

2016/2017 Geotechnical Investigation Work Plan

NorthMet Project Geotechnical Investigations

Prepared for
Poly Met Mining Inc.

June 2016

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1.0 Introduction

This document is the Geotechnical Investigation Work Plan (Work Plan) for the proposed 2016/2017 geotechnical investigations at the NorthMet Project site (Project). The purpose of this Work Plan is to present an overview of the Project geotechnical investigations, consisting of SPT and Rotasonic borings, test pits, and geophysical investigations. This Work Plan was developed to document this phase of the Mine Site and Plant Site Geotechnical Investigations. The purpose of the geotechnical investigations is to collect information on the subsurface (i.e., depth to water, depth to bedrock, stratigraphy of overburden soils). The findings from the geotechnical investigations will be used in final design of Project infrastructure. The results of these investigations will inform the need for and extent of future phases of geotechnical investigation for the Project.

Included in the Work Plan is a brief summary of the Project site infrastructure, description of the geotechnical investigations planned, and proposed material test methods and documentation. This Work Plan was developed to be a companion document to the Geotechnical Investigation Construction Stormwater Pollution Prevention Plan (SWPPPs). Items excluded from this Work Plan that can be found in the Geotechnical Investigation SWPPPs include: approximate access road layout and construction, erosion control plans, and information regarding installation of proposed groundwater monitoring wells.

2.0 Project Summary

The Project consists of the Mine Site, Plant Site, and the Dunka Road Transportation and Utility Corridor. Table 1 summarizes the infrastructure planned for additional investigations as part of this 2016/2017 Work Plan.

Table 1 Summary of 2016/2017 Geotechnical Investigation Locations

Mine Site	Plant Site
Fueling and Maintenance Facility	Flotation Tailings Basin (FTB)
Dikes and Stormwater Ponds	Flotation Tailings Basin Seepage Containment System (FTB SCS)
Rail Transfer Hopper (RTH)	Waste Water Treatment Plant (WWTP)
VSEP Concentrator Track	Plant Stormwater Controls
Stockpiles	Sewage Treatment System
Central Pumping Station	
Rail for RTH	
Category 1 Groundwater Containment System (Cat. 1 GCS)	

Information regarding previous geotechnical investigations and currently available geotechnical data for the Project can be found in:

- Geotechnical Data Package Volume 1 - Flotation Tailings Basin
- Geotechnical Data Package Volume 2 – Hydrometallurgical Residue Facility
- Geotechnical Data Package Volume 3 – Mine Site Stockpiles

3.0 Exploration Methods and Equipment

Geotechnical exploration methods will include Rotosonic drilling, hollow-stem and mud rotary auger borings and possibly other rotary drilling methods with Standard Penetration Testing (SPT), test pits, and potentially seismic surveys.

Rotosonic work will consist of Rotosonic coring, collection of soil and rock samples, installation of standpipe piezometers, and slug testing. All work will be performed in accordance with ASTM D6914, Standard Practice for Sonic Drilling for Site Characterization and Installation of Subsurface Monitoring Devices D5092. Soil samples will be classified based on the Unified Soil Classification System (USCS). Piezometers will consist of a riser with a screened pipe interval at the bottom 5 feet. Sand pack will be placed in the annulus along the screened interval and a bentonite seal will be placed above the sand to isolate the pore water pressure to the screened interval. The piezometers will then be backfilled with bentonite grout to prevent unwanted vertical migration of water. Slug tests may be performed after the piezometers are cleaned and water levels are stabilized.

The SPT geotechnical investigations will consist of SPT soil borings using mud rotary and hollow stem auger drilling methods. Rock cores will be collected to confirm depth to bedrock, typically indicated by SPT results in excess of 50 blows for less than one-half foot of penetration, and to provide qualitative information, including Rock Quality Designation (RQD) values and fracture characteristics. All split spoon sampling and standard penetration testing will be completed in accordance with ASTM D1586, Standard Test Method for SPT and Split-Barrel Sampling of Soils. Soft clay and organic soil samples will be collected with 3-inch thin-wall samplers, when feasible, in accordance with ASTM D1587. Packer testing intervals will be determined in the field with the intent to obtain the most representative data possible and provide hydraulic conductivity values of the bedrock.

Test pits will be performed to determine depth of peat, confirm subsurface conditions, and log stratigraphy. Soil samples will be collected where deemed appropriate. Test pits can be up to 15 feet deep and soil will be removed using a hydraulic excavator. Removed soils will be placed next to one side of the excavation and will be replaced and compacted upon completion of the soil profile evaluation and sample collection.

Groundwater monitoring wells will be installed as part of the individual National Pollutant Discharge Elimination System and State Disposal System (NPDES/SDS) permit application for the Project. Groundwater monitoring wells may be installed during the same timeframe as the geotechnical investigation but are not an integral part of this plan.

Geotechnical investigation phasing will be determined prior to construction. Preference will be given to completing geotechnical investigations located within wetlands when the ground is frozen. This timing will minimize the potential for discharge of sediments and other pollutants. Access routes crossing wetland areas will also be completed when the ground is frozen, when possible, to minimize temporary wetland impacts. In some cases, access to monitoring well locations is not feasible unless there are frozen

ground conditions. Where wetland impacts are required during non-frozen ground conditions, construction mats and/or low-pressure equipment will be used to minimize impacts to wetlands.

Equipment required to complete the geotechnical investigation includes all-terrain drill rigs for the SPT and Rotasonic investigations, and an excavator to perform the test pits. Non-invasive seismic equipment will be used to perform any geophysical investigations.

Existing gravel and paved roads will be used to access the geotechnical investigation locations. Existing trails and/or forest roads located throughout the Mine Site will be used where possible to access the geotechnical investigation locations and minimize soil disturbance; however it is assumed that some ground disturbance may be required with use of the existing trails and/or forest roads. Temporary access routes, including existing trails and/or forest roads, will be utilized to reach those geotechnical investigation locations not accessible from the existing gravel and paved roads.

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4.0 Construction and Erosion Control

Construction Stormwater Pollution Prevention Plans (SWPPPs) have been prepared to outline pollution prevention requirements and procedures applicable to the geotechnical investigation activities. The SWPPPs are live documents; they are based on current plans for geotechnical investigation and will be updated as needed as on-site reconnaissance is performed to confirm geotechnical investigation locations and vehicle access routes.

Existing gravel and paved roads, trails, and/or forest roads will be used to access the geotechnical investigation locations to the extent possible. Temporary access roads will need to be constructed to allow equipment to reach some of the desired investigation locations. The temporary and proposed access routes, including those in wetland areas, are shown in the Geotechnical Investigation SWPPPs figures. Best Management Practices (BMPs) established by the Minnesota Pollution Control Agency (MPCA) will serve as guidelines for developing access roads and avoiding disturbance to wetland soils. Each geotechnical location and access route will be chosen using the criteria outlined in the Geotechnical Investigation SWPPPs.

Clearing, grubbing, and grinding or chipping of vegetation (trees, snags, logs, brush, stumps, and shrubs) and pushing large rocks from temporary access roads will be performed to facilitate geotechnical investigation activities at the Project site. Trees and other vegetation designated to remain undisturbed in wetland areas will be protected from damage throughout the duration of the construction period. The limits of the area(s) to be cleared and grubbed will be marked by stakes, flags, tree markings, or other suitable methods. Trees to be left standing and uninjured will be designated by special markings that are conducive to preventing injury to the tree and will be placed on the trunk about 6 feet above the ground surface. All trees not marked for preservation and all snags, logs, brush, stumps, shrubs, and similar materials will be cleared from within the limits of the designated investigation areas to the extent needed to conduct the geotechnical investigations.

The Geotechnical Investigation SWPPPs describe the BMPs that will be implemented during the geotechnical investigations to address erosion prevention practices and sediment control practices.

5.0 Work Plan Specifics

There is currently a limited geotechnical data set available for design at each of the Project facilities. The proposed 2016/2017 investigation will provide additional information needed to move forward with final design. Additional investigations for final design will likely be required prior to construction of some features, but future geotechnical evaluations will be informed by the results of this 2016/2017 investigation.

The geotechnical investigation schedule will be determined prior to commencement of road construction. An approximate schedule is summarized in Table 2. This information is presented to provide an idea of the sequencing of each task to be performed from the start of the work to completion of the final geotechnical investigation report.

Table 2 Summary of the Geotechnical Investigation Work

Schedule	Summary of Work in Required	Owner
Fall 2016	Field reconnaissance to stake investigation locations and flag access roads, obtaining coordinates of each	Barr
	Pre-Construction Notification (PCN) to U.S. Army Corps of Engineers	PolyMet
	Obtain permits or access easements	PolyMet
	Create maps/figure based on field reconnaissance to show updated locations and access roads	Barr
	Update the Geotechnical Investigation SWPPPs based on field reconnaissance to show updated investigation locations and access roads	PolyMet/Barr
	Prepare plans and specifications for the subcontractors	PolyMet / Barr
	Coordinate/award investigation contract	PolyMet / Barr
	Install erosion controls and clear and grub along access roads	PolyMet/ Subcontractor
Winter/Spring 2017	Oversee access road construction	PolyMet / Barr
	SWPPP inspections, supervision of installation, maintenance, and repair of BMPs	To be determined prior to construction
	Perform investigations	Subcontractor / Barr
	Seeding, restoration, and final stabilization	Subcontractor
	Geotechnical material testing (in-lab)	Subcontractor / Barr
	Data analysis	Barr
	Final report	Barr

The proposed 2016/2017 geotechnical investigations include SPT borings, test pits, geophysical work and material testing. The purpose, methods, and equipment required for each are summarized below.

5.1 Standard Penetration Test Borings

There are a total of 34 Standard Penetration Test (SPT) borings proposed for the 2016/2017 geotechnical investigations, to be performed at seven future facilities. There are 20 Mine Site SPT borings, shown on Large Figure 1. Six of these have been identified as being located in wetland areas. There are 14 Plant Site SPT borings, shown on Large Figure 2, of which four have been identified as being located in wetland areas. A summary of the proposed SPT borings is provided in Large Table . Preference will be given to completing geotechnical investigations located within wetlands when the ground is frozen, as described in greater detail in the Geotechnical Investigation SWPPPs. This timing will minimize the potential for ground disturbance.

The naming convention for each SPT boring will identify the investigation method and year, followed by the investigation number. For example, BH2017-01 will represent the first (01) SPT location (BH or borehole) performed in 2017. Naming convention is preliminary and will be finalized at the time that the borings are performed.

5.2 Test Pits

The 2016/2017 geotechnical investigation has proposed 88 test pits to be performed at six future facilities. There are 81 Mine Site test pits, shown on Large Figure 1. Twenty-five of these have been identified as being located in wetland areas. There are seven Plant Site test pits, shown on Large Figure 2, all located outside of wetland areas. A summary of the proposed SPT borings is provided in Large Table 1. Ideally the test pits will be performed when the ground is firm but not frozen such as in the fall or spring. This timing will provide adequate ground support for the excavator and minimize the potential for disturbance in wetland areas.

The naming convention for the test pits will identify the investigation method and year followed by the investigation number. For example, TP2017-01 will represent the first (01) test pit (TP) performed in 2017.

5.3 Geophysical Investigations

Geophysical investigations may be performed as part of the geotechnical investigation program. The objective of these investigations will be to provide a potentially more cost effective means to:

1. Estimate the depth to bedrock along the alignment for the cut-off wall planned as part of the Flotation Tailings Basin Seepage Containment System at the Plant Site, and around the Category 1 Stockpile at the Mine Site.
2. Estimate the thickness of peat deposits in the proposed stockpile footprints at the Mine Site.

The ability to collect subsurface data through geophysical explorations from the ground surface can provide a valuable supplement to the more intrusive boreholes in developing models of the subsurface conditions. It is also assumed that the geophysical investigations will be performed in wetland areas.

Seismic refraction will be the most effective technique to map and estimate the bedrock surface beneath the proposed cut-off wall alignment at the Plant Site and Mine Site. Data would be collected simultaneously for both seismic refraction and the multi-channel analysis of surface waves (MASW) technique. This geophysical survey would produce a 2-dimensional cross-section of distance vs. depth with model layer values measured in seismic velocities. Survey results, along with existing borehole data, would be used to adjust the subsurface model cross-section and target additional borings to verify anomalous bedrock depths revealed in the seismic survey results.

Ground penetrating radar (GPR) at the Mine Site will be the most cost-effective means to estimate the thickness and extent of peat deposits in the stockpile areas. Data processing is usually minimal, and real-time images of the resulting data are produced. When coupled with GPR common depth point (CDP) soundings, reasonably accurate depth profiles are possible. Data would be analyzed to determine the depth of investigation, effectiveness of the method, and antenna selection. The desired data density would be satisfied by parallel transects in the wetland areas of each of the stockpile footprints. Lineal footage assumptions are based on an approximation assuming cross lines spaced 200' apart, crossing wetlands of each area:

- Category 1 Stockpile = 110,000 lineal feet [L.F.]
- Category 2/3 Stockpile = 22,000 L.F.
- Ore Surge Pile = 3,800 L.F.
- Central Pit (Category 4 Stockpile) = 7,200 L.F.
- Overburden Storage & Laydown Area = 6,000 L.F.

Total = 149,000 L.F. (28.2 miles)

Geophysical investigations summarized above are at the conceptual planning stages with geophysical exploration sub-contractors. Even with geophysical investigations, site access and vegetation density, as well as subsurface conditions, can interfere with survey implementation, accuracy and efficiency. These factors will be further evaluated as the time nears for Work Plan implementation.

5.4 Material Testing

Material testing will be performed on select soil samples recovered from SPT borings and test pits performed as part of the planned geotechnical exploration. Typical material testing performed in the laboratory may include but not be limited to:

- Water Content – ASTM D4643
- Sieve Analysis – ASTM D6913
- Hydrometer Analysis – ASTM D4211
- Specific Gravity – ASTM D854
- Atterberg Limits – ASTM D4221

- Standard Proctor – ASTM D698
- Permeability – ASTM D5084

In addition to the material tests summarized above, a limited quantity of in-laboratory material shear strength testing may also be performed. The material testing results will be utilized to plan horizontal and vertical extent of excavations, to confirm material type and availability for on-site construction uses, to further evaluate material strength for use in foundations support, and to determine areas of soil requiring excavation and replacement.

5.5 Documentation

Pre- and post- road development and geotechnical investigations will be documented using photographs, field notes, and electronic handheld devices which include Global Positioning Systems (GPS) and digital tablets. Digital tablets have the capability of tracking real-time data that would allow team members to remotely monitor the road construction while it is occurring, documenting the access roads in wetlands, and allowing Geotechnical Investigation SWPPP figures to be updated in a timely manner. Documentation for each geotechnical investigation will include:

- Coordinates and elevations
- Logs of stratigraphy
- Grouting details for each SPT boring
- Restoration plan and record of abandonment for each test pit

Upon completion of the geotechnical investigations, and when the soils collected from the field have been subjected to visual characterization and laboratory testing, a soil investigation report will be prepared for use in planning and design, summarizing results, and providing soil data (including boring logs). The report will contain typical geotechnical investigation information such as:

- Scope and purpose of investigation
- Geologic conditions of the site
- Summary of field investigations (SPT borings, test pits, and geophysical investigations)
- Groundwater conditions
- Laboratory testing data
- Analysis of subsurface conditions
- Design recommendations
- Anticipated construction challenges

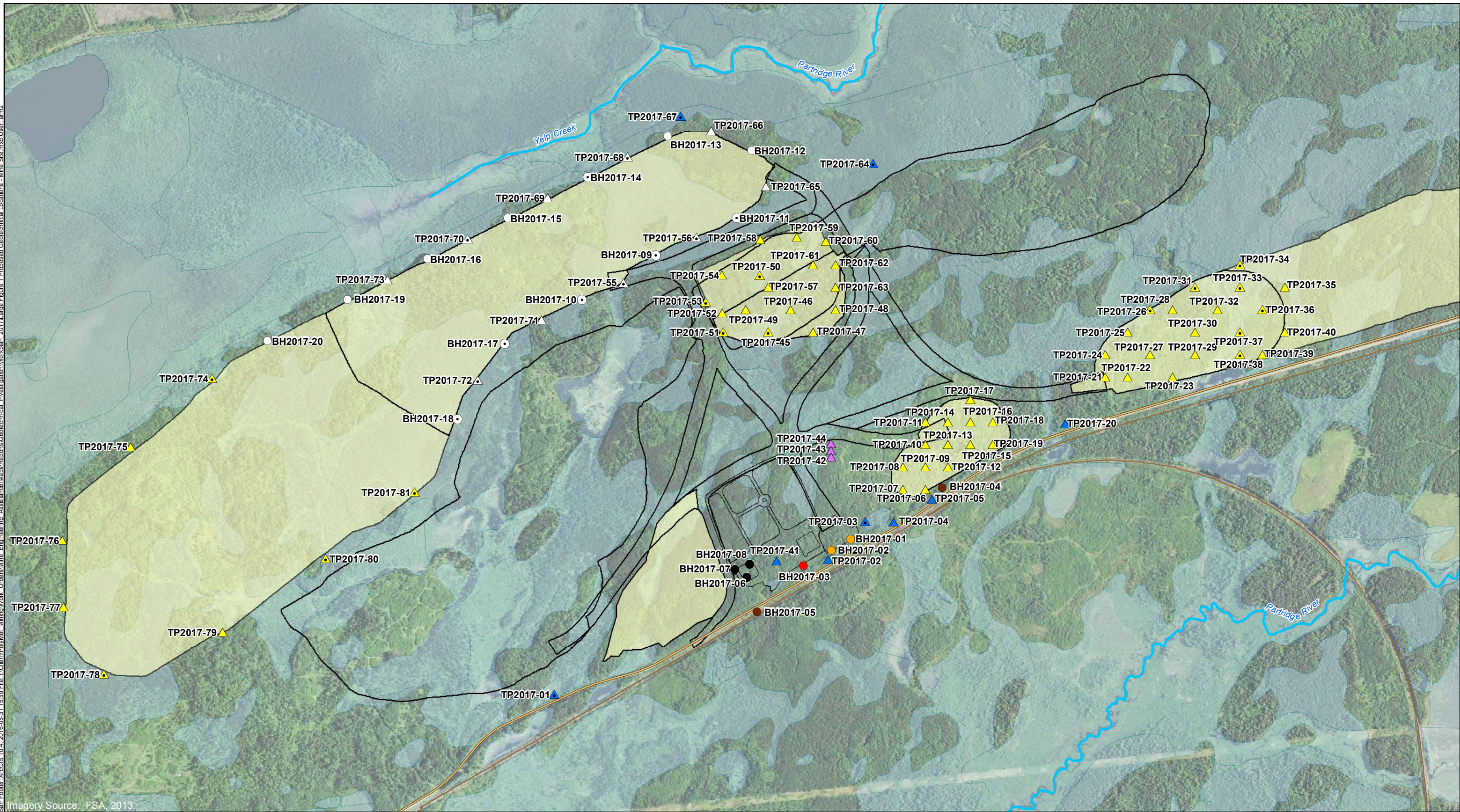
-
- Maps/figures
 - Site location
 - Location of borings with respect to infrastructure
 - Boring logs
 - Laboratory test results

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Large Figures

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Barr Footer: ArcGIS 10.4, 2016-05-31 11:59:59 File: \\Client\Polymet\Mining\Work Orders\Mine Engineering Assistance\Maps\Reports\Geotechnical Investigation\Workplan_2017\Large Figure 1 Proposed Geotechnical Locations - Mine Site.mxd User: arm2



Imagery Source: FSA, 2013.

<p>Proposed Geotechnical Locations</p> <ul style="list-style-type: none"> ▲ Fueling and Maintenance Facility Test Pits Count: 3 ▲ Stockpile Test Pits Count: 44 ▲ Stockpile Test Pits in Wetlands Count: 15 	<ul style="list-style-type: none"> ▲ Dikes and Stormwater Test Pits Count: 5 ▲ Dikes and Stormwater Test Pits in Wetlands Count: 4 ● RTH SPT Borings Count: 2 	<ul style="list-style-type: none"> ● Rail for RTH SPT Borings Count: 2 ● VSEP Concentration Track SPT Borings Count: 1 ● CPS SPT Borings Count: 3 	<ul style="list-style-type: none"> ○ Cat. 1 GCS SPT Borings Count: 6 ○ Cat. 1 GCS SPT Borings in Wetlands Count: 6 △ Cat. 1 GCS Test Pits Count: 5 △ Cat. 1 GCS Test Pits in Wetlands Count: 5 	<ul style="list-style-type: none"> — Dunka Road — Existing Private Railroad ▭ Proposed Mine Features ~ Public Waters Inventory (PWI) Watercourses ○ Wetlands 	<p>0 600 1,200 2,400</p> <p>Feet</p>		<p>DRAFT</p> <p>PROPOSED GEOTECHNICAL LOCATIONS - MINE SITE</p> <p>NorthMet Project</p> <p>Poly Met Mining Inc.</p>
<p>Large Figure 1 Geotechnical Investigation Work Plan</p>							

Barr Footer: ArcGIS 10.4, 2016-05-31 16:00 File: I:\Client\Polymet Mining\Work Orders\Mine Engineering Assistance\Maps\Reports\Geotechnical Investigation\Workplan_2017\Large Figure 2 Proposed Geotechnical Locations - Plant Site.mxd User: am2



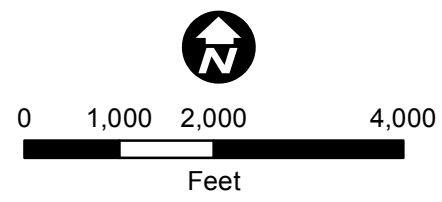
Imagery Source: FSA, 2013.

Proposed Geotechnical Locations

- FTB SCS SPT Boring
Count: 8
- FTB SCS SPT Boring in Wetland
Count: 4

- WWTP SPT Boring
Count: 2
- ▲ Plant Stormwater Test Pit
Count: 3
- ▲ Sewage Treatment Test Pit
Count: 4
- Geophysical Investigation

- Dunka Road
- +—+— Existing Private Railroad
- Colby Lake Water Pipeline
- ~ Public Waters Inventory (PWI) Watercourses¹
- Wetlands



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PROPOSED GEOTECHNICAL LOCATIONS - PLANT SITE
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Large Figure 2
 Geotechnical Investigation Work Plan

Large Tables

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