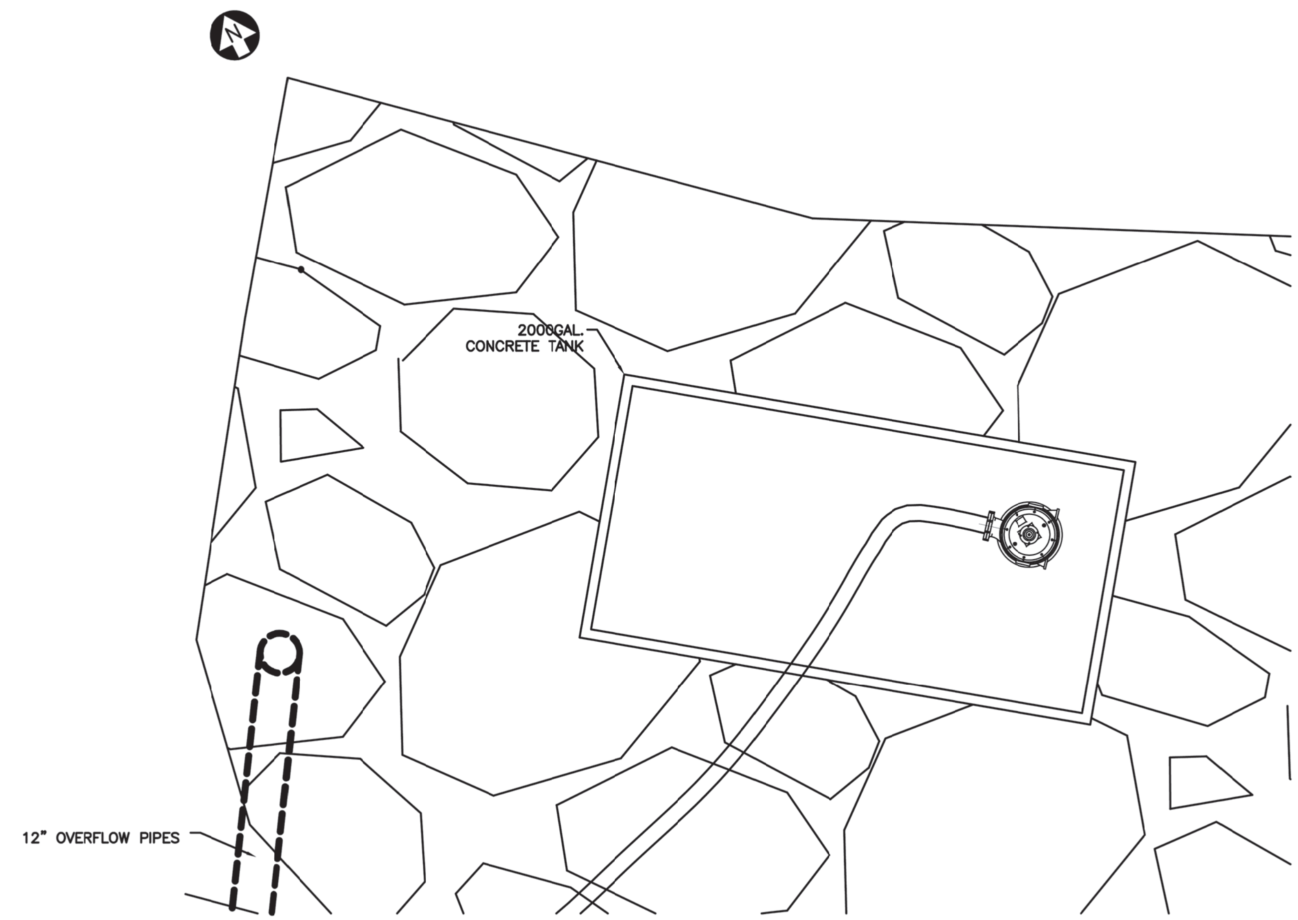
1 SH2 SECTION: DIKE



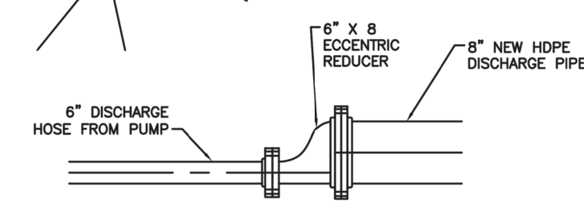
2 SH2 SECTION: DIKE



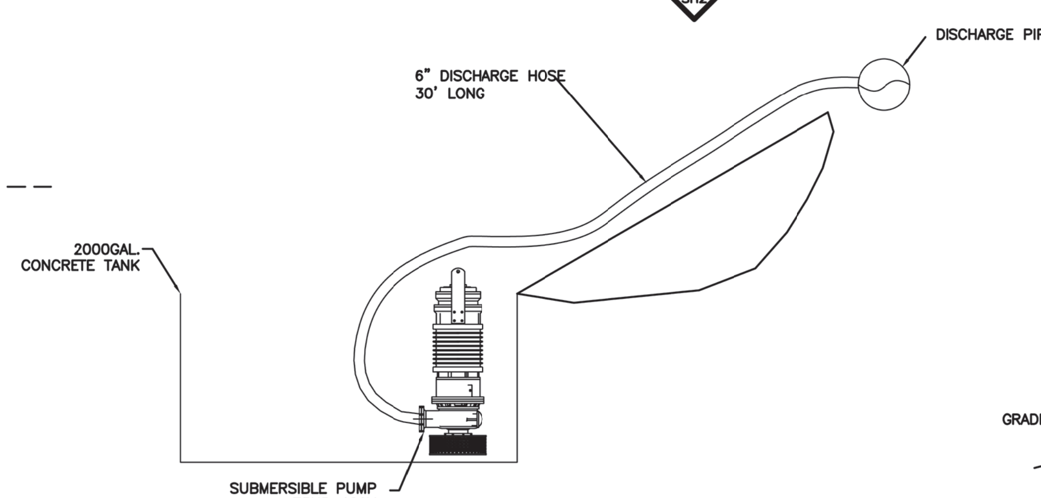
3 SH2 OVER FLOW DETAIL

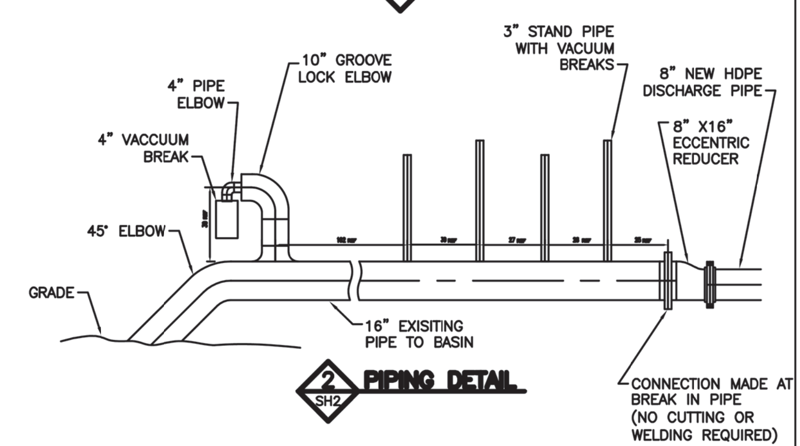


1 SH2 PIPING & SUMP DETAIL PLAN VIEW



1 SH2 PIPING DETAIL





2 SH2 PIPING DETAIL

1 SH2 PIPING & SUMP DETAIL ELEVATION VIEW

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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APPROVED FOR CONSTRUCTION	–	–	–	–	
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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

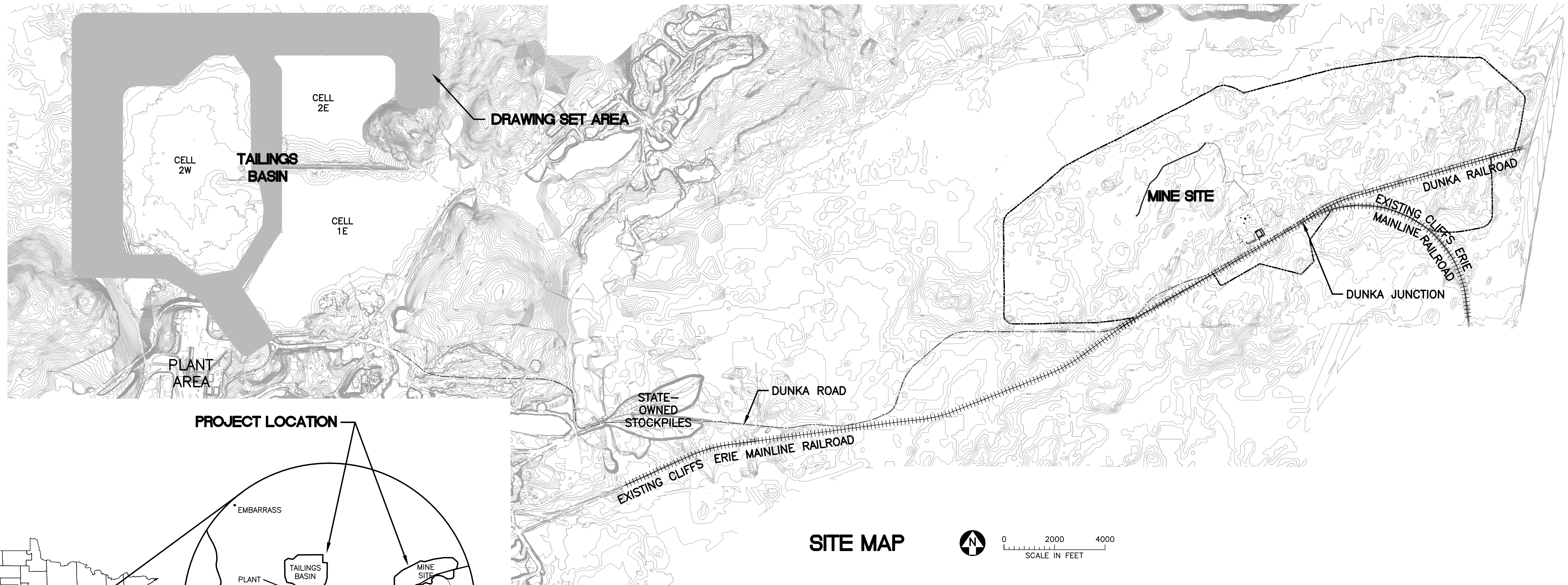
DWG. NO. TJ–2–001 REV 1

INCHES 1 2

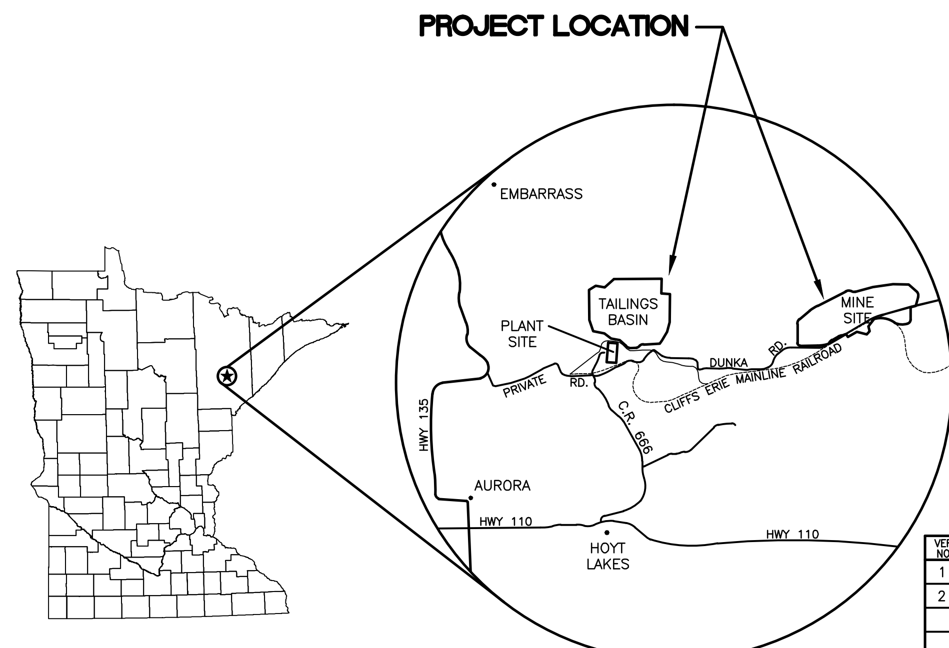
Attachment B

Flotation Tailings Basin Seepage Containment System Permit Support Drawings

POLYMET MINING INC NORTHMET PROJECT
FTB SEEPAGE CONTAINMENT
AND STREAM AUGMENTATION SYSTEMS
HOYT LAKES, MINNESOTA



SITE MAP



LOCATION MAP

NOT TO SCALE

VICINITY MAP

NOT TO SCALE

PLANT DRAWING NUMBER:

FTB SEEPAGE CONTAINMENT
AND STREAM AUGMENTATION SYSTEMS
LOCATION MAP AND SITE MAP

VER NO	DATE	DESCRIPTION
1	09/09/14	PRELIMINARY DESIGN FOR AGENCY INFORMATION
2	12/31/14	PRELIMINARY DESIGN FOR AGENCY INFORMATION

DRAWING STATUS		
ISSUED	VERSION	DATE
FOR PERMITTING	–	–
FOR CONSTRUCTION	–	–

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SIGNATURE ____________

PRINTED NAME ____________

DATE ________ REG. NO. ________

DRAWN: BDP

CHECKED: DVS/AMP

BARR PROJECT NO.: 23/69-0C29

SCALE: AS SHOWN

POLYMET MINING, INC.
NORTHMET PROJECT
HOYT LAKES, MINNESOTA

BARR ENGINEERING COMPANY
4700 WEST 77TH STREET
MINNEAPOLIS, MN.
Ph: 1-800-632-2277

DWG. NO. FTBCA-001

REV

CADD USER: Brian Hughes FILE: K:\DESIGN\23690C29.10\PERMIT_NMT-10-CU-001.DWG PLOT SCALE: 1:2 PLOT DATE: 1/6/2015 2:34 PM

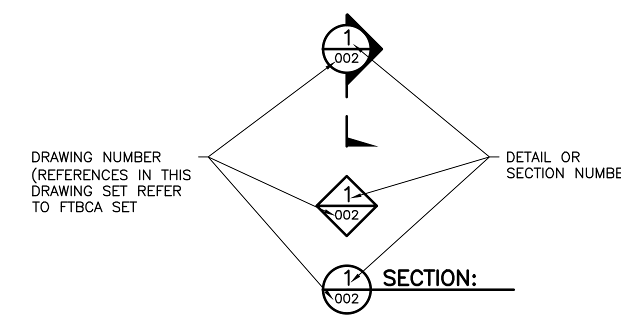
INCHES 1 2

SHEET INDEX

SHEET NO.	TITLE
GENERAL DRAWINGS	
FTBCA-001	LOCATION MAP AND SITE MAP
FTBCA-002	LEGEND AND SHEET INDEX
FTBCA-003	PLAN SHEET LAYOUT
FTBCA-004	PLAN AND PROFILE- STATION 0+00 TO STATION 30+94
FTBCA-005	PLAN AND PROFILE- STATION 30+94 TO STATION 61+88
FTBCA-006	PLAN AND PROFILE- STATION 61+88 TO STATION 92+82
FTBCA-007	PLAN AND PROFILE- STATION 92+82 TO STATION 123+76
FTBCA-008	PLAN AND PROFILE- STATION 123+76 TO STATION 154+70
FTBCA-009	PLAN AND PROFILE- STATION 154+70 TO STATION 185+64
FTBCA-010	PLAN AND PROFILE- STATION 185+64 TO STATION 216+58
FTBCA-011	PLAN AND PROFILE- STATION 216+58 TO STATION 240+17
FTBCA-012	EAST SECTION PLAN & PROFILE STATION 0+00 TO STATION 25+43
FTBCA-013	DETAILS
FTBCA-014	DETAILS
FTBCA-015	DETAILS

GENERAL LEGEND

1000	EXISTING CONTOUR - MAJOR
	EXISTING POWER POLE
	WETLAND BOUNDARY
	EXISTING STRUCTURES
P	EXISTING PIPELINE
	CUTOFF WALL ALIGNMENT



ABBREVIATIONS

EL	–	ELEVATION
FTP	–	FLOTATION TAILINGS BASIN
GAL	–	GALLONS
INV	–	INVERT
TBD	–	TO BE DETERMINED
TYP	–	TYPICAL
WWTP	–	WASTE WATER TREATMENT PLANT
N-MH-XX	–	NORTH SECTION MANHOLE
NW-MH-XX	–	NORTHWEST SECTION MANHOLE
W-MH-XX	–	WEST SECTION MANHOLE
N-MH/PS-XX	–	NORTH SECTION MANHOLE/PUMP STATION
NW-MH/PS-XX	–	NORTHWEST SECTION MANHOLE
W-MH/PS-XX	–	WEST SECTION MANHOLE/PUMP STATION

NOTES

1. COORDINATE SYSTEM IS MINNESOTA STATE PLANE NORTH ZONE, NAD83.
2. ELEVATIONS ARE MEAN SEA LEVEL (MSL), NAVD88.
3. EXISTING TOPOGRAPHIC INFORMATION SHOWN ON THE DRAWINGS WAS PREPARED BY AEROMETRIC, INC. FROM LIDAR DATA COLLECTED ON MARCH 17, 2010.

VER NO	DATE	DESCRIPTION
1	09/09/14	PRELIMINARY DESIGN FOR AGENCY INFORMATION
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DRAWING STATUS		
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CHECKED: DVS/AMP
BARR PROJECT NO.: 23/69-0C29
SCALE: AS SHOWN

PLANT DRAWING NUMBER:

FTB SEEPAGE CONTAINMENT AND STREAM AUGMENTATION SYSTEMS
LEGEND AND SHEET INDEX

POLYMET MINING, INC.
NORTHMET PROJECT
HOYT LAKES, MINNESOTA

BARR ENGINEERING COMPANY
4700 WEST 77TH STREET
MINNEAPOLIS, MN.
Ph: 1-800-632-2277

DWG. NO. FTBCA-002 | REV

CADD USER: Brian Hughes FILE: K:\DESIGN\23690C29.10\PERMIT_NMT-10-CU-002.DWG PLOT SCALE: 1:2 PLOT DATE: 1/6/2015 1:45 PM

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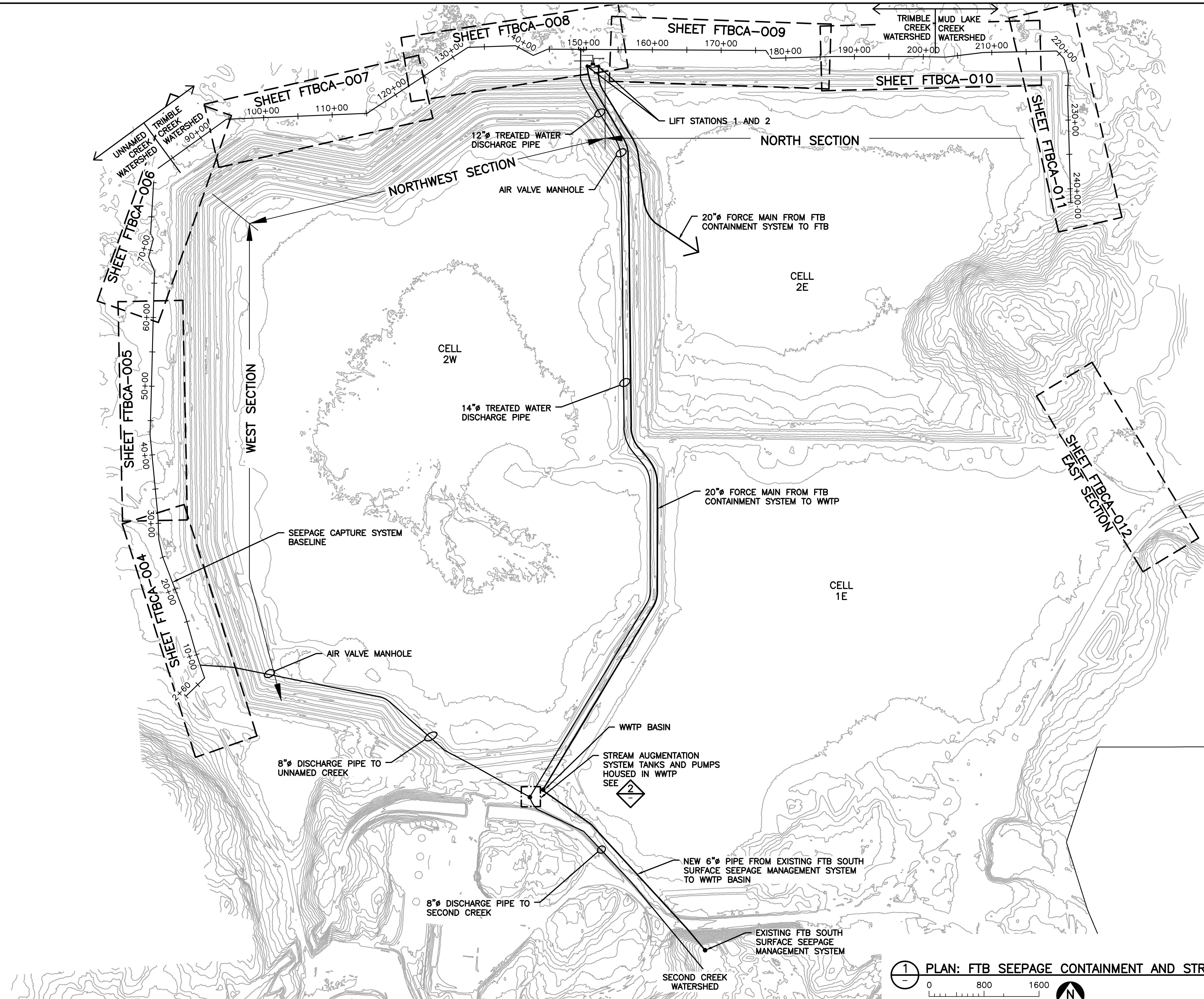
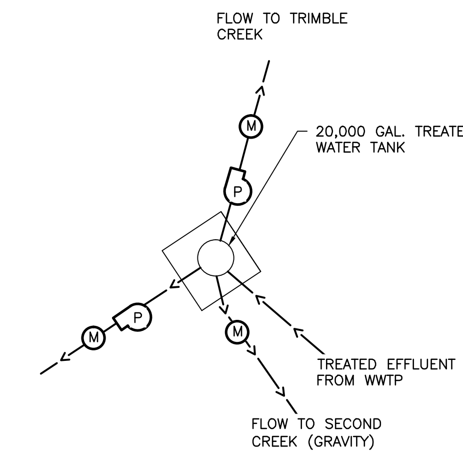


1 PLAN: FTB SEEPAGE CONTAINMENT AND STREAM AUGMENTATION LAYOUT

0 800 1600 SCALE IN FEET



2 DETAIL: CONCEPTUAL STREAM AUGMENTATION SYSTEM SUPPLY
NOT TO SCALE

NOTES

1. SEEPAGE CONTAINMENT SYSTEMS INCLUDE THE FTB CONTAINMENT SYSTEM ALONG THE WEST, NORTH AND EAST SIDES OF THE FTB, THE SOUTH SURFACE SEEPAGE MANAGEMENT SYSTEM ON THE SOUTH SIDE OF THE FTB AND CONVEYANCE TO THE WWTP EQUALIZATION BASIN.
2. STREAM AUGMENTATION SYSTEM INCLUDES TREATED WATER CONVEYANCE AND DISCHARGE TO UNNAMED CREEK, TRIMBLE CREEK, AND SECOND CREEK WATERSHEDS.
3. FTB SEEPAGE CONTAINMENT AND STREAM AUGMENTATION SYSTEMS DESIGN REFERENCE BASELINE SHOWN ON THIS SHEET. SEE SUBSEQUENT SHEETS FOR PROPOSED LAYOUT OF SYSTEMS ALONG BASELINE.

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BARR PROJECT NO.: 23/69-0C29
SCALE: AS SHOWN

PLANT DRAWING NUMBER:

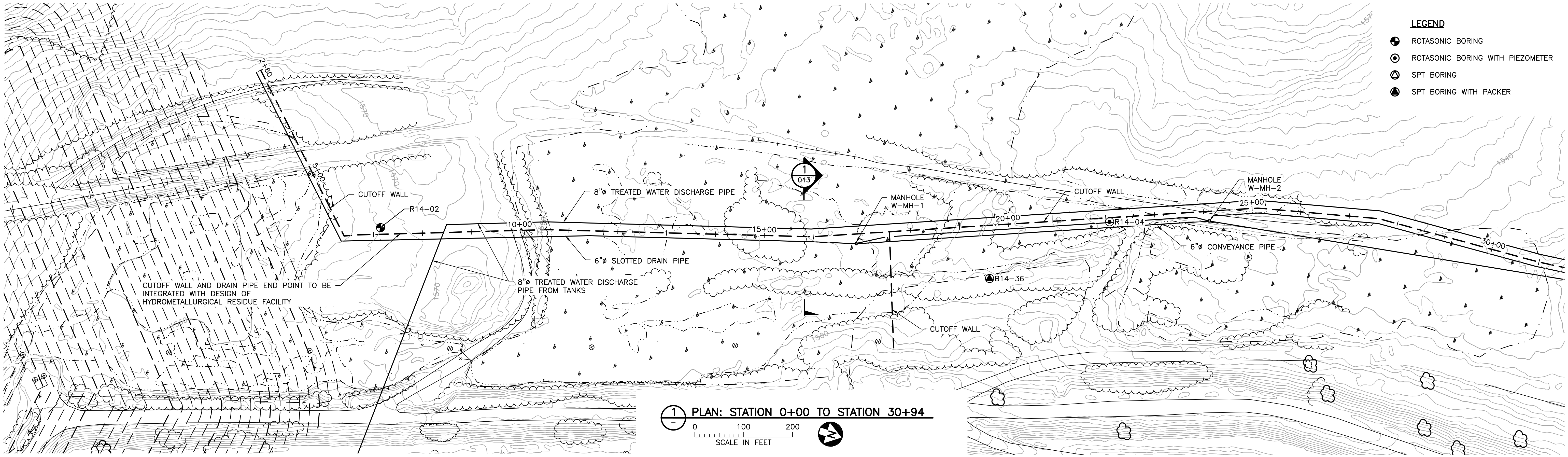
FTB SEEPAGE CONTAINMENT
AND STREAM AUGMENTATION SYSTEMS
PLAN SHEET LAYOUT

POLYMET MINING, INC.
NORTHMET PROJECT
HOYT LAKES, MINNESOTA

BARR ENGINEERING COMPANY
4700 WEST 77TH STREET
MINNEAPOLIS, MN.
Ph: 1-800-632-2277

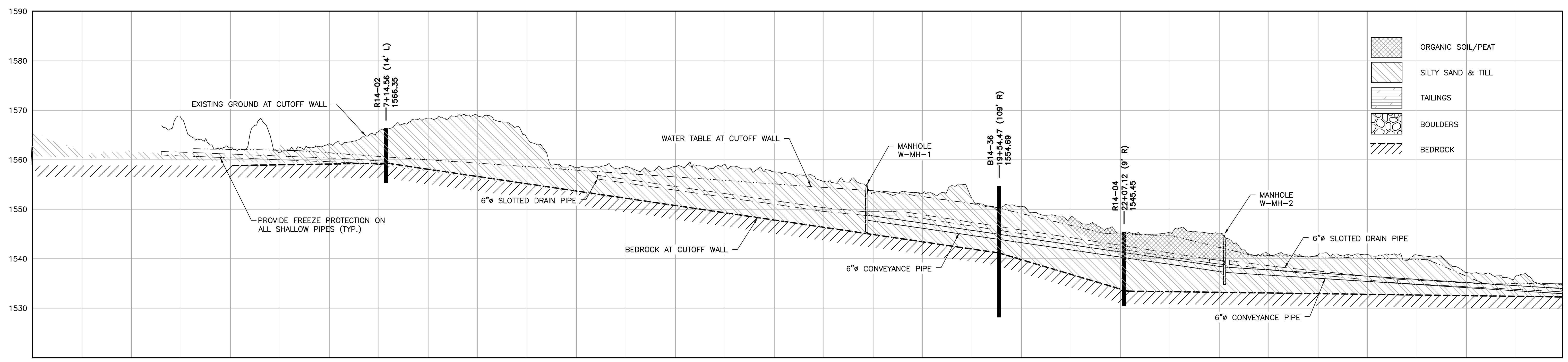
DWG. NO. FTBCA-003 REV

CADD USER: Brian Hughes FILE: K:\DESIGN\23690C29.10\PERMIT_NMT-10-CU-003.DWG PLOT SCALE: 1:2 PLOT DATE: 1/6/2015 2:40 PM



1 PLAN: STATION 0+00 TO STATION 30+94

0 100 200 SCALE IN FEET



2 PROFILE: 0+00 TO STATION 30+94

0 100 200 SCALE IN FEET HORIZONTAL

0 10 20 SCALE IN FEET VERTICAL

NOTES:

1. HORIZONTAL LOCATION OF FORCE MAIN, SEEPAGE CONVEYANCE PIPES AND STREAM AUGMENTATION PIPES/DISCHARGE POINTS ON THIS SHEET AND SUBSEQUENT SHEETS SHOWN FOR CLARITY. ACTUAL LOCATION TO BE DETERMINED DURING FINAL DESIGN.
2. MANHOLE LOCATIONS ON THIS SHEET AND SUBSEQUENT SHEETS ARE PRELIMINARY.
3. ACCESS ROAD NOT SHOWN ON THIS SHEET AND SUBSEQUENT SHEETS.
4. TREATED WATER DISCHARGE PIPES NOT SHOWN IN PROFILE ON THIS SHEET AND SUBSEQUENT SHEETS.
5. WATER TABLE ELEVATIONS ARE ESTIMATED BASED ON PIEZOMETERS, BORING LOGS, SOIL TYPES AND AERIAL PHOTOGRAPHY.
6. GROUND SURFACE ELEVATIONS ARE BASED ON 2010 LIDAR DATA (NAVD88). BORING ELEVATIONS SHOWN ARE BASED ON 2010 LIDAR DATA (NAVC88) ADJUSTED AFTER GEOTECHNICAL EXPLORATION (03-11-2014 THRU 05-20-2014). STRATIGRAPHY AND WATER TABLES ARE BASED ON THE 2014 FIELD INVESTIGATION LOGS.
7. BORING LOCATION OFFSETS FROM PROPOSED CUTOFF WALL ALIGNMENT ARE SHOWN. SUBSURFACE CONDITIONS ON WALL ALIGNMENT WILL DIFFER FROM THOSE SHOWN.
8. AREAS OF COBBLES AND BOULDERS BETWEEN BORING LOCATIONS AND ADJACENT BORING LOCATIONS SHOULD BE ASSUMED TO EXIST.

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PRINTED NAME

DATE REG. NO.

DRAWN: BJH

CHECKED: .

BARR PROJECT NO.: 23/69-0C29

SCALE: AS SHOWN

PLANT DRAWING NUMBER:

FTB SEEPAGE CONTAINMENT AND STREAM AUGMENTATION SYSTEMS WEST SECTION – PLAN & PROFILE

POLYMET MINING

POLYMET MINING INC.
NORTHMET PROJECT
HOYT LAKES, MINNESOTA

BARR

BARR ENGINEERING COMPANY
4700 WEST 77TH STREET
MINNEAPOLIS, MN.
Ph: 1-800-632-2277

DWG. NO. FTBCA-004

REV

CADD USER: Brian Hughes FILE: K:\DESIGN\23690C29.10\PERMIT_NMT-10-CU-004.DWG PLOT SCALE: 1:2 PLOT DATE: 1/6/2015 3:11 PM

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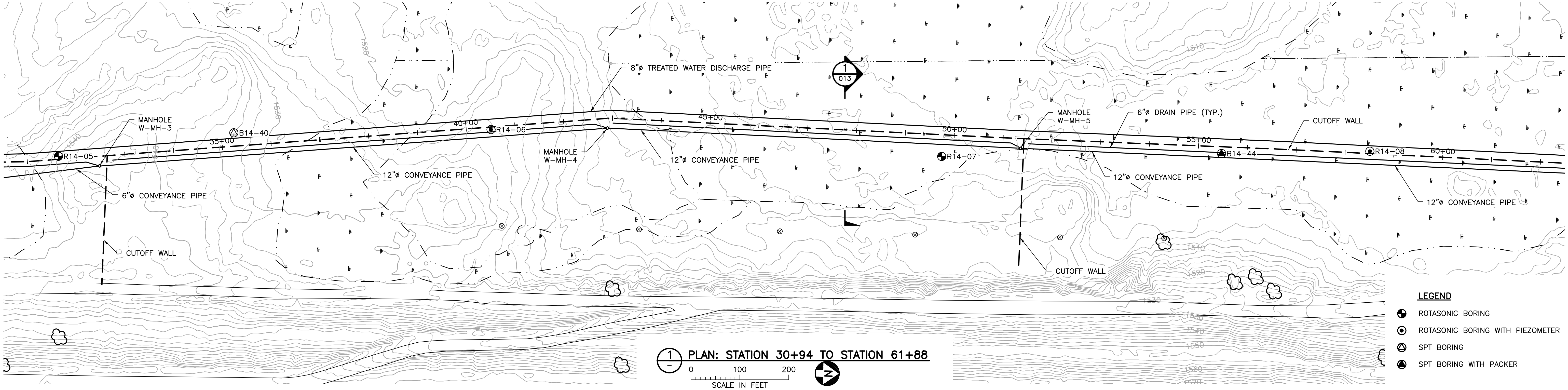
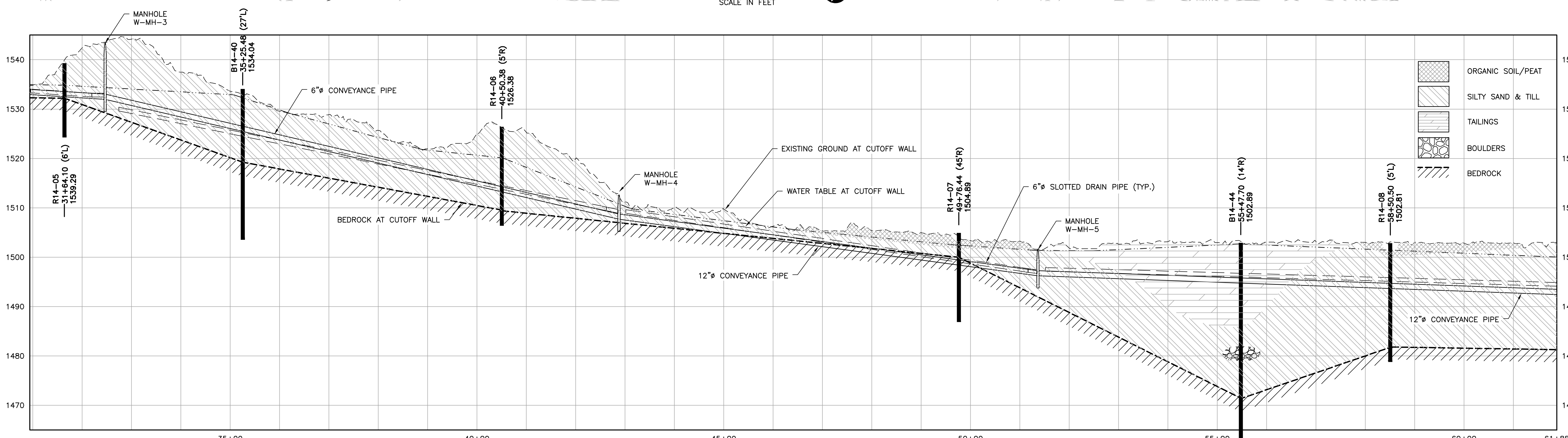


1 PLAN: STATION 30+94 TO STATION 61+88

0 100 200 SCALE IN FEET



2 PROFILE: 30+94 TO STATION 61+88

0 100 200 SCALE IN FEET HORIZONTAL

0 10 20 SCALE IN FEET VERTICAL

PLANT DRAWING NUMBER:

FTB SEEPAGE CONTAINMENT AND STREAM AUGMENTATION SYSTEMS WEST SECTION – PLAN & PROFILE

VER NO	DATE	DESCRIPTION
1	09/09/14	PRELIMINARY DESIGN FOR AGENCY INFORMATION
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BARR PROJECT NO.: 23/69-0C29

SCALE: AS SHOWN

POLYMET MINING

POLYMET MINING INC.
NORTHMET PROJECT
HOYT LAKES, MINNESOTA

BARR

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4700 WEST 77TH STREET
MINNEAPOLIS, MN.
Ph: 1-800-632-2277

DWG. NO. FTBCA-005

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INCHES 1 2

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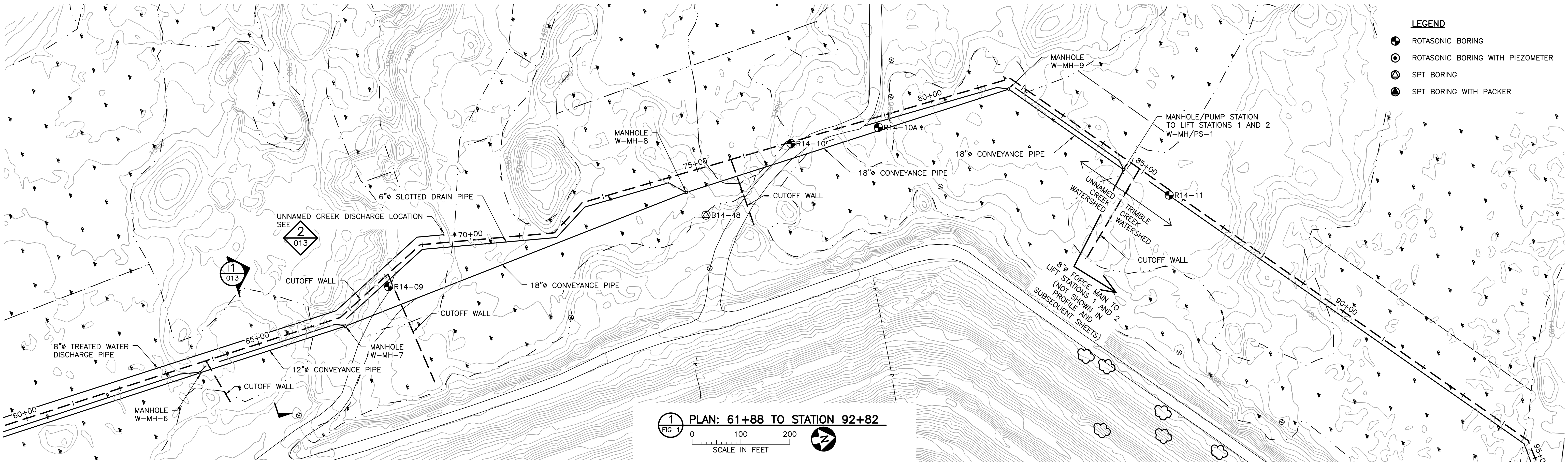
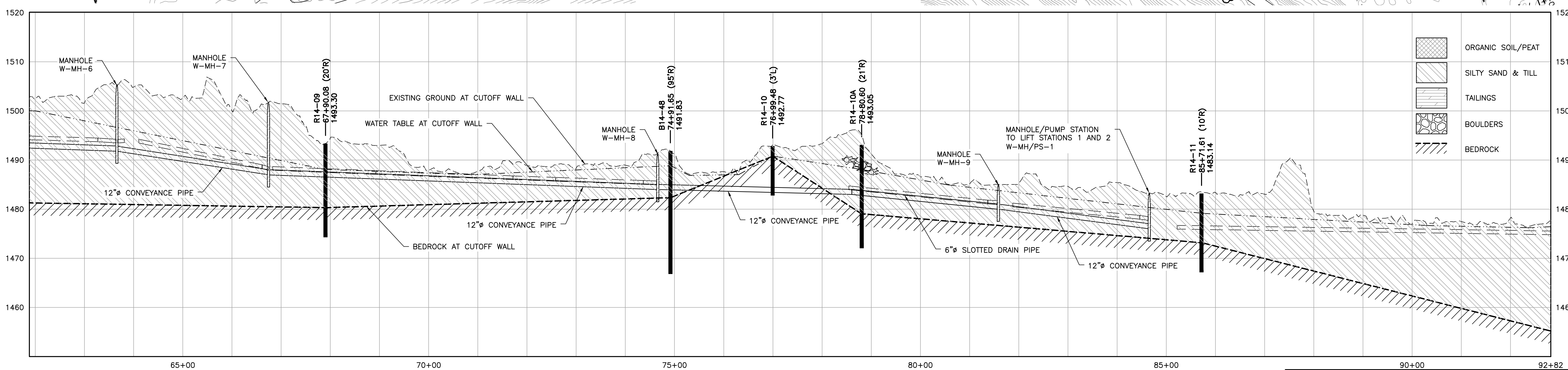


1 FIG 1 PLAN: 61+88 TO STATION 92+82

0 100 200 SCALE IN FEET



2 – PROFILE: 61+88 TO STATION 92+82

0 100 200 SCALE IN FEET HORIZONTAL

0 10 20 SCALE IN FEET VERTICAL

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CHECKED: -

BARR PROJECT NO.: 23/69-0C29

SCALE: AS SHOWN

PLANT DRAWING NUMBER:

FTB SEEPAGE CONTAINMENT AND STREAM AUGMENTATION SYSTEMS PLAN & PROFILE

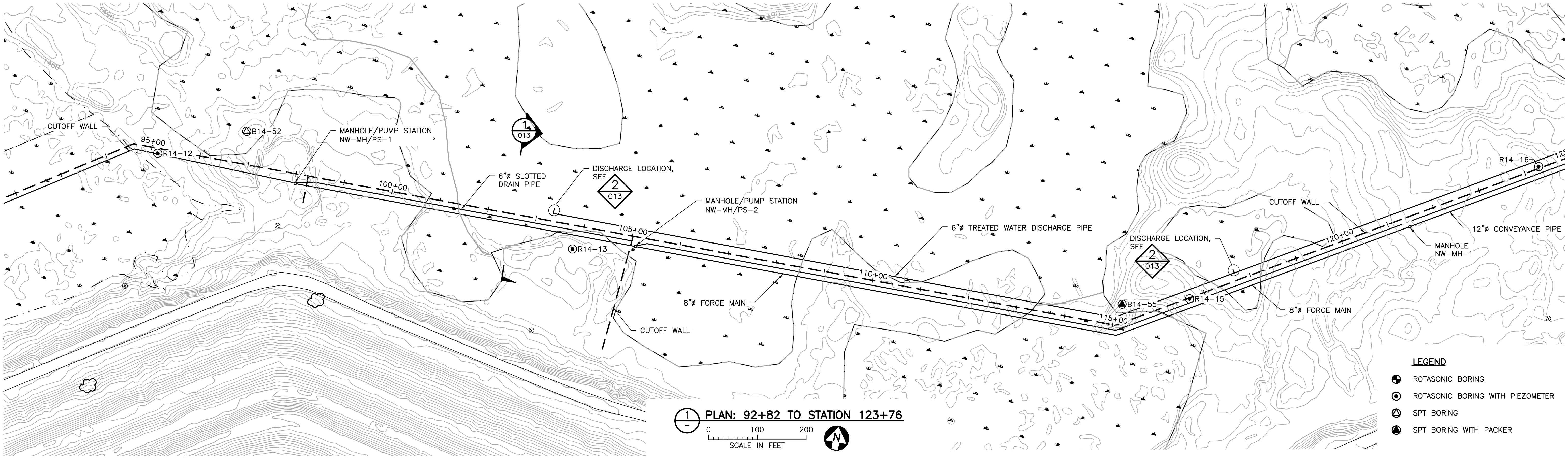
POLYMET MINING INC.
NORTHMET PROJECT
HOYT LAKES, MINNESOTA

BARR ENGINEERING COMPANY
4700 WEST 77TH STREET
MINNEAPOLIS, MN.
Ph: 1-800-632-2277

DWG. NO. FTBCA-006

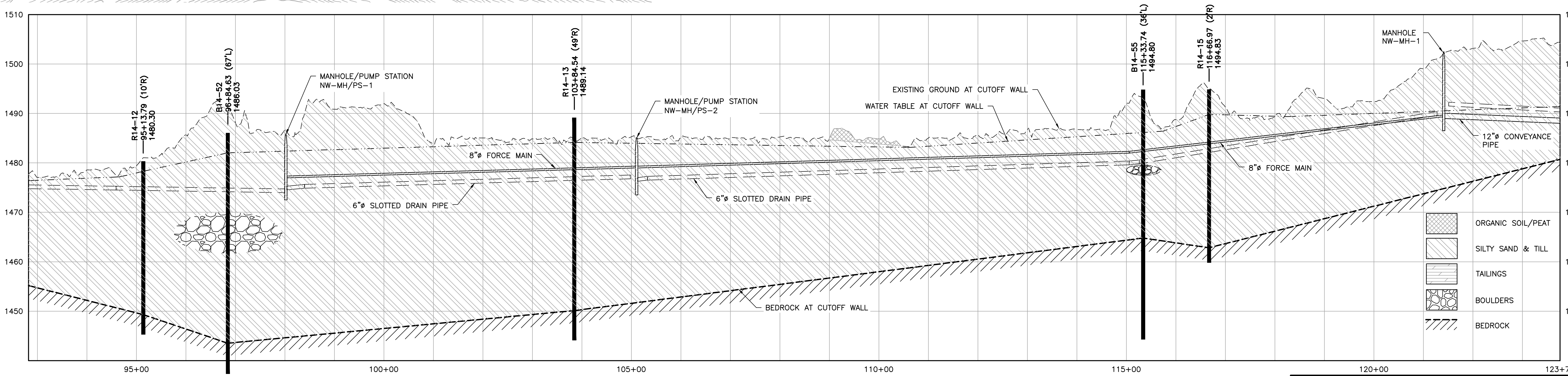
REV

INCHES 1 2



1 PLAN: 92+82 TO STATION 123+76

0 100 200
SCALE IN FEET



2 PROFILE: 92+82 TO STATION 123+76

0 100 200
SCALE IN FEET
HORIZONTAL

0 10 20
SCALE IN FEET
VERTICAL

VER NO	DATE	DESCRIPTION
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SCALE: AS SHOWN

PLANT DRAWING NUMBER:

FTB SEEPAGE CONTAINMENT
AND STREAM AUGMENTATION SYSTEMS
PLAN & PROFILE

POLYMET MINING
POLYMET MINING INC.
NORTHMET PROJECT
HOYT LAKES, MINNESOTA

BARR
BARR ENGINEERING COMPANY
4700 WEST 77TH STREET
MINNEAPOLIS, MN.
Ph: 1-800-632-2277

DWG. NO. FTBCA-007
REV

CADD USER: Brian Hughes FILE: K:\DESIGN\23690C29.10\PERMIT_NMT-10-CU-007.DWG PLOT SCALE: 1:2 PLOT DATE: 1/6/2015 1:01 PM

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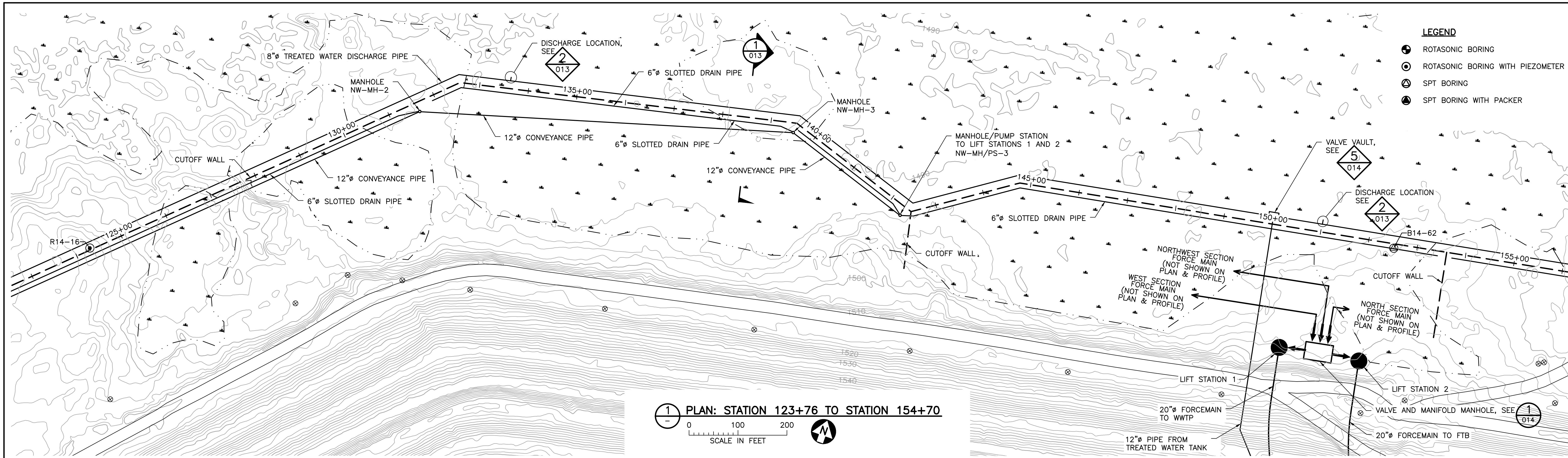
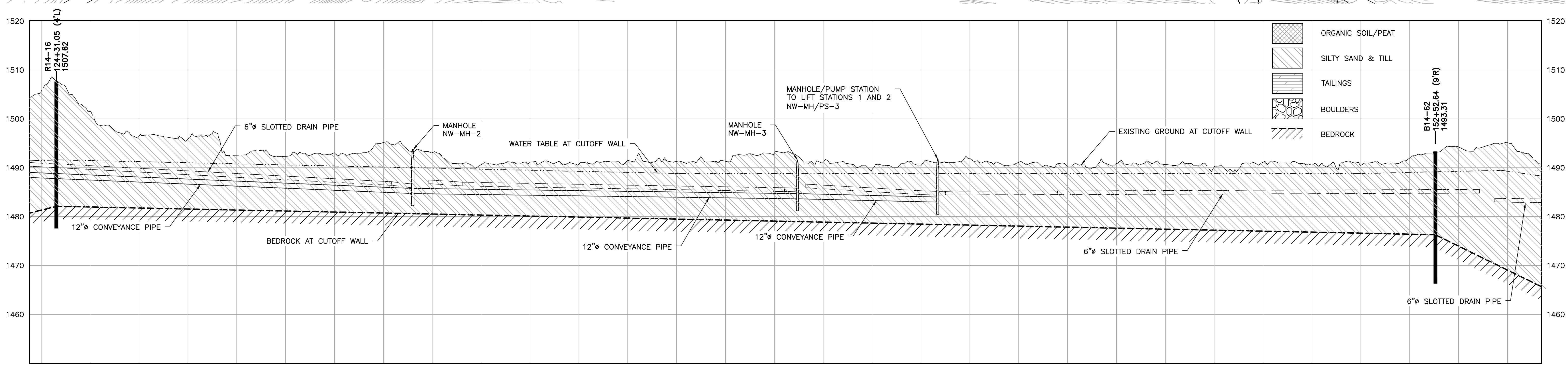


1 PLAN: STATION 123+76 TO STATION 154+70

0 100 200 SCALE IN FEET



2 PROFILE: STATION 123+76 TO STATION 154+70

0 100 200 SCALE IN FEET HORIZONTAL

0 10 20 SCALE IN FEET VERTICAL

PLANT DRAWING NUMBER:

FTB SEEPAGE CONTAINMENT AND STREAM AUGMENTATION SYSTEMS PLAN & PROFILE

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BARR PROJECT NO.: 23/69-0C29

SCALE: AS SHOWN

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POLYMET MINING INC.
NORTHMET PROJECT
HOYT LAKES, MINNESOTA

BARR

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MINNEAPOLIS, MN.
Ph: 1-800-632-2277

DWG. NO. FTBCA-008

REV

CADD USER: Brian Hughes FILE: K:\DESIGN\23690C29.10\PERMIT_NMT-10-CU-008.DWG PLOT SCALE: 1:2 PLOT DATE: 1/6/2015 1:03 PM

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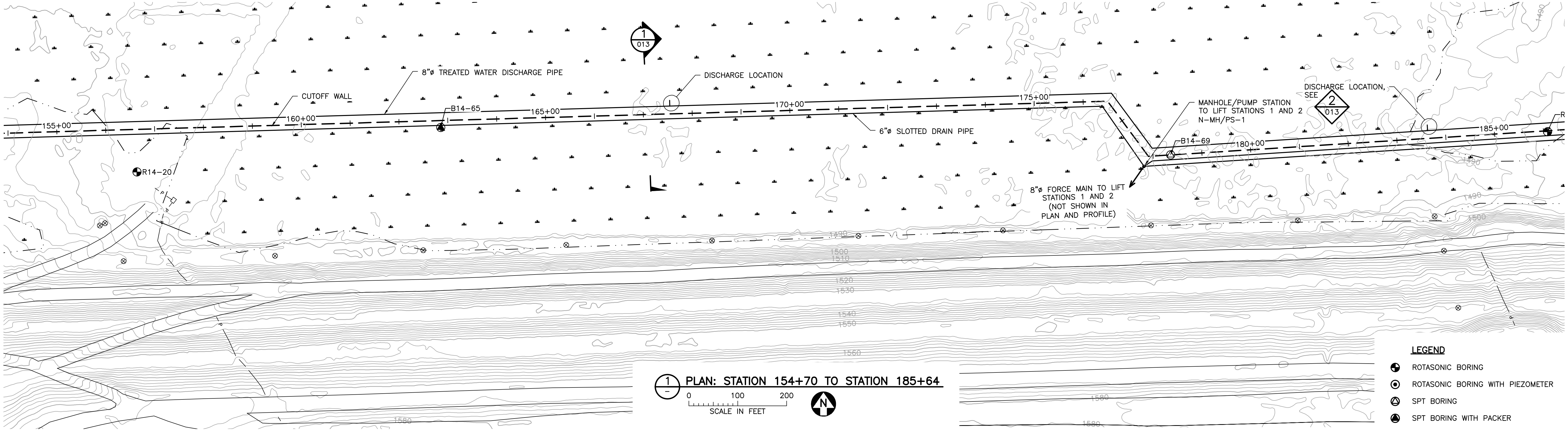
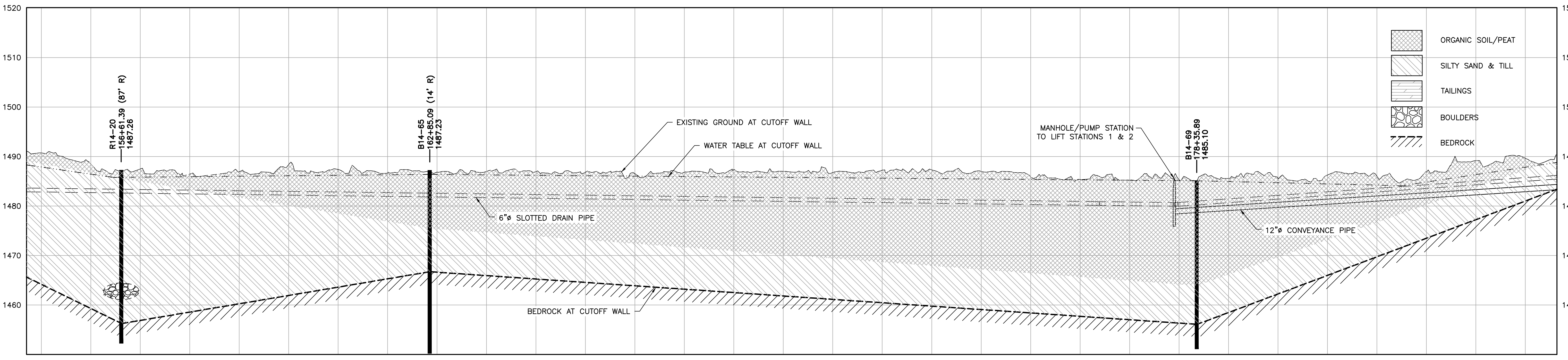


1/– PLAN: STATION 154+70 TO STATION 185+64

0 100 200
SCALE IN FEET



2/– PROFILE: STATION 154+70 TO STATION 185+64

0 100 200
SCALE IN FEET
HORIZONTAL

0 10 20
SCALE IN FEET
VERTICAL

VER NO	DATE	DESCRIPTION
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CHECKED: .
BARR PROJECT NO.: 23/69-0C29
SCALE: AS SHOWN

PLANT DRAWING NUMBER:

FTB SEEPAGE CONTAINMENT AND STREAM AUGMENTATION SYSTEMS PLAN & PROFILE

POLYMET MINING
POLYMET MINING INC.
NORTHMET PROJECT
HOYT LAKES, MINNESOTA

BARR
BARR ENGINEERING COMPANY
4700 WEST 77TH STREET
MINNEAPOLIS, MN.
Ph: 1-800-632-2277

DWG. NO. FTBCA-009
REV

CADD USER: Brian Hughes FILE: K:\DESIGN\23690C29.10\PERMIT_NMT-10-CU-009.DWG PLOT SCALE: 1:2 PLOT DATE: 1/6/2015 1:09 PM

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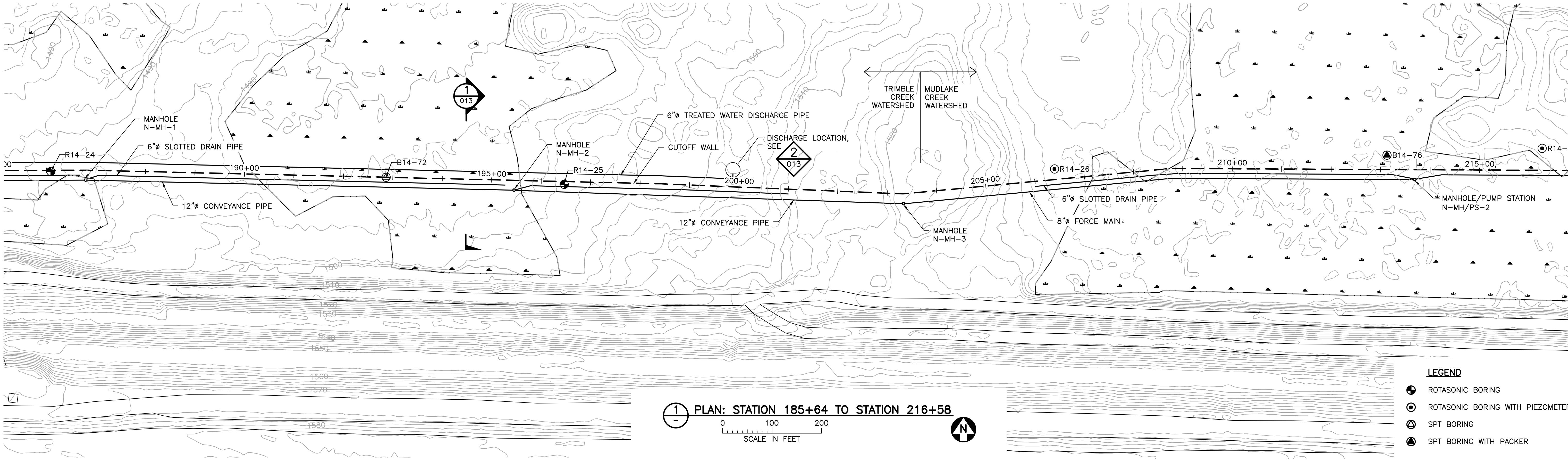
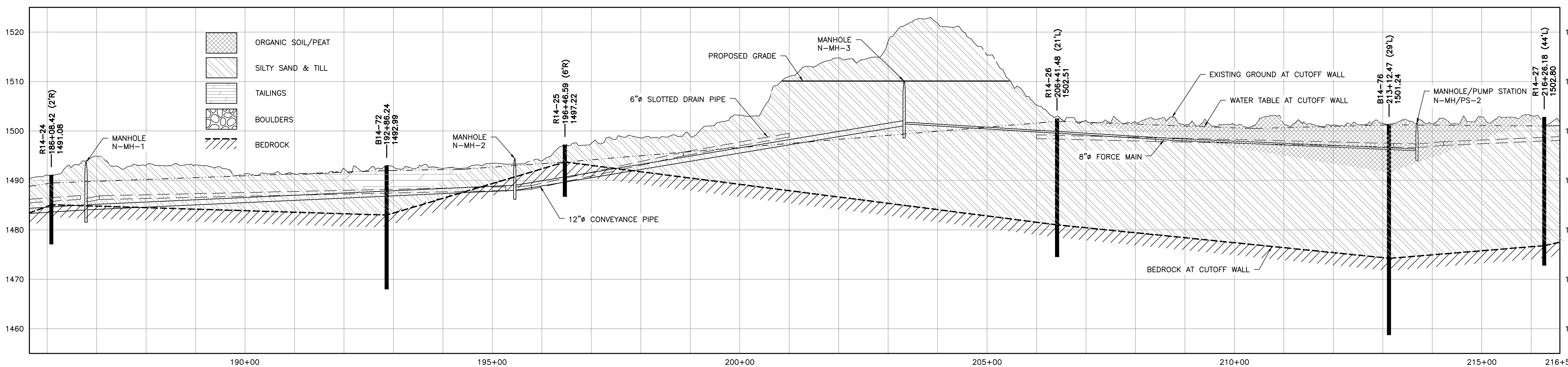


1 PLAN: STATION 185+64 TO STATION 216+58



2 PROFILE: STATION 185+64 TO STATION 216+58

0 100 200 SCALE IN FEET HORIZONTAL

0 10 20 SCALE IN FEET VERTICAL

VER NO	DATE	DESCRIPTION
1	09/09/14	PRELIMINARY DESIGN FOR AGENCY INFORMATION
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PRINTED NAME ____________

DATE ________ REG. NO. ________

DRAWN: BJH

CHECKED: .

BARR PROJECT NO.: 23/69-0C29

SCALE: AS SHOWN

PLANT DRAWING NUMBER:

FTB SEEPAGE CONTAINMENT AND STREAM AUGMENTATION SYSTEMS PLAN & PROFILE

POLYMET MINING

POLYMET MINING INC.
NORTHMET PROJECT
HOYT LAKES, MINNESOTA

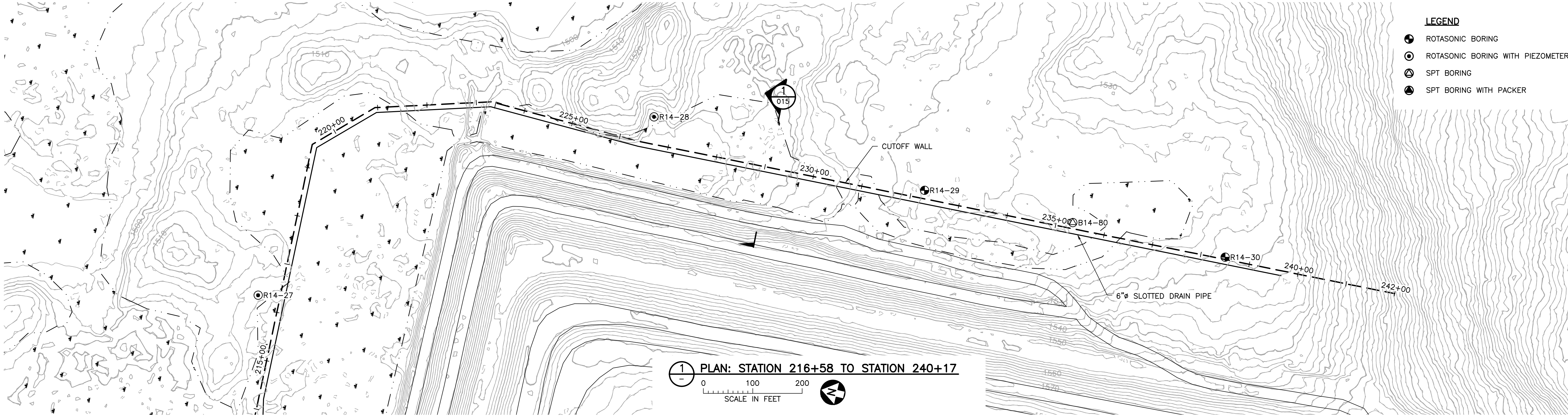
BARR

BARR ENGINEERING COMPANY
4700 WEST 77TH STREET
MINNEAPOLIS, MN.
Ph: 1-800-632-2277

DWG. NO. FTBCA-010

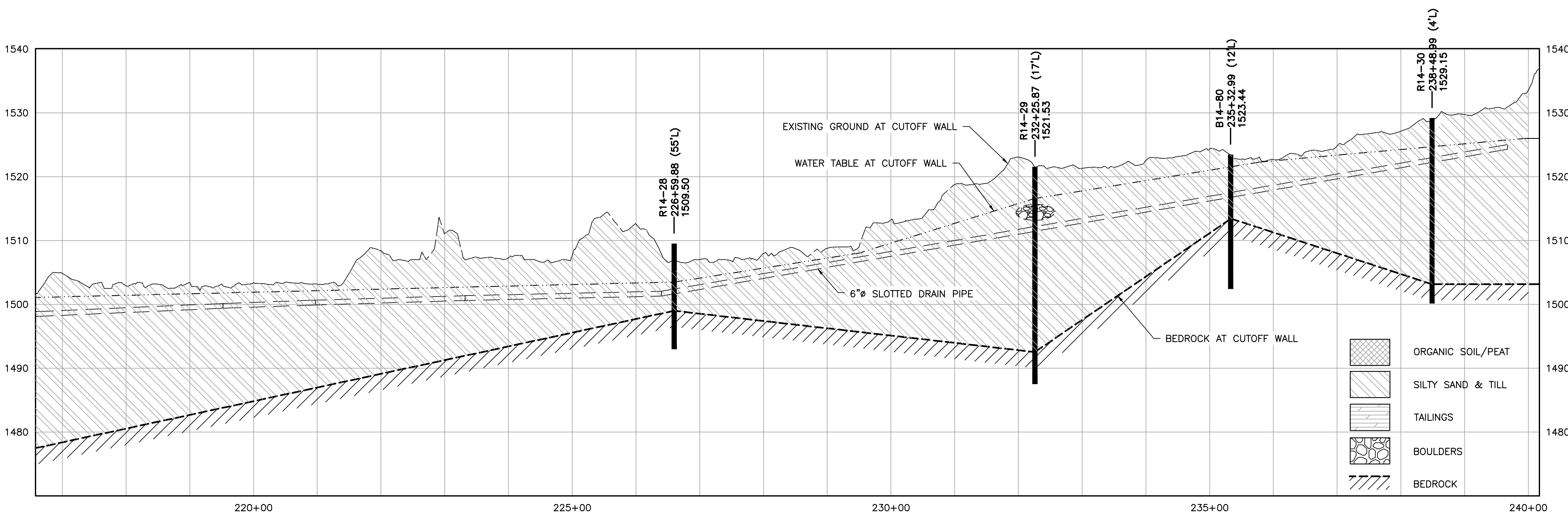
REV

INCHES 1 2



1 PLAN: STATION 216+58 TO STATION 240+17

0 100 200 SCALE IN FEET



2 PROFILE: STATION 216+58 TO STATION 240+17

0 100 200 SCALE IN FEET HORIZONTAL

0 10 20 SCALE IN FEET VERTICAL

PLANT DRAWING NUMBER:

FTB SEEPAGE CONTAINMENT AND STREAM AUGMENTATION SYSTEMS PLAN & PROFILE

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CHECKED: .

BARR PROJECT NO.: 23/69-0C29

SCALE: AS SHOWN

POLYMET MINING

POLYMET MINING INC.
NORTHMET PROJECT
HOYT LAKES, MINNESOTA

BARR

BARR ENGINEERING COMPANY
4700 WEST 77TH STREET
MINNEAPOLIS, MN.
Ph: 1-800-632-2277

DWG. NO. FTBCA-011

REV

CADD USER: Brian Hughes FILE: K:\DESIGN\23690C29.10\PERMIT_NMT-10-CU-011.DWG PLOT SCALE: 1:2 PLOT DATE: 1/6/2015 1:15 PM

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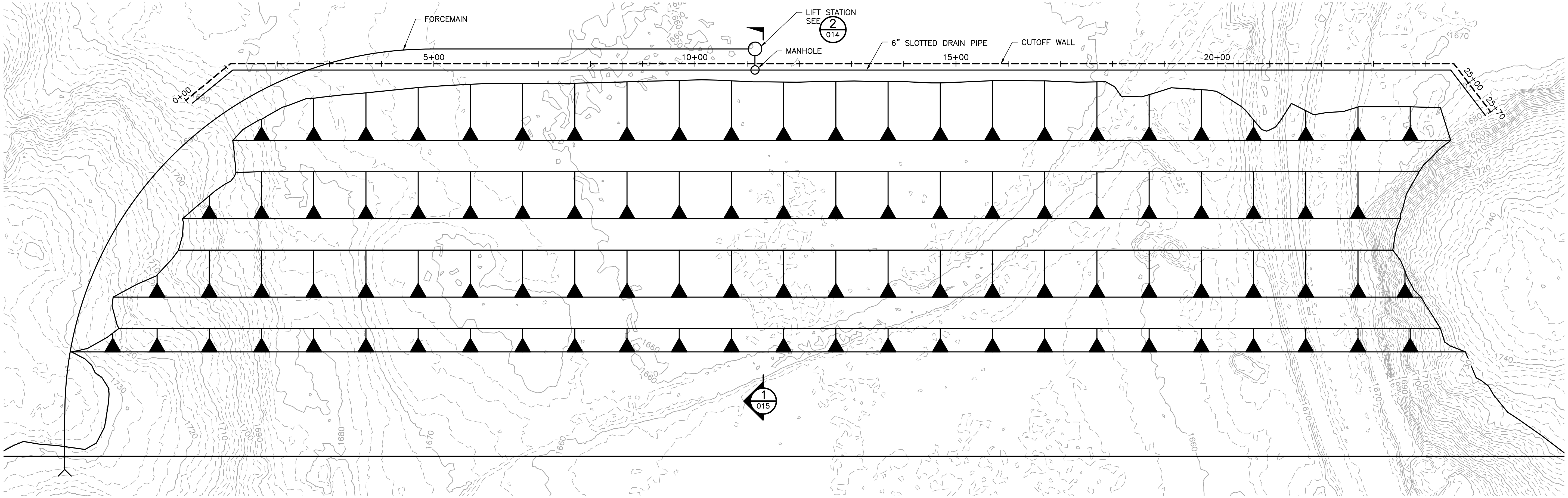
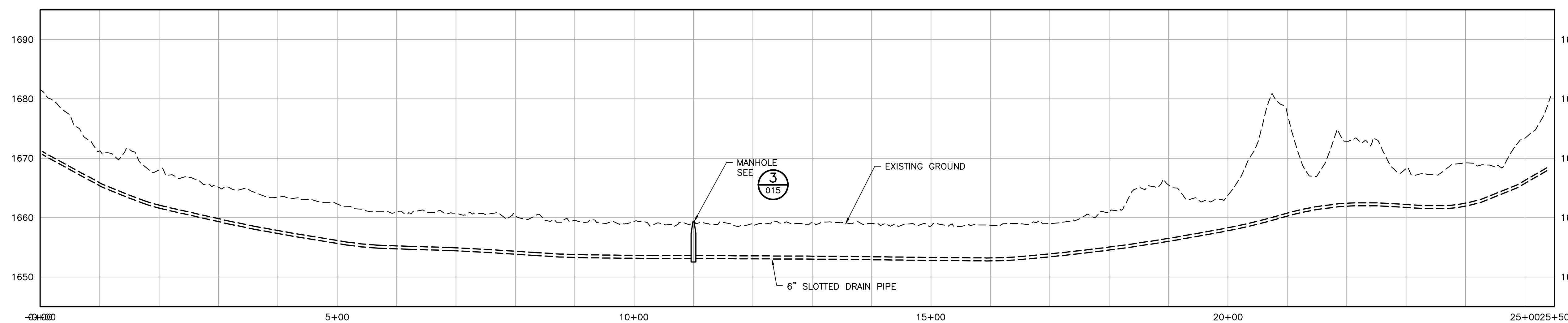


1 PLAN: STATION 0+00 TO STATION 23+33

0 100 200 SCALE IN FEET



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PLANT DRAWING NUMBER:

FTB SEEPAGE CONTAINMENT AND STREAM AUGMENTATION SYSTEMS DETAILS

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BARR

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MINNEAPOLIS, MN.
Ph: 1-800-632-2277

DWG. NO. FTBCA-012

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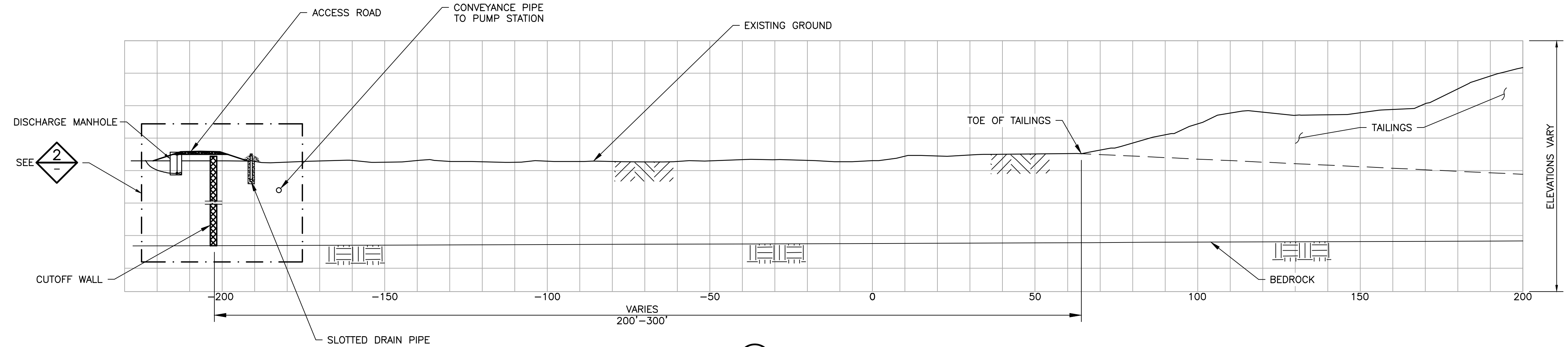

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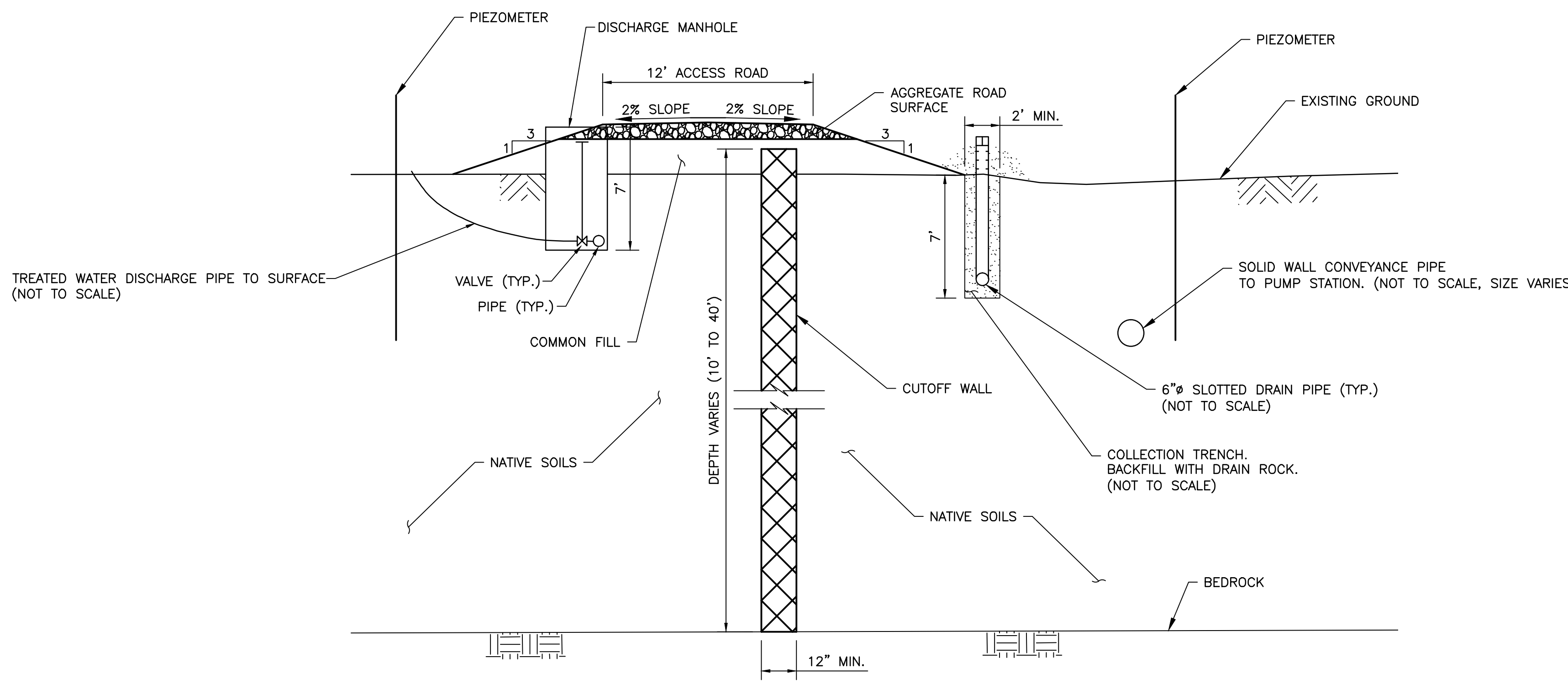

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NOTES:

1. DIFFUSER TO BE INSTALLED ON DISCHARGE PIPES AS REQUIRED TO PREVENT EROSION.
2. CUTOFF WALL MAXIMUM DESIGN HYDRAULIC CONDUCTIVITY = $1X10^{-6}$CM/SEC

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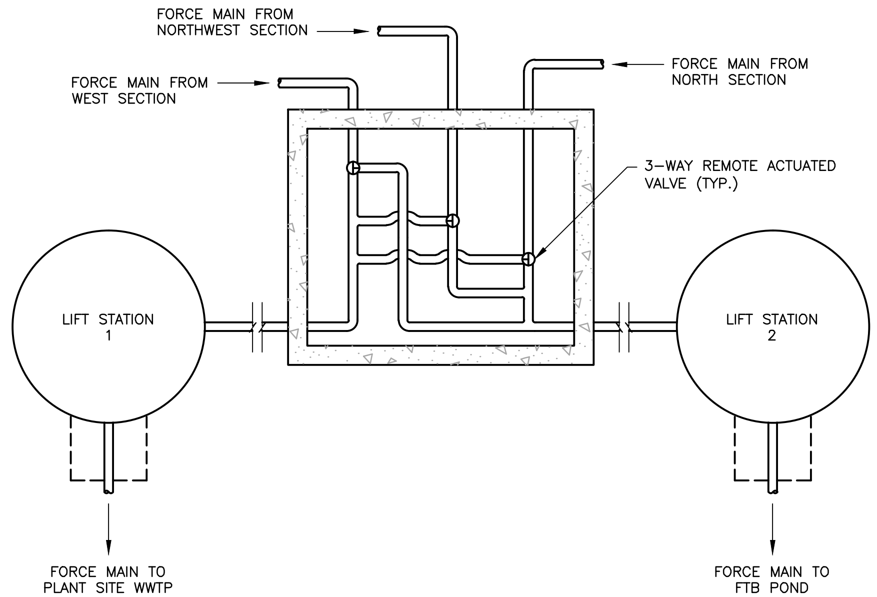

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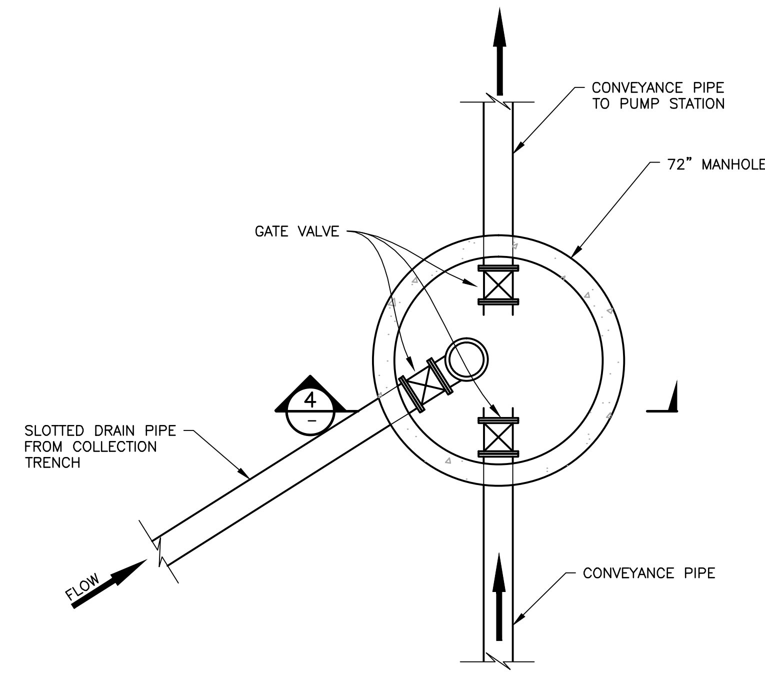

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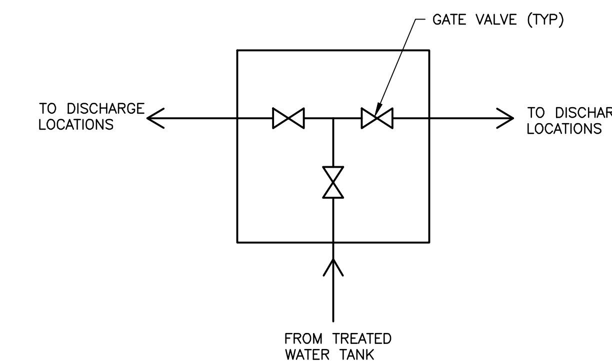

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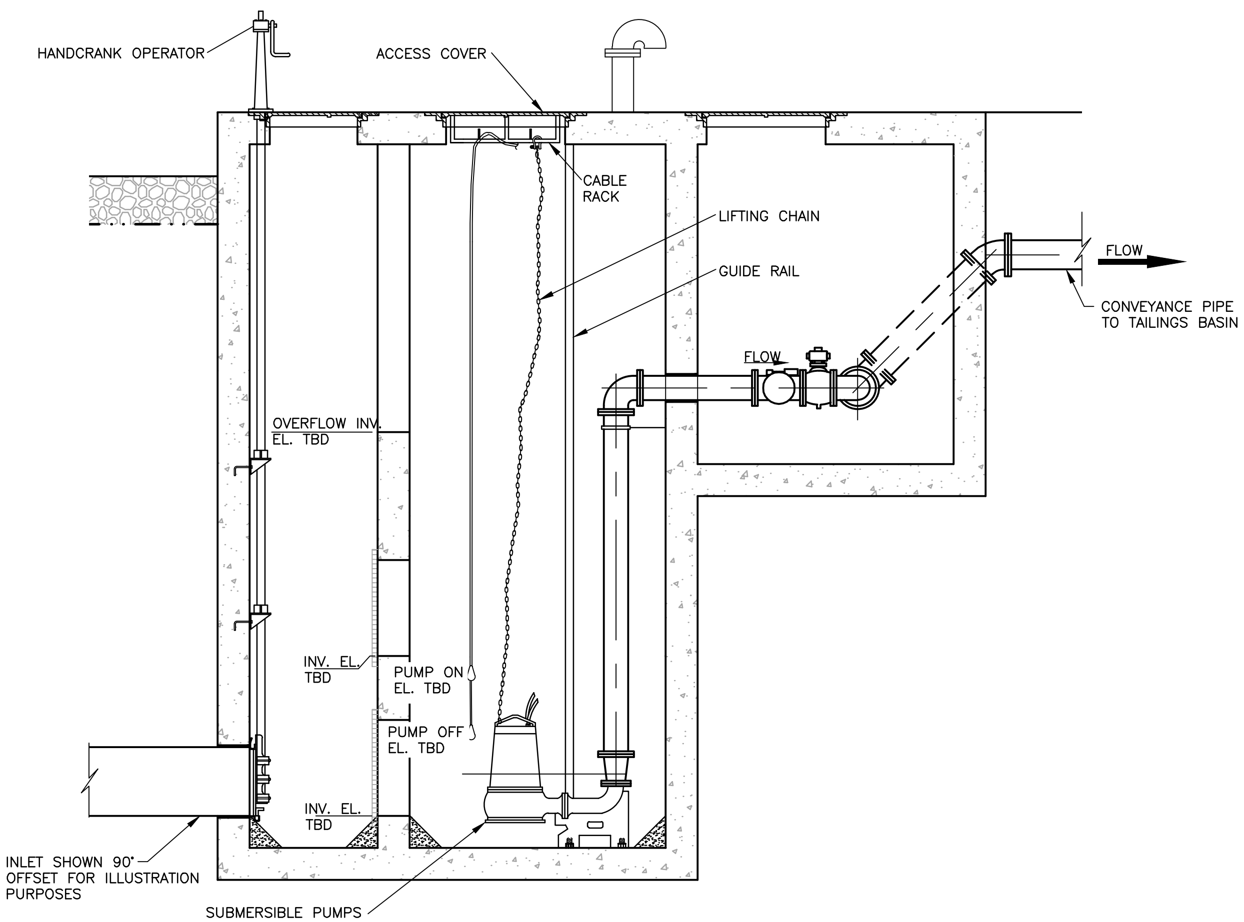

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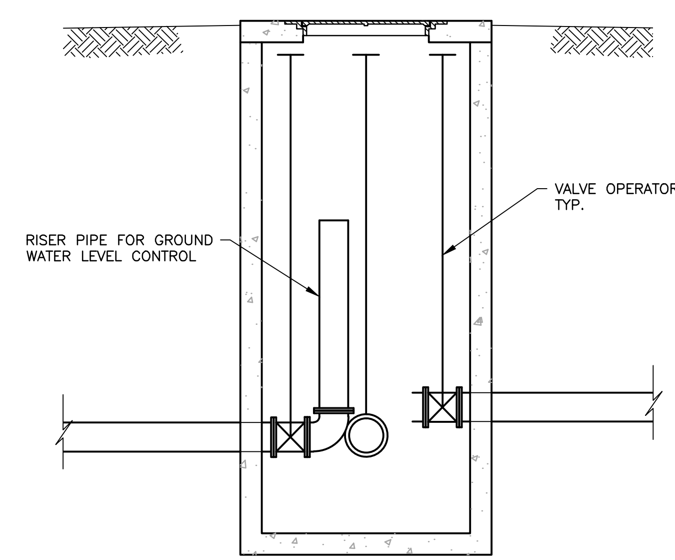

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NOTES:

1. LIFT STATION, MANHOLE AND VAULT CONFIGURATIONS SHOWN ON THIS SHEET ARE INTENDED TO BE REPRESENTATIVE OF TYPICAL FACILITIES NEEDED FOR OPERATION OF THE SEEPAGE CONTAINMENT AND STREAM AUGMENTATION SYSTEMS. THE ACTUAL DESIGN FOR EACH LIFT STATION, PUMP STATION, MANHOLE, AND VAULT WILL BE DEVELOPED DURING DETAILED DESIGN TO REFLECT THE SPECIFIC EQUIPMENT REQUIREMENTS FOR EACH LOCATION.
2. PUMP STATIONS WILL BE SIMILAR TO MANHOLE SHOWN IN 3 / – WITH SMALL SUBMERSIBLE PUMP.
3. FLOW METERS WILL BE PROVIDED FOR DISCHARGE FROM ALL LIFT AND PUMP STATIONS AND AT OTHER LOCATIONS AS REQUIRED FOR OPERATIONS.

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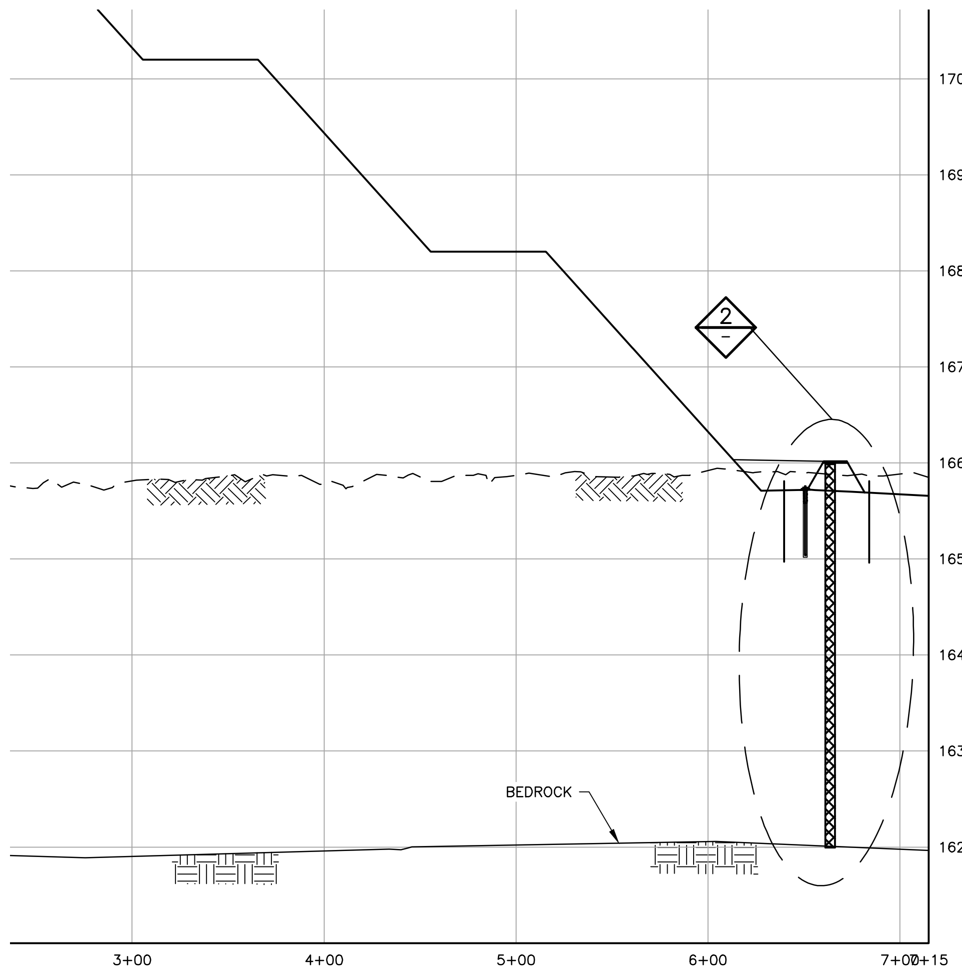

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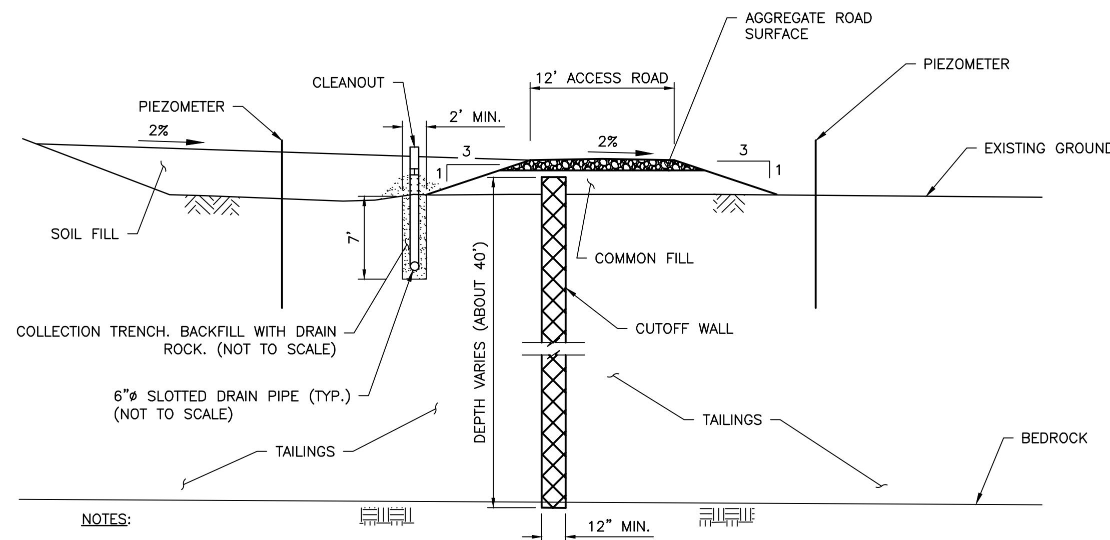

NOTES:

1. CUTOFF WALL MAXIMUM DESIGN HYDRAULIC CONDUCTIVITY = $1X10^{-6}$CM/SEC

2 / – TYPICAL DETAIL

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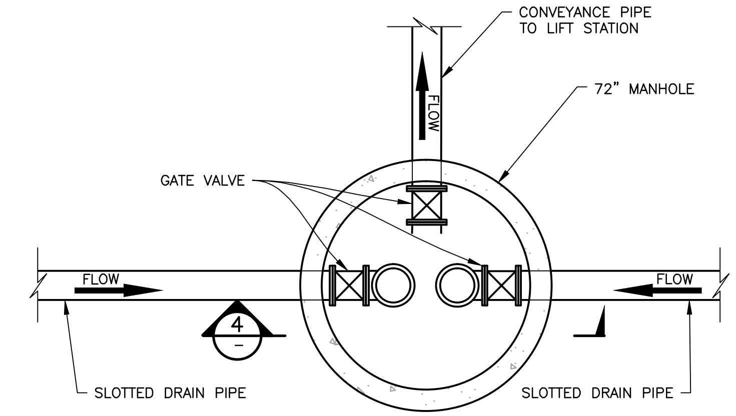

3 / – PLAN: MANHOLE (TYP.)

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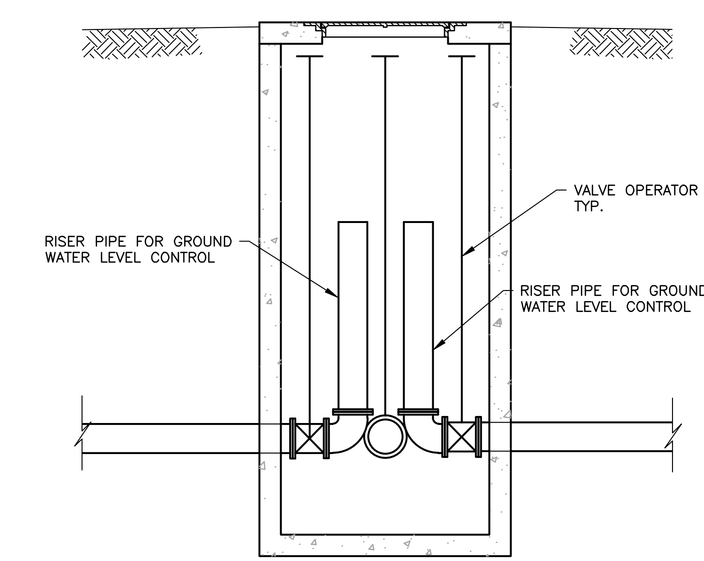

4 / – SECTION: MANHOLE (TYP.)

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Attachment C

Groundwater Modeling of the NorthMet Flotation Tailings Basin 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
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Groundwater Modeling of the NorthMet Flotation Tailings Basin Containment System

January 2015

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List of Figures

List of Large Figures

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)).

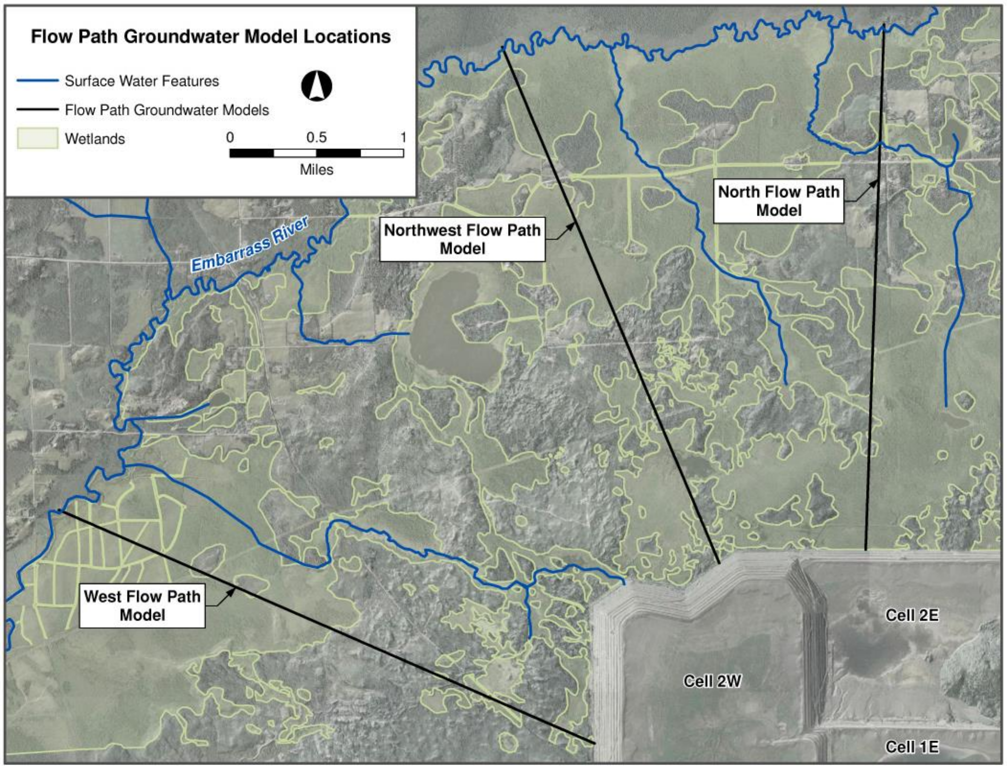

Figure 1-1 Locations of Flow Path Models Used to Evaluate the FTB Containment System

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.

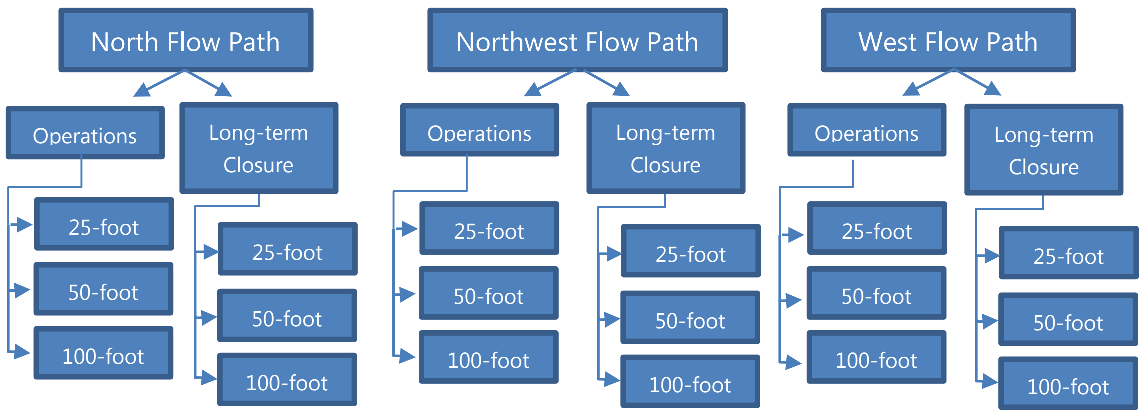

Figure 3-1 Model Simulations for the Flow Path Groundwater Models for Two Different Flow Conditions and Three Different Bedrock Thicknesses

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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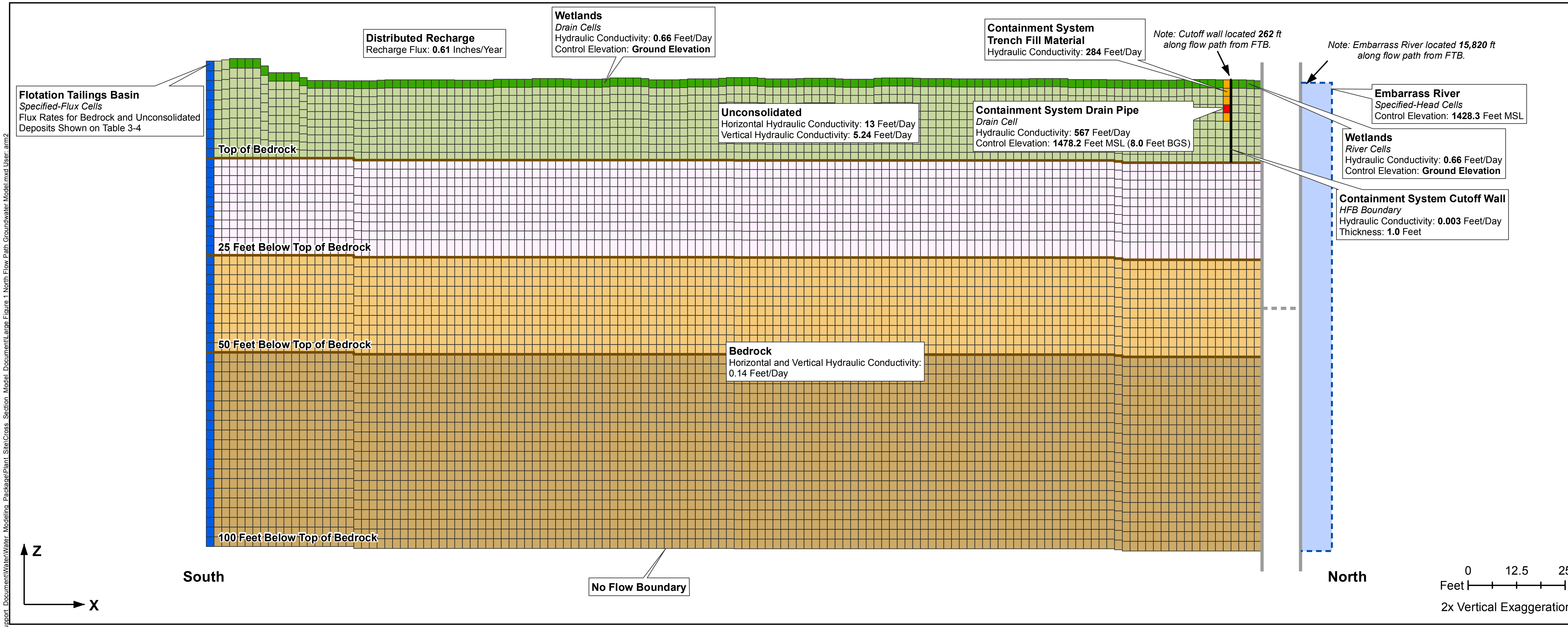
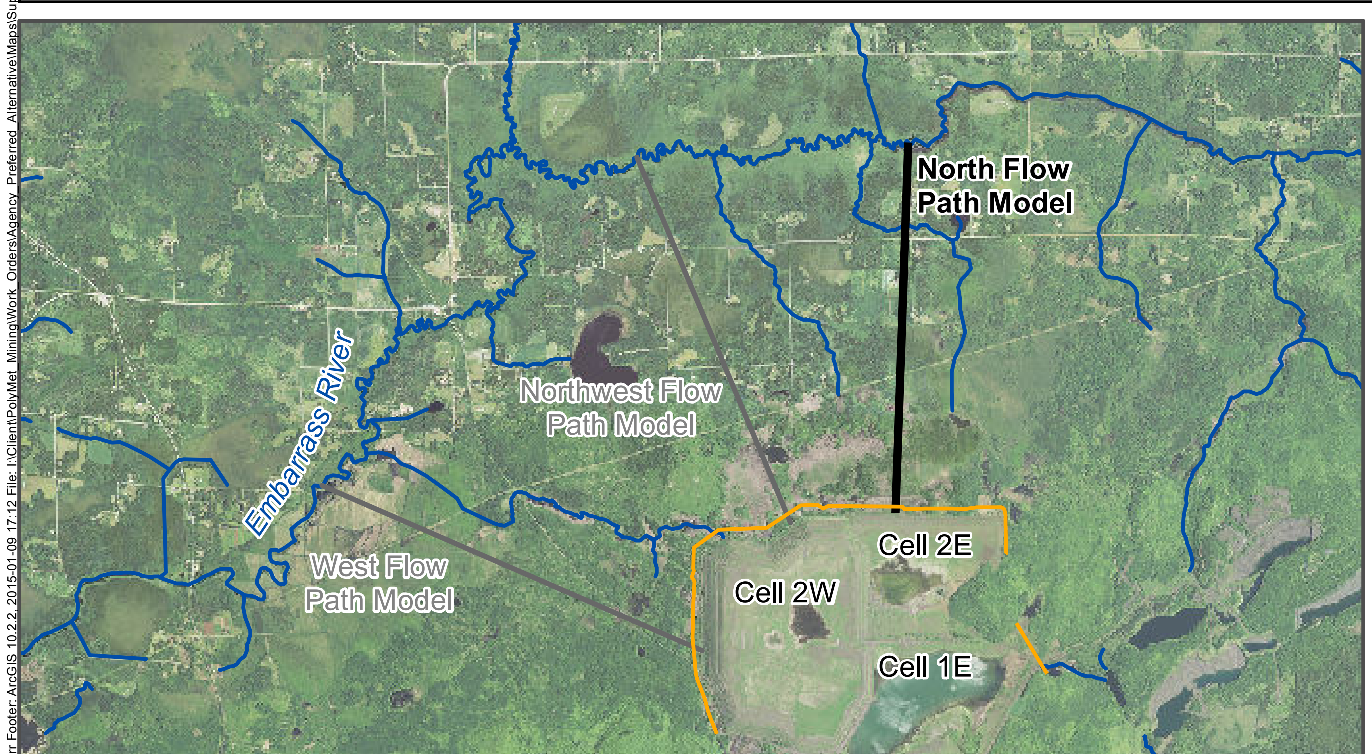
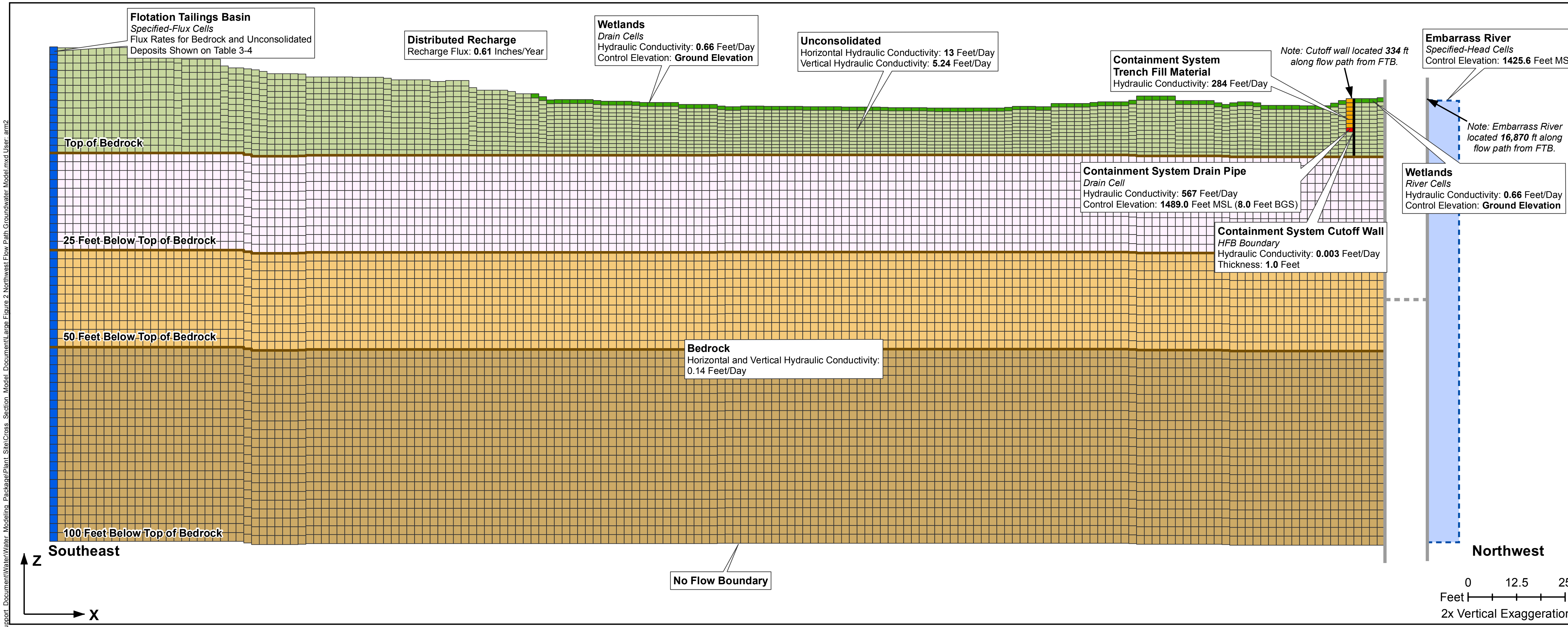
Large Figures

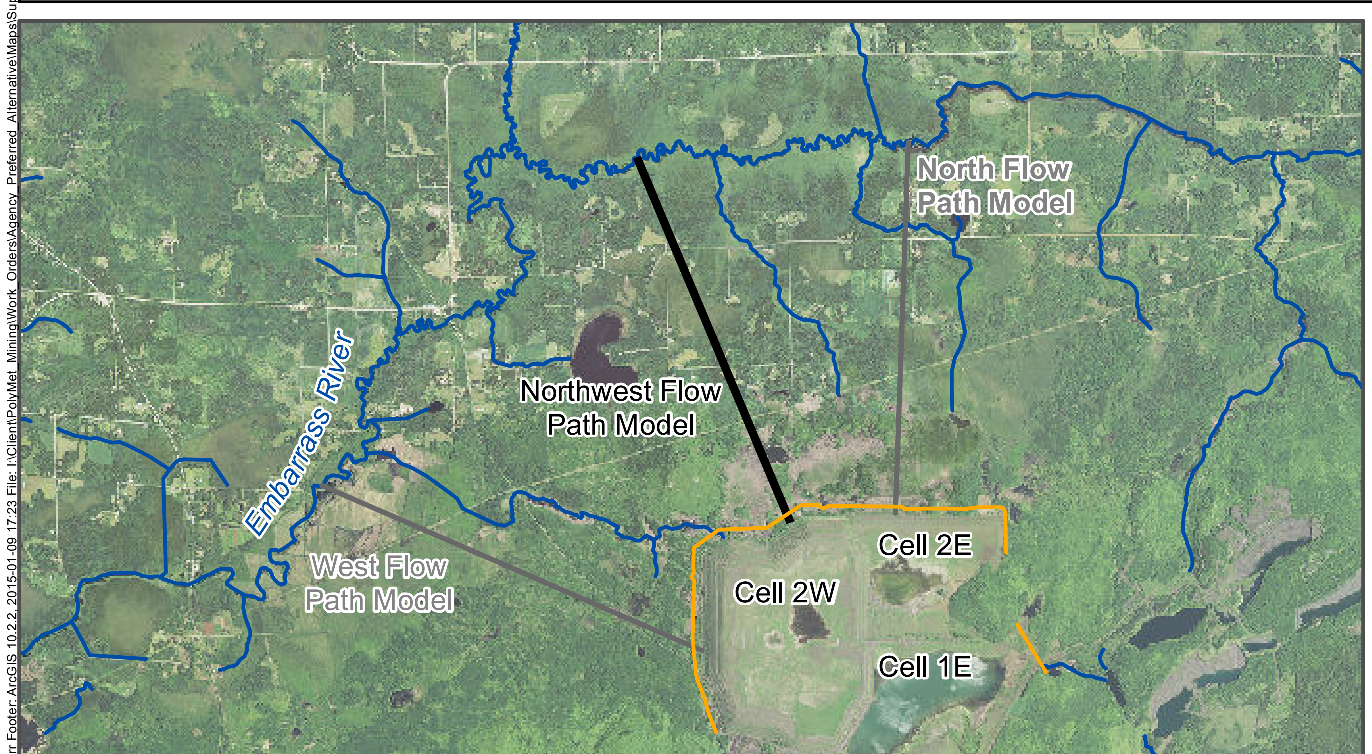


Note: North Flow Path Models included the top 25, 50, or 100 feet of bedrock. The total depth shown represents 100 feet of bedrock with the 25- and 50-foot depth intervals shown.



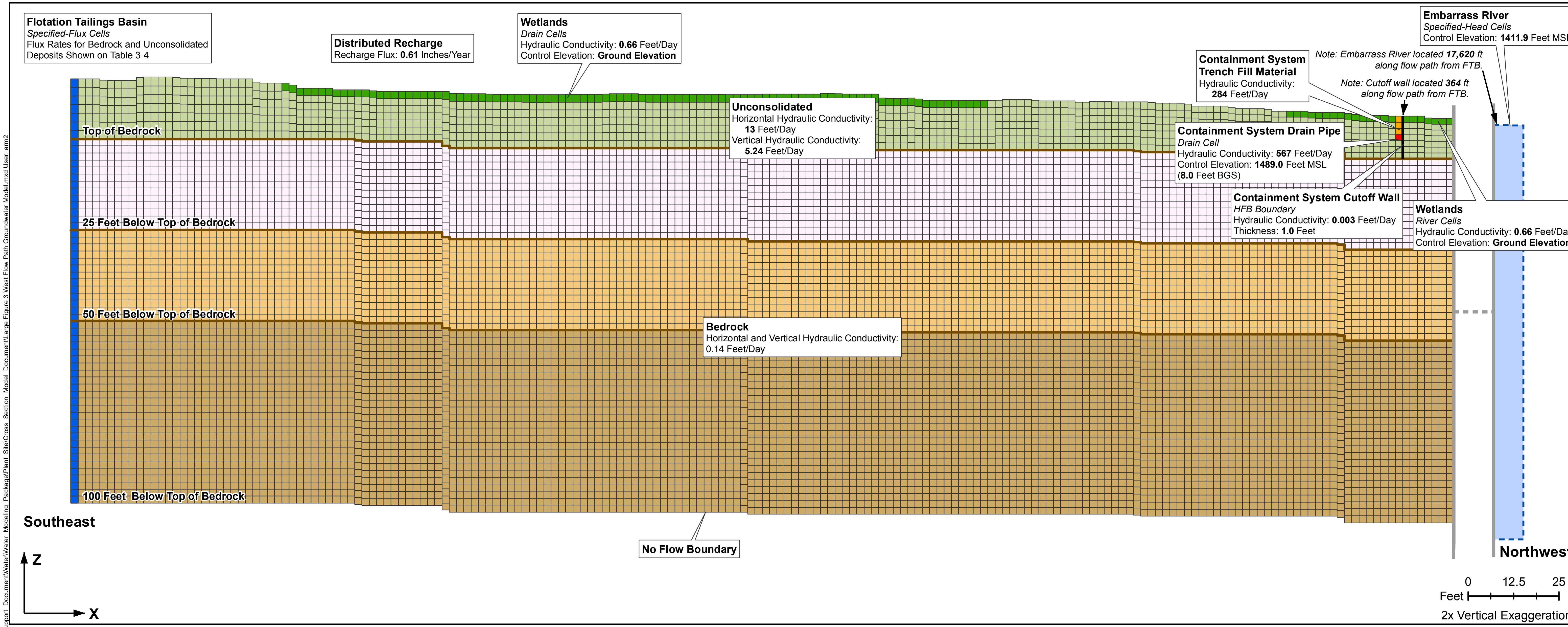
Large Figure 1
NORTH FLOW PATH GROUNDWATER MODEL
NorthMet Project
Poly Met Mining, Inc.
Hoyt Lakes, MN



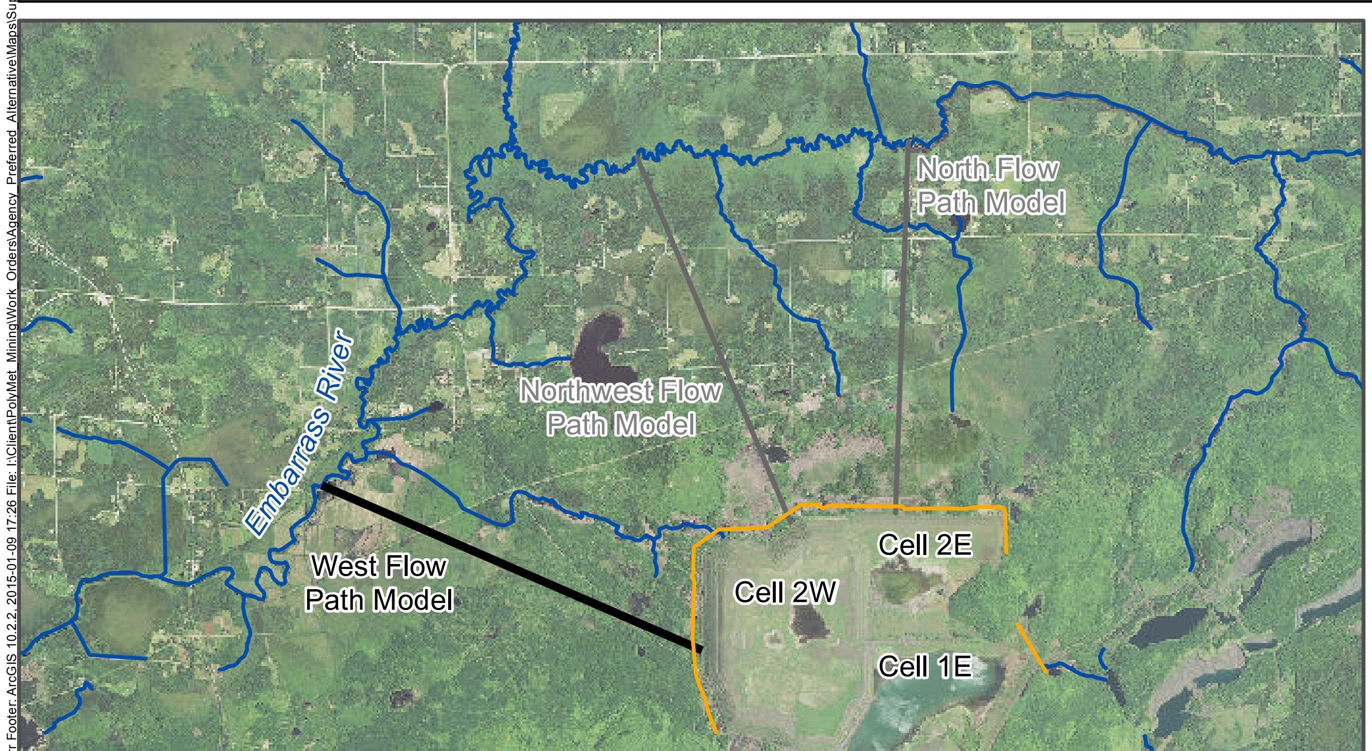


Note: Northwest Flow Path Models included the top 25, 50, or 100 feet of bedrock. The total depth shown represents 100 feet of bedrock with the 25- and 50-foot depth intervals shown.

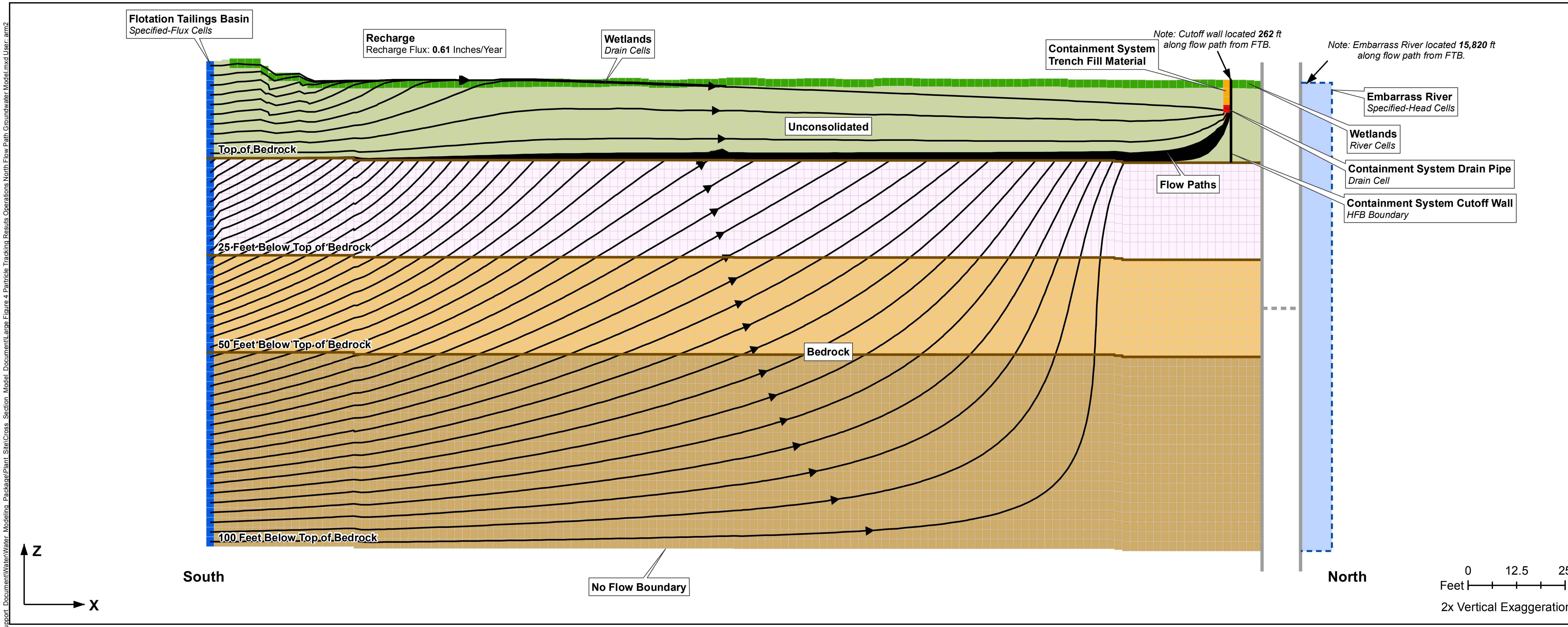
Large Figure 2
NORTHWEST FLOW PATH GROUNDWATER MODEL
NorthMet Project
Poly Met Mining, Inc.
Hoyt Lakes, MN

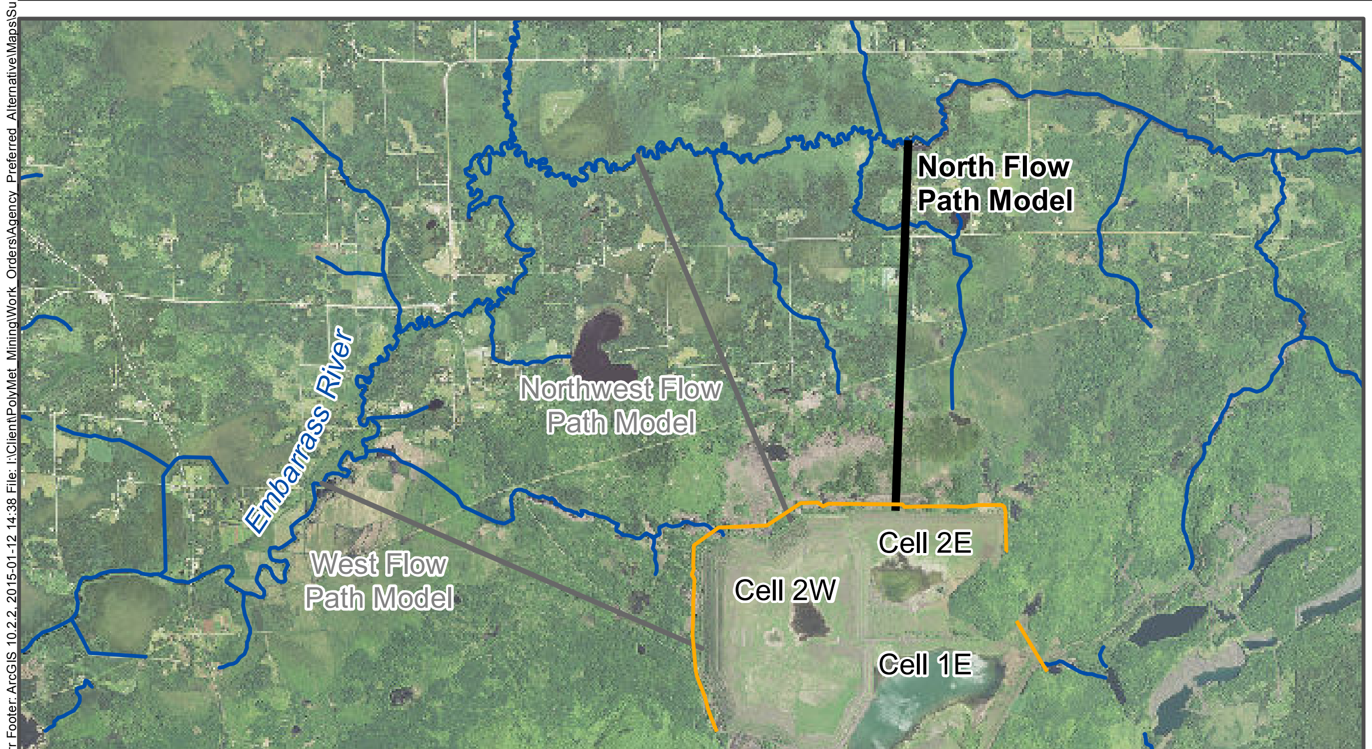


Note: West Flow Path Models included the top 25, 50, or 100 feet of bedrock. The total depth shown represents 100 feet of bedrock with the 25- and 50-foot depth intervals indicated.



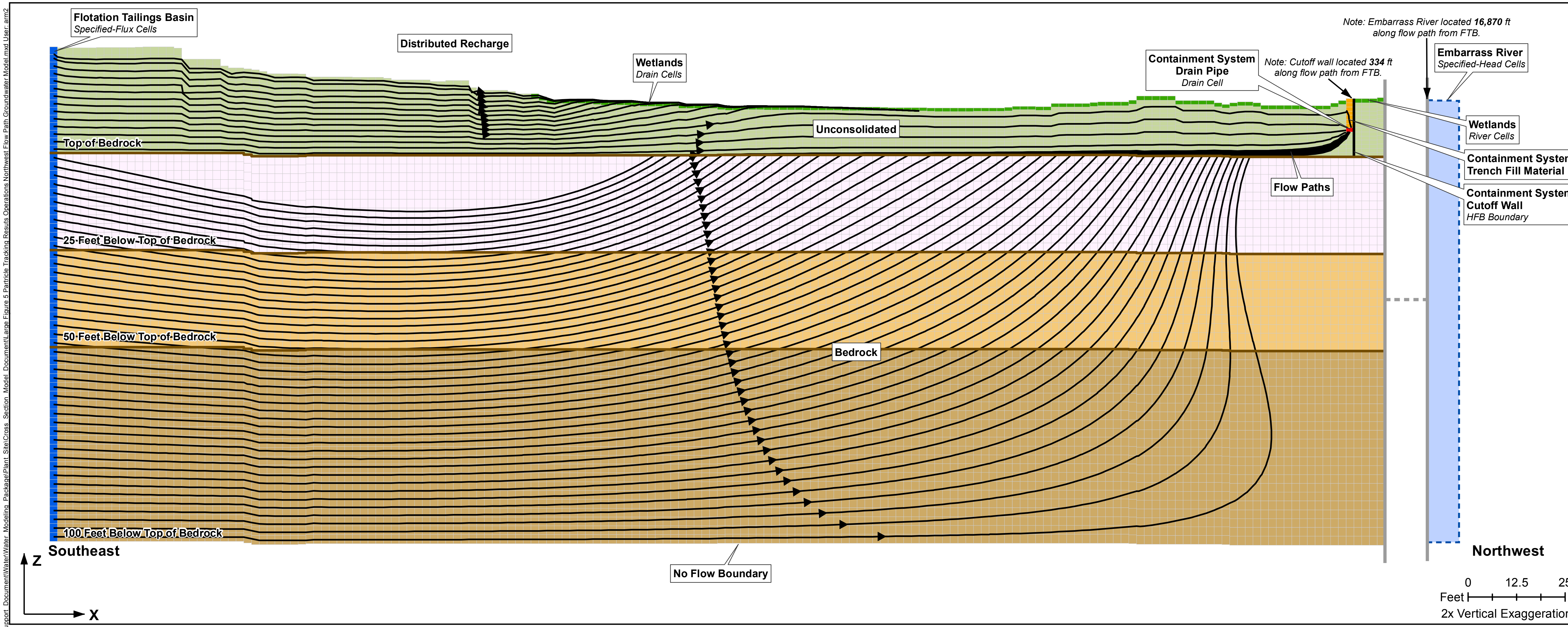
Large Figure 3
WEST FLOW PATH
GROUNDWATER MODEL
NorthMet Project
Poly Met Mining Inc.
Hoyt Lakes, MN

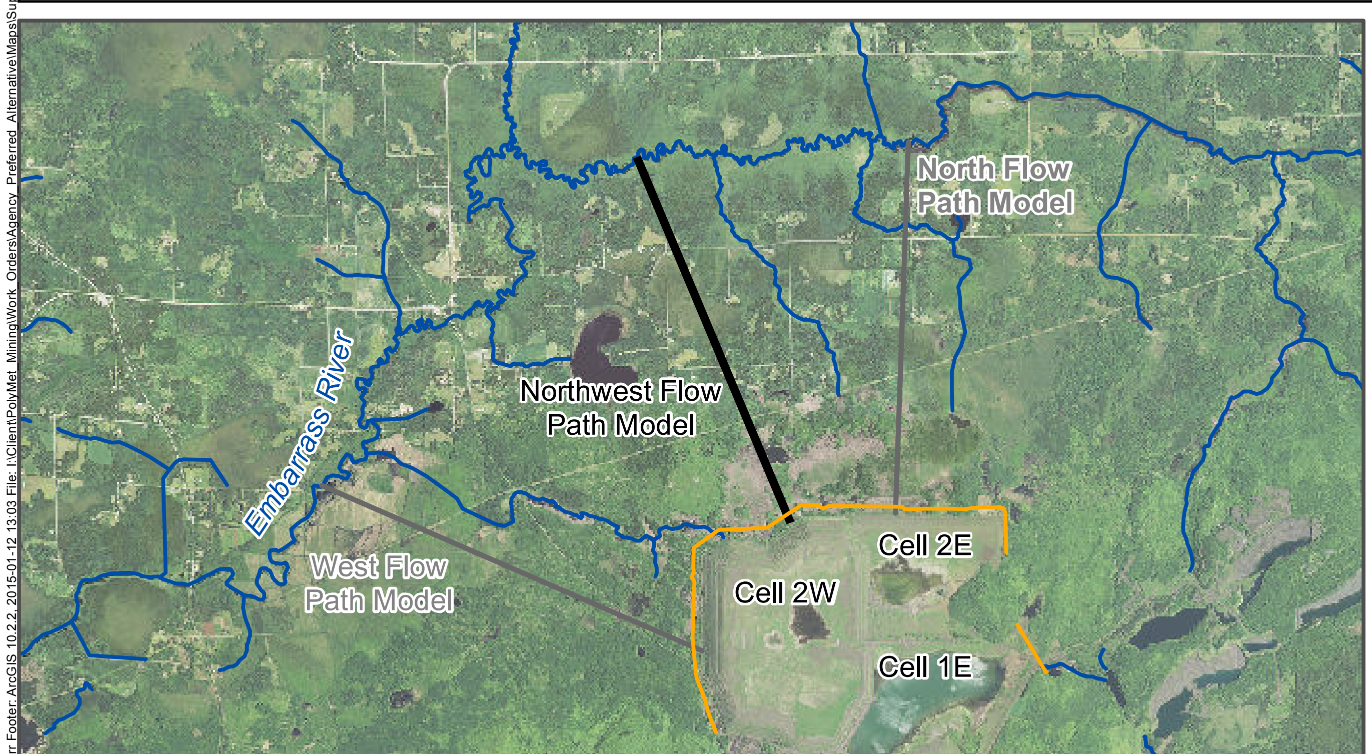




Note: North Flow Path Models included the top 25, 50, or 100 feet of bedrock. The total depth shown represents 100 feet of bedrock with the 25- and 50-foot depth intervals indicated. Particle tracking results are only shown for the simulation with 100 feet of bedrock.

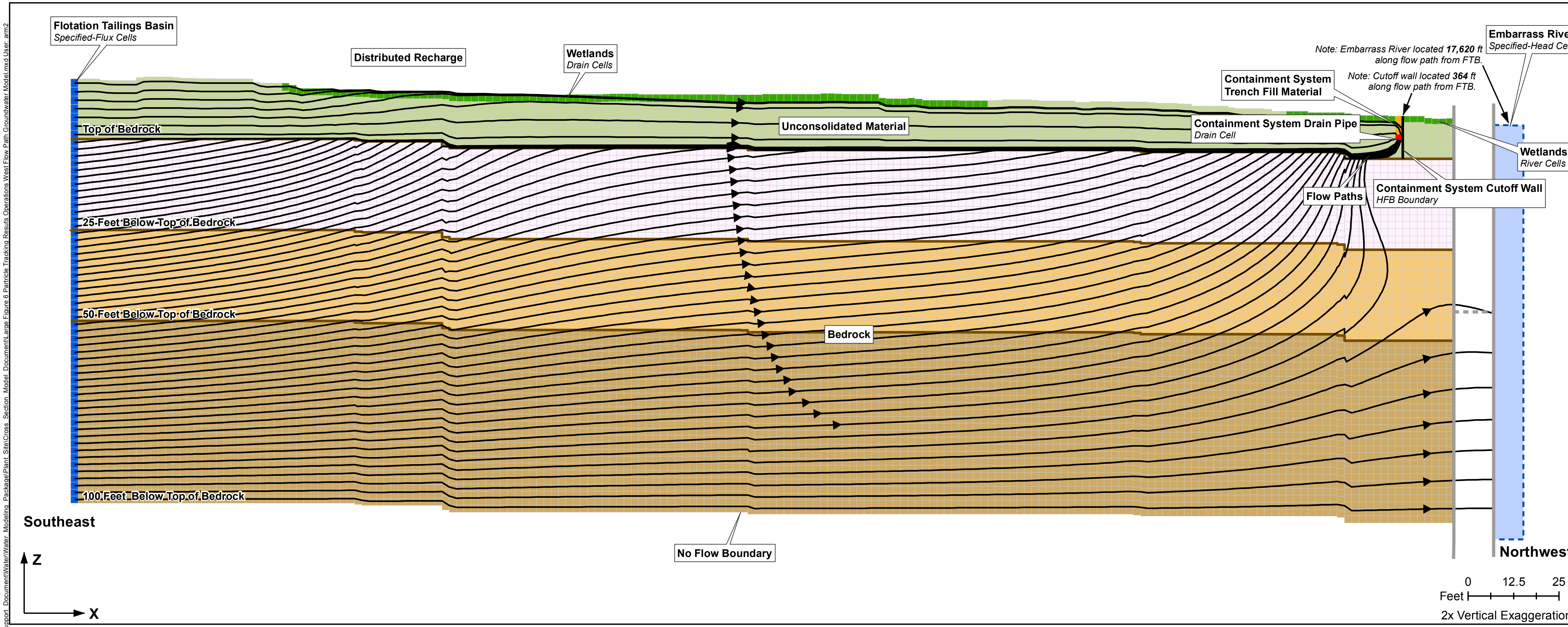
Large Figure 4
PARTICLE TRACKING RESULTS, OPERATIONS
NORTH FLOW PATH GROUNDWATER MODEL
NorthMet Project
Poly Met Mining, Inc.
Hoyt Lakes, MN

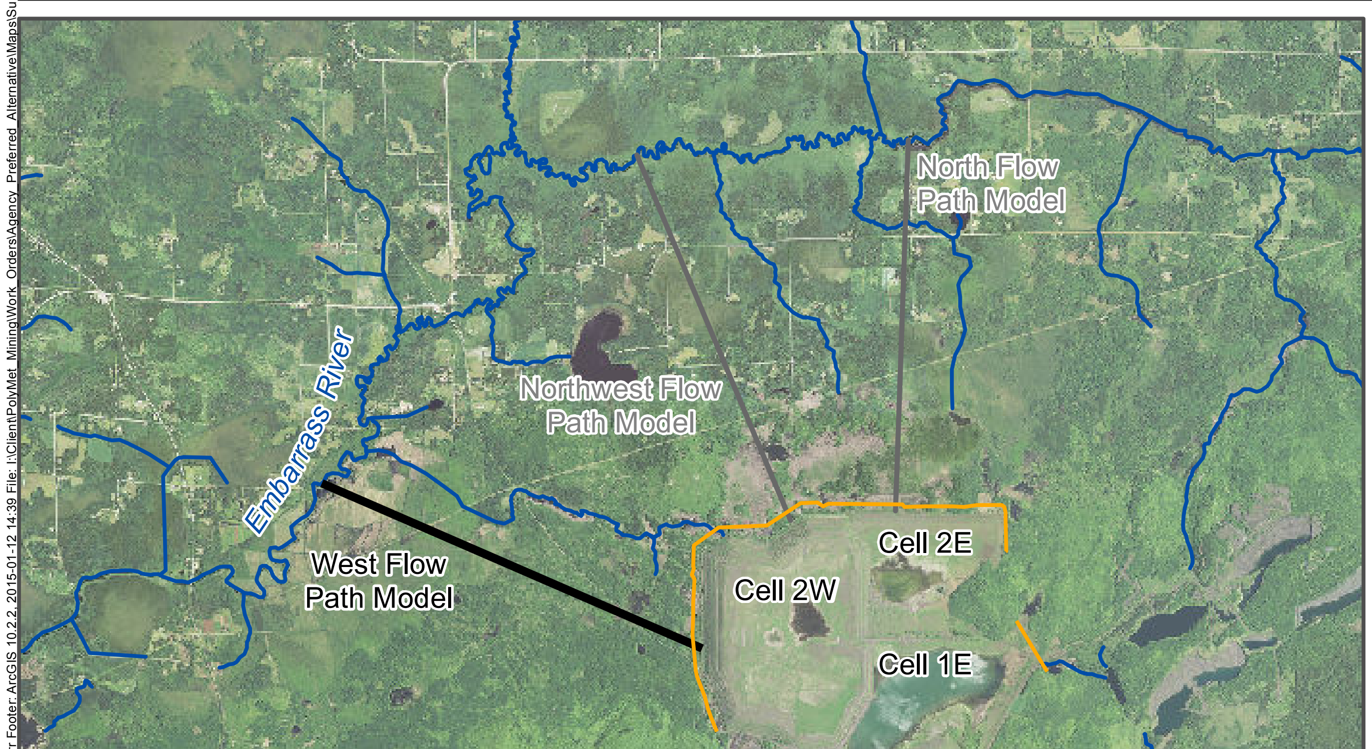




Note: Northwest Flow Path Models included the top 25, 50, or 100 feet of bedrock. The total depth shown represents 100 feet of bedrock with the 25- and 50-foot depth intervals indicated. Particle tracking results are only shown for the simulation with 100 feet of bedrock.

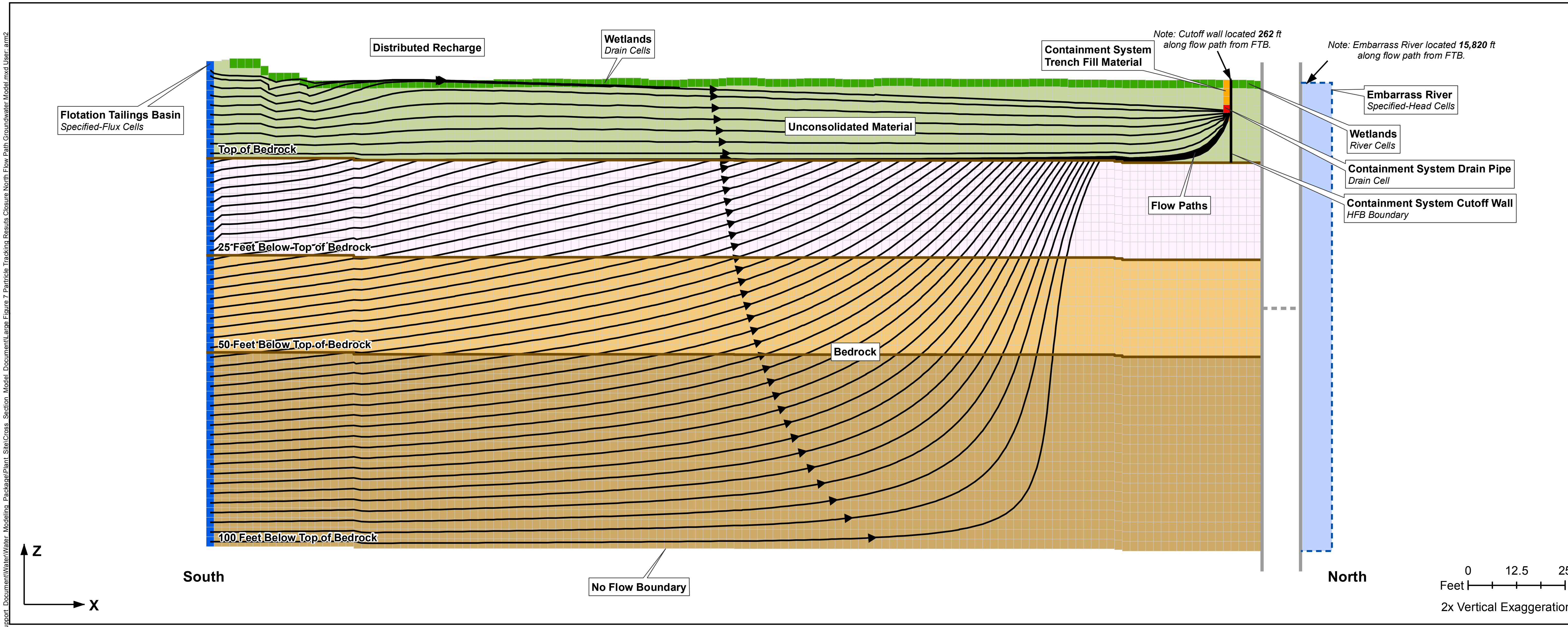
Large Figure 5
PARTICLE TRACKING RESULTS, OPERATIONS
NORTHWEST FLOW PATH GROUNDWATER MODEL
NorthMet Project
Poly Met Mining, Inc.
Hoyt Lakes, MN

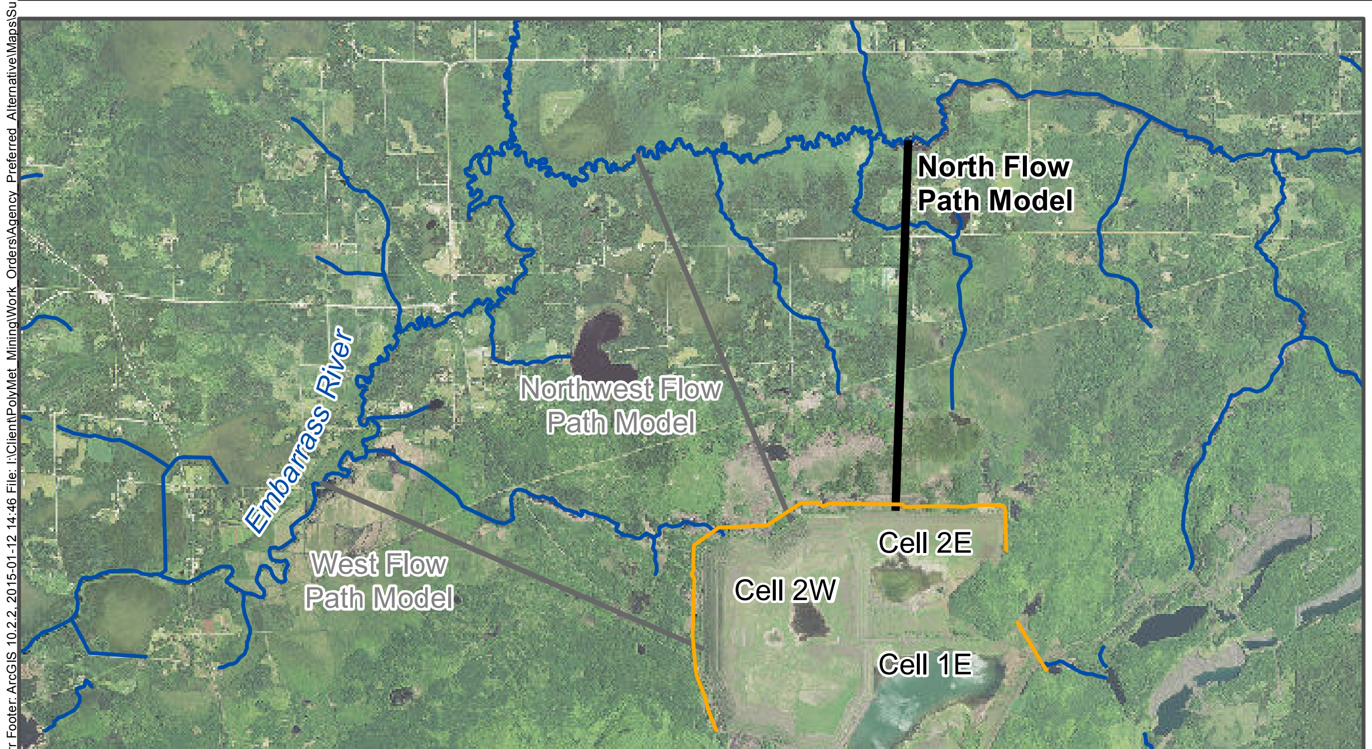




Note: West Flow Path Models included the top 25, 50, or 100 feet of bedrock. The total depth shown represents 100 feet of bedrock with the 25- and 50-foot depth intervals indicated. Particle tracking results are only shown for the simulation with 100 feet of bedrock.

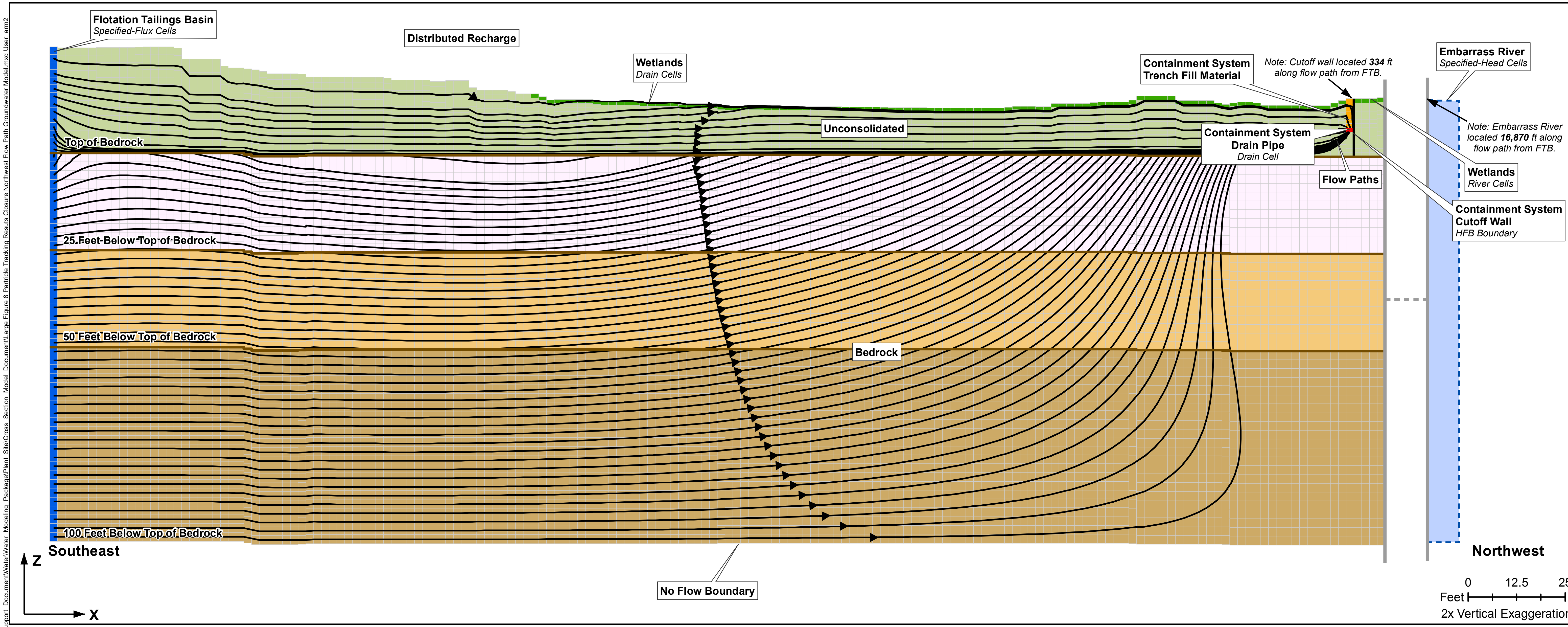
Large Figure 6
PARTICLE TRACKING RESULTS, OPERATIONS
WEST FLOW PATH GROUNDWATER MODEL
NorthMet Project
Poly Met Mining Inc.
Hoyt Lakes, MN

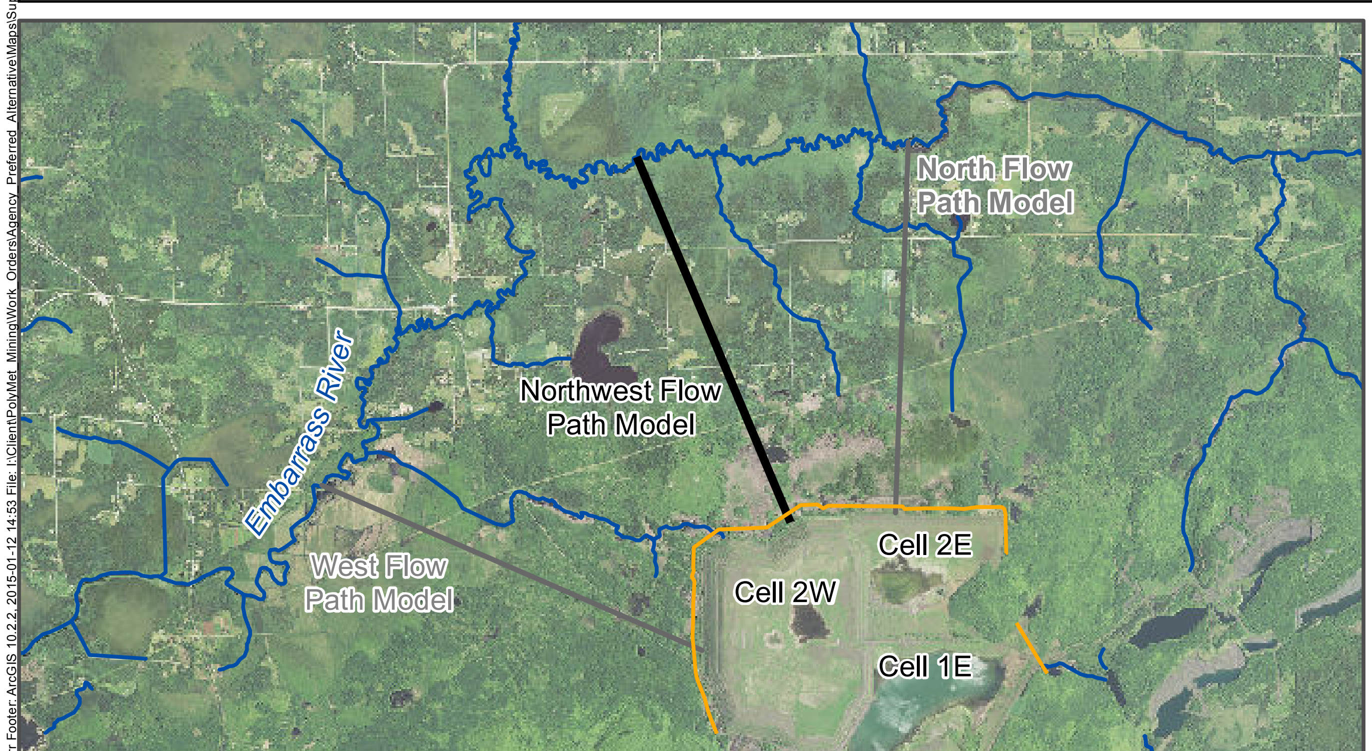




Note: North Flow Path Models included the top 25, 50, or 100 feet of bedrock. The total depth shown represents 100 feet of bedrock with the 25- and 50-foot depth intervals indicated. Particle tracking results are only shown for the simulation with 100 feet of bedrock.

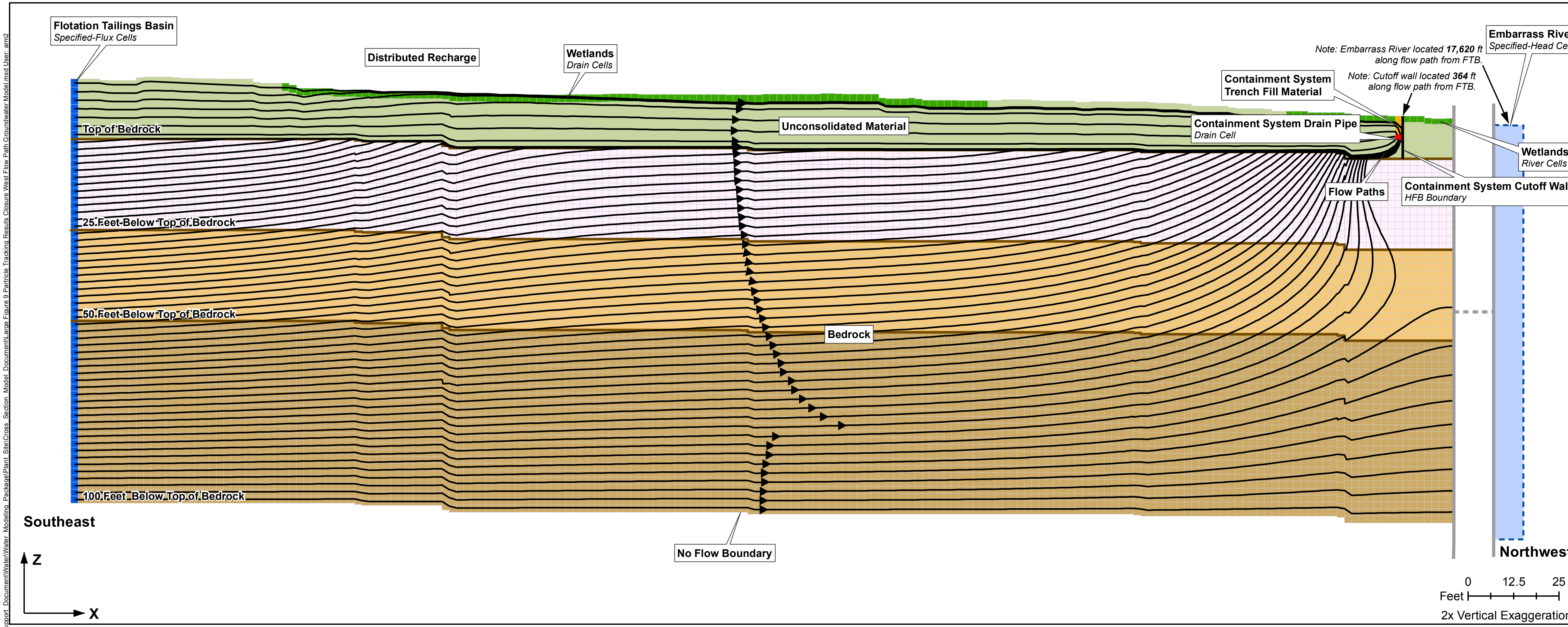
Large Figure 7
PARTICLE TRACKING RESULTS, CLOSURE
NORTH FLOW PATH GROUNDWATER MODEL
NorthMet Project
Poly Met Mining, Inc.
Hoyt Lakes, MN

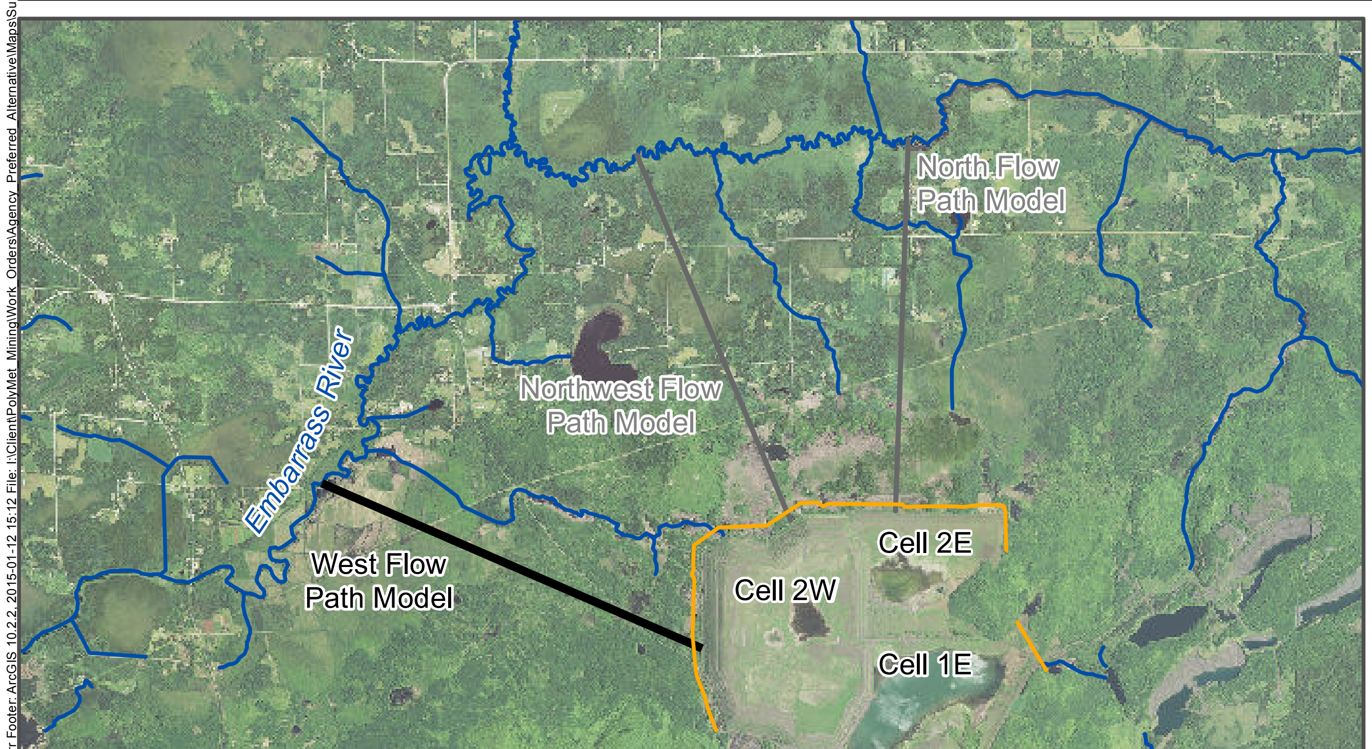




Note: Northwest Flow Path Models included the top 25, 50, or 100 feet of bedrock. The total depth shown represents 100 feet of bedrock with the 25- and 50-foot depth intervals indicated. Particle tracking results are only shown for the simulation with 100 feet of bedrock.

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 D

Plant Site Storm Water Pollution Prevention Plan (SWPPP) - PLACEHOLDER

Attachment E

Industrial Storm Water Pollution Prevention Plan (SWPPP) - PLACEHOLDER

Attachment F

Plant Site Spill Prevention Control and Countermeasures (SPCC) Plan - PLACEHOLDER