5.0 ENVIRONMENTAL CONSEQUENCES

5.1 INTRODUCTION

Pursuant to the requirements of NEPA regulations at 40 CFR 1502.16 and *Minnesota Rules*, part 4410.2300, Chapter 5 describes the potential environmental consequences of the NorthMet Project Proposed Action and Land Exchange Proposed Action on the affected environment as described in Chapter 4.

As defined in 40 CFR 1508.8, this chapter addresses the following types of effects:

- Direct effects, which are caused by the action and occur at the same time and place; and
- Indirect effects, which are caused by the action and are later in time or farther removed in distance, but are still reasonably foreseeable. Indirect effects may include growth-inducing effects and other effects related to induced changes in the pattern of land use, population density or growth rate, and related effects on air and water and other natural systems, including ecosystems.

Evaluation criteria and analysis methodology are identified where applicable for each resource topic. Environmental effects were determined based on qualitative and/or quantitative assessment.

As listed in Table 5.1-1, this chapter follows the same structure and order of resource topics as Chapter 4. Section 5.2 describes the environmental consequences of the NorthMet Project Proposed Action and the NorthMet Project No Action Alternative. Section 5.3 describes the environmental consequences of the Land Exchange Proposed Action, Land Exchange Alternative B, and Land Exchange No Action Alternative.

The proposed lands to be exchanged are described in Section 5.3. Disclosure of appraisal information in the EIS is not required. Any decision, documented in the ROD, to move forward with a land exchange will be supported by a current appraisal, approved by the USFS, which verifies that the exchange meets the equal value requirements of applicable federal law and regulation. Requests for appraisal reports and appraisal review reports are processed under Freedom of Information Act procedures. Appraisals must conform to Uniform Appraisal Standards for Federal Land Acquisitions and the Uniform Standards of Professional Appraisal Practice of the Appraisal Foundation. The final proposed configuration of land would be determined after the market value of the parcels is determined by appraisals and the environmental analysis has been completed. This information will be presented in the ROD.

As previously indicated, the land exchange acreages used in the Project Description section are described in GLO acreages, while the acreages used in the Affected Environment and Environmental Consequences sections are described in GIS acreages. The environment consequences presented in Section 5.3 are based upon GIS data. GIS values indicate the size of the federal and non-federal parcels as computed geometrically using mapping software, which may be different than the GLO legal acreage. Unless noted as GLO acres, all values shown are derived from GIS data.

Table 5.1-1 Resource Topic Areas Discussed in Chapter 5

Resource Topic	NorthMet Project Proposed Action	Land Exchange Proposed Action
Land Use	5.2.1	5.3.1
Water Resources	5.2.2	5.3.2
Wetlands	5.2.3	5.3.3
Vegetation	5.2.4	5.3.4
Wildlife	5.2.5	5.3.5
Aquatic Species	5.2.6	5.3.6
Air Quality	5.2.7	5.3.7
Noise and Vibration	5.2.8	5.3.8
Cultural Resources	5.2.9	5.3.9
Socioeconomics	5.2.10	5.3.10
Recreation and Visual Resources	5.2.11	5.3.11
Wilderness and Special Designation Areas	5.2.12	5.3.12
Hazardous Materials	5.2.13	5.3.13
Geotechnical Stability	5.2.14	5.3.14

5.2 NORTHMET PROJECT

5.2.1 Land Use

This section evaluates the NorthMet Project Proposed Action against existing and applicable land use plans. The specific focus is on the consistency of the NorthMet Project Proposed Action with accepted plans, zoning ordinances, or land use agency management plans. It also addresses the legacy contamination and how it would be affected by proposed activities.

Summary

Components of the NorthMet Project Proposed Action are subject to the requirements of local comprehensive land use plans or the Superior National Forest Plan. In all cases, the NorthMet Project Proposed Action activities are consistent with the formally adopted plans. The NorthMet Project Proposed Action would decrease the amount of land available for public access and use, and would decrease portions of the 1854 Ceded Territory available for use by the Bands. Given the historic use of the federal lands within the Mine Site for mineral exploration and ongoing restrictions on public access (see Section 4.2.11), the NorthMet Project Proposed Action would result in little or no change in actual public use of these lands.

5.2.1.1 Methodology and Evaluation Criteria

The USFS uses the management area framework to broadly define the desired conditions and activities on lands within national forests. Land use outside the Superior National Forest is governed by local zoning and comprehensive plans. The management area designations applicable to the Mine Site and portions of the Transportation and Utility Corridor, as defined in the Forest Plan, are described in Section 4.2.1, as are zoning designations for land outside of the Superior National Forest.

The NorthMet Project Proposed Action is evaluated against the following evaluation criteria:

- Compatibility of proposed land use with existing land use, land use plans, zoning ordinances, 1854 Treaty obligations, and adjacent USFS management areas;
- Anticipated outcomes related to identified contaminated lands; and
- The degree to which past, ongoing, or planned investigation and remediation actions at legacy contamination sites would be affected by disturbance associated with the NorthMet Project Proposed Action.

5.2.1.2 NorthMet Project Proposed Action

5.2.1.2.1 Consistency with Zoning and Comprehensive Plans

The NorthMet Project area lies within the Mineral Mining zoning districts of the cities of Babbitt and Hoyt Lakes (Arrowhead 2014; Hoyt Lakes Planning Commission 2010), and an industrial use district of St. Louis County (St. Louis County 2011). Therefore, the NorthMet Project area is compatible with the zoning ordinance and draft revised Comprehensive Land Use Plan, and would not require an amendment of the respective zoning ordinances or Comprehensive Land Use Plans (Arrowhead 2014; City of Babbitt 1996). Both the county and municipal zoning districts surrounding the Plant Site are designated for industrial or mining use; the NorthMet

Project area is compatible with these designations and would not require amendments to current land uses. Privately owned parcels adjacent to the Mine Site fall under the same or similar zoning and land use designations; therefore, the NorthMet Project Proposed Action would not have the potential to conflict with surrounding land uses.

5.2.1.2.2 Consistency with Superior National Forest Plan

The Mine Site is located within the Superior National Forest and on lands designated as a General Forest-Longer Rotation Management Area (USFS 2011a). In such areas, the USFS allows exploration, development, and processing of mineral resources under conditions where activities are consistent with sound environmental management so as to contribute to economic growth. In addition to managing project development, the USFS also requires preparation of associated reclamation plans to ensure the long term protection and restoration of the natural resources (USFS 2004b). The NorthMet Project Proposed Action would be consistent with these policies.

The NorthMet Project Proposed Action would represent a reactivation of the Transportation and Utility Corridor (including the Dunka Road and the associated rail line) for mining, which would be compatible with existing corridor land uses. Under the NorthMet Project Proposed Action, Dunka Road would remain private for mine operation use. Superior National Forest lands to the east, south, and southwest of the Transportation and Utility Corridor are accessible by forest roads and are not dependent on Dunka Road for access (see Figure 4.3.1-1), although Forest Road 113 connects Dunka Road to CR 110 near Skibo, Minnesota. The NorthMet Project Proposed Action represents no anticipated change in the level of public access to either of these adjacent Superior National Forest parcels.

5.2.1.2.3 Areas of Concern

The land within the NorthMet Project area contains 59 AOCs listed under the VIC program of the MPCA. PolyMet became responsible for 29 of these AOCs (see legacy contamination discussion in Section 4.2.1.4.2). Of these, six have already been closed or have received a No Further Action letter from the MPCA (see Table 4.2.1-2). Additional investigation would be required to determine whether the remaining AOCs require further action. The NorthMet Project Proposed Action offers no direct resolution for the 33 AOCs that are designated as the responsibility of parties other than PolyMet (see Table 4.2.1-2). The MPCA VIC program would be utilized to facilitate and oversee remediation activity for any remaining potential historical releases on the 29 AOCs under the NorthMet Project Proposed Action.

5.2.1.3 NorthMet Project No Action Alternative

The NorthMet Project No Action Alternative would not result in any change in land management at the Mine Site or Transportation and Utility Corridor. Land at the Plant Site would continue to be managed in accordance with the existing closure plan and Consent Decree. The existing 1854 Treaty obligations for the Mine Site and Plant Site would remain unchanged.

5.2.2 Water Resources

This section is organized into a description of the criteria used for evaluating NorthMet Project Proposed Action-related effects, the methodologies used to predict these effects, and a discussion of the effects resulting from the NorthMet Project Proposed Action. A summary of the primary effects of the NorthMet Project Proposed Action on water resources is provided below.

Summary

The NorthMet Project Proposed Action would be located in an historic mining area, known as the Mesabi Iron Range, and in the vicinity of other past, present, and potential future mining projects. Although the Mine Site would be on undeveloped land, PolyMet proposes to re-use many of the former LTVSMC facilities at the brownfield Plant Site, which is located about 8 miles west of the Mine Site. While reusing the existing LTVSMC Tailings Basin for tailings disposal offers environmental benefits (e.g., reducing wetland effects and addressing legacy water quality issues), it does create challenges because the existing LTVSMC Tailings Basin is not lined and currently releases seepage with elevated concentrations of sulfate, TDS, and hardness, among other constituents. Many of the engineering controls proposed by PolyMet at the Plant Site are related to managing seepage from the combined existing LTVSMC tailings and the future NorthMet tailings.

The NorthMet Project Proposed Action would have the potential to affect groundwater and surface water hydrology and quality in both the Partridge River and Embarrass River watersheds. These two rivers are both tributaries to the St. Louis River and within the Lake Superior Basin. The rivers are not located within Rainy River Watershed (which is in the Hudson Bay Basin) and do not flow to or affect the water quality of the BWCAW.

The presence of perennial streams and watershed divides at both the Mine Site and Plant Site constrain the hydrologic effects of the NorthMet Project Proposed Action to the Partridge River and Embarrass River watersheds. There are two surficial groundwater and surface water hydrologic barriers between the Mine Site and the Rainy River Watershed (which is hydrologically connected to the BWCAW), including:

- High ground north of the Partridge River that creates a watershed divide separating the Superior Basin and Rainy River Watershed, which prevents surface water from passing between the two. This major watershed divide is included in the National Atlas, as well as in USGS and MDNR data.
- Yelp Creek and the Partridge River encircle the northern, eastern, and southern sides of the Mine Site. These streams act as hydrologic sinks for surficial groundwater and surface water originating at the Mine Site. Surface runoff or surficial groundwater seepage leaving the Mine Site would flow into Yelp Creek or the Partridge River, and eventually into the St. Louis River.

Potential cumulative effects on bedrock flow direction north of the Mine Site and are discussed in Section 6.2.2.3.1.

The NorthMet Project Proposed Action would represent the first copper-nickel-PGE mine in Minnesota, with the ore and waste rock containing various amounts of sulfide minerals. Sulfide minerals, when exposed to oxygen and water, have the potential to release soluble metals and sulfate and produce acid mine drainage. The sulfide sulfur (S) concentrations of the NorthMet waste rock would be relatively low compared to many other mines with sulfide-bearing rock around the world. The NorthMet waste rock is predicted to average 0.15 percent sulfide S, while concentrations in other mines with sulfide-bearing rock can be as high as 40 percent (Minesite Drainage Assessment Group 2013).

Most of the bedrock in and around the NorthMet Deposit contains silicate minerals that have a small but measurable potential to neutralize acidity. Multi-year weathering tests demonstrate that the acid-generating potential of the Category 1 waste rock stockpile and the tailings (i.e., material containing less than or equal to 0.12 percent sulfide S) would be low enough that these facilities would not produce acidic leachate (PolyMet 2015q).

Where the pore water pH remains near-neutral, metal mobility tends to be limited as some metals released by oxidation are removed from solution by adsorption or co-precipitation. The Category 2/3 and Category 4 waste rock would have sulfide S concentrations that could produce acid drainage if exposed to oxygen and water; however, the mine plan calls for temporary storage (less than 20 years) of this waste rock on geomembrane lined stockpiles with a seepage collection system, and then subaqueous disposal in the East Pit where oxidation would be very limited and acid drainage would not occur.

The sulfate released from the NorthMet waste rock and tailings is especially important because there are waters supporting the production of wild rice downstream from both the Mine Site and Tailings Basin. Research indicates that elevated sulfate concentrations can affect the growth and viability of wild rice. The MPCA has established a 10 mg/L sulfate water quality standard for waterbodies designated as waters used for production of wild rice.

In anticipation of eventual NPDES/SDS permitting, the MPCA had previously developed draft staff recommendations as to what specific waters in the Project area were to be considered as waters used for production of wild rice. These included the waters described in Section 4.2.2.1.3 of this FEIS, the nearest being portions of the Partridge River downstream of the Mine Site near Colby Lake and portions of the Embarrass River downstream of the Plant Site above Sabin Lake.

Since the development of the draft MPCA staff recommendations, the MPCA has conducted preliminary evaluations of data collected as part of its legislatively mandated wild rice study and has identified conceptual approaches to revising both the numeric sulfate water quality standard of 10 mg/L and the identification of what waters would be subject to any revised standard (for wild rice waters). These conceptual approaches will continue to evolve, eventually resulting in a proposed rule. The proposed rule will likely evolve during the rulemaking process as well.

The final outcome of the evaluations and rulemaking is uncertain. The rulemaking could result in changes in the numeric standard and to what water it would apply. Therefore, this FEIS relies upon the current sulfate water quality standard of 10 mg/L that is being applied to the waters specifically identified in the previously developed draft MPCA staff recommendations for its analysis of potential NorthMet Project Proposed Action impacts.

In previously identified draft MPCA staff-recommended wild rice waters along the Partridge River, the sulfate concentration currently exceeds the 10 mg/L standard about half of the time, largely due to sulfate loading associated with water discharges from the Northshore Mine operation located upstream of the proposed NorthMet Mine Site.

In previously identified draft MPCA staff-recommended wild rice waters along the Embarrass River, the sulfate concentration exceeds the 10 mg/L standard nearly all the time due to discharges from Cliffs Erie Area 5 NW mine pit and the existing tailings basin to upstream tributaries of the Embarrass River. Given the 10 mg/L sulfate exceedances that occur on both the Partridge River and Embarrass River, it must be demonstrated that the NorthMet Project Proposed Action would not cause or add to exceedances of an effluent limit based on the 10 mg/L standard for permitting. In addition, for the Embarrass River and several of its tributaries at the Plant Site, the MPCA has developed supplemental requirements for acceptable sulfate concentrations and mass loadings.

As described in Section 2.3.2.1, the Co-lead Agencies prompted PolyMet to substantially modify the NorthMet Project Proposed Action between the DEIS and SDEIS. Additional modifications were made between the SDEIS and this FEIS to further protect water resources. The proposed engineering controls would provide a higher degree of reliability and flexibility to ensure that the evaluation criteria would continue to be met in the future, when nearly all contact/process water at the NorthMet Project Proposed Action area would be treated at the WWTF or the WWTP before being released to the environment.

At the Mine Site, the more reactive types of waste rock types (Category 2/3 and 4) and some of the less reactive Category 1 waste rock is now proposed for subaqueous disposal in the East Pit to limit oxidation of sulfide minerals and associated release of soluble metals. The majority of the less-reactive Category 1 waste rock would be permanently stored in a surface stockpile covered by a geomembrane with a vegetated soil cover (to reduce infiltration), and surrounded by a groundwater containment (capture) system.

The Category 1 containment system would consist of a barrier wall keyed into bedrock and an interior collection trench backfilled with permeable material containing necessary pipes and pumps to remove the collected water. It is estimated that more than 98 percent of affected groundwater seepage from the Category 1 stockpile would be captured by the containment system or would migrate as groundwater into the West Pit and East Pit (PolyMet 2015h). The affected water collected by the containment system and mine pits would be pumped to a WWTF, treated to acceptable chemical concentrations, and sent to the Plant Site. Following closure, once the West Pit is fully flooded, the treated water would be discharged, as necessary, to the West Pit Outlet Creek that flows into the Partridge River. The WWTF would use chemical precipitation and filtration up to the end of reclamation (approximately mine year 52) and then be converted to RO (or an equivalent treatment technology) to provide water treatment during post-closure maintenance. For RO operation, a distillation process would reduce the concentrate to a moist solid that would be disposed of offsite. After project operations, the only appreciable non-treated mine water leaving the Mine Site would be about 10 gpm of groundwater seepage in the surficial aquifer that would migrate south and eventually be released to the Partridge River.

At the Plant Site, it is estimated that the existing LTVSMC Tailings Basin produces about 200 gpm of surficial groundwater seepage, most of which emerges within adjacent surface waters, and about 2,400 gpm of surface water seepage, most of which reaches the Embarrass River. While this seepage has a high sulfate load, it appears that much of the sulfate is sequestered by natural processes in wetlands between the Tailings Basin and the Embarrass River.

The surface water and groundwater seepage containment systems along the northern, northwestern, and western portions of the proposed NorthMet Tailings Basin would capture about 99 percent of the seepage from the Tailings Basin (i.e., 100 percent of shallow surface seepage and greater than 90 percent of groundwater seepage). As a consequence, the flow of tailings water towards the Embarrass River would be reduced to zero surface seepage and about 20 gpm of affected groundwater. The water collected by the seepage containment system would be sent to a WWTP operating with an RO or equivalently performing system, and the treated effluent would be sent either to the Mine Site to accelerate flooding of the West Pit or to tributaries of the Embarrass River to replace the flow captured by the containment system, or both. On the eastern side of the Tailings Basin, a seepage containment system would be installed, that due to the hydrogeologic conditions, would be expected to capture 100 percent of tailings surface seepage and groundwater seepage.

On the Tailings Basin itself, PolyMet proposes bentonite amendments on the side slopes (installed as they are constructed during operations) and on the beaches after the end of operations to reduce infiltration and oxygen diffusion into the tailings. A layer of bentonite would also be placed at the bottom of the Tailings Basin pond to reduce leakage. The objective of the bentonite amendments is to reduce tailings seepage and its chemical load during reclamation and post-closure. This would have the long-term effect of reducing influent flow rates and chemical loads to the WWTP.

During post-closure, the WWTF and the WWTP (both mechanical treatment facilities) would continue operating until monitoring and pilot-testing demonstrated that a transition could be made to non-mechanical treatment systems, which may consist of constructed wetlands, permeable reactive barriers (PRBs), permeable sorptive barriers (PSBs), and/or other technologies to be identified. Based on the results of field demonstrations, non-mechanical treatment systems would be implemented only when monitoring at mine facilities indicated that the water quality requirements could be met and flow rates are amenable to these measures. In this FEIS, non-mechanical treatment systems are not described in detail because the potential effects of the NorthMet Project Proposed Action are based on mechanical treatment that would operate indefinitely. However, implementation of non-mechanical systems is considered a long-term goal for closure.

The objective of closure is to provide mechanical or non-mechanical treatment for as long as necessary to protect water quality at applicable groundwater and surface water compliance points. Both mechanical and non-mechanical treatments would require periodic maintenance and monitoring activities. Mechanical water treatment is part of the modeled NorthMet Project Proposed Action for the duration of the simulations—these are 200 years at the Mine Site and 500 years at the Plant Site. The duration of the simulations ensured that peak groundwater concentrations at the locations of release to surface water would occur during the model simulations.

Water quality modeling performed in support of this FEIS indicates that water treatment systems would be needed indefinitely at the Mine Site and Plant Site. The water models constructed to assess the potential effects from the NorthMet Project Proposed Action were not designed to predict the duration of treatment nor do they capture all the factors that influence the duration of treatment (e.g., potential future regulatory and technological changes). Therefore, the models cannot be used to predict when treatment would end. Actual treatment requirements would be assessed on a recurring basis throughout operations, reclamation, and closure considering influent and effluent water quality and monitoring results. Those periodic assessments would be carried out to ensure continuous protection of groundwater and surface water quality and compliance with water quality-based effluent limits. The periodic assessment process would rely on monitoring results coupled with predictive modeling rather than the results of the predictive modeling alone. Regardless of the precise duration of effects or water treatment at either the Mine Site or Plant Site, there are measures available to address impacts to natural resources, such as those identified in this FEIS. PolyMet would be responsible for maintenance and monitoring required under any permit and would not be released from financial assurance until all permit conditions have been met.

Several groundwater, surface water, and water quality models (MODFLOW, XP-SWMM, and GoldSim, respectively) were used to predict the potential hydrologic and water quality effects of the NorthMet Project Proposed Action. GoldSim independently modeled 27 chemical parameters and provided values to further calculate two more chemical parameters, TDS and hardness. GoldSim uses probabilistic (Monte Carlo) simulations that take into account the uncertainty of the model inputs and generated outputs taking the form of cumulative probability distributions. The Co-lead Agencies have selected the 90th percentile probability (P90) as their evaluation threshold in determining whether the model results meet established evaluation criteria (i.e., there is at least a 90 percent probability that a constituent would not exceed the water quality evaluation criteria) when the waterbody does not currently exceed the evaluation criteria.

This FEIS also assesses whether the NorthMet Project Proposed Action discharges would cause or add to an exceedance. This was done by evaluating the two modeling events. The first event (Event A) evaluated: 1) how often the NorthMet Project Proposed Action exceeded an evaluation criterion when the Continuation of Exiting Conditions (CEC) modeling scenario did not, and 2) the magnitude of the exceedance. The second event (Event B) evaluated: 1) how often the NorthMet Project Proposed Action concentrations exceeded CEC concentrations when both concentrations were above the evaluation criterion, and 2) the magnitude of the exceedance.

Probabilistic chemical concentrations predicted by GoldSim were compared against water quality evaluation criteria and CEC model results at eight groundwater and eight surface water evaluation locations at the Mine Site, and three groundwater and ten surface water evaluation locations at the Plant Site.

All of the 29 water quality parameters were screened against evaluation criteria to determine which ones require further analysis. Through initial and secondary screening evaluations in the Partridge River Watershed, Colby Lake, and the Embarrass River Watershed, only aluminum in the Embarrass River required further assessment to determine its potential project-related impacts. However, additional discussion is offered on other constituents of interest.

With the proposed engineering controls, the water quality model predicts that the NorthMet Project Proposed Action would not cause any significant water quality impacts because: 1) exceedances of the P90 threshold did not occur, 2) the NorthMet Project Proposed Action concentrations were no higher than concentrations predicted for the Continuation of Existing Conditions scenario, 3) the frequency or magnitude of exceedances for NorthMet Project Proposed Action conditions was within an acceptable range, or 4) the effects were not attributable to NorthMet Project Proposed Action discharges.

Flow modeling indicated that the NorthMet Project Proposed Action would not result in any substantial changes at the Mine Site nor at the Plant Site to surface water flows based upon established evaluation criteria when compared to the continuation of existing conditions.

Many of the lakes and rivers in the NorthMet Project Proposed Action area are classified as "impaired waters" by the MPCA because of elevated mercury in fish. There are several factors that cause elevated mercury in fish, including the increased availability of methylmercury. The production of methylmercury is dependent on sulfate concentrations and environmental conditions required for sulfate-reducing bacteria to live (e.g., sufficient organic carbon and lack of oxygen).

The NorthMet Project Proposed Action area is located within the Lake Superior Basin, so it is subject to the Great Lakes Initiative (GLI) mercury water quality standard of 1.3 ng/L. The NorthMet ore and waste rock contain trace amounts of mercury, but mass balance modeling and analog data from other natural lakes and mine pit lakes in northeastern Minnesota suggest that the mercury concentration in the West Pit Lake would stabilize at approximately 0.9 ng/L.

There would also be mercury in the tailings, although about 92 percent of the mercury in the ore is predicted to remain in the ore concentrate and the mercury concentration in seepage from the Tailings Basin is expected to be less than the standard. The WWTF and the WWTP would be designed to meet water quality based effluent limits that are protective of the GLI 1.3 ng/L mercury standard. Overall, the NorthMet Project Proposed Action is predicted to increase mercury loadings in the Embarrass River. Mercury loadings in the Partridge River would decrease. The net effect of these changes would be an overall reduction in mercury loadings to the downstream St. Louis River upstream of the Fond du Lac Reservation boundary. Therefore, the NorthMet Project Proposed Action would not add to any potential exceedance of the Fond du Lac mercury water quality standard of 0.77 ng/L within the Reservation.

PolyMet would be required by its permits to monitor the NorthMet Project Proposed Action's effects on surface water and groundwater hydrology and water quality in order to refine modeling to help predict future conditions. In the event that the monitoring coupled with modeling identifies the potential for any water quality exceedances, PolyMet has proposed an Adaptive Water Management Plan (AWMP) that identifies additional mitigation measures that could be taken, if necessary, to further protect water quality (see Section 5.2.2.3.5).

5.2.2.1 Evaluation Criteria

In general, water resource evaluation criteria focus on groundwater and surface water hydrology and water quality and are defined as thresholds or changes in the existing physical, chemical, and biological environment with the goal of protecting overall waterbody health.

5.2.2.1.1 Groundwater

This section discusses evaluation criteria for the effects of the NorthMet Project Proposed Action on groundwater hydrology (primarily groundwater levels) and water quality.

Hydrogeologic Evaluation Criteria

There are no state or federal regulatory standards for the maximum allowable change in groundwater levels. It is recognized that groundwater elevations would decrease within a small area around the mine pits. Groundwater elevations may also decrease near the Tailings Basin's containment system as a result of pumping on the Tailings Basin side of the cutoff wall. The significance of any changes in groundwater levels is evaluated in terms of its effects on other resources (e.g., wetlands) and these potential effects are discussed in the appropriate resource sections. The magnitude of any changes in groundwater levels are quantified in this section.

Water Quality Evaluation Criteria

A total of 27 analytes were selected to be directly modeled because concentrations of those analytes could be altered by the NorthMet Project Proposed Action. The list of analytes was constructed considering host rock mineralogy and the results of geochemistry analyses. It includes the following analytes:

- Alkalinity
- Calcium
- Chloride
- Fluoride
- Sulfate
- Magnesium
- Potassium
- Sodium
- Aluminum
- Antimony
- Arsenic
- Barium
- Beryllium
- Boron
- Cadmium
- Chromium III
- Cobalt
- Copper
- Iron
- Lead
- Manganese
- Nickel
- Selenium
- Silver
- Thallium
- Vanadium
- Zinc

This suite of directly modeled solutes does not include hardness and TDS. Hardness was calculated from modeled calcium and magnesium concentrations. TDS was estimated by summing its constituent concentrations that were directly modeled, including calcium, chloride, fluoride, magnesium, potassium, sulfate, and a portion of alkalinity.

This FEIS assesses effects by comparing the predicted NorthMet Project Proposed Action-related water quality with a modeled existing water quality (as characterized by groundwater quality monitoring) and applicable Minnesota groundwater quality standards, which are based on Minnesota water use classifications (*Minnesota Rules*, chapters 7060, 7050, and 7052). Groundwater quality standards are USEPA primary MCLs (pMCL), USEPA sMCL, and MDH HRLs. The groundwater quality evaluation criteria, for the purposes of this FEIS, are defined as the strictest (i.e., lowest) concentration among the USEPA pMCLs, USEPA sMCLs, and the MDH HRLs, with the following exceptions:

- Human health-based primary drinking water standards for copper and lead are "at the tap" values applicable to treated water systems and not to "in situ" groundwater values (see Note 3 to Table 5.2.2-2). *Minnesota Rules* addressing the water quality standards applicable to Class 1 waters used for domestic consumption specifically state that the primary drinking water standards for copper and lead do not apply to Class 1 surface waters or groundwater. This FEIS uses the USEPA sMCL of 1,000 μg/L as the groundwater evaluation criteria for copper. Modeling predictions for lead are presented but without a groundwater evaluation criterion because no sMCL or an HRL is available for this analyte.

- Natural (unaffected) groundwater concentrations for aluminum and iron at the Mine Site and Plant Site are greater than secondary drinking water standards. The concentrations for these two solutes in groundwater are heavily influenced by processes not readily captured in water quality models (e.g., site-specific redox reactions). Furthermore, these sMCLs were established by the USEPA as guidelines to assist public water systems in managing their drinking water for aesthetic considerations, and can be removed from groundwater with simple readily available treatment technologies, and are not enforced by the USEPA. For example, concentrations above the aluminum sMCL (200 µg/L) may result in colored water and concentrations above the iron sMCL (300 µg/L) may result in rusty color, metallic taste, and reddish or orange staining.

- Natural (unaffected) groundwater concentrations for beryllium, manganese, and thallium (bedrock unit only) at the Mine Site and beryllium and manganese at the Plant Site are greater than secondary drinking water standards and/or the HRL (see Table 5.2.2-1). These elevated concentrations are consistent with concentrations seen elsewhere in the Iron Range and northeast Minnesota. *Minnesota Rules*, part 7060.0600, subpart 8, states that “where the background level of natural origin is reasonably definable and is higher than the accepted standard for potable water and the hydrology and extent of the aquifer are known, the natural level may be used as the standard.”

The evaluation criteria for these solutes were set at either: 1) the 95 percent Upper Prediction Limit, 2) the second-highest value when there was a limited number of measured concentrations above the detection limit, or 3) half the detection limit when there were no detected concentrations pursuant to USEPA guidance (USEPA 2009b) (see Table 5.2.2-1).

Table 5.2.2-1 Beryllium, Manganese, and Thallium Evaluation Criteria

	Units	USEPA pMCL	USEPA sMCL	HRL	# samples	Range	Mean[5]	Recommended Evaluation Criteria
Mine Site		**Surficial**						
Beryllium	µg/L	4	--	0.08	320	ND–1.6	0.13	0.39[(1)]
Manganese	µg/L	--	50	100	311	ND–1,900	288	1,002[(1)(2)(6)]
Mine Site		**Bedrock**						
Beryllium	µg/L	4	--	0.08	49	ND–0.2	0.11	0.2[(3)]
Manganese	µg/L	--	50	100	49	ND–383	112	307[(1)(2)]
Thallium	µg/L	2	--	0.6	49	ND (0.2–2.0)	0.37	1.0[(4)]
Plant Site		**Surficial**						
Beryllium	µg/L	4	--	0.08	50	ND–2.72	0.20	0.54[(3)]
Manganese	µg/L	--	50	100	50	4.3–2,140	271	704[(1)]

Source: PolyMet 2015m and PolyMet 2015j.

Notes:
ND = Non-detect
1 95 percent Upper Prediction Limit (UPL) used as evaluation criteria.
2 Kaplan-Meier Method used to determine UPL.
3 Second-highest detected concentration used as evaluation criteria.
4 One half of the highest detection limit used as evaluation criteria.
5 Where non-detects occur, the mean was calculated using half the detection limit.
6 Risk Assessment Advice (RAA) levels of 100 µg/L for infants and 300 µg/L for children and adults.

Table 5.2.2-2 presents the pMCL, sMCL, HRL, and the evaluation criteria used in this FEIS.

Table 5.2.2-2 Groundwater Evaluation Criteria Applicable to the NorthMet Project Proposed Action

Solute	Units	USEPA pMCL	MDH HRL	USEPA sMCL	FEIS Evaluation Criteria
General Parameters					
Alkalinity	mg/L	--	--	--	--
Calcium	mg/L	--	--		
Chloride	mg/L	--	--	250	250
Fluoride	mg/L	4	--	2	2
Hardness	mg/L	--	--	--	--
Magnesium	mg/L	--	--	--	--
Potassium	mg/L	--	--	--	--
Sodium	mg/L	--	--	--	--
Sulfate	mg/L	--	--	250	250
Total Dissolved Solids	mg/L	--	--	500	500
Metals					
Aluminum	µg/L	--	--	50-200[(4)]	--[4]
Antimony	µg/L	6	6	--	6
Arsenic	µg/L	10	--	--	10
Barium	µg/L	2,000	2,000	--	2,000
Beryllium	µg/L	4	0.08	--	0.39/0.2/0.54[(1)]
Boron	µg/L	--	1,000[(2)]	--	1,000
Cadmium	µg/L	5	4	--	4
Chromium[6] III	µg/L	100	--	--	100
Cobalt	µg/L	--	--	--	--
Copper	µg/L	--[3]	--	1,000	1,000
Iron	µg/L	--	--	300[(4)]	--[4]
Lead	µg/L	--[3]	--	--	--
Manganese	µg/L	--	100	50	1,002/307/704[(1)]
Nickel (soluble salts)[5]	µg/L	--	100	--	100
Selenium	µg/L	50	30	--	30
Silver	µg/L	--	30	100	30
Thallium (salts)[5]	µg/L	2	0.6	--	0.6/1.0[(1)]
Vanadium	µg/L	--	50	--	50
Zinc	µg/L	--	2,000	5,000	2,000

Source: pMCLs (40 CFR 141), sMCLs (40 CFR 143), and HRLs (*Minnesota Rules*, part 4717.7500).

Notes:

1 Beryllium, manganese, and thallium (Mine Site bedrock unit only). Evaluation criteria differ by location (Mine Site Surficial Aquifer/Bedrock Aquifer/Plant Site Surficial Aquifer) based on background water quality (see Table 5.2.2-1). Criteria are based on dissolved concentrations unless otherwise noted (MPCA 2014g).

2 See MDH guidance: www.health.state.mn.us/divs/eh/risk/guidance/gw/boron.html.

3 Lead and copper enter drinking water primarily through plumbing materials. In 1991, the USEPA published the Lead and Copper Rule (USEPA 1991). This rule requires water systems to monitor drinking water at customer taps. The 1,300µg/L copper concentration and 15µg/L lead concentration represent action levels that, when exceeded at 10 percent of customer taps, require the water system to take additional actions to control corrosion. Therefore, these values reflect concentrations at the customer tap. Additionally, *Minnesota Rules*, part 7050.0221, subpart 1B, states that the primary drinking water standards for copper and lead are not applicable to Class 1 groundwater.

4 Aluminum and iron were excluded from groundwater evaluation criteria due to baseline USEPA sMCL standard exceedances in the Iron Range and Northeast Minnesota and because these concentrations are heavily influenced by processes not captured in the proposed models (e.g., site-specific redox reactions). Further, standards for these parameters were established for management of aesthetic conditions in treated drinking water and are readily removed from groundwater with simple readily

available treatment technologies. This policy was adopted by the Co-lead Agencies in the NorthMet EIS Groundwater Impact Assessment Planning Final Summary Memo (June 27, 2011) (MDNR et al. 2011).

5 Nickel and thallium. The MDH HRL is based on the salt form of this parameter. It is conservatively assumed, for purposes of this FEIS, that the salt form is equivalent to the total concentrations of this parameter.

6 Chromium III is used in this FEIS because it is the most likely form of chromium to be present at NorthMet Project Proposed Action project site.

These groundwater quality evaluation criteria are assessed at the following evaluation locations (see Figures 5.2.2-7 and 5.2.2-9):

- Partridge River Watershed:
  - Surficial Aquifer
    - East Pit and Category 2/3 Flowpath – at the Partridge River (coinciding with property boundary)
    - Ore Surge Pile Flowpath – at the Partridge River
    - WWTF Flowpath – at the property boundary
    - Overburden Storage and Laydown Area Flowpath – at the old property boundary (a short distance south of Dunka Road) which is this FEIS Mine Site boundary
    - West Pit Flowpath – at the property boundary
  - Bedrock
    - East Pit Bedrock Flowpath – at the property boundary
    - West Pit Bedrock Flowpath toward SW-004 – at the property boundary
    - West Pit Bedrock Flowpath toward SW-004a – at the property boundary
- Embarrass River Watershed (all surficial aquifer, see Section 5.2.2.2.3):
  - North Flowpath – at the north property boundary
  - Northwest Flowpath – at the northwest property boundary
  - West Flowpath – at the west property boundary

5.2.2.1.2 Surface Waters

This section discusses evaluation criteria for the effects of the NorthMet Project Proposed Action on surface water hydrology and quality.

<u>Hydrologic Alteration of Streams and Lakes Evaluation Criteria</u>

Hydrologic evaluation criteria include a comparison of proposed hydrologic changes with both existing natural conditions and historic hydrologic alterations from permitted mining practices, an assessment of present and predicted channel stability, and review of any appropriate physical or biological stream data. Evaluation criteria for streamflows in the Partridge River Watershed and changes in lake or reservoir levels in the NorthMet Project Proposed Action area are those developed by (Richter et al.1996; 1998) related to alteration of hydrology and were adopted by the Co-lead Agencies during the IAP process (MDNR et al. 2011b).

The main parameters recommended for this “range of variability” approach include:

- Annual mean daily flow by month;
- Annual maximum 1-day, 3-day, 7-day, 30-day, and 90-day flows;
- Annual minimum 1-day, 3-day, 7-day, 30-day, and 90-day flows;
- Number of high pulses (i.e., the number of times per year the mean daily flow increases above the 75th percentile of all simulated mean daily flows);
- Number of low pulses (i.e., the number of times per year the mean daily flow falls below the 25th percentile of all simulated mean daily flows);
- Duration of high pulses (i.e., the number of days per year with mean flows above the 75th percentile of all simulated daily mean flows);
- Duration of low pulses (i.e., the number of days per year with mean flows below the 25th percentile of all simulated daily mean flows);
- Mean duration of high pulses (i.e., the ratio of duration of high pulses to number of high pulses);
- Mean duration of low pulses (i.e., the ratio of duration of low pulses to number of low pulses); and
- Annual mean, annual maximum, and annual minimum lake levels in Colby Lake and Whitewater Reservoir.

The magnitude of deviation from existing conditions in the hydrologic parameters, based on XP-SWMM modeling prepared for the Partridge River Watershed, helps determine the degree of potential effect on stream ecology. These values are not expressed as compliance standards, but would assist in monitoring effects and recommending potential mitigation measures as appropriate.

Flow characteristics for different reaches of the Embarrass River and selected tributaries were estimated by extrapolating flows from USGS gaging station 04017000 (located just downstream of PM-12.3) on a catchment area basis. Flow parameters estimated in the Embarrass River Watershed include groundwater baseflow, annual 1-day minimum flow, annual 1-day maximum flow, and annual daily mean flow.

The MDNR also has recommended maintaining surface flows within plus or minus 20 percent of existing conditions in NorthMet Project Proposed Action-affected streams to maintain existing aquatic ecology (Chisholm 2006). See section 5.2.6 for more details.

<u>Water Quality Evaluation Criteria</u>

This FEIS assesses effects on water by comparing the predicted water quality under the NorthMet Project Proposed Action against evaluation criteria based on the State of Minnesota water quality standards and use classifications (*Minnesota Rules*, chapters 7050 and 7052). Applicable use classifications of the primary surface waters potentially affected by the NorthMet Project Proposed Action are described in Section 4.2.2 and are summarized in Table 5.2.2-3.

Table 5.2.2-3 Applicable Use Classifications of the Primary Surface Waters in the NorthMet Project Proposed Action Area

		Domestic Consumption	Aquatic Life and Recreation			Industrial Consumption		Agriculture and Wildlife		Aesthetic Enjoyment	Other uses
Watershed	**Stream Name**	**1B**	**2A**	**2B**	**2Bd**	**3B**	**3C**	**4A**	**4B**	**5**	**6**
Partridge	Partridge River			X			X	X	X	X	X
Partridge	West Pit Outlet Creek			X			X	X	X	X	X[1]
Partridge	Wetlegs Creek			X			X	X	X	X	X
Partridge	Longnose Creek			X			X	X	X	X	X
Partridge	Wyman Creek	X	X			X	X	X	X	X	X
Partridge	Colby Lake	X			X		X	X	X	X	X
Embarrass	Embarrass River			X			X	X	X	X	X
Embarrass	Trimble Creek			X			X	X	X	X	X
Embarrass	Mud Lake Creek			X			X	X	X	X	X
Embarrass	Second Creek			X			X	X	X	X	X
Embarrass	Unnamed Creek			X			X	X	X	X	X

Note:
[1] The WWTF would discharge to the West Pit Outlet Creek.

In *Minnesota Rules*, part 7050.0221, the USEPA primary and secondary drinking water standards are adopted for Class 1B waters (i.e., those treated with simple chlorination for domestic consumption). The USEPA primary drinking water standards (40 CFR 141) set mandatory MCLs for drinking water contaminants to protect the public from consuming water that presents a risk to human health. The USEPA has also established secondary drinking water standards (40 CFR 143) for 15 contaminants that are intended to assist public water systems in managing their drinking water for aesthetic considerations such as taste, color, and odor. These contaminants are not considered a risk to human health.

The same suite of solutes was modeled for surface waters as described above for groundwater. As mentioned above, hardness and TDS concentrations were not directly modeled.

Because the NorthMet Project Proposed Action area is located in the Lake Superior Basin, the GLI (Lake Superior) water quality standards also apply (*Minnesota Rules*, chapter 7052). These Lake Superior standards can differ from the water quality standards for the same parameters in *Minnesota Rules*, chapter 7050. Where different, the 7052 standards supersede the 7050 standards, even if the 7052 rules are less stringent. For parameters not listed in chapter 7052, the standards from chapter 7050 apply.

Surface water standards are “in-stream” standards applicable at the surface water in question, which include the Partridge River and its tributaries for the Mine Site, Transportation and Utility Corridor, and the Plant Site, and the Embarrass River and its tributaries for the majority of the Tailings Basin.

Applicable surface water quality evaluation criteria, for the purposes of this FEIS, are listed by use classification in Table 5.2.2-4, with the strictest (i.e., lowest) concentration from the applicable water use classifications applying.

It should be noted that the water quality standards for metals are expressed for total metals in the table, but are applied as dissolved metal criteria for application to surface waters (*Minnesota Rules*, part 7050.0220). For the majority of metals, the ratio of the total metal criteria to the dissolved metal criteria is sufficiently close to one such that the total standard is adequately representative of the applicable criteria.

Table 5.2.2-4 Surface Water Quality Evaluation Criteria Applicable to Different Classes of Surface Water

Parameter	Units	Class 1B pMCL	Class 1B sMCL	Class 2A	Class 2Bd[3]	Class 2B[3]	Class 3B[4]	Class 3C[4]	Class 4A[5]	Class 4B[5]	Class 5	Class 6
General												
Alkalinity	mg/L	--	--	--	--	--	--	--	--	--	--	--
Calcium	mg/L	--	--	--	--	--	--	--	--	--	--	--
Chloride	mg/L	--	250	230	230	230	100	250	--	--	--	--
Fluoride	mg/L	4	2	--	--	--	--	--	--	--	--	--
Hardness	mg/L	--	--	--	--	--	250	500	--	--	--	--
Magnesium	mg/L	--	--	--	--	--	--	--	--	--	--	--
pH	s.u.	--	6.5–8.5	6.5–8.5	6.5–9.0	6.5–9.0	6.0–9.0	6.0–9.0	6.0–8.5	6.0–9.0	6.0–9.0	--
Potassium	mg/L	--	--	--	--	--	--	--	--	--	--	--
Sodium	mg/L	--	--	--	--	--	--	--	--	--	--	--
Sulfate	mg/L	--	250	--	--	--	--	--	10[(2)]	--	--	--
TDS	mg/L	--	500	--	--	--	--	--	700	--	--	--
Metals Total[7]							--	--	--	--	--	--
Aluminum	µg/L	--	50–200	87	125	125	--	--	--	--	--	--
Antimony	µg/L	6	--	5.5	5.5	31	--	--	--	--	--	--
Arsenic	µg/L	10	--	2.0[(1)]	2.0[(1)]	53[(1)]	--	--	--	--	--	--
Barium	µg/L	2,000	--	--	--	--	--	--	--	--	--	--
Beryllium	µg/L	4.0	--	--	--	--	--	--	--	--	--	--
Boron	µg/L	--	--	--	--	--	--	--	500	--	--	--
Cadmium[6]	µg/L	5	--	2.5[(1)]	2.5[(1)]	2.5[(1)]	--	--	--	--	--	--
Chromium (III)[6]	µg/L	100	--	86[(1)]	86[(1)]	86[(1)]	--	--	--	--	--	--
Cobalt	µg/L	--	--	2.8	2.8	5.0	--	--	--	--	--	--
Copper[6]	µg/L	--[8]	1,000	9.3[(1)]	9.3[(1)]	9.3[(1)]	--	--	--	--	--	--
Iron	µg/L	--	300	--	--	--	--	--	--	--	--	--
Lead[6]	µg/L	--[8]	--	3.2	3.2	3.2	--	--	--	--	--	--
Manganese	µg/L	--	50	--	--	--	--	--	--	--	--	--
Mercury	ng/L	2,000	--	1.3[(1)]	1.3[(1)]	1.3[(1)]	--	--	--	--	--	--
Nickel[6]	µg/L	--	--	52[(1)]	52[(1)]	52[(1)]	--	--	--	--	--	--
Selenium	µg/L	50	--	5.0[(1)]	5.0[(1)]	5.0[(1)]	--	--	--	--	--	--
Silver	µg/L	--	100	0.12	1.0	1.0	--	--	--	--	--	--
Thallium	µg/L	2	--	0.28	0.28	0.56	--	--	--	--	--	--
Vanadium	µg/L	--	--	--	--	--	--	--	--	--	--	--
Zinc[6]	µg/L	--	5,000	120[(1)]	120[(1)]	120[(1)]	--	--	--	--	--	--

Source: *Minnesota Rules*, chapters 7050 and 7052; USEPA pMCL (40 CFR 141); sMCL (40 CFR 143).

Notes:
All values represent total concentration unless otherwise noted.

[1] Based on *Minnesota Rules*, part 7052.0100, *Water Quality Standards Applicable to Lake Superior Basin*, which supersedes standards listed in *Minnesota Rules*, part 7050.0140.

[2] The quality of Class 4A waters of the state shall be such as to permit their use for irrigation without significant damage or adverse effects upon any crops or vegetation usually grown in the waters or area… The following standards shall be used as a guide in determining the suitability of the waters for such uses… Sulfates (SO_4) - 10 mg/L, applicable to water used for production of wild rice during periods when the rice may be susceptible to damage by high sulfate levels.

[3] *Minnesota Rules*, parts 7050.0222 and 7052.0100.

[4] *Minnesota Rules*, part 7050.0223.

[5] *Minnesota Rules*, part 7050.0224.

[6] Water quality standard for this metal is hardness dependent. The listed value assumes a hardness of 100 mg/L.

[7] Standards for metals are expressed as total metals, but must be implemented as dissolved metal standards. Factors for converting total to dissolved metals are listed in *Minnesota Rules*, parts 7050.0222 and 7052.0360.

[8] Lead and copper enter drinking water primarily through plumbing materials. In 1991, USEPA published the Lead and Copper Rule (http://www.epa.gov/safewater/lcrmr/index.html). This rule requires water systems to monitor drinking water at customer taps. The 1,300-µg/L copper concentration and 15-µg/L lead concentration represent action levels that, when exceeded at 10 percent of customer taps, require the water system to take additional actions to control corrosion. Therefore, these values reflect concentrations at the customer tap. Additionally, *Minnesota Rules*, part 7050.0221, subpart 1B, states that the primary drinking water standards for copper and lead are not applicable to Class 1 surface waters.

Surface Water Quality Evaluation Locations

These surface water evaluation criteria are assessed at the following surface water evaluation locations (see Figures 5.2.2-28 and 5.2.2-13):

- Partridge River Watershed
  - Partridge River – at SW-002, SW-003, SW-004, SW-004a, SW-004b, SW-005, and SW-006; and
  - Colby Lake.
- Embarrass River Watershed
  - Embarrass River – at PM-12, PM-12.2, PM-12.3, PM-12.4, and PM-13 (note that model results for evaluation locations PM-12.3 and PM-12.4 did not show anything different so are not discussed further in this FEIS);
  - Mud Lake Creek – at MLC-2 and MLC-3;
  - Trimble Creek – at TC-1 and PM-19; and
  - Unnamed Creek – at PM-11.

Relationship of Hardness to Evaluation Locations

There are six metals evaluated whose surface water quality standards vary with hardness concentrations: cadmium, chromium III, copper, lead, nickel, and zinc. Calcium and magnesium ions that contribute to water hardness generally lower metals toxicity (i.e., as hardness concentration increases, the water quality standard for these metals also increases). In the case of this FEIS, as hardness increases, evaluation criteria increase simultaneously. Within the water quality modeling, estimated concentrations for these six metals are compared to NorthMet Project Proposed Action hardness-based evaluation criteria at each model evaluation location and each model time step to determine the frequency and magnitude of evaluation criteria exceedances. See Section 5.2.2.2.3 for more information.

Downstream Water Quality Standards

The Fond du Lac Band has promulgated water quality standards that are protective of specific, designated, or beneficial uses for waterbodies on the Fond du Lac Reservation. This Reservation is located approximately 70 miles downstream of the NorthMet Project Proposed Action area on the St. Louis River. These standards were approved by the USEPA in December 2001. They apply to all waters, including wetlands, within the Reservation. The Fond du Lac water quality standards include determination of designated or beneficial uses, narrative and numeric criteria to support or sustain those uses, and anti-degradation provisions. This FEIS analyzes compliance with their mercury standard.

Based upon results of Fond du Lac Band water quality monitoring, as well as additional resource investigations, the Reservation's reach of the St. Louis River is attaining all of its beneficial uses and meeting all applicable water quality standards with the exception of mercury. In-stream mercury concentrations in the St. Louis River, measured by the Fond du Lac Band, have been below the GLI Chronic Wildlife Standard of 1.3 ng/L, but exceed the Fond du Lac Band's human health chronic standard of 0.77 ng/L. For this reason, the Fond du Lac Band is especially concerned about any new or expanded discharges to the St. Louis River upstream of the Reservation that may adversely affect mercury bioaccumulation in fish in the St. Louis River (Fond du Lac, Pers. Comm., March 6, 2012).

The MDNR conducted studies in the St. Louis River in 2012, which included an unusually wet spring and early summer followed by a long dry period (Berndt et al. 2014). The studies found that mercury concentrations in filtered samples collected in Cloquet were 3.5 ng/L in May, increased to 7 ng/L in July, and then fell gradually through the rest of the summer to 1.4 ng/L by late October. Upstream from the Partridge River, mercury concentrations over the same period ranged from 5.2 ng/L up to a peak of 11.8 ng/L in late June, eventually decreasing only to 2.3 ng/L by late October when the study ended. Thus, mercury was never below the 1.3 ng/L standard during these study periods. These results indicate the importance of considering seasonal variability when evaluating mercury concentrations in rivers.

Mercury Evaluation Criteria

Mercury numeric standards are based on total (particulate plus dissolved) concentrations. For the Lake Superior Basin, which is where the NorthMet Project Proposed Action is located, the Class 2B (aquatic life and recreation) numeric chronic standard for mercury in the water column protective of wildlife is 1.3 ng/L. This is the evaluation criteria used and is consistent with the GLI standard. The criterion is applied at in-stream surface water evaluation locations and to modeled WWTF and WWTP effluent. This FEIS also considers the 0.77 ng/L standard at the Fond du Lac Reservation. Mercury was not included in GoldSim modeling and was evaluated separately. There is a relationship, only partially understood, between sulfate concentration and the conversion of inorganic mercury by sulfate-reducing bacteria into methylmercury. The MDNR has been conducting numerous studies in the region that indicate a strong contextual component is needed when considering impacts of sulfate on methylmercury production and transport (Berndt et al. 2014). When, how, and where the sulfate is added to a stream or watershed must be considered to evaluate impacts to the mercury cycle.

Methylmercury is more bioavailable than inorganic mercury, and it can bioaccumulate in the aquatic food chain (e.g., fish, wildlife, and humans) to concentrations of concern. Currently, there is no State of Minnesota surface water quality standard for methylmercury, or for sulfate in the context of its potential for effect on methylmercury concentrations, as the production of methylmercury is not only dependent on sulfate concentrations, but also on environmental conditions required for sulfate-reducing bacteria to live (e.g., sufficient organic carbon and lack of oxygen). However, the State of Minnesota has a fish tissue water quality standard for mercury of 0.2 milligram per kilogram (mg/kg), which was amended in *Minnesota Rules*, chapter 7050, in 2008. In 2006, the MPCA also developed a *Strategy to Address Indirect Effects of Elevated Sulfate on Methylmercury Production and Phosphorus Availability*, which identifies policies and review procedures for evaluating the potential of proposed projects to produce methylmercury. This strategy includes recommendations to avoid or minimize the discharge of water with elevated sulfate concentrations to methylmercury “high-risk” situations (MPCA 2006a).

The *Minnesota Rules* fish tissue standard for mercury of 0.2 mg/kg is lower than the USEPA criterion of 0.3 mg/kg (wet weight, per USEPA criteria) to adjust for the higher per capita consumption of wild-caught fish in Minnesota. Methylmercury is the only form of mercury that accumulates appreciably in fish. This criterion reflects this fact by assuming that all fish tissue mercury is in the methylmercury form.

Research suggests that total mercury concentrations in streams and methylmercury content in fish are roughly proportional within individual watersheds (USGS 2010), such that an increase in total mercury in water would be expected to result in an increase in mercury content in fish within that watershed. MPCA's Mercury Risk Estimation Method (MMREM) was used to assess the potential changes in fish mercury concentrations in nearby lakes (Barr 2015f). The MMREM relies on empirical fish contamination data combined with the principle of proportionality between mercury in fish and atmospheric deposition (MPCA 2006c). The potential incremental change in fish mercury concentration is discussed further in Section 6.2.6.3.3.

Waters Used for Production of Wild Rice Evaluation Criteria

Minnesota Rules, part 7050.0224, defines the Class 4A water quality standards for the Agriculture and Wildlife Use Classification, which includes a 10 mg/L sulfate standard "applicable to water used for production of wild rice during periods when the rice may be susceptible to damage by high sulfate levels." Application of this standard is therefore dependent on the identification of specific waters used for production of wild rice. When evaluating any facility or project with potential effects on wild rice production, the MPCA considers all available information to determine on a case-by-case basis which surface waters are used for production of wild rice (MPCA 2012b). For the NorthMet Project Proposed Action, the MPCA considered available lists of wild rice beds not promulgated by rule assembled by the MDNR, the 1854 Treaty Authority and the Wild Rice Management Workgroup (a coalition of federal, state, and tribal resource managers and other wild rice stakeholders), and the results off site-specific wild rice field surveys conducted in 2009, 2010, and 2011 in the Partridge and Embarrass rivers. To date within the NorthMet Project Proposed Action area, MPCA (2012b) has reached a draft staff recommendation that the following are waters used for production of wild rice (see Figure 5.2.2-1):

- Within the Embarrass River Watershed:
  - That segment of the Embarrass River from MN Highway 135 bridge to the inlet to Sabin Lake;
  - The northernmost tip of Wynne Lake (Embarrass River inlet); and
  - Embarrass Lake north of the railroad crossing.
- Within the Partridge River Watershed:
  - That portion of Upper Partridge River from river mile approximately 22, just upstream of the railroad bridge near Allen Junction, to the inlet to Colby Lake;
  - That portion of Lower Partridge River from the outlet of Colby Lake to its confluence with the St. Louis River; and
  - That portion of Second Creek from First Creek to the confluence with Partridge River.

Since the development of the draft MPCA staff recommendations, the MPCA has conducted preliminary evaluations of data collected as part of its legislatively mandated wild rice study and has identified conceptual approaches to revising both the numeric sulfate water quality standard of 10 mg/L and the identification of what waters would be subject to any revised standard (wild rice waters). These conceptual approaches will continue to evolve, eventually resulting in a proposed rule. The proposed rule will likely evolve during the rulemaking process as well.

The final outcome of the evaluations and rulemaking is uncertain. The rulemaking could result in changes in the numeric standard and to what waters it would apply. Therefore, this FEIS relies on the current sulfate water quality standard of 10 mg/L that is being applied to the waters specifically identified in the previously developed draft MPCA staff recommendations for its analysis of potential NorthMet Project Proposed Action impacts.

Therefore, of the surface water quality evaluation locations identified in Figure 5.2.2-1, the wild rice evaluation criterion is applied at PM-13 on the Embarrass River, and at SW-005 and SW-006 on the Partridge River. The MPCA may, in the near future and as part of its ongoing rule revision process, propose additional or alternate waters to be protected for wild rice; however, this process is not yet complete. Therefore, the above-described waters used for production of wild rice evaluation criteria is used for the analyses presented in this FEIS.

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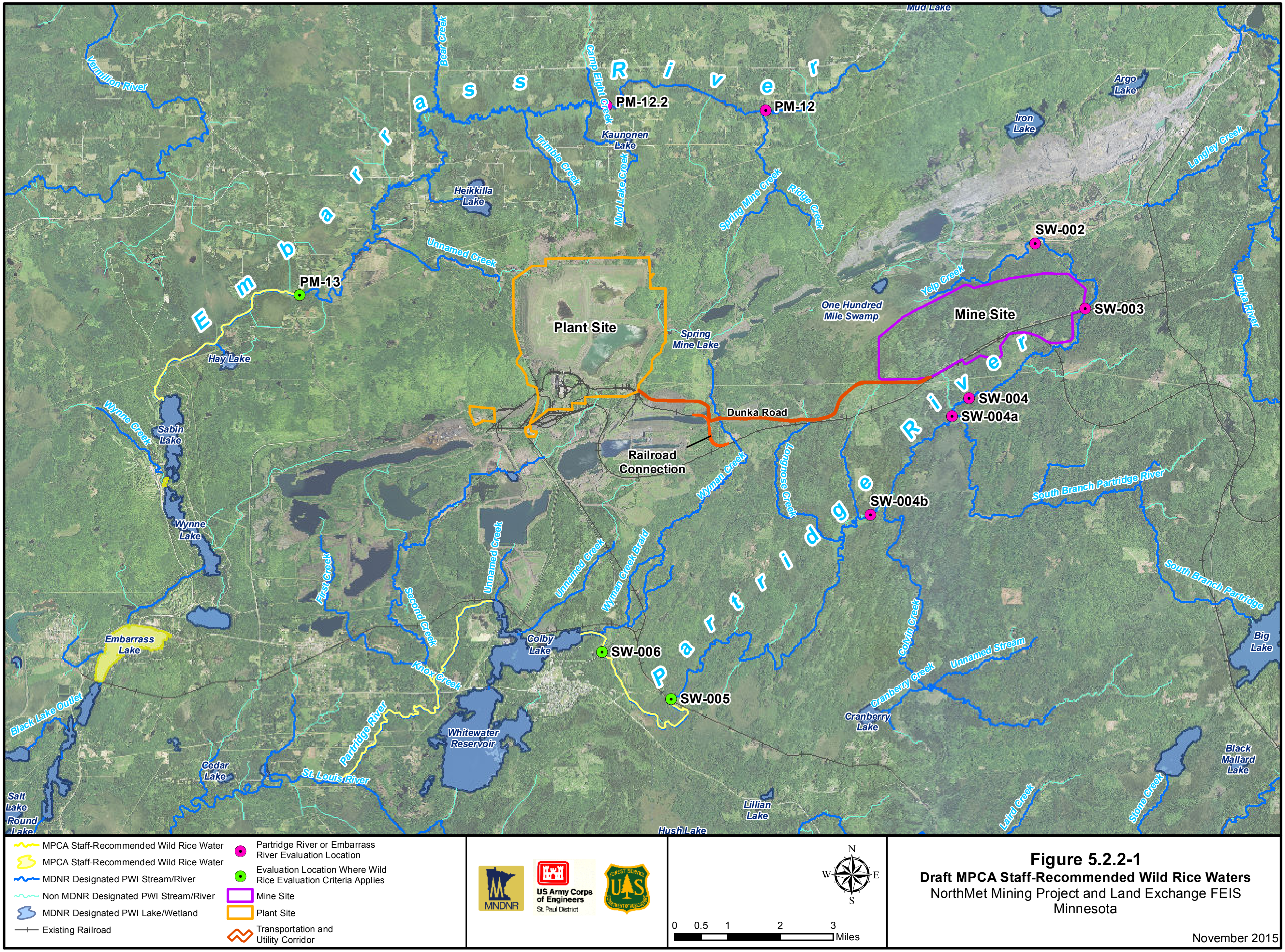

Figure 5.2.2-1
Draft MPCA Staff-Recommended Wild Rice Waters
NorthMet Mining Project and Land Exchange FEIS
Minnesota

November 2015

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5.2.2.2 Methodology

There have been substantial changes to the methodology used for predicting NorthMet Project Proposed Action effects on groundwater and surface flow and quality since the DEIS. Terminology necessary to understand the differences between the DEIS and FEIS impact assessment methodologies is provided in Table 5.2.2-5. For example, the DEIS evaluated water quality at the Mine Site using three deterministic cases (i.e., low-, medium-, and high-flow conditions), in an attempt to capture uncertainty associated with some of the input values. This was supplemented by limited uncertainty analysis to help assess whether the deterministic modeling produced conservative values. The uncertainty analysis in the DEIS indicated mixed results regarding the conservatism of the deterministic modeling.

Table 5.2.2-5 Definition of Terminology used in this FEIS

Term	Definition
Uncertainty	Incomplete knowledge of a process, quantity, value, or outcome, which can be quantified as a cumulative probability distribution.
Variability	There is no single correct absolute value; values vary in time and/or space.
Deterministic Simulation	Prediction is made based on a model for which all input parameters are represented as single values; i.e., no uncertainty is applied to the inputs. The model results are expressed as a set of fixed outcomes.
Probabilistic Simulation	Prediction is made based on a model that incorporates the uncertainty of model inputs; i.e., the cumulative probability distributions of input parameters are incorporated into the calculations. The model results are expressed as a set of cumulative probability distributions.

For this FEIS, a probabilistic modeling approach was used for predicting NorthMet Project Proposed Action effects on water resources. Probabilistic modeling is a statistical method that estimates the probability of a given outcome using inputs in a form of probabilistic distributions. It is different than deterministic modeling, where all inputs have single (deterministic) values and the model always produces a single result without explicitly accounting for uncertainty. The probabilistic approach not only enables prediction of effects on groundwater and surface water from the NorthMet Project Proposed Action, but it also helps quantify the probability of the effects occurring. Table 5.2.2-6 compares the modeling approach used in the DEIS with the approach used in this FEIS.

Table 5.2.2-6 Comparison of EIS Modeling Approaches

Previous DEIS	Current FEIS
Stand-alone model components	Linked source-to-evaluation location
Discrete points in time with interpolation	Continuous through time until or near when steady-state conditions reached
Deterministic with three cases	Probabilistic, including uncertainty and variability
Separate uncertainty analysis of select components	Fully integrated uncertainty analysis of entire model

The effects of the NorthMet Project Proposed Action on groundwater and surface water quality within the Partridge River Watershed were evaluated using MODFLOW for groundwater hydrologic modeling, XP-SWMM for surface water hydrologic modeling and GoldSim for water quality modeling. MODFLOW and XP-SWMM were used as deterministic models, while GoldSim was run in a probability mode. Detailed descriptions of how these models were applied to the Mine Site are provided in the Mine Site Water Modeling Data Package (PolyMet 2015m) and Mine Site Water Modeling Work Plan (Barr 2012c). At the Plant Site, the modeling consisted of MODFLOW, GoldSim, and a spreadsheet compilation of streamflows for different watersheds based on Embarrass River stream gauging data. Detailed descriptions of how these models were applied to the Plant Site are provided in the Plant Site Water Modeling Data Package (PolyMet 2013j) and Plant Site Water Modeling Work Plan (Barr 2012d). Each of the three model types is summarized below.

5.2.2.2.1 Groundwater Hydrologic Modeling

Regional (large-scale) and site-scale (local-scale) modeling of groundwater flow systems was performed using MODFLOW, a public-domain, numerical, finite-difference groundwater flow model that can simulate three-dimensional saturated flow in heterogeneous media (McDonald and Harbaugh 1988). Input to the model included delineation of the areal and vertical extent of geologic materials, hydrologic characteristics of those materials (e.g., hydraulic conductivity), meteoric aquifer recharge, and alignment of hydrologic boundaries (e.g., perennial stream channels). MODFLOW provided estimates of hydraulic head distributions, groundwater flows/directions in the surficial aquifer and bedrock units, and groundwater releases to perennial streams (groundwater baseflow). By adjusting hydraulic conductivity and recharge inputs, the MODFLOW models were calibrated to measured hydraulic heads in monitoring wells and estimated groundwater baseflows in the Partridge River.

MODFLOW modeling results and site characterization data were used to delineate groundwater flowpaths at the Mine Site and Plant Site. The flowpaths were used to model groundwater flow and solute transport from mine facilities to groundwater evaluation locations and to locations where groundwater releases to surface water. Those flowpaths were programmed into the Mine Site and Plant Site water quality models.

Mine Site

For the DEIS, a regional MODFLOW model was developed to evaluate areally distributed aquifer recharge, hydraulic head distributions, and groundwater flow directions (Barr 2007c). The regional model contained two layers—one for the surficial deposits and one for bedrock. The model boundary conditions were mostly regional drainage divides (treated as no-flow boundaries) and perennial streams (treated as prescribed head boundaries). Revisions to the XP-SWMM model since the DEIS provided groundwater baseflow estimates at different locations along the Partridge River. By varying areal recharge and material hydraulic conductivities, the regional model was roughly calibrated to hydraulic heads measured in monitoring wells. As such, the model provides a simplified representation of the hydraulic conductivity of the shallow bedrock-surficial deposits system.

To evaluate the Mine Site hydrogeology in more detail, a second site-scale MODFLOW model of the Mine Site and adjacent area was developed that was a "window" within the regional model. The site-scale MODFLOW model contained eight layers—one for the surficial aquifer and seven for bedrock. Where not coincident with perennial streams or drainage divides, the prescribed head conditions along the external boundaries of the site-scale model were taken from the head distributions predicted by the regional model. The footprints and vertical extent of the mine features were modified from the DEIS model to reflect the current Mine Plan. The areal extent of the site-scale MODFLOW model and simulated hydrologic features are shown on Figure 5.2.2-2 and Figure 5.2.2-3.

The automated-inverse modeling code PEST (Watermark 2005) was used to perform the site-scale MODFLOW calibration. The model was calibrated by adjusting the distribution of hydraulic conductivities and river conductances to provide a reasonable match between: 1) modeled hydraulic heads and measured water levels at site monitoring wells, and 2) between model-estimated groundwater baseflows along the Partridge River and interpreted groundwater baseflows based on stream gaging data and XP-SMMM results.

Using the revised groundwater baseflow estimates, the site-scale MODFLOW model was calibrated using target groundwater baseflow values of 0.41, 0.51, and 0.92 cfs at SW-002, SW-003, and SW-004, respectively. During calibration, the ratio of horizontal/vertical hydraulic conductivity of all bedrock units was fixed at 10 and the vertical hydraulic conductivity of surficial deposits was not modified from the pre-calibration value of 0.0028 ft/day. The automated PEST calibration used field-measured hydraulic conductivities to help constrain the range of allowed hydraulic conductivities in the model. Information on calibration of the site-scale MODFLOW model is provided in PolyMet (2015m).

The calibrated site MODFLOW model provided optimized hydraulic conductivities of different subunits of the surficial aquifer and bedrock, which are summarized in Table 5.2.2-7. Specific storage and specific yield were set at $3x10^{-6}$ ft^{-1} and 0.25, respectively, for both surficial deposits and bedrock. For the surficial aquifer in the Site MODFLOW model, the meteoric recharge flux was 1.8 inches per year (in/yr) for glacial drift and 0.36 in/yr for wetland deposits. The areally-averaged meteoric recharge flux was about 0.75 in/yr, which equates to a groundwater baseflow yield of 0.055 cubic feet per second per square mile (cfs/mi^2).

Table 5.2.2-7 Mine Site Hydraulic Conductivities Based on Calibration of the MODFLOW Model and Field Testing

Major Unit	Subunit	Horizontal Hydraulic Conductivity Minimum ft/day	Horizontal Hydraulic Conductivity Mean ft/day	Horizontal Hydraulic Conductivity Maximum ft/day	Vertical Hydraulic Conductivity ft/day
Surficial Materials	Glacial drift	0.056	19.2	167	0.0028
	Wetland deposits	0.003	23.7	224	0.0028
Bedrock[1]	Giants Range Batholith	---	0.029	---	0.0029
	Biwabik Iron Fm.	---	0.87	---	0.087
	Upper Virginia Fm.	---	0.31	---	0.031
	Duluth Complex	---	0.00044	---	0.000044
	Lower Virginia Fm.	---	0.079	---	0.0079

Note:
[1] Single-value calibration values were developed for bedrock units; min/max values were not evaluated.

The primary purpose of the Mine Site MODFLOW model was to estimate transient groundwater inflows to the mine pits during operations and subsequent closure. These flow rates were directly transferred from the calibrated MODFLOW model to the Mine Site GoldSim model. No other MODFLOW results were directly transferred to GoldSim. A secondary purpose of the MODFLOW model was to confirm inputs in the GoldSim model that were determined from site characterization data, including hydraulic conductivities, aquifer recharge, groundwater flow directions, hydraulic gradients, and the distribution of groundwater baseflows along the Partridge River. An evaluation of these parameters showed that the GoldSim setup/inputs were generally consistent with the MODFLOW results.

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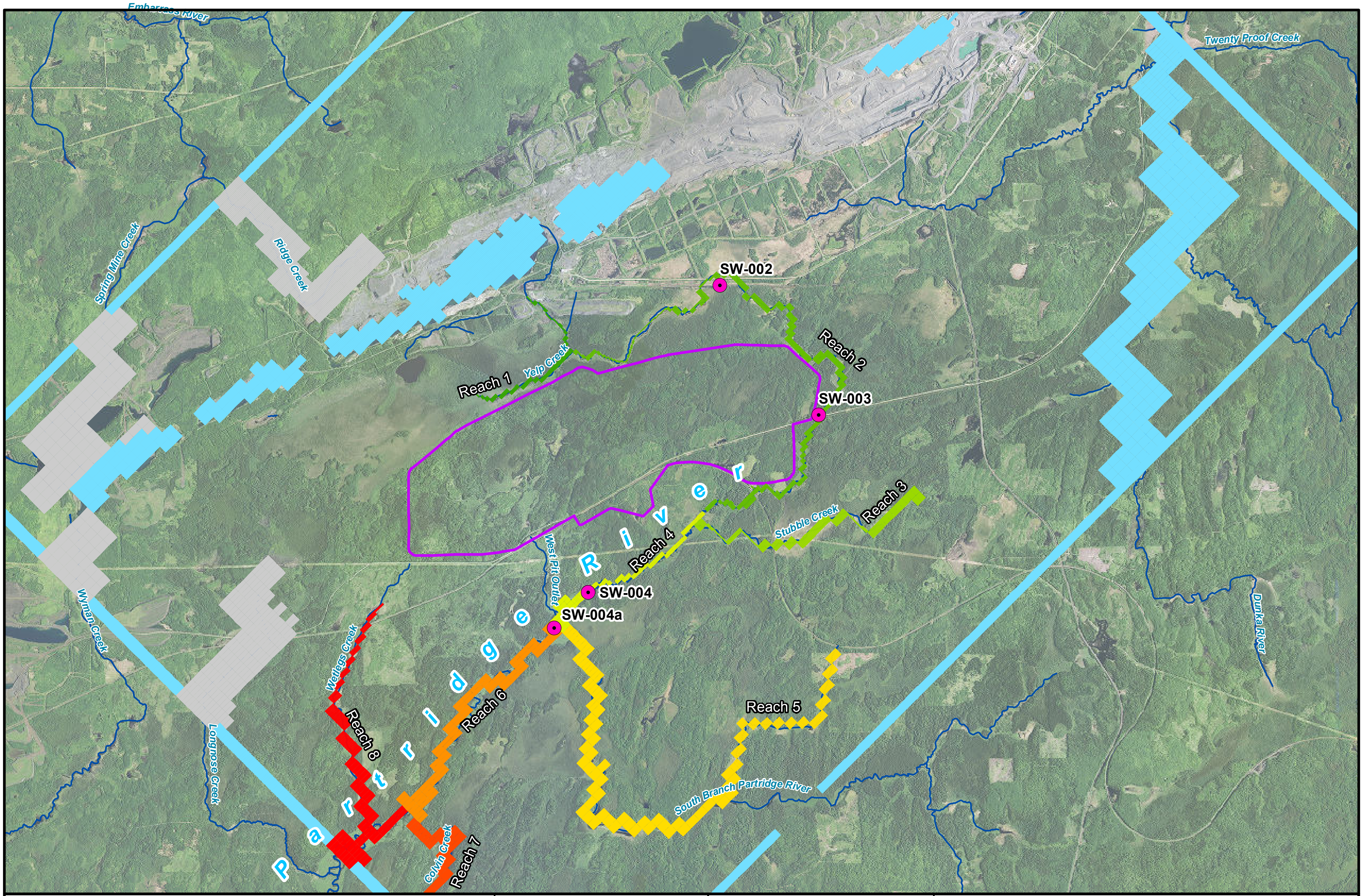

Surface Water Modeling/Monitoring Location

River Cells Not Adjusted During Calibration

River Cells Adusted During Calibration (River Reaches)

1
2
3
4
5
6
7
8

Mine Site

Specified Head Cells

Stream/River

MNDNR

US Army Corps of Engineers St. Paul District

N W E S

0 0.25 0.5 1 1.5 Miles

Figure 5.2.2-2

Mine Site Local MODFLOW Model - River Reaches

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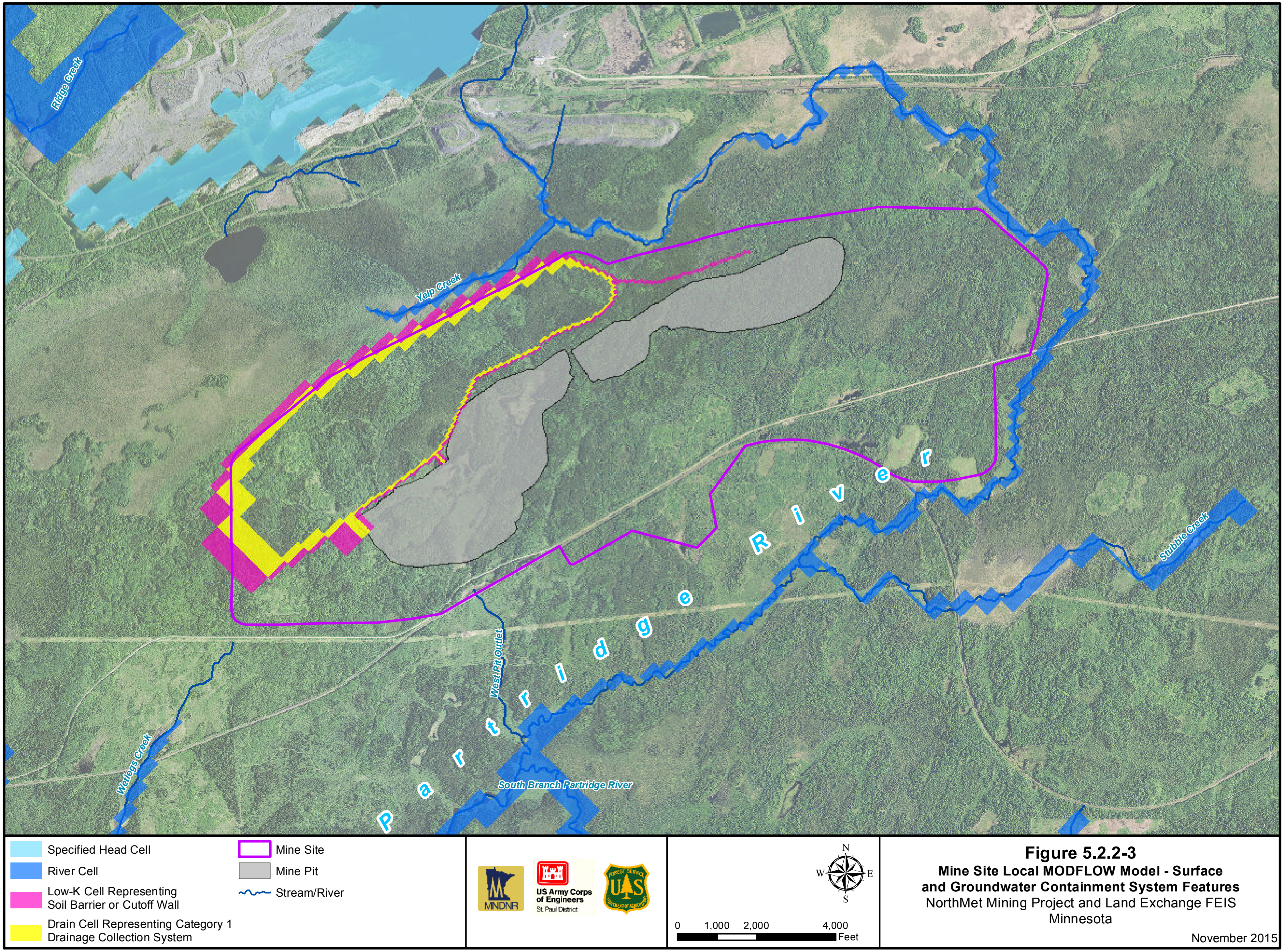

Specified Head Cell
River Cell
Low-K Cell Representing Soil Barrier or Cutoff Wall
Drain Cell Representing Category 1 Drainage Collection System
Mine Site
Mine Pit
Stream/River

MNDNR
US Army Corps of Engineers St. Paul District

Figure 5.2.2-3

Mine Site Local MODFLOW Model - Surface and Groundwater Containment System Features

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Figure 5.2.2-7 shows surficial groundwater flowpaths with the potential to transport mine-affected groundwater from identified source areas to designated evaluation locations. These surficial groundwater flowpaths were evaluated from site characterization information. MODFLOW confirmed that the flowpaths were reasonable. The hydrologic characteristics of each surficial flowpath are summarized in Table 5.2.2-8. Three bedrock flowpaths to the Partridge River were also delineated in the model: West Pit to SW-004, West Pit to SW-004a, and East Pit to SW-004. Due to the low bulk hydraulic conductivity of Duluth Complex rocks that comprise these bedrock flowpaths, the groundwater flow rates to the Partridge River are very low and travel times are very long. The three bedrock flowpaths are included in the GoldSim water quality model, but results show that these flowpaths do not provide a mine-related chemical load to the Partridge River over the 200 year simulation.

A sequence of steady-state MODFLOW model simulations, or sensitivity runs, was used to evaluate groundwater inflows into the West Pit that would occur during its flooding. Figure 5.2.2-4 and Figure 5.2.2-5 shows groundwater inflow rates into the West Pit and East Pit estimated by transient MODFLOW model simulations of the mine operations. Figure 5.2.2-6 shows a plot of inflows versus water surface elevation in the West Pit, Central Pit, and East Pit.

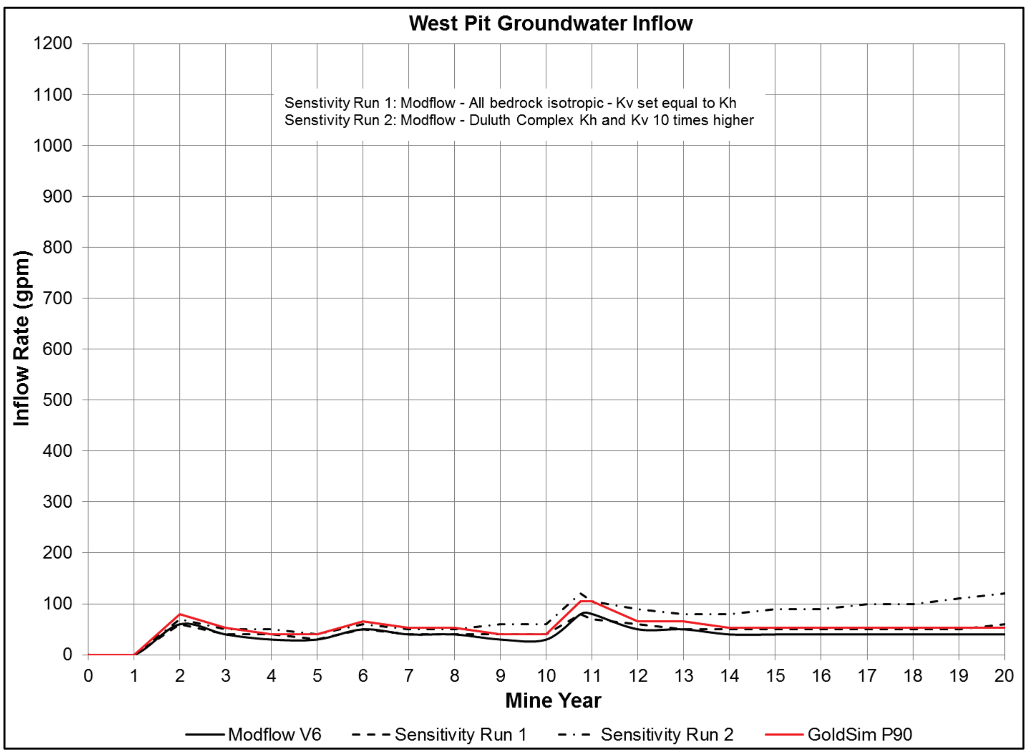

Figure 5.2.2-4 West Pit Groundwater Inflow

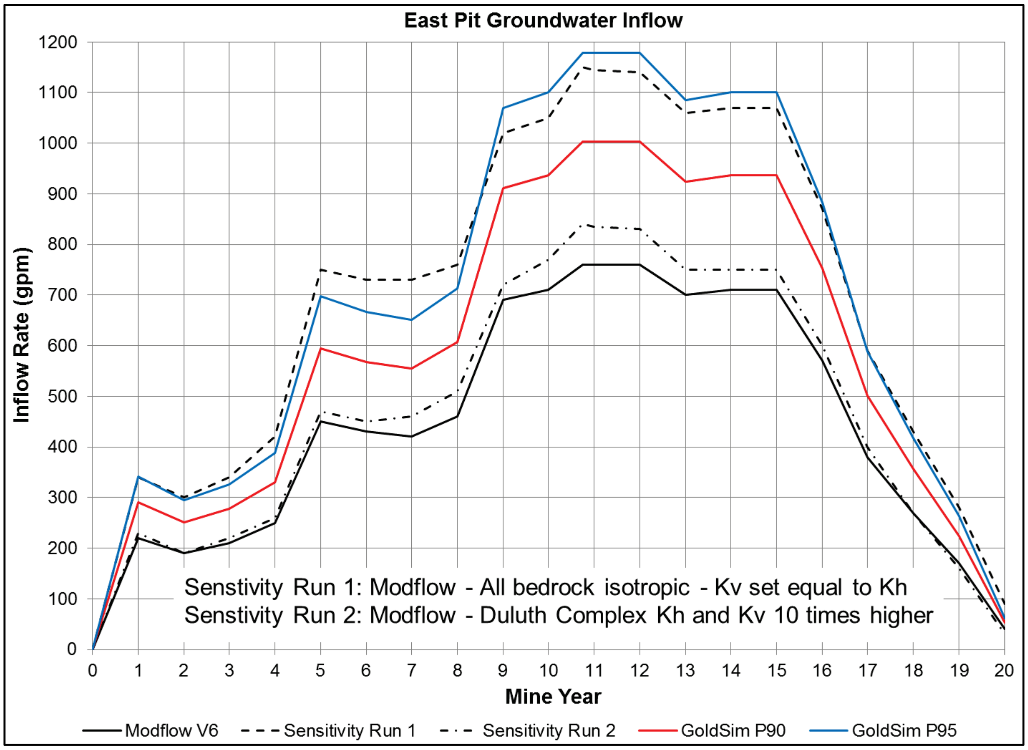

Figure 5.2.2-5 East Pit Groundwater Inflow

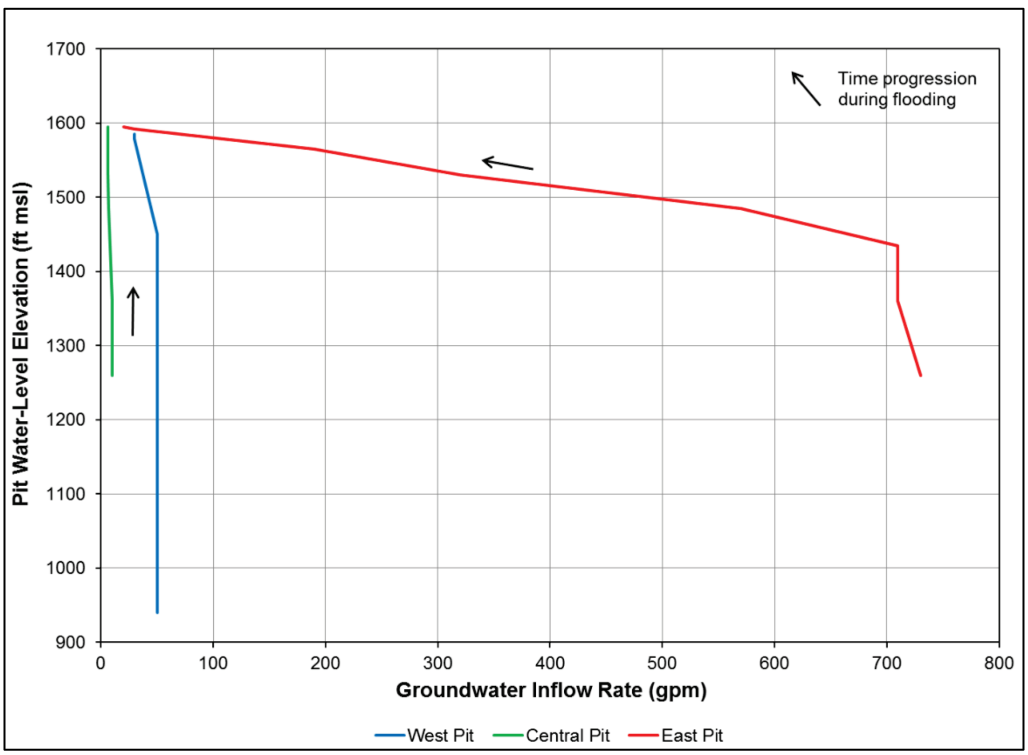

Figure 5.2.2-6 Groundwater Inflow Rate vs Pit Water-Level Elevation for the West Pit, Central Pit, and East Pit

The West Pit and Central Pit are surrounded by a low permeability Duluth Complex rock. As a consequence, the model simulated groundwater inflow rates are relatively low. The north wall of the East Pit is excavated into the higher permeability Virginia Formation, and this caused higher estimated inflow rates into the East Pit.

The following key time events during mine operations were represented in transient model simulations and analysis:

Mine Year	**Key Event**
1 – 10	East Pit and West Pit mined and dewatered
11	East Pit reaches a maximum depth and East Pit mining ceases
11 – 16	Central Pit Mining and East Pit and Central Pit converge
12	Start of backfill placement in East Pit
10 – 20	Continuation of West Pit mining and dewatering
20	East Pit and Central Pit backfilled and re-saturated
20	Start of West Pit flooding

Bedrock flowpaths and evaluation locations were assessed, but because the bedrock (primarily the Duluth Complex) is highly competent with very low bulk hydraulic conductivities (see Table 5.2.2-7), very little groundwater transport occurs within the bedrock flowpaths and travel times to evaluation locations are predicted to be in the thousands of years. Attachment B of the Mine Site Water Modeling Data package (PolyMet 2015m) provides a complete description of the Mine Site MODFLOW model.

Concerns have been raised that fractures or faults may exist at the Mine Site that could function as high-permeability conduits for groundwater over long distances through the bedrock. Such features have been identified elsewhere on the Canadian Shield. A few studies have identified the presence of fracturing and faults in the Duluth Complex, but these structures are believed to have formed during emplacement of the Duluth Complex and are unlikely to transmit water. Where fractures were found, some were largely filled with gouge (Foose and Cooper 1979; 1981), which is granular or clayey material of small grain size, or related to an unusual cleavage pattern known to occur in one location west of Duluth, about 70 miles from the Mine Site (Foster and Huddelston 1986).

At the Mine Site and Plant Site, there is no field evidence to suggest that bedrock faults or fracture zones provide enhanced groundwater flow to the Partridge and Embarrass Rivers. It is possible that structural features with enhanced groundwater flow exist, but they are improbable given the body of evidence for the Project Site and other mines sites in the Iron Range. Further, if such features do exist, it is highly unlikely that they could be intercepted and characterized by any reasonable field program of exploratory boreholes. This FEIS documents the need for a robust monitoring program during operations and closure to provide direct or indirect evidence on the existence of, or lack of, hydrologically significant faults. If significant fractures are identified (that is, fractures which could lead to violation of water quality standards or dewatered wetlands), then contingency mitigation measures would be employed to mitigate the fracture-related effects.

Boring log data indicates that the bedrock appears competent, with a relatively low fracture frequency. Hydrogeologic investigations have indicated that the bulk hydraulic conductivity of Duluth Complex bedrock at the Mine Site is very low. See Section 4.2.2.2.1 for additional information.

The effects of this limited fracturing are incorporated into the bulk hydraulic conductivity values used to characterize bedrock for the water quality impact assessment modeling (discussed in Section 5.2.2.2.3). This is common practice in large-scale evaluations of bedrock hydraulics. The Mine Site GoldSim model was updated for this FEIS to better represent the likelihood of the presence of an upper bedrock zone that is more fractured than deeper bedrock.

Site characterization data (see Section 4.2.2.2.1 and 4.2.2.3.1) indicate that the bulk hydraulic conductivity of upper bedrock is two to three orders-of-magnitude lower than the hydraulic conductivity of the surficial aquifer. Thus, groundwater flow and transport at both the Mine Site and Plant Site are dominated by the hydraulics of the surficial aquifer, and bedrock plays a negligible role in transporting site-derived contaminants to the Partridge and Embarrass Rivers.

The Mine Site model and the Plant Site model explicitly consider buried stream channels by including a rendering of bedrock topography based on a compilation of bedrock topographic data. Channel deposits that formed in the periglacial environment (e.g., eskers or outwash) also occur embedded within the surficial deposits, and can contain materials higher in permeability than adjacent materials. However, drill hole data do not indicate that these features are laterally continuous, which limits their influence on the bulk hydraulic conductivity of the surficial deposit. Variation in the hydraulic conductivity of surficial deposits (like that caused by buried channel deposits) is represented in the probabilistic approach used in the GoldSim model, where hydraulic conductivity is defined by a probability distribution, rather than assigned a fixed, deterministic value.

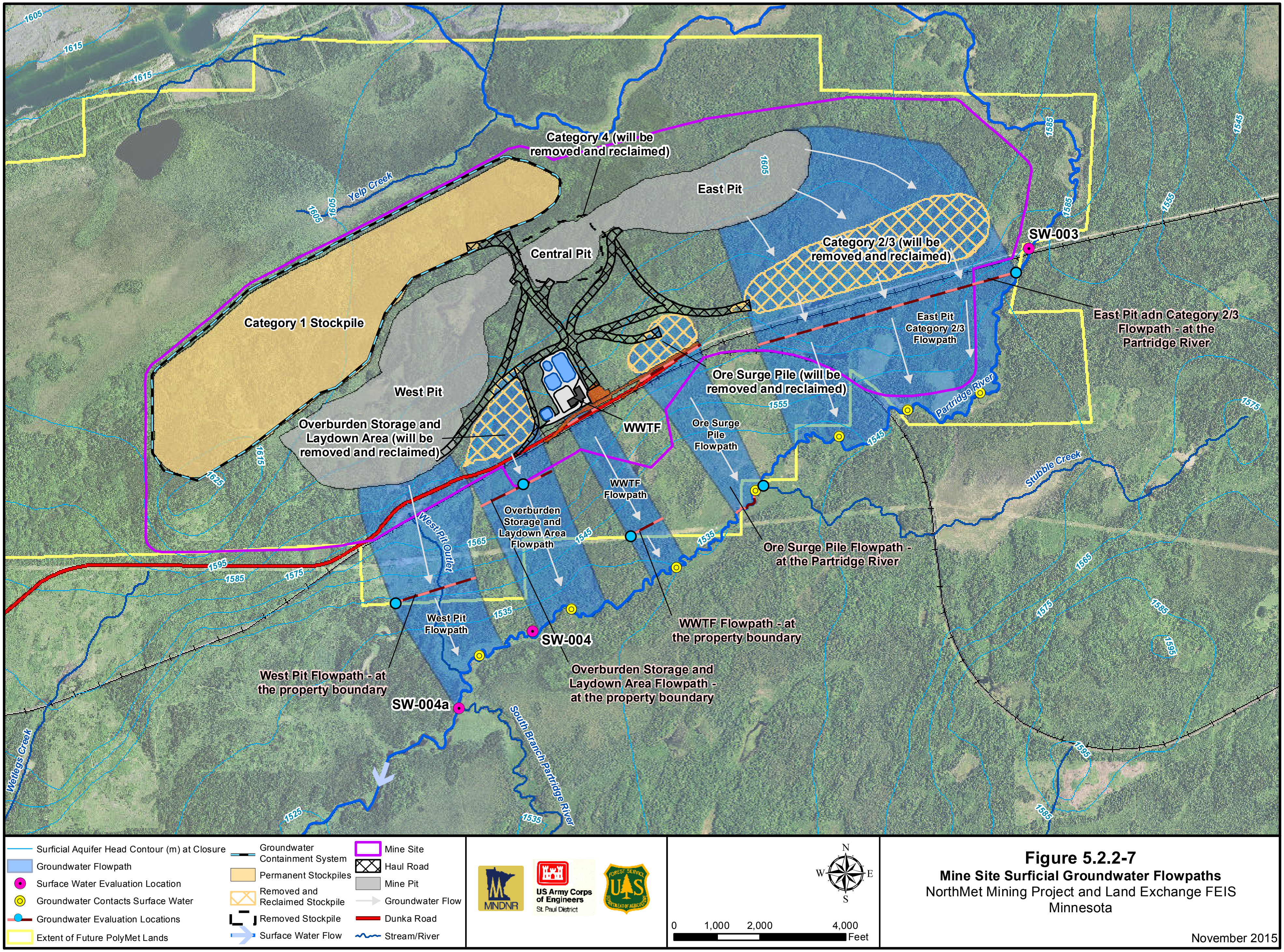

Figure 5.2.2-7
Mine Site Surficial Groundwater Flowpaths
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Table 5.2.2-8 Mine Site Surficial Groundwater Flowpaths used in GoldSim Based on Best-Estimate (P50) Values

Description	Units	West Pit	Overburden Storage Laydown Area	Wastewater Treatment Facility	Ore Surge Pile	Cat 2/3[4]	East Pit[4]
Flowpath total length	meter	1,505	1,600	1,730	1,415	2,120	2,120
Flowpath width	meter	665	550	240	430	1,440	1,440
Flowpath thickness	meter	5	5	5	5	5	5
Aquifer porosity	---	0.3	0.3	0.3	0.3	0.3	0.3
Aquifer recharge flux	in/yr	0.82	1.15	0.70	0.95	0.91	0.91
Contaminant source begin time	mine yr	48(1)	0	0	0	0	20(1)
Contaminant source end time	mine yr	Continuous	20	33	21	20	Continuous
Flow rate of affected water from contaminant source into upgradient portion of flowpath	gpm	6.1(1)	14.0(2) [0]	0.014(3) [0]	0.0012(3) [0]	0.019(3) [0]	3.8(1)
Aquifer recharge flow rate into flowpath	gpm	10.6	9.9 [12.8]	3.9 [3.7]	6.1 [7.3]	28.8 [39.2](5)	35.4
Groundwater discharge rate to Partridge River	gpm	16.7	23.9 [12.8]	3.9 [3.7]	6.1 [7.3]	28.8 [39.2]	39.2
Distance from contaminant source to groundwater evaluation location	meter	860	260	970	1,070	180	910
Distance from contaminant source to surface water discharge (Partridge River)	meter	1,360	1,230	1,310	1,070	910	1,610

Notes:
Brackets indicate closure value (after facility is decommissioned).
1 Pit water level rises above base of surficial aquifer.
2 Infiltration of meteoric water at top of facility.
3 Liner leakage at bottom of facility.
4 Category 2/3 stockpile and East Pit release affected water into the same flowpath at different times.
5 Includes East Pit discharge into flowpath.

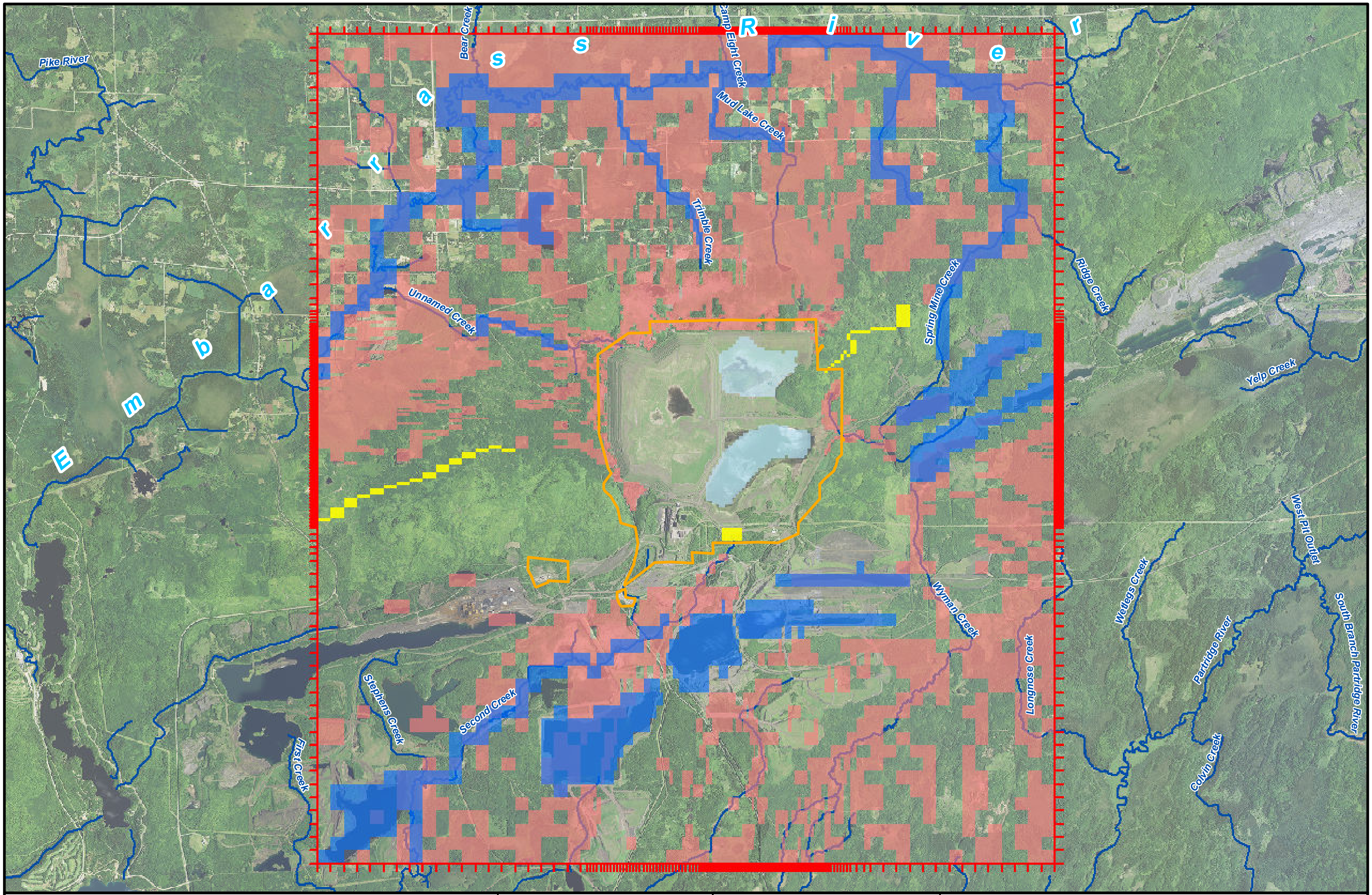
Plant Site

A series of numerical groundwater models were developed for the Tailings Basin's area. All those model versions are collectively referred to as the Plant Site MODFLOW model. The primary objectives for that modeling were to estimate:

- Seepage loss from the LTVSMC Tailings Basin ponds under various conditions;
- Average annual infiltration rate;
- Seepage rates for each of the groundwater flowpaths represented in the GoldSim model;
- Hydraulic conductivities of natural surficial materials, tailings, and bedrock;
- Areal aquifer recharge;
- Specific yield;
- Distribution of tailings seepage to different segments of the Tailings Basin perimeter;
- Depth of the phreatic surface; and
- The rate of contaminated groundwater flow that would bypass the Tailings Basin seepage containment system.

The initial Plant Site MODFLOW model was constructed with two layers. The upper layer represented the current LTVSMC tailing, while the lower layer represented surficial deposits and bedrock outcrops. The model simulated groundwater flow in tailings materials and in the underlying shallow groundwater system. It did not have layers to represent bedrock below surficial deposits. Thus, the base of surficial deposits was treated as a no-flow boundary. This was justified because bulk hydraulic conductivity of the upper bedrock is estimated to be about two orders-of-magnitude lower than the hydraulic conductivity of the surficial aquifer. Further, interpretation of available data indicates that deeper bedrock has substantially lower hydraulic conductivity than shallow bedrock. The upper model layer, layer 1, was set to be inactive outside of the Tailings Basin's footprint.

The areal extent of the Plant Site MODFLOW model and model-simulated hydrologic features are shown on Figure 5.2.2-8.



Plant Site
Constant Head Cell Layer 1
Constant Head Cell Layer 2
River Cells (Wetlands) - Layer 2
Drain Cell - Layer 2
Model Grid

MNDNR
US Army Corps of Engineers St. Paul District

N W E S

0 0.5 1 2 Miles

Figure 5.2.2-8
Plant Site MODFLOW Model - Extent and Boundary Conditions
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The original versions of the model were calibrated to simulate steady-state conditions. They did not simulate changes in water levels within the Tailings Basin. An initial steady-state model calibration was conducted using water level data collected through 2002, measured seepage rates, and leakage from ponds within cells 1E and 2E estimated using a water balance analysis. The re-calibrations were performed by varying input hydraulic conductivities, specific yields, and aquifer recharge, such that the model-predicted hydraulic heads reasonably match water levels measured in monitoring wells. An emphasis during re-calibration was to prevent the model from computing water levels that were significantly above the ground surface.

After LTVSMC operations and deposition of tailings ceased in 2001, the groundwater mound beneath the Tailings Basin began to dissipate, and the quantity of seepage leaving the Tailings Basin area decreased. The original model was calibrated to represent the changing (transient) conditions from the time of LTVSMC closure until present and to simulate the observed dissipation of the groundwater mound beneath the basin. Transient model calibration was accomplished using water levels measured in years 2002 – 2013 and the observed seepage flow rates. The results of that calibration included refined horizontal and vertical hydraulic conductivities of various materials present within the Tailings Basin pond area, their specific yield, and refined recharge rates.

The thickness of surficial deposits at the Plant Site is interpreted to vary below and adjacent to the Tailings Basin. The interpretation relies upon: 1) a preconstruction topographic map of the area, 2) a 2014 geotechnical investigation conducted along the Tailings Basin perimeter (PolyMet 2015l), and 3) an interpreted map for the top of the underlying bedrock (PolyMet 2015j). This information allowed the model to partially represent the presence of buried stream channels. The variable thickness of surficial deposits interpreted from this data was incorporated into the Plant Site MODFLOW model.

A description of the MODFLOW model and calibration process is provided in the Water Modeling Data Package, Volume 2 – Plant Site (PolyMet 2015j, Attachment A). The MODFLOW-calibrated hydraulic parameters for different geologic units and tailings types are summarized in Table 5.2.2-9 and Table 5.2.2-10.

Table 5.2.2-9 Plant Site Hydraulic Conductivity and Specific Yield Based on MODFLOW Calibration

Model Zone	Hydraulic conductivity		Specific yield (---)
	Horizontal (ft/day)	Vertical (ft/day)	
Cell 2W fine tailings	0.2	0.05	0.033
Cell 2W coarse tailings	4.02	0.07	0.07
Cell 1E fine tailings	0.06	0.0135	0.01
Cell 1E embankments [2]	0.23	0.077	0.01–0.3
Cell 1E coarse tailings	12.55	8.98	0.3
Cell 2E fine tailings	1.07	0.77	0.015
Cell 2E coarse tailings	4.98	3.56	0.024
Cell 2E embankments	0.23	0.77	0.015–0.024
Surficial deposits	68.4	32.53	0.00018[(1)]
Bedrock outcrops	0.0217	0.000602	0.000210

Sources: PolyMet 2015m; Barr 2013i.

1 Value represents storage coefficient. Specific yield not estimated by MODFLOW model for this material type.
2 Model zone used in predictive model simulations only.

Table 5.2.2-10 Plant Site Aquifer Recharge Based on MODFLOW Calibration

Model Zone	Aquifier Recharge	
	Steady-State Calibration (in/yr)	Transient Calibration (in/yr)
Exterior dams[1]	0.2–6.0	0.2–6.0
Cell 2W coarse tailings[2]	28.4[(2)]	18
Cell 2W fine tailings[2]	19.7[(2)]	17.5
1E and 2E fine tailings[1]	0.2–6.0	0.2–6.0
1E and 2E coarse tailings[1]	0.2–6.0	0.2–6.0
Surficial deposits	6.0	6.0
Bedrock outcrops	0.2	0.2

Source: PolyMet 2015j.

Notes:
1 Ponds within cells 1E and 2E receive 0 in/yr of aquifer recharge. Outside the ponds, aquifer recharge zones are based on the underlying materials, whether surficial deposits or bedrock outcrops.
2 In the steady-state portion of the CEC model, the two zones used to represent Cell 2W (coarse and fine tailings) were assigned higher aquifer recharge rates than during the transient portion of the simulation to reproduce the groundwater mound beneath the Tailings Basin that formed during LTVSMC operations as new tailings were deposited. The aquifer recharge rates applied to Cell 2W during the steady-state portion of the simulation may not represent actual aquifer recharge rates during that time period; rather, they were calibrated to obtain the initial conditions for the transient portion of the simulation. The aquifer recharge applied to Cell 2W during the transient portion of the CEC simulation was representative of conditions in Cell 2W following the end of LTVSMC operations.

The calibrated Plant Site MODFLOW model was used in a predictive mode to evaluate groundwater conditions associated with the NorthMet Project Proposed Action. These predictive simulations evaluated the growth and dissipation of the groundwater mound below the Tailings Basin, pond leakage changing over time, the distribution of groundwater flows, and flow changes over time from sub-areas of the Tailings Basin to the northern, northwestern, western, southern, and eastern toes of the Tailings Basin. The Plant Site MODFLOW model was not calibrated to groundwater baseflow in the Embarrass River, nor was the model used to estimate groundwater baseflow. See Table 5.2.2-11 for the results of the simulations.

All the model calibrations and predictive simulations were carried out considering the following time benchmarks:

- 2002 – Shortly after the LTVSMC operations ended, the groundwater mound beneath the Tailings Basin ponds, pond leakages and seep flows are at their maximum.
- 2002 – 2013 – The groundwater mound beneath the LTVSMC Tailings Basin ponds is dissipating, pond leakages and seep flows are decreasing.
- Mine year 1 – The start of NorthMet Tailings Basin tailings disposal.
- Mine years 1 to 20 – Slurried NorthMet tailings are deposited in Cells 1E and 2E, ponds increase in size, elevation of the surface of tailings and ponds systematically increase. As new tailings are added to Cells 1E and 2E, the groundwater mound beneath the Tailings Basin develops causing an increase of seepage at and outside of the Tailings Basin's toes.
- Mine year 20 – Disposal of NorthMet tailings stops. Cells 1E and 2E reach their maximum height, and the groundwater mound begins to dissipate.
- Mine year 55 – NorthMetWest Pit is flooded.

Table 5.2.2-11 Results of Steady-State Model Predictive Simulations

Time (Mine Year)	Number of FTB Tailings Model Layers	Elevation of Pond 1E (amsl)	Elevation of Pond 2E (amsl)	Total Model Layers[2]	Pond(s) Boundary Condition
1	2	1,657.8	1,578.75	4	Head
7	5	1,657.8	1,651.75	7	Head
8	5	1,660.25	1,660.25	7	Head
18	6	1,710.25[(1)]	1,710.25[(1)]	8	Head
20	6	1,717.25[(1)]	1,717.25[(1)]	8	Head
55+ (Closure)	6	1,717.25[(1)]	1,717.25[(1)]	8	River Cell[3]

Notes:
1 Ponds 1E and 2E combine.
2 Includes one layer for LTVSMC tailings and one layer for surficial deposits and bedrock outcrops' bottom.
3 Conductance term in the model's river cells simulate a low hydraulic conductivity (bentonite) layer placed at the bottom of pond during reclamation to achieve a leakage rate of about 6.5 in/year.

Figure 5.2.2-9 was constructed using the results of MODFLOW model simulations. It shows surficial groundwater flowpaths that have the potential to transport Tailings Basin-affected groundwater from contaminant source areas to the Embarrass River or its tributaries. It should be noted that all seepage would be captured from the east and south sides if the Tailings Basin and pumped back to the Tailings Basin pond. This figure also shows the groundwater evaluation locations (property boundary) used to assess compliance with evaluation criteria. The hydrologic characteristics of each surficial flowpath were estimated based on a combination of MODFLOW results and site characterization information. Deterministic model inputs include length, average width, saturated thickness, hydraulic gradient (essentially ground slope), and effective porosity. Uncertain inputs are hydraulic conductivity and aquifer recharge.

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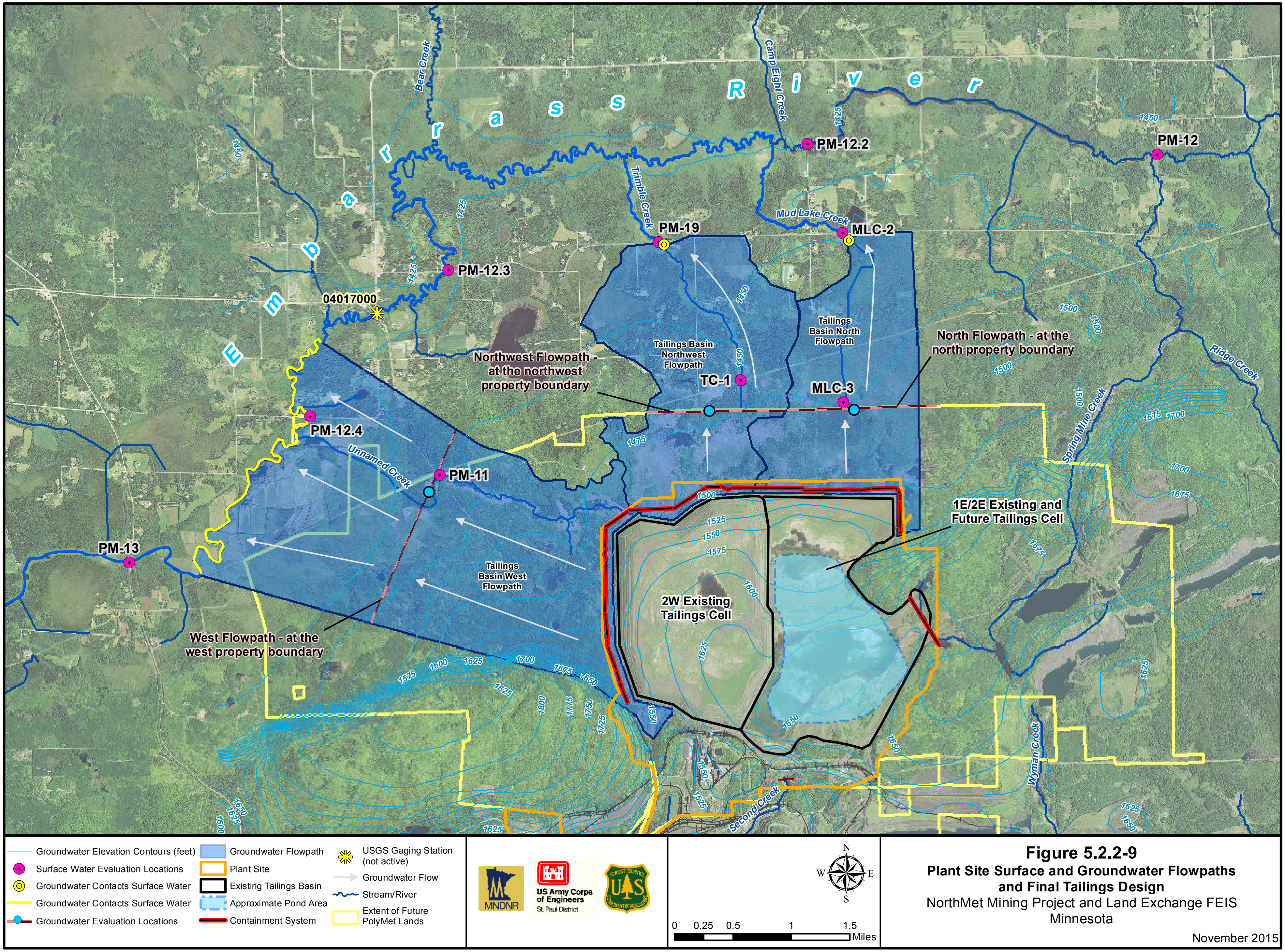

Figure 5.2.2-9
Plant Site Surface and Groundwater Flowpaths and Final Tailings Design
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Summary information for the groundwater flowpaths is provided in Table 5.2.2-12. Using deterministic inputs and 50th percentile probability (P50) values for uncertain inputs (including hydraulic conductivity and aquifer recharge) produces the model-estimated total release rate of flowpath groundwater into the Embarrass River or its tributaries of approximately 306 gpm for all project phases (operation, reclamation, and closure).

Another set of groundwater models were developed to help estimate the rate of seepage from the Tailings Basin that may bypass its containment system and that system's capture effectiveness (see discussion in Section 5.2.2.2.3). Three cross-sectional MODFLOW models simulated groundwater flow along the three Tailings Basin flowpaths: north, northwest and west. These flowpaths originate at the Tailings Basin dams and terminate at or near the Embarrass River. Seepage from the Tailings Basin to each flowpath was set using results of the Plant Site MODFLOW model simulations. Each of the three models was developed in three versions, assuming different thickness of the fractured bedrock: 25, 50 and 100 ft. The fractured bedrock medium is represented in the model as an "equivalent porous medium." Its hydraulic conductivity was set equal to 0.14 ft/day, which is a geometric mean derived from packer tests conducted in borings near the Tailings Basin (see discussion in Section 4.2.2.3.1).

Steady-state model simulations were completed for each flowpath under both operations and closure conditions. In total, 18 model simulations were completed. Model results indicate that all seepage from the Tailings Basin would be captured along the north and northwest flowpaths under all assumptions of the bedrock fractured zone thickness. All the seepage would be captured also along the west flowpath, except when the thickness of fractured zone is assumed to be 100 ft. Under this one scenario, the model-computed rate of seepage bypassing the Tailings Basin containment system is 8 gpm during operations, and 7 gpm during closure and long-term maintenance. These results indicate that the Plant Site GoldSim model assumption (that groundwater seepage equal to 10 percent of the aquifer's transmissive capacity bypasses the Tailings Basin containment system) is conservative. The modeling shows that the seepage bypassing the containment system represents no more than 7 percent of the aquifer's transmissive capacity (see discussion in Section 5.2.2.2.3) (Barr 2015b).

Table 5.2.2-12 Plant Site Surficial Groundwater Flowpaths used in GoldSim Based on Best-Estimate (P50) Values

Description	Units	North	Northwest	West	Total
Flowpath total length (Tailings Basin toe to Embarrass River or surface water discharge location)	Meter	3,260	3,715	5,410	
Flowpath width	Meter	1,920	2,090	2,920	
Flowpath thickness	Meter	7	7	7	
Aquifer porosity	---	0.3	0.3	0.3	
Aquifer recharge flux	in/yr	0.76	0.76	0.76	
Contaminant source begin time	mine year	0	0	0	
Contaminant source end time	mine year	Continuous	Continuous	Continuous	
Flow rate of groundwater approaching containment system	gpm	42.1	52.9	105.0	200.0
Flow rate of groundwater captured by containment system (90% capture efficiency)	gpm	37.9	47.6	94.5	180.0
Flow rate of groundwater by-passing the containment system (10%)	gpm	4.21	5.3	10.5	20.0
Aquifer recharge flow rate downgradient of containment system	gpm	59.7	74.2	151.7	285.6
Groundwater contribution rate to Embarrass River or tributary to the River	gpm	63.9	79.5	162.2	305.6
Tailings surface seepage flow rate captured by containment system (100% capture efficiency) - End of operations	gpm	1,375.5	385.9	755.6	2,517.0
Tailings Basin surface seepage flow rate captured by containment system (100% capture efficiency) – Closure	gpm	430.7	354.8	550.8	1,336.3
Distance from containment system to groundwater evaluation location[1]	Meter	1,135	1,255	3,040	
Distance from containment system to surface water discharge (Embarrass River or tributary) [1]	Meter	3,190	3,645	5,340	

Note:
[1] Assume containment system located 70 meters from Tailings Basin toe.

5.2.2.2.2 Surface Water Hydrologic Modeling

This section describes the methods used to model surface water hydrology in the Partridge River and Embarrass River watersheds. The Plant Site represents a very small portion of the natural (pre-LTVSMC Tailings Basin) Second Creek Watershed and, as a consequence, Second Creek was not included in the surface water hydrologic modeling. However, the loss of natural watershed flow to the headwaters of Second Creek is addressed.

<u>Partridge River Watershed</u>

Surface water flow within the Partridge River Watershed was modeled using XP-SWMM, a model that estimates stormwater runoff, streamflow, and groundwater-controlled baseflow for a network of streams. Input to the model includes sub-drainage delineation, ground conditions, stream channel alignments, and a rainfall database. XP-SWMM estimates monthly average streamflow rates at different locations along the Partridge River and its important tributaries. To improve the results, the model inputs were adjusted so that flow estimates were calibrated to available measured flow rates in the Partridge River at USGS hydrometric station 04015475 in the Partridge River above Colby Lake (Table 5.2.2-13). A description of the XP-SWMM model for the Mine Site is provided in the Mine Site Water Modeling Data Package (PolyMet 2015j). A summary of the model results for seven Partridge River monitoring stations (see Figure 5.2.2-28) is provided in Table 5.2.2-13.

Table 5.2.2-13 Mine Site Surface Water Flows for Existing Conditions Based on XP-SWMM Model Results Adjusted to Match USGS Stream Gaging Data

Stream	Station	Groundwater Baseflow[1]	Annual 7-Day Minimum Flow with 10-year Return Period[2]	Annual 1-Day Minimum Flow[3]	Annual Daily Mean Flow[3]	Annual 1-day Maximum Flow[3]	Annual 1-Day Minimum Flow with 10-year Return Period[2]
		cfs	cfs	cfs	cfs	cfs	cfs
Partridge River	SW-002	0.4	0.4	0.4	6.1	82	118
	SW-003	0.5	0.5	0.5	7.4	93	132
	SW-004	0.9	0.7	0.9	14	156	215
	SW-004a	2.4	1.7	2.1	38	468	678
	SW-004b	3.8	2.8	3.4	58	631	895
	SW-005	4.9	3.6	4.3	75	737	1,081
	SW-006	5.3	3.9	4.7	79	761	1,127

Source: PolyMet 2015m, Appendix J; Barr 2015i.

Notes:
1 Average annual 30-day minimum.
2 10-year values are based on individual model year flow statistics not published in Attachment J of PolyMet 2015m. Values in Attachment J represent averages of the 10-year model period.
3 Long-term average.

Embarrass River Watershed

Flow characteristics for different reaches of the Embarrass River and selected tributaries were estimated by extrapolating flows from USGS gaging station 04017000 (located just downstream of PM-12.3) on a catchment area basis. A summary of the flow results for different stations on Embarrass River, Mud Lake Creek, Trimble Creek, and Unnamed Creek is provided in Table 5.2.2-14. Flow contributed by the Tailings Basin seepage is separated from the flows derived using the catchment area basis in the table to provide greater clarity of water origins. Tailings Basin flows presented in the last column of Table 5.2.2-14 can be added to the annual flow characteristics presented in the table to determine the appropriate flow volume.

Table 5.2.2-14 Plant Site Surface Water Flows for Natural Conditions Based on Embarrass River Stream Gaging Results Applied to Contributing Watersheds and Additional from Tailings Basin Seepage and Flowpath Discharge

Stream	Embarrass River or Tributary Surface Water Station	Existing Watershed Area Excluding TB Footprint (mi^2)	Estimated Groundwater Baseflow (cfs)	Annual 7-Day Minimum Flow with 10-year Return Period[1] (cfs)	Annual 1-Day Minimum Flow[1,2] (cfs)	Annual Daily Mean Flow[1,2] (cfs)	Annual 1-day Maximum Flow[1,2] (cfs)	Annual 1-day Maximum Flow with 10-year Return Period[1] (cfs)	Additional Flow to Station from Tailings Basin Seepage (cfs)
Embarrass River	PM-12	19.0	0.86	0.4	0.74	13.8	145	259	0.00
	PM-12.2	34.2	1.55	0.7	1.34	24.9	261	467	0.00
	PM-12.3	83.0	3.76	1.79	3.24	60.5	633	1,135	4.41
	PM-12.4	94.4	4.27	2.07	3.69	68.8	720	1,290	4.43
	PM-13[(3)]	107	4.83	2.33	4.17	77.8	814	1,457	5.77[(4)]
Mud Lake Creek	MLC-3	1.40	0.06	0.07	0.05	1.02	10.7	19.2	0.83
	MLC-2	3.57	0.16	0.07	0.14	2.60	27.2	49.1	0.93
Trimble Creek	TC-1	2.18	0.10	0.04	0.09	1.59	16.6	29.6	3.36
	PM-19	3.94	0.18	0.12	0.15	2.87	30.1	53.5	3.48
Unnamed Creek	UC-1a	2.29	0.10	0.09	0.09	1.67	17.5	30.9	1.11
	PM-11	3.37	0.15	0.09	0.13	2.46	25.7	45.9	1.11

Source: Barr 2015i.

Notes:
1 Based on USGS record applied to watershed area, flow from the Tailings Basin (last column) is in addition to the flow values presented.
2 Long-term average.
3 Values differ from those in Table 4-5 of the Plant Site Water Modeling Data Package (Barr 2015j), which were based on the historical drainage area of 88.3 mi^2.
4 5.77 cfs (2,590 gpm) is the estimated total seepage from the Tailings Basin.

5.2.2.2.3 Water Quality Modeling (GoldSim)

GoldSim is a commercially available "systems" model that allows for probabilistic simulations and was used by PolyMet to simulate time-varying surface water and groundwater quality. GoldSim was programmed with a suite of algorithms to estimate the release of contaminants from mine facilities (i.e., "sources") and their transport to groundwater and surface water evaluation locations. An overview of the modeling of contaminant release and transport in GoldSim is provided below. The sections below also provide a geochemistry overview of the waste rock and tailings, and describe the methodology used to estimate contaminant release and transport at the Mine Site (Partridge River Watershed) and Tailings Basin (Embarrass River Watershed).

A characteristic of the GoldSim models (Plant Site and Mine Site) was to not explicitly simulate flow/transport between wetlands and groundwater in the underlying surficial deposits. However, the flow interaction between wetlands and surficial deposits is approximated by the assumed aquifer recharge rate reaching surficial deposits groundwater. This approximation was considered reasonable because field observations in the Iron Range suggest that downward leakage from wetlands to the underlying groundwater system is variable and can be limited. To address potential impacts to wetlands, this FEIS proposes extensive monitoring during mine operations and closure to assess if changes in wetlands flow/chemistry would raise concerns for permitting agencies. If monitoring data indicate trends toward permit non-compliance, then adaptive mitigation measures would be implemented. See Section 5.2.2.3.5 for more information on adaptive mitigation measures and Section 5.2.2.3.6 for more information on monitoring.

The GoldSim models did not explicitly simulate flow/transport between surficial deposits and groundwater in the underlying Duluth Complex bedrock. Scoping calculations and the Mine Site MODFLOW results indicated that flow between these geologic units would be minimal. At the Mine Site, bedrock flowpaths were included in the GoldSim model because mine pits with chemically affected water would extend downward into bedrock. However, the bedrock flowpaths were mathematically treated as independent of the surficial deposits flowpaths because of the minimal flow between the two. Scoping calculations and GoldSim results indicated that groundwater flow/transport within the Mine Site bedrock flowpaths would not be sufficient to affect water chemistry at the groundwater evaluation locations or in the Partridge River. Given the Mine Site results, a decision was made to not incorporate bedrock flowpaths in the Plant Site GoldSim model as such flowpaths would not come in direct contact with chemical sources (such as mine pits).

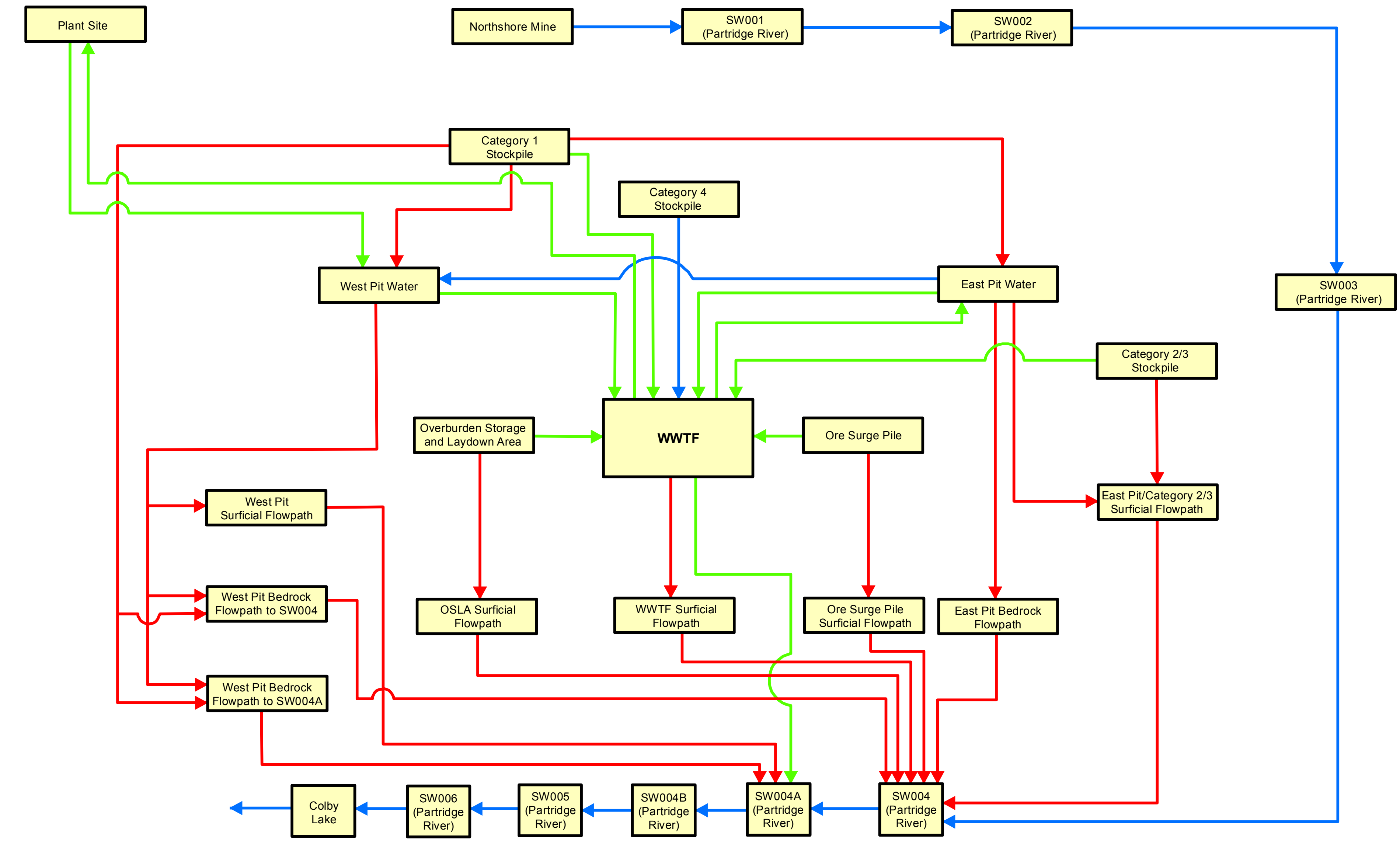
The pH in leachate from the various mining features was not predicted by the GoldSim model. The permanent storage facilities (such as the Category 1 stockpile and Tailings Basin) would contain material that is not expected to produce acidic leachate. The non-acid generating waste was identified using multi-year kinetic tests (humidity cells) on NorthMet rock samples and tailings. Waste rock with 0.12 percent sulfide S or less is the threshold for selecting non-acid generating mine waste and is supported by long-term humidity cell tests on NorthMet waste (i.e., 38 samples of Category 1 waste rock, with tests now run between 187 and 337 weeks; and 33 humidity cell tests on NorthMet tailings run between 84 and 304 weeks (PolyMet 2015q Attachments C and F).

These tests demonstrate that tailings and Category 1 waste rock materials would not generate acidic leachate. All Category 2/3 and 4 waste rock, which would have the potential to generate acid leachate, would be permanently subaqueously disposed of in the East Pit, effectively eliminating access to oxygen, which is required to create acidic leachate. The NorthMet Project Proposed Action design thus prevents the introduction of acidic leachate to surface water that could affect water and aquatic resources.

Regarding the tailings in particular, the pH values in the tailings humidity cells have been observed to be stable or increasing (becoming less acidic) between 100 and 300 weeks of humidity cell testing. However, pH of the tailings in the GoldSim model is not directly based on, or extrapolated from, the observed pH in the humidity cells. As noted above, the humidity cells provide information on rates of acid producing and acid neutralizing reactions, which are similar for tailings and Category 1 waste rock due to the similar sulfur content of these materials. A separate geochemical model was used to estimate long-term pH resulting from these reactions. This geochemical model used a CO_2 partial pressure greater than natural atmospheric conditions to account for bacterial respiration and other CO_2 generating chemical reactions. Increasing the CO_2 partial pressure resulted in decreasing the pH of the system.

Partridge River Watershed

This section describes the geochemistry of the NorthMet Deposit waste rock and the factors affecting contaminant release and transport from the various contaminant sources at the Mine Site. An overall flowchart of the Mine Site GoldSim model is provided as Figure 5.2.2-10.



Surface Water Flow
Seepage or Groundwater Flow
Piped Flow

MNDNR
US Army Corps of Engineers St. Paul District

Figure 5.2.2-10
Mine Site GoldSim Overview Flow Chart
NorthMet Mining Project and Land Exchange FEIS
Minnesota

November 2015

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NorthMet Waste Rock Geochemistry

The mechanism most responsible for the release of solutes from waste rock is oxidation of sulfide minerals, primarily pyrrhotite ($Fe_{1-x}S$) in NorthMet Deposit rock. The sulfide-oxidation reaction produces sulfuric acid, and releases soluble metals (e.g., cobalt, copper, iron, and nickel) that were bound in sulfide minerals. Secondary effects include leaching of some metals (primarily nickel and chromium) from silicate minerals, particularly where acidic pore waters increase silicate solubility. Mine-related blasting and excavation dramatically increases the surface area and porosity of the rock, which allows rapid introduction of atmospheric oxygen and flushing of solutes by water. Within the pit walls, the blasting effects are limited in terms of lateral penetration and do not have much effect on solute transport in bedrock. Where the pore water pH remains near-neutral, metal mobility can be limited as some constituents released by oxidation are removed from solution by adsorption, co-precipitation, or solubility-controlled precipitation of secondary minerals. The onset of acidic pore water is also of concern, as these conditions can cause the rate of sulfide oxidation to increase, pH to increase, and the concentration of metals to increase as precipitates dissolve that were previously stored in the rock under neutral or basic conditions.

Key environmental characteristics of the NorthMet waste rock include the following:

- Most of the waste rock and pit wall rock would contain some sulfide S, mainly as mineral pyrrhotite, which can produce acid leachate and soluble metals when it oxidizes;
- There are essentially no acid-neutralizing carbonate minerals in NorthMet waste rock, but silicate minerals—including plagioclase feldspar ($[Na,Ca][Si,Al]_4O_8$), olivine ($[Mg,Fe]_2SiO_4$), and pyroxenes (e.g., diopside, $MgCaSi_2O_6$)—neutralize some acid, which would delay acid onset in some rock and prevent entirely the onset of acidic conditions in rock with less than 0.12 percent sulfur;
- In rock with less than 0.12 percent sulfur (S), the oxidation rate is slow enough that all acid produced during weathering would be completely neutralized by reaction with silicate minerals, so this low-sulfur rock (classified at Category 1 waste rock in the NorthMet Project Proposed Action) is predicted to never generate acidic leachate;
- Sulfide-bearing rock from the NorthMet Project Proposed Action may oxidize for several years before producing acidic leachate;
- The rate of sulfide mineral oxidation in excavated NorthMet waste rock would be approximately proportional to the total sulfur content of the material, and the rate could increase several fold if the pore water were to become acidic;
- Chemical reactions, including mineral precipitation and surface adsorption, would limit the concentration of many contaminants in non-acidic waste rock effluent and thus would reduce the rate at which contaminants were released; and
- If the pore water pH were to shift from neutral to acidic, then the rate of sulfide mineral oxidation and associated release of some metal cations (e.g., nickel and copper) would increase dramatically (e.g., average increase in oxidation upon onset of acidic conditions is a factor of 8.2 relative to non-acidic conditions [Table 8-4 in PolyMet 2015q]).

The environmental classification of NorthMet waste rock is based primarily on the sulfur concentration, and the distribution of sulfur through the deposit is based on spatial interpolation between 24,861 analyses of rock samples collected as part of the exploration drilling (PolyMet 2007c). Rates of oxidation and contaminant release are based on 78 "humidity cell" tests (in addition to 7 duplicate samples), which measured solute concentrations in leachate as rocks were subjected to over 3 years of simulated weathering cycles. These include tests on 82 samples of Category 1 through Category 4 waste rock, and 3 samples of ore from the NorthMet Deposit (PolyMet 2015q, Attachment C, Table 2). In addition, splits of 7 waste rock samples were subjected to duplicate humidity cell tests, but these were stopped in 2009 when results indicated good reproducibility in trends of reaction rates and solute release. Estimates for changes in oxidation rates and solute release during long-term weathering were supplemented with 17 independent tests conducted by the MDNR on rock from a similar proximal deposit (the Dunka Blast Hole). These tests on Dunka rock used smaller fragment size rock (termed "MDNR Reactors"), and results were used to refine estimates of oxidation-rate changes during weathering (PolyMet 2015q, Attachment A, Table 3). Total leachable metal concentrations are based on 61 analyses of metals extracted from waste rock by acidic digestions (SRK 2007b). For constituents that are assumed to be released in proportion to dissolution of another constituent (e.g., copper and zinc were always modeled as being released in proportion to sulfide sulfur oxidation), the concentration ratios were estimated using the average total constituent concentrations measured in all available assayed samples of either Category 1, Category 2/3, or Category 4 waste rock; ore, or Category 4 Virginia Formation (i.e., approximately 18,800 total whole-rock analyses, see Large Table 2 and Section 8.1.2.3 in PolyMet 2015q). Finally, the concentration of metals in mineral phases was based on electron microprobe analysis, which measured the concentration of metals in 630 individual mineral grains (74 oxides, 268 sulfides, and 288 silicates [SRK 2007b; SRK 2007c]).

These environmental characteristics have been used to classify NorthMet waste rock into the following four environmental categories (PolyMet 2015q, Figure 4-8 to 4-10):

- Category 1: Sulfide S range is less than or equal to 0.12 percent, and would not produce acidic leachate.
- Category 2: Sulfide S range is greater than 0.12 percent and less than or equal to 0.31 percent, and could produce acidic leachate if allowed to weather for several years.
- Category 3: Sulfide S range is greater than 0.31 percent and less than or equal to 0.60 percent, and could produce acidic leachate if allowed to weather for several years.
  - Categories 2 and 3 are combined to produce the Category 2/3 stockpile with sulfur content greater than 0.12 percent and less than or equal to 0.60 percent, could produce acidic leachate if allowed to weather for several years.
- Category 4 (Duluth Complex): Sulfide S range is greater than 0.60 percent, and would produce acidic leachate if allowed to weather for several years.
- Category 4 (Virginia formation): Sulfide S range is from 0.4 to 5.0 percent, and would produce acidic leachate immediately upon weathering.
- Ore would behave similarly to Category 4 Duluth complex waste rock, but other than residual ore in pit wall rock, would not remain on the surface for any extended periods. Ore would move in and out of the Ore Surge Pile (a lined facility) throughout operations.

The sulfide S concentration of the NorthMet waste rock is relatively low compared to many other mines with sulfide-bearing rock around the world. Data from the International Kinetic Database, which includes humidity cell test results from 71 mines, shows sulfide S concentrations ranging as high as 40 percent, with an average of 3.6 percent (see Figure 5.2.2-11) (Mine Site Drainage Assessment Group 2013). In comparison, most (70 percent) of the NorthMet waste rock would be the low-sulfur, non-acid-generating Category 1 material (i.e., average sulfur would equal 0.06 percent, and range from 0.01 to 0.12 percent). The only NorthMet waste rock that would contain greater on average than 1 percent sulfide is the Virginia Formation waste rock, which has an average sulfide S concentration of 2.43 percent, but it would only comprise about 1.8 percent of the total NorthMet Deposit waste rock. It should be noted, however, that not all sulfide S has the same potential for release.

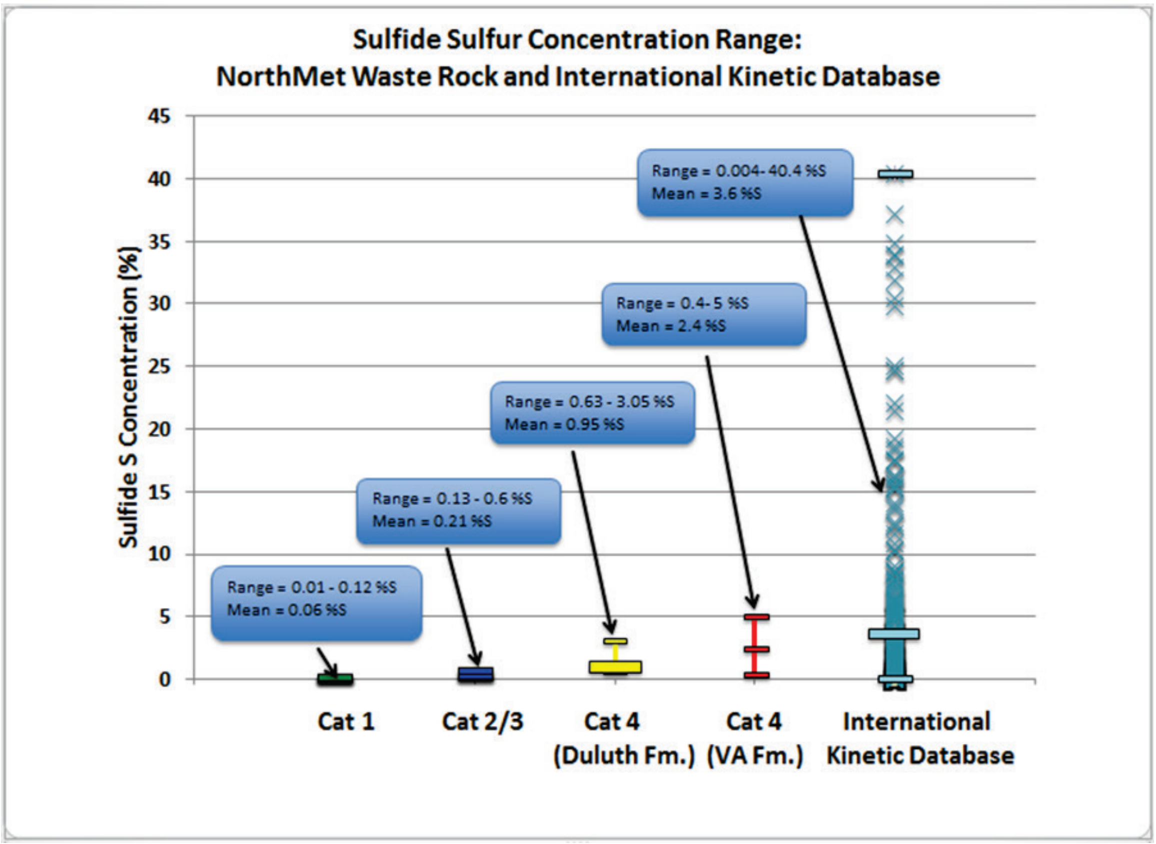


Figure 5.2.2-11 Comparison of NorthMet Project Waste Rock Sulfide Sulfur Concentrations with Other Mines

Constituent Release from Waste Rock

The GoldSim model simulates constituent release from waste rock by applying scaling factors to laboratory tests to provide quantitative estimates of loading that are then combined with hydrologic estimates to predict solute concentrations. The predictive models assume that the entire mass of waste rock in each of the stockpiles is oxygenated and is thus capable of reacting with air (some waste rock stockpiles can have zones with lower than atmospheric oxygen concentrations, so this assumption tends toward producing higher rates of pollutant release than may exist). Field oxidation rates are then estimated by scaling from lab rates to account for effects of temperature (oxidation is slower at the lower temperatures), differences in pH (potential acidification), fragment size (waste rock fragments would be larger than rock tested in the lab, and would thus react more slowly), pore-water pH (oxidation rates in NorthMet rock are assumed to increase when pore water becomes acidic), and the fraction of rock flushed by percolating water (some fraction of waste rock under field conditions is hydraulically isolated).

For the Category 1 waste rock (i.e., the waste rock with the lowest sulfide sulfur content, but which would remain stored permanently on the surface after closure), instead of using lab tests on rock from the NorthMet Deposit, the rate of oxidation and constituent release in the field was estimated from lab release rates that were scaled using the results of studies of seepage release measured in Dunka Mine rock, which is a nearby source of waste rock with similar chemical composition that has been monitored under field conditions. The rate of contaminant release is modeled as a load rate (e.g., mg contaminant per month), estimated as the product of the mass of the waste (kg waste) and the rate of contaminants are released (mg contaminant per kg waste per month).

This transport simulation assumes that solutes released by oxidation can dissolve when contacted by rain and snowmelt percolating through the waste rock, and dissolved constituents are flushed immediately through the rock. Where the concentration of contaminants in percolating water is not limited, the entire load released over a time step can dissolve in any available water. In this case, decreasing the water flow would still collect the entire contaminant load, producing a more concentrated leachate, but the same solute load rate. In most NorthMet waste rock, however, modeled contaminant concentrations are limited by “concentration caps”—empirical upper-concentration values. Concentration caps are estimated in part using measured behavior of laboratory tests on waste rock from the NorthMet Deposit, but rely heavily on concentrations of dissolved constituents measured in effluent from field-scale facilities of similar waste rock (including rock from the Amax and Dunka mine deposits in Minnesota, and the Whistle and Vangorda mines in Canada (PolyMet 2015q). When solute concentrations are capped in modeling, solute loads are proportional to flow rate, so that reduced flow rates would result in a proportional reduction in solute load to the environment. The Category 1 Stockpile is the clearest example of this effect, because solutes would be released over time by oxidation, but the pore water would maintain a near-neutral pH, where many solutes have limited solubility. The effect of concentration caps in the Category 1 Stockpile would be further enhanced in closure and long-term maintenance, when a proposed geomembrane cover would reduce infiltration, producing a proportional reduction in the load rate of those solutes at their pore-water concentration caps. The GoldSim model tracks the total mass of these capped solutes, so that constituents removed from solution to meet concentration caps are retained in the model for later release when solute concentrations would otherwise decrease below the concentration caps. In contrast, for the more acid-generating materials, including the ore and Category 4 waste rock, concentration caps are much higher or may not attain the cap value, and load to the environment is more closely related to the rate of solute release regardless of water flow rate through the waste.

Detailed descriptions of the assumptions and algorithms used to estimate solute release from mine-related facilities is provided in the Waste Characterization Data Package (PolyMet 2015q).

Contaminant Transport in Groundwater from Waste Rock

At the Mine Site contaminated groundwater would seep from the East and West Pits along the surficial aquifer and bedrock groundwater flowpaths. Such seepage would become environmentally important when water levels in the pits would rise above the base of the surficial aquifer. In addition, leakage from the Category 2/3 Stockpile, Category 4 Stockpile, Ore Surge Pile, Overburden Storage and Laydown Area, and WWTF ponds would also enter groundwater flowpaths within the surficial aquifer. Finally, water by-passing the Category 1 Stockpile's containment system at a low rate would enter the bedrock groundwater flowpath too. Contaminated water would migrate along the groundwater flowpaths to the property boundary and, ultimately, to the Partridge River.

At the Mine Site, five surficial groundwater flowpaths were identified, as described previously. Groundwater flow rates and flow directions in the GoldSim model were estimated from site characterization information and were verified by the MODFLOW results. Time-varying surface water flow rates were taken either from the XP-SWMM results or were estimated from stream gaging data.

Site characterization data indicate that the bulk hydraulic conductivity of upper bedrock is two to three orders-of-magnitude lower than the hydraulic conductivity of the surficial aquifer. Thus, groundwater flow and transport at the Mine Site are dominated by the hydraulics of the surficial aquifer. Bedrock plays a negligible role in transporting site-derived contaminants to the Partridge River.

Still, contaminated waters entering the groundwater bedrock flowpaths were also programmed into GoldSim. However, due to the very low bulk hydraulic conductivity of bedrock, groundwater flow rates in these flowpaths were not large enough to affect water quality at the groundwater and surface water evaluation locations. The GoldSim model does not consider a northward flowpath north of the Mine Site facilities as there in uncertainty that such a flowpath would ever exist. However, if monitoring indicated a potential northern flowpath, mitigation measure(s) would be employed to prevent impacted bedrock groundwater flow to the north (MDNR et al. 2015c).

Solutes, while migrating along the groundwater flowpaths (either at the Mine Site or Plant Site), would be subject to attenuating processes reducing their concentrations. Attenuating processes slow solute transport by adsorption or sorption onto mineral surfaces in the aquifer. Table 5.2.2-15 defines fate and transport mechanism terminology in this FEIS.

Among those attenuating processes would be:

- Mechanical dispersion, which would spread out the leading front of the contaminant plume; and
- Mixing with meteoric water recharging the aquifer.

In addition, over time the concentration of contaminants leaking from the sources would decrease, as the sources would gradually degrade, diminishing in strength. Those, and other processes would result in contaminant concentrations decreasing with time and distance from the source.

Given these attenuating processes, contaminant transport to evaluation locations can be described by noting the time the contaminant arrives at that point and the time when the contaminant concentration reaches its peak.

Table 5.2.2-15 Definition of Fate and Transport Mechanism Terminology used in this FEIS

Term	Definition
Adsorption (Sorption)	The process by which ions of a solute are attracted to and accumulate at the interface between a solid phase and an aqueous phase.
Attenuation	In groundwater transport this refers to mechanisms that reduce a solute's concentration or rate of migration in groundwater, such as adsorption, degradation, dispersion or dilution.
Constituent-loading	The rate at which a constituent is added or released (mass per unit time).
Groundwater Plume	The spread of contaminated groundwater downgradient of the source.
Mechanical Dispersion	The process whereby solutes spread out because of differences in the groundwater movement's velocity at the pore level and within different sediment/rock strata.
Partition Coefficient (Kd)	The ratio of the sorbed metal concentration (expressed in milligrams of chemical per kilograms of sorbing material) to the dissolved chemical concentration (expressed in milligrams of chemical per liter of solution) at equilibrium.

Some of the constituents modeled as un-attenuated in the GoldSim model may in fact be subject to some attenuation due to adsorption onto surfaces in the surficial and bedrock aquifer. The peak concentrations of these solutes would arrive at the evaluation locations later than estimated in the GoldSim model, and the peak concentrations of such late-arriving solutes would be lower than the concentrations estimated under the assumption in this FEIS of un-attenuated transport.

In the NorthMet Project Proposed Action GoldSim water quality model, four solutes are assumed to be attenuated by adsorption in the aquifer: arsenic, antimony, copper, and nickel. Definition of the metal partition coefficient (K_d) controlling this process is provided in Table 5.2.2-15. Higher K_d values represent higher sorption capacity of the aquifer, and thus slower apparent migration of a solute in groundwater.

Literature values are available for estimating metal partition coefficients (USEPA 1996; 2005). These values have been adopted by MPCA as part of its risk-based guidance for State Superfund and VIC program sites (MPCA 1998). In addition, PolyMet conducted site-specific sorption testing on soil samples collected from the most permeable zone of two borings at the Mine Site. Batch sorption tests were conducted in the laboratory generally using standard ASTM procedures (Barr 2009h). Table 5.2.2-16 presents the USEPA literature values, the results of the site-specific sorption testing, and the K_d values accepted for use in groundwater modeling. The lower K_d values for antimony reflect greater uncertainty regarding antimony sorption in the scientific literature and site-specific testing.

Table 5.2.2-16 Comparison of Site-specific and Literature Sorption Values at the Mine Site

Parameter	USEPA K_d Screening Value Used in DEIS	Site-specific Sorption (K_d) Values[1] Boring RS-22	Boring RS- 24	Average	K_d used in GoldSim Model	Associated Retardation Factor used in GoldSim Model[2]
	(L/kg)	(L/kg)	(L/kg)	(L/kg)	(L/kg)	(---)
Antimony	45	1.6	22	12	1.3, 1.6, 6.1[(3)]	7.5, 9.0, 31[(3)]
Arsenic	25	>52	590	~320	25[(4)]	126[(4)]
Copper	22	1,047	463	755	22[(4)]	111[(4)]
Nickel	16	73	40	56	16[(4)]	81[(4)]

Notes:
1 Modified from: Barr 2009h.
2 Assuming porosity of 0.3 and dry bulk density of 1,500 kg/m^3.
3 Uncertain input with triangular distribution. Minimum, mode, and maximum values, respectively.
4 Deterministic value.

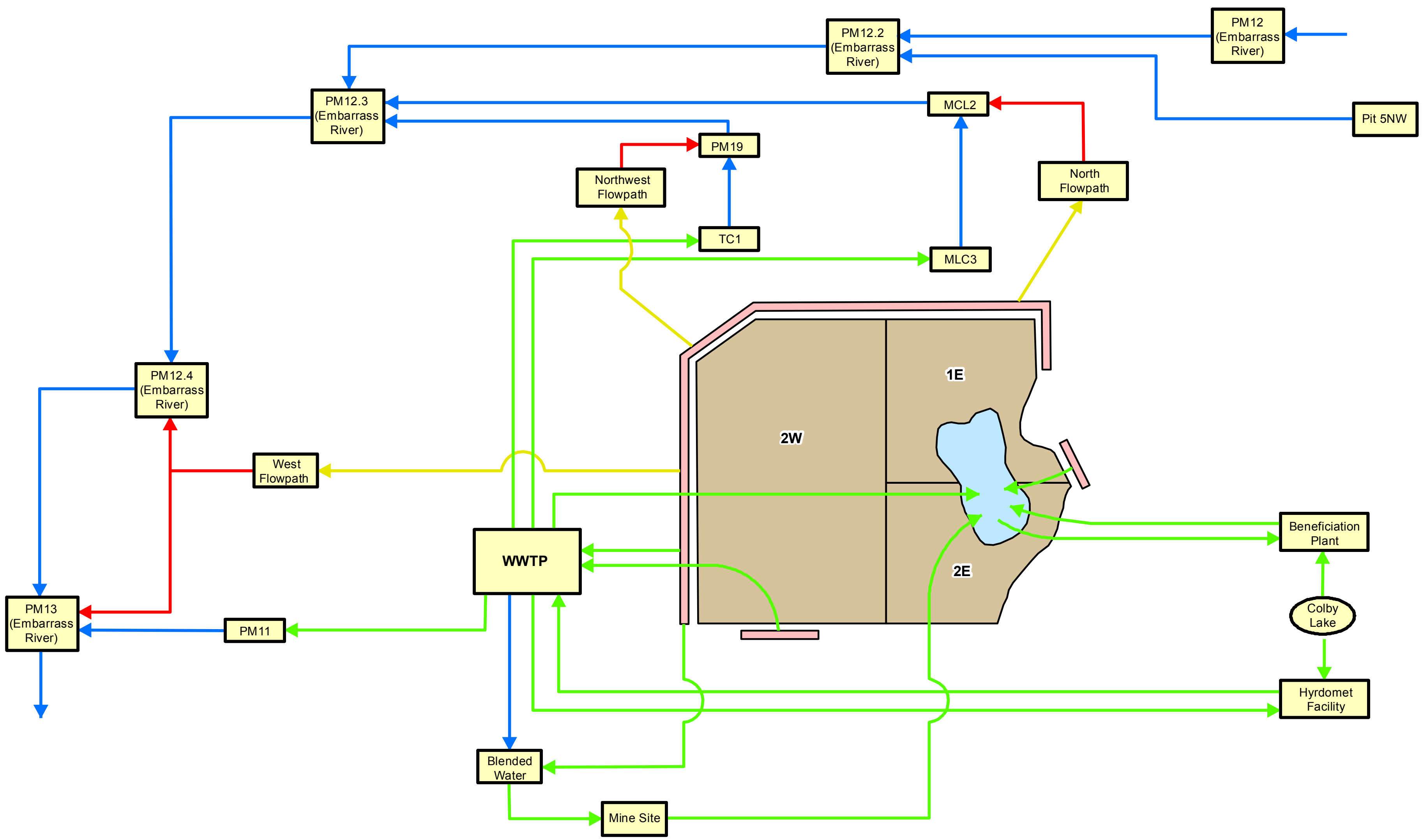
The attenuation effect resulting from sorption is significant enough that arsenic, copper, and nickel are not predicted to travel from source areas to any groundwater evaluation locations or the Partridge River within the 200-year model simulation period (PolyMet 2014v). Analytical calculations suggest that the travel times for these solutes would be on the order of thousands of years.

Antimony, which is modeled with lower K_d values, reaches the groundwater evaluation location in the East Pit Category 2/3 surficial flowpath at about 23 years, but the predicted concentration increase is very small. Model results indicate that the 90th percentile concentration of antimony for the West Pit surficial flowpath at Dunka Road peaks at the 164th year of model simulation and is below the evaluation criterion of 6.0 µg/L. That concentration would be reduced when the peak arrives at the property boundary due to attenuation processes.

The seepage capture efficiency at the Category 1 Stockpile of the surrounding containment system, West Pit, and East Pit was assessed using a separate three-dimensional MODFLOW model (PolyMet 2015h). The model predicted that during mine operations, when portions of the stockpile would be uncovered, some uncollected affected seepage could migrate north of the Category 1 Stockpile at a flow rate of less than or equal to 0.2 gpm, and this groundwater could be released to bedrock and/or surficial deposits adjacent to the stockpile. Given that this small flow would be distributed over the 2 mile length of the stockpile, it would be unlikely to cause any measureable impact to groundwater or surface water. After operations, when the stockpile is fully covered, the uncollected north seepage from the stockpile is predicted to be less than equal to 0.01 gpm. As such, a north surficial groundwater flowpath was not included in the GoldSim model. During operations and closure, surficial groundwater monitoring would be conducted at a minimum of three locations adjacent to the north side of the Category 1 Stockpile, and if NorthMet Project Proposed Action effects on surficial groundwater were greater than predicted, mitigation measures would be implemented.

Embarrass River Watershed

GoldSim has been programmed to incorporate surface water flow, contaminant release from tailings, groundwater transport of bypass from the containment system to the Embarrass River system, water transfers between mine facilities, and discharge of WWTP-treated effluent to the Embarrass River tributaries for flow augmentation. An overview flowchart of the GoldSim model is provided as Figure 5.2.2-12. The sources identified above are the only NorthMet Project Proposed Action containment sources considered. The Hydrometallurgical Residue Facility, due to its engineering, is not expected to be a contaminant source. This section describes the geochemistry of the NorthMet Project Proposed Action tailings and the factors affecting contaminant release and transport from the Tailings Basin.



Containment System
Pond
Tailings Basin
Surface Water Flow
Seepage or Groundwater Flow
Piped Flow
Groundwater Flow

Figure 5.2.2-12
Plant Site GoldSim Overview Flow Chart
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NorthMet Tailings Geochemistry

Figure 5.2.2-13 is a base map of the Plant Site showing the tailings facilities that have the potential to be contaminant sources to groundwater and surface water, including Cell 2W, Cell 1E/2E, and a Tailings Basin pond of varying surface area that would continue to exist on top of Cell 1E/2E. The current tailings in Cell 2W and Cell 1E/2E are referred to as LTVSMC tailings and new tailings that would be generated by the NorthMet Project Proposed Action are referred to as NorthMet tailings.

The NorthMet Project Proposed Action tailings are predicted to have less than 0.12 percent sulfur, which kinetic tests demonstrate is low enough that it would not produce acidic leachate (PolyMet 2015q). The bulk sulfide flotation process used in handling the ore would maintain the sulfide S below 0.12 percent in the tailings discharged to the Tailings Basin.

The assumptions regarding the environmental behavior of the tailings are based on 33 humidity cells (coarse tailings and fine tailings) generated in the pilot-plant processing tests conducted to refine the metal recovery process. The tailings samples were analyzed to determine concentrations of total metals, acid-generating sulfur, and acid-neutralizing carbonate carbon, and were then subjected to humidity cell testing (PolyMet 2015q Attachment F, Table 1). The oxidation rates in tailings are based on multi-year humidity cell tests where solute release rates were used to extrapolate back to estimate the initial oxidation rate in the sample before any of the sulfide sulfur was depleted. In the final waste characterization report used to support this FEIS, the total duration of the humidity cell tests ranged from 84 to 304 weeks (PolyMet 2015q).

Tailings samples subjected to humidity cell tests included a range of sulfide S concentrations (0.06 to 0.24 percent S) and size fractions selected to represent the ranges expected under various depositional environments in the Tailings Basin (PolyMet 2015q, Attachment C, Table 4):

- Coarse (greater than 0.150 mm [“+100 mesh”]);
- Median (less than 0.150 mm and greater than 0.076 mm [“-100+200 mesh”]); and
- Fine (less than 0.076 mm [“-200 mesh”]).

The NorthMet Tailings Basin dam would be constructed with coarse tailings from the LTVSMC facility, which has a size distribution that is approximately 87 percent greater than 0.076 mm (PolyMet 2014x, Table 5-1 Summary of Index Properties of LTVSMC coarse tailings).

Results of the humidity cell tests on pilot-plant tailings had similar results to Category 1 waste rock, with sulfate release rates increasing roughly in proportion to total sulfur, and declining sulfate production over time as the sulfide minerals are consumed (PolyMet 2015q Attachment F, Figure 5). The GoldSim model estimates the moisture content in the tailings and dams materials through time, and uses this to estimate the quantity of tailings oxidizing, the oxidation rate of sulfide minerals, and the associated release of solutes.

The predicted concentration of contaminants in tailings seepage is limited by “concentration caps.” Concentration caps are empirical upper-concentration values based primarily on measured effluent from field-scale waste rock facilities that are chemically similar to the NorthMet Deposit. For solutes modeled at their concentration caps, the load leaving the tailings would be proportional to water flow; but the GoldSim model tracks the mass of contaminants stored in the tailings, so reductions in predicted seepage loading due to concentration cap limits are balanced by a longer total duration of contaminant release.

The pH of effluent from oxidizing tailings ranges between 6 and approximately 8.3, though the pH in effluent from tailings with sulfur similar to that of the Tailings Basin (sulfur approximately 0.12 percent) is generally above 7 (PolyMet 2015q). Humidity cell test results indicate that under oxygenated conditions at room temperature, tailings material oxidation releases about 5 mg SO_4 per kg tailings per week (see Tables 1-13 and 1-14 in PolyMet 2015j), and the range in most tests is between approximately 2 and 8 mg SO_4 per kg tailings per week (PolyMet 2015q, Attachment F). In those samples where the oxidation rate was high enough to reduce pH, most showed an associated increase in the concentrations of some metal cations, such as nickel. By the end of the longest humidity cell tests (304 weeks), approximately 20 to 40 percent of the original sulfide S in the tailings had been oxidized, and the reacted sulfur leached out as soluble sulfate.

These multi-year humidity cell tests on NorthMet tailings yield two important results. First, the rate at which sulfide minerals oxidize is approximately proportional to the concentration of sulfide remaining in the sample, so that the oxidation rate (and thus the acid-production rate) decreases over time as the sulfide S is consumed (PolyMet 2015q, Attachment C [2015 Update on Kinetic Test Data], Attachment A [Graphs]). Second, at some time between approximately 100 and 200 weeks after starting the kinetic tests, the pH of the effluents reaches a minimum, and thereafter the pH becomes steady or increases slightly (becomes less acidic) (PolyMet 2015q, Attachment F Update on Tailings Humidity Cell Test Data). These long-term weathering tests demonstrate empirically that the NorthMet tailings would oxidize without ever producing acidic leachate. The GoldSim model used to estimate solute release from tailings does not include a prediction of specific pH over time in the tailings effluent. However, the concentration caps of some metals were simulated as being dependent on pH. Thus, the GoldSim model for the tailings incorporates an estimated range for pH, but not a temporal trend. Based on the measured pH in multi-year weathering tests on tailings (and also results from tests on Category 1 waste rock, which also contains less than or equal to 0.12 percent sulfide S), and incorporating a small correction for the possibility that CO_2 pressure may be higher in the tailings than in the atmosphere, the PolyMet tailings effluent over the long-term (i.e., 50 to 100 years, and beyond) should range between pH values of approximately 7.1 and 7.7, and the general trend should be for pH values to increase from the low end to the high end of this pH range with increasing time (PolyMet 2015q, Figure 8-18 Modeled Category 1 Waste Rock pH).

Finally, acid base accounting and humidity cell tests were also conducted on the existing LTVSMC tailings, which would underlie the NorthMet Project Proposed Action tailings. These were produced from a separate deposit and contain enough carbonate minerals to be net-neutralizing, so they have a low risk of producing acidic leachate. Concentrations of specific carbonate minerals in the LTVSMC tailings, based on X-ray diffraction analyses on 16 samples, included from 0.1 to 1 percent calcite ($CaCO_3$), from 2 to 7 percent ankerite ($Ca(Fe^{2+},Mg,Mn)(CO_3)_2$), between 2 and 8 percent siderite ($FeCO_3$; Table 5-1 in SRK 2007c).

Leachate from humidity cell tests produced stable pH (between 7.3 and 8.1) and stable release rates for the primary constituents of concern, which were used as the basis of predicting solute release under field conditions (PolyMet 2015q, Attachment F). The LTVSMC tailings have been in place for years, so the model estimates for effluent release from the LTVSMC tailings are constrained by measured solute concentrations in the receiving waters (e.g., wells GW-001 and GW-012 for release to the north, GW-006 for release to the northwest, and GW-007 for release to the west; Figure 4.2.2-16). The initial model extrapolation of laboratory constituent-release rates measured on LTVSMC tailings under oxidizing conditions overestimated the concentrations of sulfate and several other constituents relative to field measurements, even when the release rates were adjusted for scale factors (primarily oxygen concentration in pore gas, and temperature; PolyMet 2015q). This discrepancy was rectified in part by applying an empirical "correction factor," which reduced the modeled sulfate release from the LTVSMC tailings by factors of approximately 2 to 3 (see Figures 10-4 and 10-5 in PolyMet 2015q). Even after reducing sulfate release rates to match observed concentrations downgradient of the Tailings Basin, the water quality model overestimated the concentrations of several solutes, including many metals. In response, the LTVSMC tailings model was further adjusted by applying empirical "calibration factors" to all remaining constituents that were also overestimated relative to observed concentrations. These calibration factors (listed in PolyMet 2015j, Attachment B, Table 1-21) reduced the concentration of 11 constituents by greater than 90 percent relative to the uncorrected model estimates, including reduction by greater than 99 percent the predicted concentration of seven constituents. The fact that measured solute release rates need to be corrected down an order of magnitude for the model to match observed constituent concentrations in down-gradient waters suggests that: 1) laboratory-based sulfate and metal release rates that are performed exclusively under oxidizing conditions and cannot take into account reactions that might occur at greater depths within the tailings column or in the sediments beneath; and/or 2) there are additional chemical processes (e.g., chemical reduction and adsorption) that occurred prior to water reaching the sampling point.

Pathways within the tailings, from the surface and through the unsaturated and saturated tailings areas, were estimated using groundwater flow models, and these pathways were used to route the solutes released by oxidation in the tailings.

Contaminant Release from the Tailings Basin

GoldSim is programmed with algorithms for estimating the release of solutes from tailings. For the NorthMet Project Proposed Action, a groundwater and surface water containment system would be constructed at the beginning of operations along the northern, northwestern, western, and portions of the eastern perimeters of the Tailings Basin to intercept affected water seeping from the facility. The physical and material characteristics of each source area are summarized in Table 5.2.2-17. In GoldSim, the overall Tailings Basin is divided into sub-areas that are described in Table 5.2.2-18. For each sub-area, the contaminant release is associated with a particular material including different types of LTVSMC tailings and NorthMet tailings. The release rate in each sub-area is based on characteristics of the underlying material and the rate of atmospheric oxygen diffusion into the tailings. The proposed bentonite amendments to surface material during operations and closure are intended to reduce oxygen diffusion into the sub-surface and thereby decrease contaminant release rates from the underlying materials. Using the GoldSim model for existing conditions, the contaminant release parameters for LTVSMC tailings were calibrated to measured water quality in current tailings seepage and groundwater. For the future NorthMet tailings, contaminant release parameters are based on a combination of laboratory tests and water quality observations at similar tailings facilities in northern Minnesota. The time-varying chemistry of the tailings pond water is computed during the GoldSim simulation based on evaporation and mixing of rainwater, stormwater runoff, and NorthMet Project Proposed Action-related water transfers to and from the other mining facilities.

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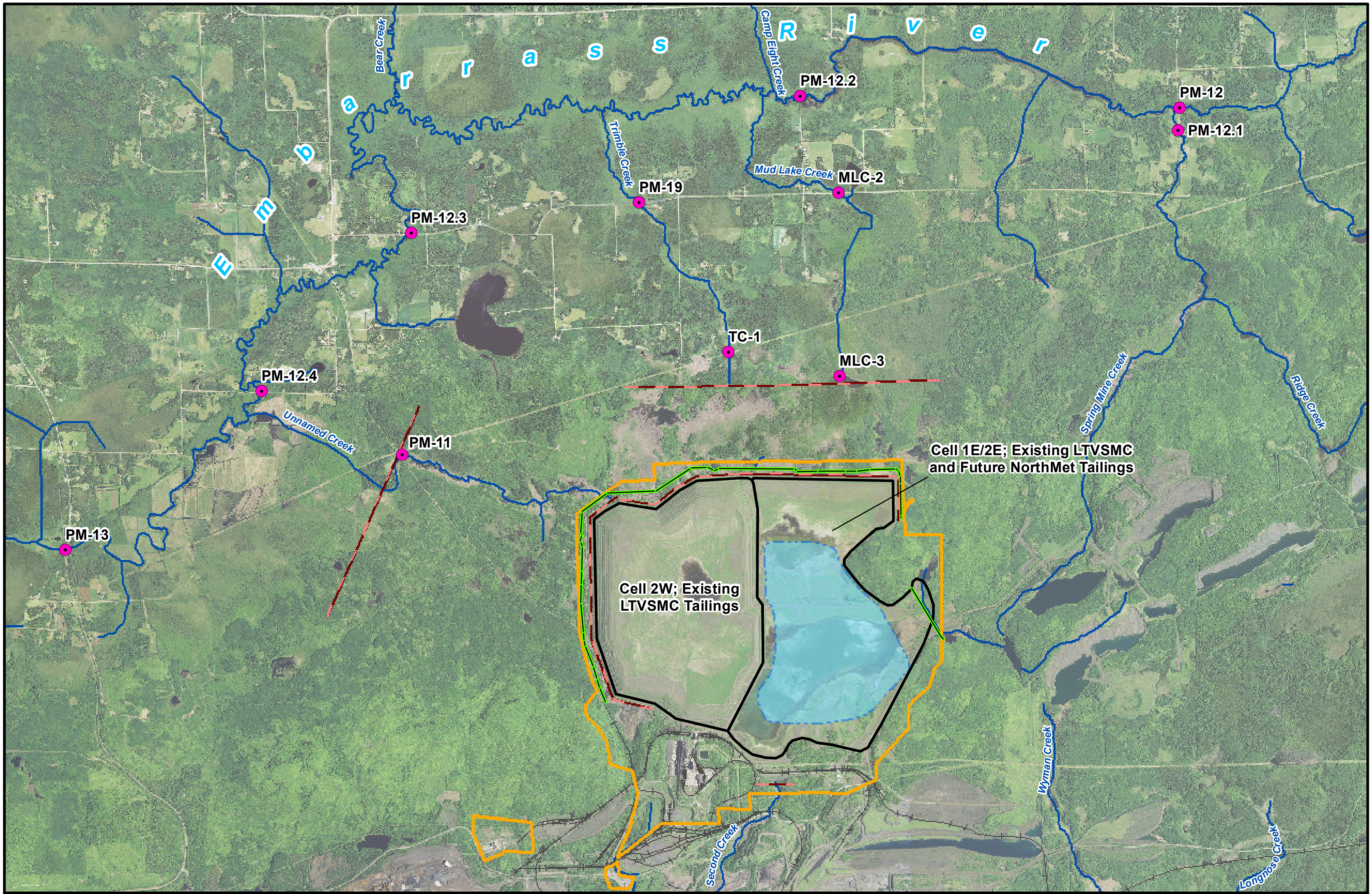

Groundwater Evaluation Locations
Groundwater Elevation Contours (feet)
Surface Water Evaluation Locations
Containment System
Stream/River
Plant Site
Existing Tailings Basin
Approximate Pond Area

MNDNR
US Army Corps of Engineers St. Paul District

N W E S

0 0.25 0.5 1 1.5 Miles

Figure 5.2.2-13
Plant Site Contaminant Source Areas and Evaluation Locations
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Table 5.2.2-17 General Description and Solute-Release Mechanisms of the Existing LTVSMC Tailings Facilities

Facility	Engineered Features	Chemical Mechanisms
2W	It is part of the existing LTVSMC Tailings Basinand would not be used for the NorthMet Project Proposed Action. The soil surface has natural vegetation to reduce infiltration. The containment system would collect groundwater and surface seepage.	Sulfide oxidation and associated release of sulfate and metals.
1E/2E	It is part of the existing LTVSMC Tailings Basin and would receive new NorthMet tailings generated by NorthMet Project Proposed Action. The containment system would collect groundwater and surface seepage. During operations, new dams built on top of cells 1E/2E would be amended with bentonite. During closure, surface soils would be amended with bentonite and vegetated to reduce infiltration and oxygen entry.	Sulfide oxidation and associated release of sulfate and metals.
Pond	During closure, the cell 1E/2E pond bottom would be amended with bentonite to reduce seepage.	Seepage of pond water and its associated water quality and dissolved oxygen.

Source: PolyMet 2015i.

Table 5.2.2-18 Tailings Basin Solute Source Sub-areas used in GoldSim for Closure

Source Area	Tailings Basin Sub-area	Tailings Material Assumed to Control Solute Release	Bentonite-Amended	Area (acre)	Aquifer recharge[1] (in/yr)	Bottom Seepage[6] (gpm)	Basis for Solute Release Calculations
1E/2E	North Dam banks (outer slopes)	LTVSMC bulk (other)	Operations and closure	249.0	6.07	78.1	Calibration[2]
	East Dam banks (outer slopes)	LTVSMC bulk (other)	Operations and closure	40.0	6.07	12.5	Calibration[2]
	South Dam banks (outer slopes)	LTVSMC bulk (other)	Operations and closure	91.0	6.07	28.5	Calibration[2]
	North Beach	35% NorthMet fine, 65% NorthMet coarse	Closure Only	90.2	6.07	28.3	Lab/other sites[3]
	East Beach	35% NorthMet fine, 65% NorthMet coarse	Closure Only	45.6	6.07	14.3	Lab/other sites[3]
	South Beach	35% NorthMet fine, 65% NorthMet coarse	Closure Only	103.1	6.07	32.3	Lab/other sites[3]
	Closure Beach	35% NorthMet fine, 65% NorthMet coarse	Closure Only	188.6	6.07	59.2	Lab/other sites[3]
	1E coarse	LTVSMC coarse	None	3.4	4.32	0.8	Calibration[2]
	1E fine[5]	LTVSMC fine	NA	NA	NA	NA	NA
	2E coarse[5]	LTVSMC coarse	NA	NA	NA	NA	NA

Source Area	Tailings Basin Sub-area	Tailings Material Assumed to Control Solute Release	Bentonite-Amended	Area (acre)	Aquifer recharge[1] (in/yr)	Bottom Seepage[6] (gpm)	Basis for Solute Release Calculations
	2E fine[5]	LTVSMC fine	NA	NA	NA	NA	NA
	2E banks	LTVSMC coarse	None	75.3	6.06	23.5	Calibration[2]
	North Buttress banks	Category 1 waste rock	None	115.0	13.24	78.7	Lab/other sites[3]
Pond	Pond	NA	Closure (after 30 years)	905.3	6.50[7]	304.0	Computed[4]
2W	2W coarse	LTVSMC coarse	None	220.1	17.53	199.1	Calibration[2]
	2W fine	LTVSMC fine	None	748.1	17.63	681.0	Calibration[2]
	2W banks	LTVSMC coarse	None	339.2	9.10	159.3	Calibration[2]
	South Buttress banks	Category 1 waste rock	None	15.0	13.27	10.3	Lab/other sites[3]
Total				**3,229**		**1,710**	

Source: PolyMet 2015i; PolyMet 2015q.

Notes:
1 Net infiltration of meteoric water. Based on a percentage of P50 annual rainfall (27.82 in/yr).
2 Calibrated to water quality of existing affected seepage and groundwater.
3 Laboratory humidity cell tests and water quality at similar mine sites.
4 Pond contaminant concentrations computed during GoldSim simulation.
5 Does not exist in closure.
6 Bottom seepage assumed equal to aquifer recharge multiplied by associated area.
7 Design specification.

Contaminant Transport from the Tailings Basin

At the Plant Site, most groundwater flow occurs in surficial deposits that constitute a surficial aquifer of about 7 meter saturated thickness. Below the surficial deposits is a low-permeability fractured bedrock, mainly the Giants Range batholith. Groundwater flow rates in the bedrock are much lower than in the overlying surficial deposits. As at the Mine Site, it is assumed that most of the contaminants released travel in the same direction and at the same flow rate as surficial groundwater flow (accounting for some dispersion) and ultimately emerging in downgradient surface water. Groundwater flow rates and flow directions in the model were taken directly from the MODFLOW results, or were programmed to be consistent with the MODFLOW results. Unlike the Mine Site, however, PolyMet proposes to install a containment system along the northern, northwestern, and western perimeters of the Tailings Basin, and at the proposed dam along a portion of the eastern side of the Tailings Basin. This containment system would intercept seepage migrating away from the Tailings Basin toe via ground surface, surficial deposits and shallow bedrock. See Figure 5.2.2-14 and Figure 5.2.2-15. The south-side containment system capture efficiency would also be improved as necessary.

Design and performance modeling of the containment system predict that it would achieve complete capture of groundwater moving via the surficial aquifer and upper bedrock (PolyMet 2015i). In the GoldSim model, the containment system is conservatively assumed to be 90 percent efficient in capturing surficial groundwater, which means that 10 percent of the surficial groundwater bypasses the system and continues to migrate toward the Embarrass River. This affected groundwater migrates in the flowpaths to the north, northwest, and west (groundwater migration is not expected to the east or south), and concentrations change progressively as the groundwater approaches downgradient evaluation locations. The affected groundwater ultimately reaches and emerges directly into the Embarrass River (west flowpath) or into its tributaries (northwest and north flowpaths). Performance modeling of the north and northwest flowpaths has indicated that the proposed systems would provide greater than 90 percent capture of surficial aquifier and bedrock groundwater to 100 ft below the top of bedrock. Containment systems are assumed to capture 100 percent of tailings surface seepage, which consists of toe seepage and groundwater that upwells to ground surface between the Tailings Basin and the containment system.

Detailed descriptions of the assumptions and algorithms used to estimate solute release from the Tailings Basin are provided in the Waste Characterization Data Package (PolyMet 2015q).

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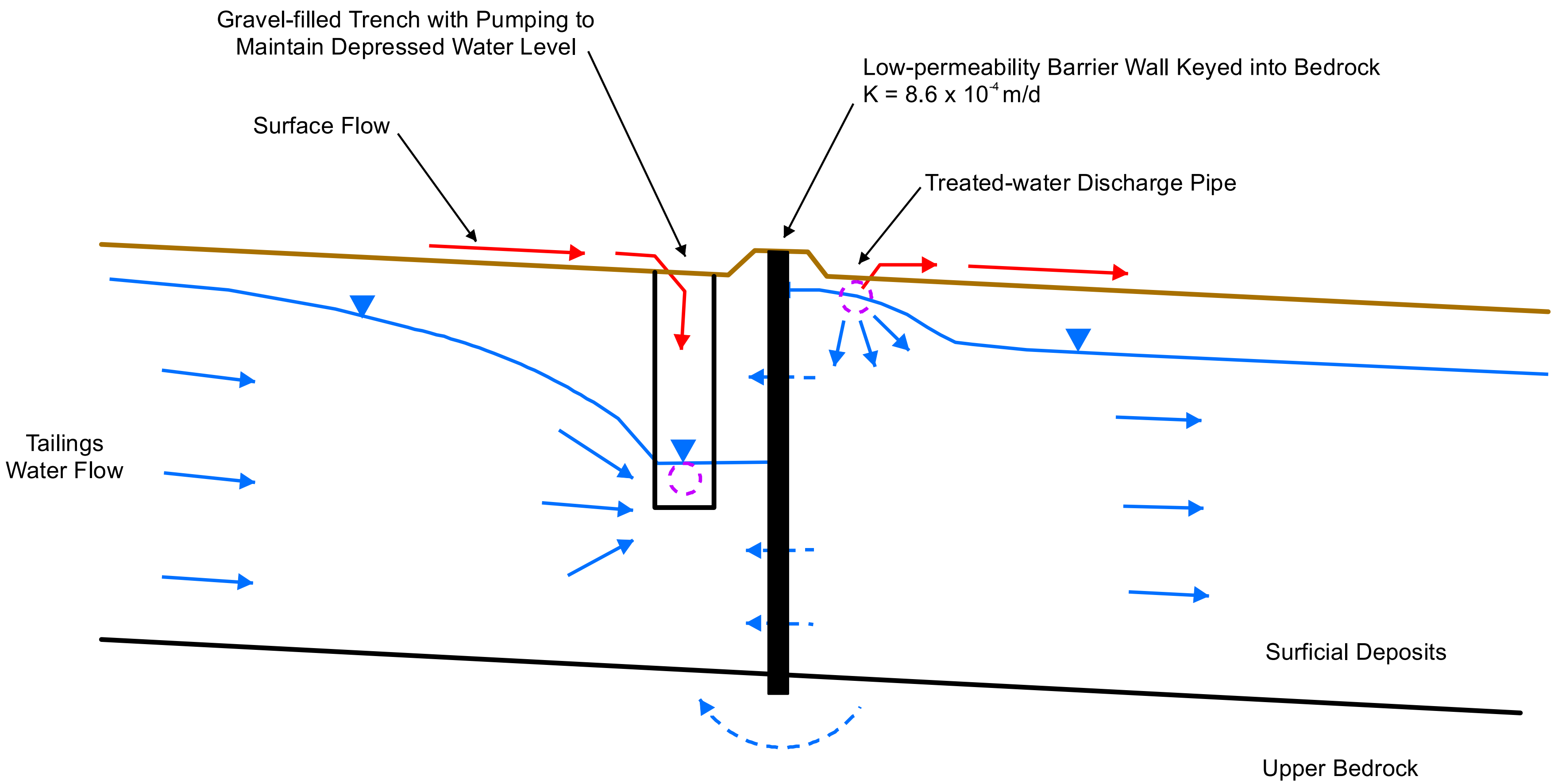

Not to Scale

- Groundwater Flow
- Very low Groundwater Flow
- Surface Water Flow
- Water Return Pipe

Figure 5.2.2-14

North/Northwest and West Tailings Basin Containment System Diagram

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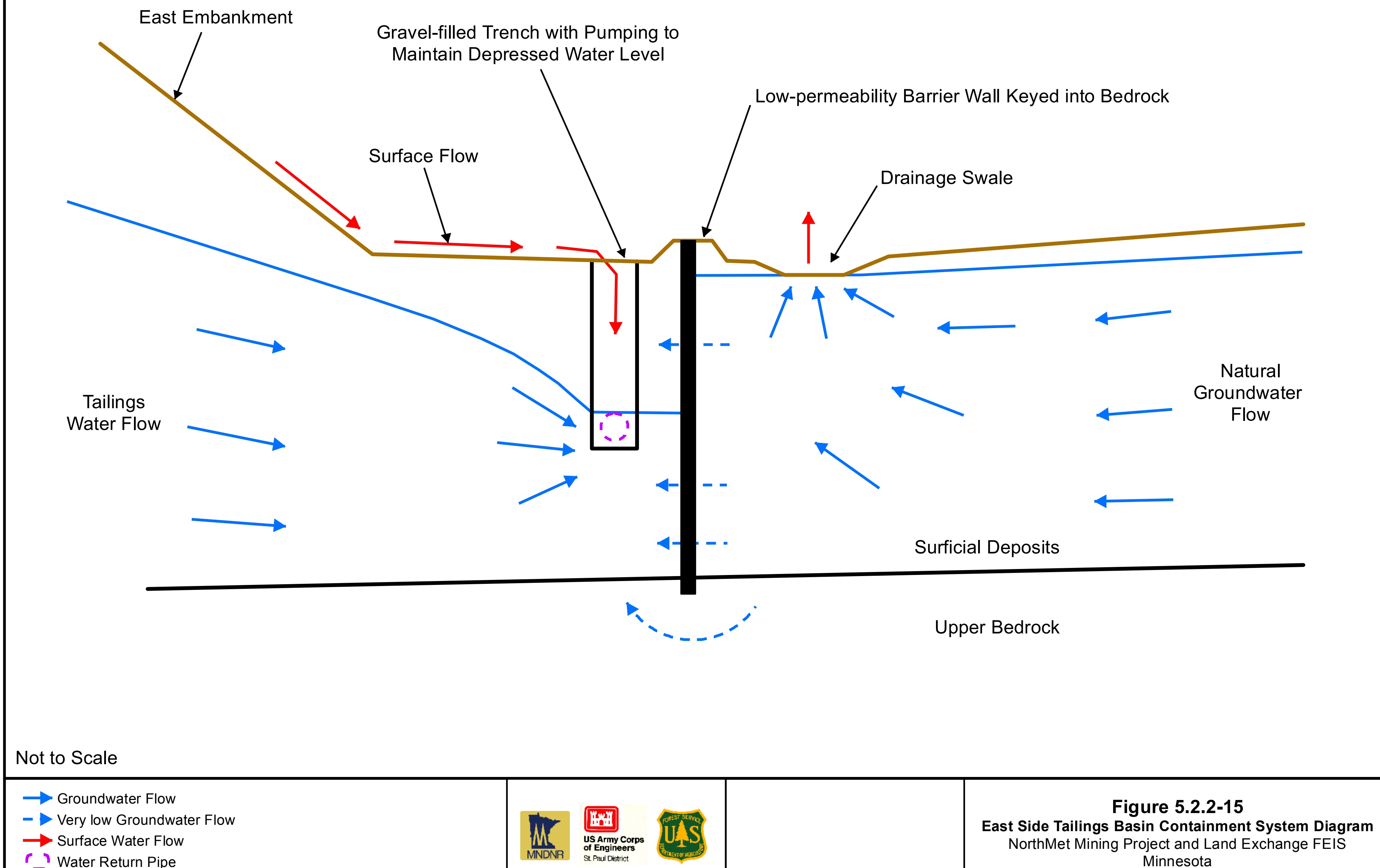

Figure 5.2.2-15
East Side Tailings Basin Containment System Diagram
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GoldSim Model Operations and Output

The GoldSim program has utilities for performing probabilistic simulations addressing the uncertainty of inputs. For this method, selected "uncertain" inputs are entered into the program as cumulative probability functions rather than single fixed values. The probability functions are selected considering the variability of measured data, professional judgment, or both. Figure 5.2.2-16 is an example of the cumulative probability function of a hypothetical input. Point A on the figure indicates that there is a 10 percent probability that the true input value is less than or equal to 14. Point B (median) indicates a 50 percent probability that the true input is less than or equal to 22, and Point C indicates a 90 percent probability that the true input is less than or equal to 30.3. At the beginning of a model run, GoldSim selects a random probability number between zero and 100 percent for each uncertain input and uses the associated cumulative probability distribution to determine the numerical input value. If for example, the program-selected random probability is 38.1 percent, the input value for the hypothetical input on Figure 5.2.2-16 would be 20.3 (Point D). For some inputs, such as annual rainfall, the random sampling is performed at the beginning of each simulation year as the program progresses through time. With the resulting suite of inputs, a single transient model run is performed (referred to as a "realization") and the results are saved. The process of statistical sampling is then repeated using new, randomly selected input values and the next realization is run.

The GoldSim model uses a Monte Carlo simulation approach, where the model is run 500 times, with each of the 500 realizations based on a unique suite of statistically sampled inputs. At the end of the Monte Carlo simulation, the multiple model run results are compiled for each monthly timestep. Consider, for example, a model estimate of contaminant concentration at a particular evaluation location at month 1,200 (year 100). The GoldSim model will provide 500 numerical values for this result, one for each realization. This suite of resulting values is ordered and used to construct a cumulative frequency plot (see Figure 5.2.2-17), which is interpreted in a manner similar to the input plots. The contents of Figure 5.2.2-17, for example, show that there is a 90 percent probability that the concentration at year 100 would be less than or equal to 120.8 (Point C). For results that change over time, a convenient way to present the probabilistic results is to prepare a time-series plot showing the 10, 50, and 90 percent probability results, as shown on Figure 5.2.2-18. Consider point C on the 90 percent probability line on this plot. At a simulation time of 100 years, the value on the curve is 120.8, indicating a 90 percent probability that the true result would be less than or equal to 120.8, which is consistent with Point C on the 100-year frequency plot shown on Figure 5.2.2-17.

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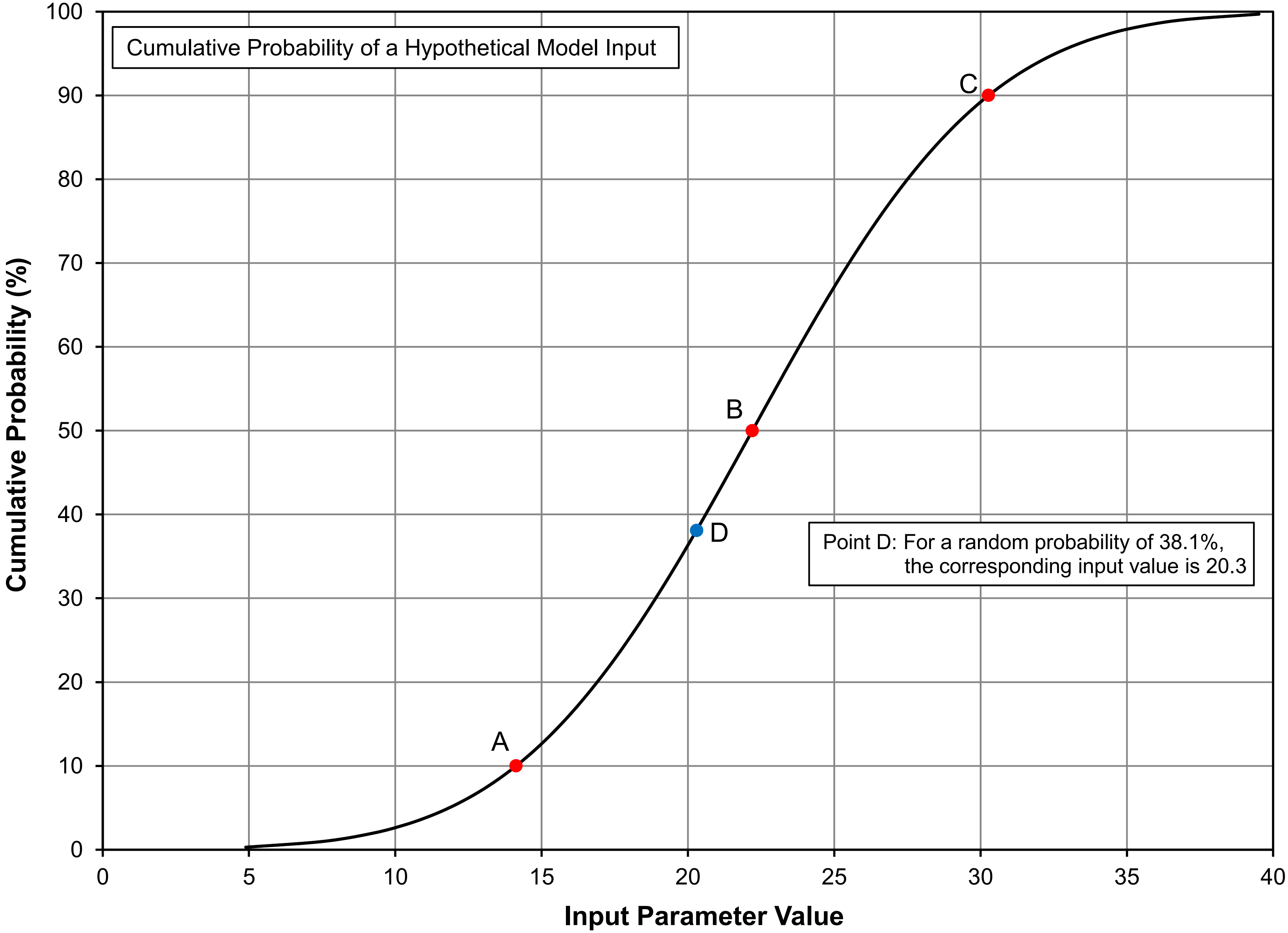

Figure 5.2.2-16
Cumulative Probability of a Hypothetical Model Input
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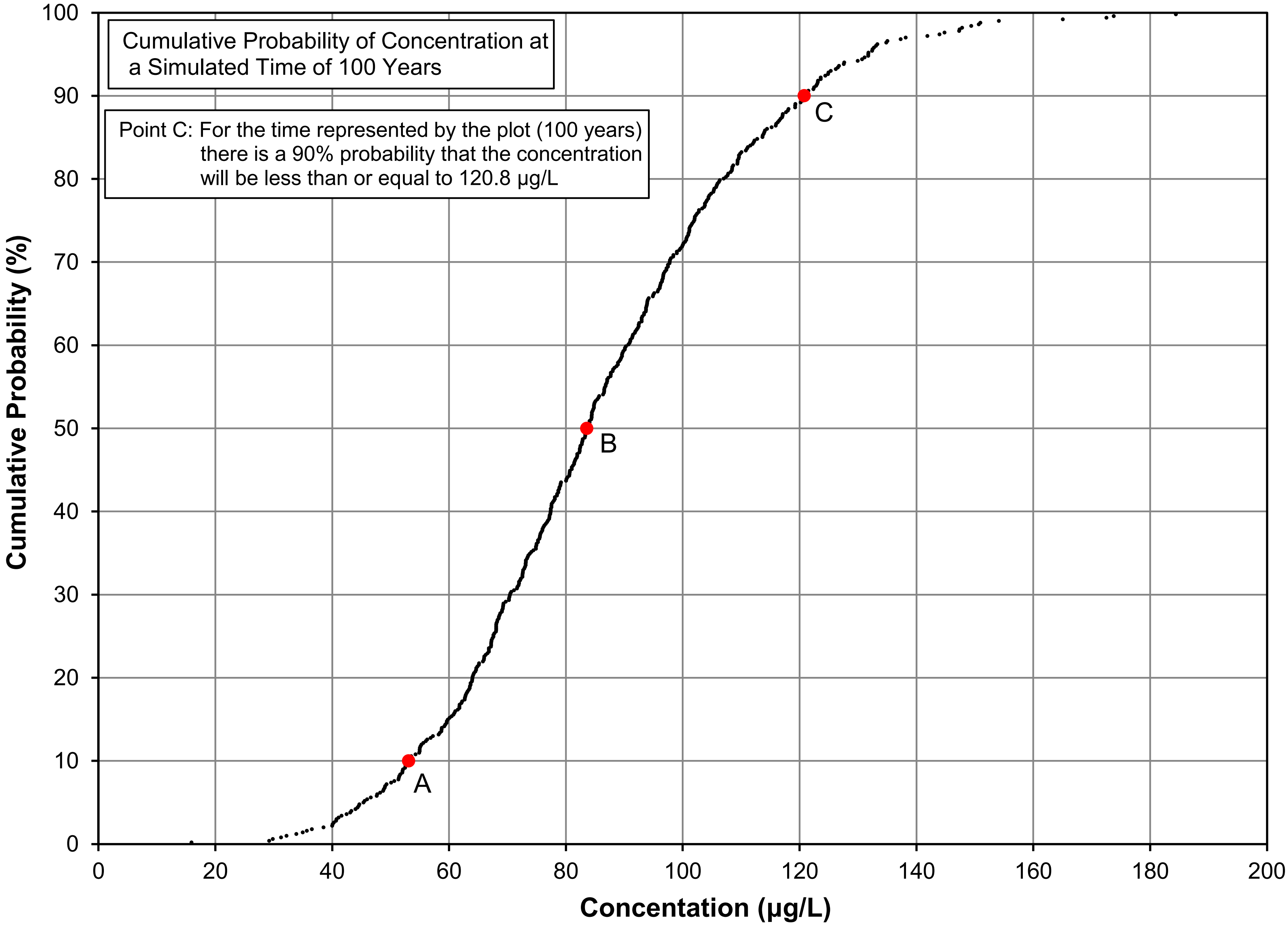

Figure 5.2.2-17
Cumulative Probability of Concentration at a Simulated Time
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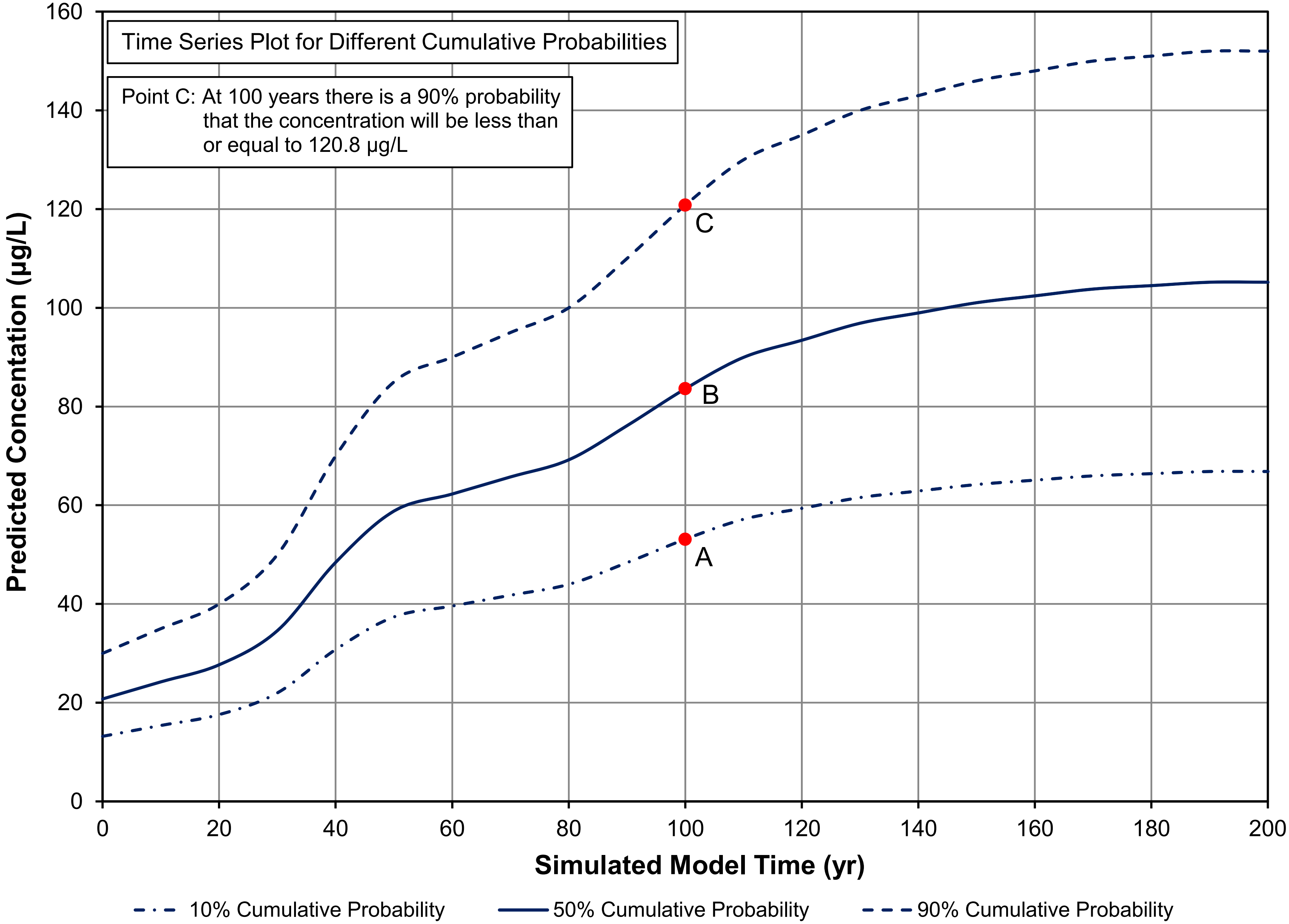

Figure 5.2.2-18
Time Series Plot for Different Cumulative Probabilities
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Application of Evaluation Criteria to Probabilistic Modeling Results

PolyMet used the GoldSim probabilistic model to estimate potential effects from the NorthMet Project Proposed Action on groundwater and surface water quality including whether a water quality evaluation criterion is likely to be exceeded. Surface water and groundwater evaluation locations are points or lines on the landscape where GoldSim generates model results that are compared to applicable water quality evaluation criteria for each constituent. Evaluation locations were identified during the preparation of this FEIS to provide decisions-makers and the public with a discrete point from which impacts can be understood and evaluated. Evaluation criteria are a basic and essential component of this water resources impact assessment and were geographically located for the purpose of environmental review.

Initial Screening

For each constituent at each evaluation location, GoldSim produces 500 predictions (or realizations) of concentrations each month and orders them to generate a cumulative frequency distribution. The 90^{th} percentile value of the distribution is referred to as the P90 concentration. The 50^{th} percentile is the P50 concentration and the 10^{th} percentile is the P10 concentration. The P90 annual maximum for a mine year is the highest P90 value over the 12 monthly timesteps that comprise that year. The maximum P90 concentration for the simulation is the highest P90 value for all of the mine years (200 years at the Mine Site and 500 years at the Plant Site). For non-hardness based evaluation criteria, the modeling results are initially screened for further analysis by comparing the maximum P90 concentration against the criterion value. If the maximum P90 concentration is less than the evaluation criterion, it is concluded that the constituent would not cause an impact of concern at the evaluation location over the entire simulated time period. If the maximum P90 concentration exceeded the evaluation criteria and the NorthMet Project Proposed Action P90 concentration was greater than the CEC scenario concentration, the initial screening process identified it for secondary screening and further analysis. While the P50 concentration is considered the best-estimate, the maximum P90 concentrations provide assurance that this FEIS is not underestimating potential water quality impacts from the NorthMet Project Proposed Action.

To further illustrate how the probabilistic modeling results are used in this FEIS, consider the example of where the predicted maximum P90 concentration of a solute is exactly equal to the evaluation criterion. In this case there is a minimum 90 percent probability that the actual concentration would be below the criterion over the entire model simulation. This threshold, however, does not imply and is not equivalent to saying that water quality evaluation criteria would be exceeded 10 percent of the time. Rather, there is a 10 percent probability that the actual concentration would be above the criterion over the entire model simulation.

As an example of the initial screening process, consider cobalt at Partridge River station SW-004a. Cobalt is a useful screening example because it is expected to be released from Mine Site contaminant sources at predicted concentrations significantly higher than background concentrations already occurring in groundwater and surface water. Figure 5.2.2-19 is a plot of predicted P10, P50, and P90 annual maximum cobalt concentrations at SW-004a. In this FEIS, a constituent is concluded to not warrant additional assessment if its P90 concentrations are less than its associated water quality evaluation criterion. As shown on Figure 5.2.2-19, the P90 plot of annual maximum cobalt concentrations for all years is about 3 μg/L, which is lower than the water quality evaluation criterion of 5 μg/L, so cobalt would be predicted to not have a significant impact at this evaluation location. A closer inspection of the GoldSim output indicates that the maximum P90 cobalt concentration of all mine years (2,400 timesteps) is 3.11 µg/L as shown on the plot. The screening process would conclude that cobalt at SW-004a would not be retained for further evaluation.

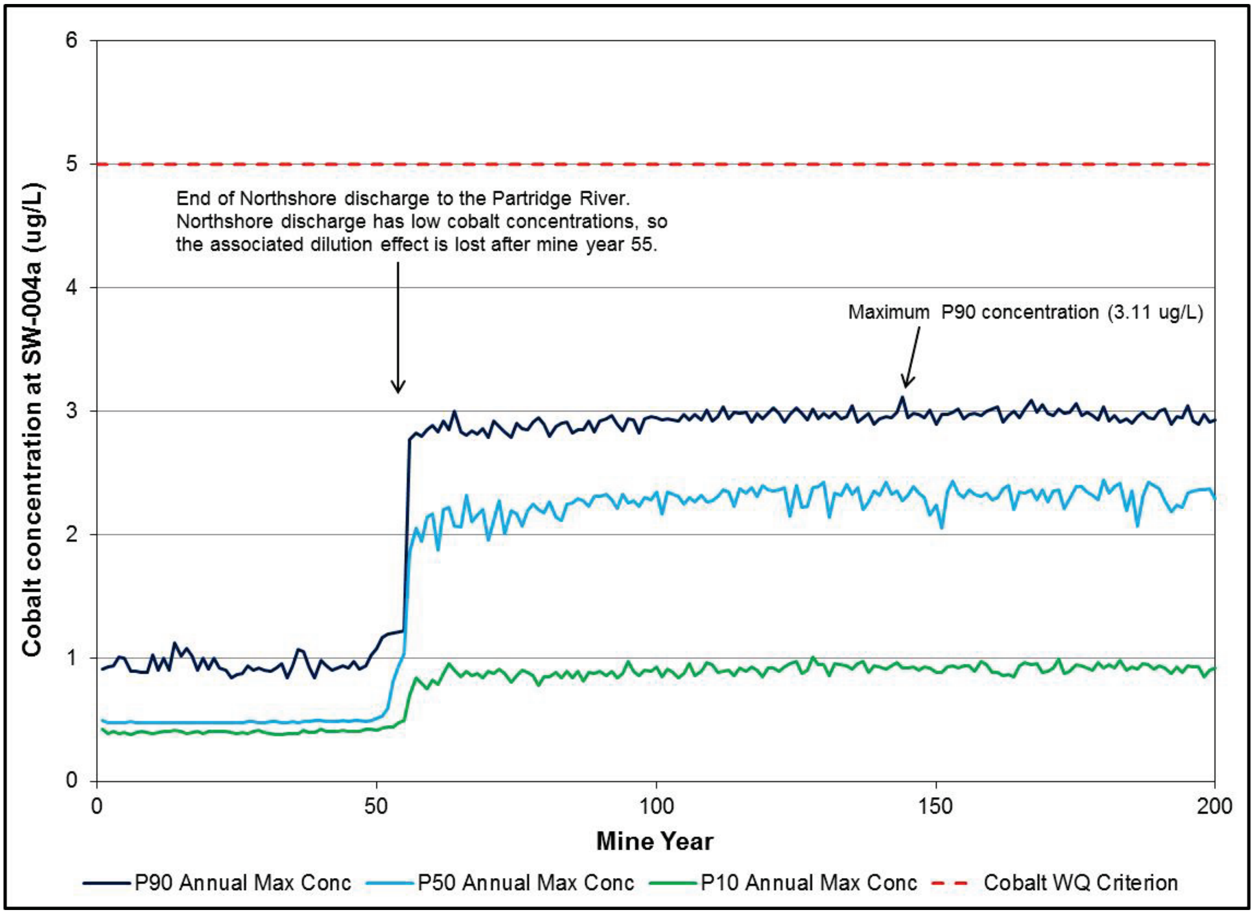

Figure 5.2.2-19 GoldSim-predicted Annual Maximum Cobalt Concentrations at SW-004a

The P90 threshold was adopted in another mining NEPA document where probabilistic modeling was used (Idaho Cobalt Project [USFS 2009b]). Regarding the selection of the maximum P90 threshold for initial screening, the Co-lead Agencies also considered other modeling analyses and screening approaches for evaluating the significance of particular constituents.

For the purposes of screening review, the first year of model data were excluded when calculating maximum P10, P50, and P90 values. Solute concentrations between model cells can take several timesteps to stabilize from the input initial conditions, and the predicted concentrations for these initial timesteps may be unreliable and not representative of the expected conditions. To avoid including these numerical artifacts in the screening analysis, the first twelve timesteps of the model data (mine year 1) were not used to generate the maximum P90 concentrations used for screening.

The use of the P90 criterion for determining whether or not evaluation criteria are being met is not equivalent to how water quality-based effluent limits (WQBELs) would be developed for

NPDES permitting. Appropriate WQBELs would be derived based on water quality standards and implemented in the permit. Discharges would be evaluated during the NPDES permitting stage and WQBELs applied according to 40 CFR 122.44(d).

Secondary Screening

A secondary screening method was developed to evaluate constituents and evaluation locations that were identified for further assessment during the initial screening process described above. It was also used for constituents with hardness-based water quality evaluation criteria that could not be evaluated by the initial screening method because of their variable evaluation criteria. This FEIS defines the following events to indicate a potential NorthMet Project Proposed Action impact:

- Event A: Proposed Action concentration exceeds the Proposed Action evaluation criteria and CEC concentration is below the CEC evaluation criteria. The magnitude of the event is defined as Proposed Action concentration minus the Proposed Action evaluation criteria.
- Event B: Both Proposed Action and CEC concentrations exceed their respective evaluation criteria, and the Proposed Action concentration is greater than CEC concentration. The magnitude of the event is defined as the Proposed Action concentration minus the CEC concentration.

For the secondary screening method, a constituent/evaluation location is retained for further assessment if for either time period (mine years 1 to 55 or 56 to 200/500): 1) there is a 10 percent probability that either event would occur more than 10 percent of the time, ***and*** 2) there is a 10 percent probability that the event magnitude is more than 5 percent of the applicable Proposed Action evaluation criteria. This test was applied to the Mine Site and Plant Site constituents in sections 5.2.2.3.2 and 5.2.2.3.3, respectively.

Continuation of Existing Conditions Scenario

The overall analysis of NorthMet Project Proposed Action effects on water quality takes into consideration the extent to which predicted water quality for the NorthMet Project Proposed Action compares with modeled existing conditions. There are some processes, however, that most water quality models, including the one used for this FEIS, do not fully capture, which limits the ability to simply compare the predicted effects of the NorthMet Project Proposed Action from water quality models with existing water quality for some constituents. These include sulfate reduction between the LTVSMC Tailings Basin and the Embarrass River and site-specific redox reactions (see Section 4.2.2.3.2 for more discussion of sulfate reduction in the Embarrass River Watershed). For this reason, a CEC scenario was modeled within GoldSim.

The CEC scenario model represents conditions in the absence of the NorthMet Project Proposed Action and also in the absence of future activities that may improve water quality under the Consent Decree between the MCPA and Cliffs Erie. The one exception is ending Northshore discharge to the Partridge River in mine year 55, which is included in both the NorthMet Project Proposed Action and CEC scenarios for the assessment of cumulative effects. Modeling both scenarios in the same way allows for a direct comparison of predicted water quality model results and facilitates an assessment of the extent to which implementation of the NorthMet Project Proposed Action would result in changes in existing water quality.

The CEC scenario draws from the same existing condition hydrologic and water quality dataset in GoldSim that was used for modeling the NorthMet Project Proposed Action, but does not introduce any NorthMet mine features or activities. Otherwise, both scenarios were modeled the same way, using 500 Monte Carlo simulations for the same model durations and the results were displayed in the same probabilistic manner. Note, however, that this modeled CEC scenario is not the same as the No Action Alternative, the impacts of which are described in Section 5.2.2.4. The CEC scenario assumes one change in baseline conditions. The only modeled source of constituent loading to the groundwater or surface water that does not represent background sources is the Peter Mitchell Pit discharge to the Partridge River, which is assumed to stop in approximately 2070 because it is expected to occur. Other than this change the CEC scenario model does not include future expected additional mitigation such as water quality mitigation at the existing LTVSMC Tailings Basin, because these measures have not yet been determined Nor does it try to account for climate change. The No Action Alternative, on the other hand, is not static and anticipates for other predictable changes in the NorthMet Project Proposed Action area, such as other planned projects, required mitigation, and climate change.

Comparison of NorthMet Project Proposed Action with the CEC Scenario

The analysis of the model results that follows (see Section 5.2.2.3) compares predicted solute concentrations for both the NorthMet Project Proposed Action and CEC scenario to applicable groundwater and surface water evaluation criteria. These comparisons are made at each of the Mine Site and Plant Site groundwater and surface water evaluation locations (a combined total of eight groundwater and 18 surface water evaluation locations) using the GoldSim P90 probabilistic results.

5.2.2.3 NorthMet Project Proposed Action

This section discusses the potential environmental consequences of the NorthMet Project Proposed Action on groundwater and surface water levels and quality at both the Mine Site and Plant Site (Tailings Basin) and the Transportation and Utility Corridor. Figure 5.2.2-20 and 5.2.2-21 illustrate Mine Site and Plant Site water management timelines.

5.2.2.3.1 NorthMet Project Proposed Action Water Budget Overview

This section briefly describes the water budget under the NorthMet Project Proposed Action at the Mine Site and Plant Site. Under the NorthMet Project Proposed Action, the following water sources would have to be managed:

- Stormwater runoff on mine facilities (e.g., waste rock stockpiles, mine pits, Tailings Basin);
- Seepage from mine facilities into groundwater and surface water;
- Pit lakes and saturated pit backfill, which include groundwater entering the mine pits;
- Process plant makeup water withdrawn from Colby Lake;
- Discharge of excess water from the WWTF and WWTP, including that used for stream augmentation;
- Transport and use of excess Mine Site water for process makeup at the Plant Site; and

- Transport and use of excess Plant Site Water to accelerate re-flooding of the West Pit at the Mine Site.

An overall water process flow diagram, shown on Figures 5.2.2-10 and 5.2.2.12, illustrates the principle NorthMet Project Proposed Action components and their relationship to surface water and groundwater resources.

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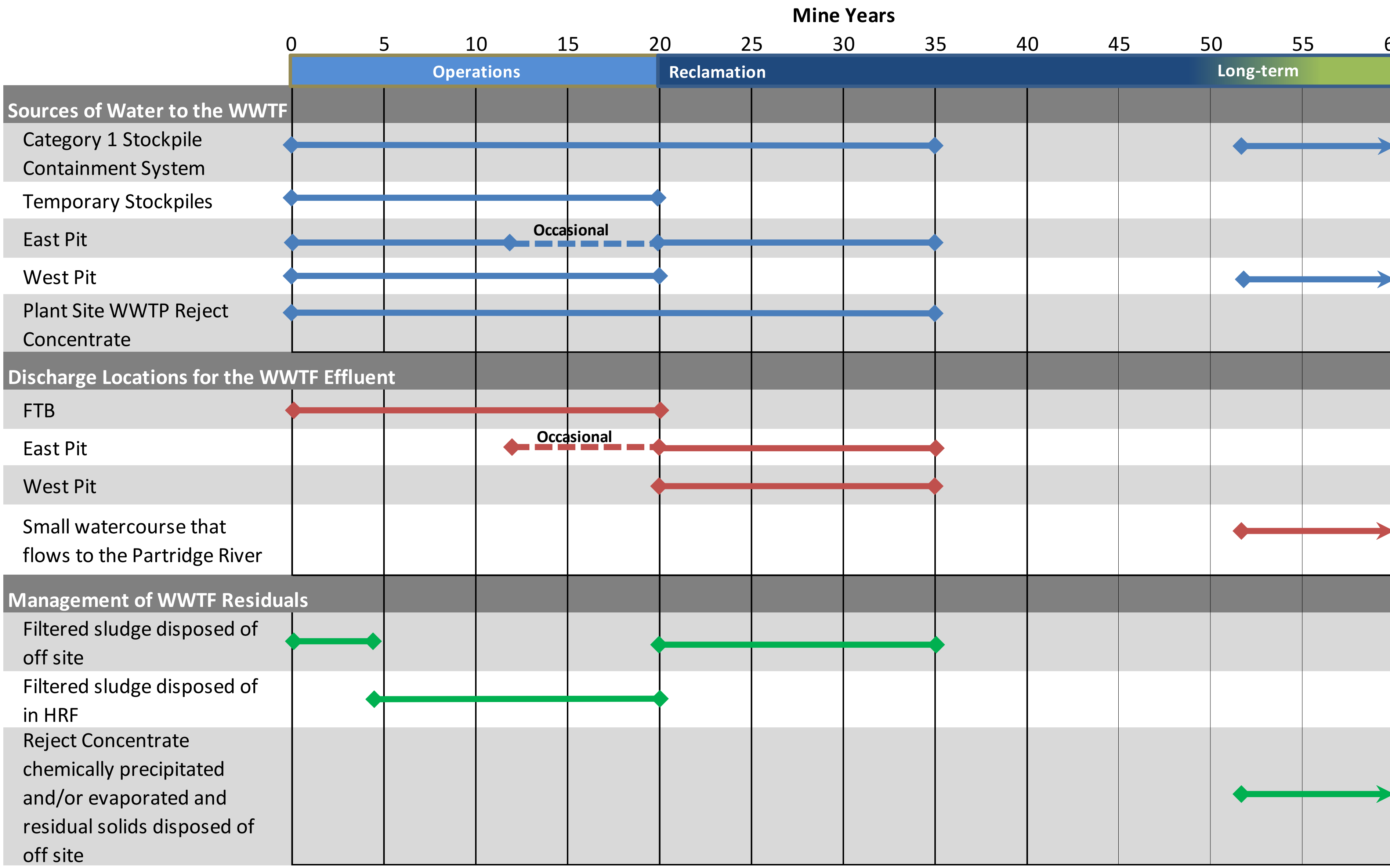

Note: Actual start and end years are variable due to uncertainties and variability in the water and chemical balances. Dates shown are approximate and represent average estimates.

Figure 5.2.2-20
Mine Site Water Management Timeline
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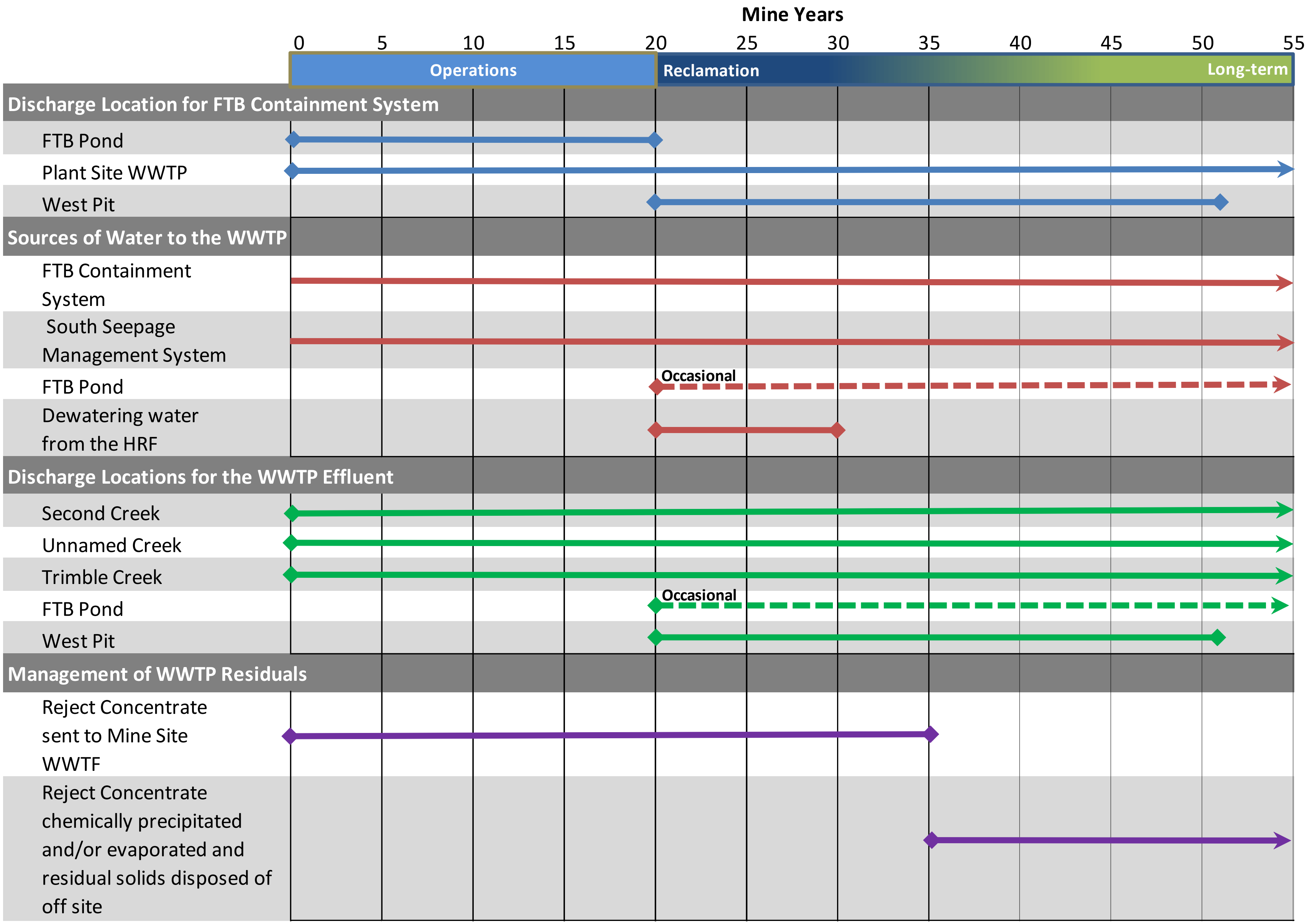

Note: Actual start and end years are variable due to uncertainties and variability in the water and chemical balances. Dates shown are approximate.

MNDNR | US Army Corps of Engineers St. Paul District | US Forest Service

Figure 5.2.2-21
Plant Site Water Management Timeline with Mechanical Treatment
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Operations (Year 0 to 20)

Mine Site

During operations, the West Pit (years 0-20), Central Pit (years 12-16) and East Pit (years 0-11) would be dewatered due to pit inflows from groundwater. A process water pipeline would carry this water to the WWTF West Equalization Basin. Temporary liners, underdrains and ditches associated with the Category 2/3 Stockpile, Category 4 Stockpile, Ore Surge Pile, would capture surface runoff and groundwater seepage and convey this contact water to lined ponds. Process water pipelines would carry this water to the WWTF West Equalization Basin. The Category 1 Stockpile containment system, Rail Transfer Hopper pond liners and Haul Road pond liner would capture contact water which would be directed to the WWTF East Equalization Basin. Groundwater seepage through lined and unlined mine features would begin migrating in the surficial aquifer and bedrock toward the Partridge River during operations.

Initial construction activity involving wetland dewatering (effluent management) would be addressed by construction stormwater management during permitting. Surface runoff from the Overburden Storage and Laydown Area would drain to a process water pond. Pond water quality and operational demands would determine if it is piped to the Central Pumping Station, to the Tailings Basin or to the East Pit during filling.

Interior ditches, exclusion dikes (including perimeter and rim pit dikes) would be used to manage non-contact stormwater and prevent contact with mine wastes. Five sedimentation ponds would be used to reduce total suspended solids and allow for controlled discharge off site. Runoff from the covered Category 1 Stockpile would be managed as stormwater and discharged off site via a sedimentation pond. The geomembrane cover construction would begin at mine year 14 and be complete by mine year 21.

The WWTF would include chemical precipitation which would treat process water from the West and East equalization ponds. Effluent would flow to the clay-lined Central Pumping Station Pond where it would be blended with Overburden Storage and Laydown Area runoff. The Central Pumping Station would then pump the treated water to the Tailings Basin or to the East Pit during filling (after mine year 11). No water would be discharged off site.

Filtered sludge from the chemical precipitation process would be sent off site for disposal or stored at the Hydrometallurgical Residue Facility. The reject concentrate stream from the Plant Site WWTP would be transported to the WWTF via rail tank cars where it would be added to the West Equalization Basin.

Beginning in year 11, after East Pit mining would be completed, the pit would be backfilled with Category 2/3 and 4 waste rock from the temporary waste rock stockpiles and from ongoing operations. The East Pit backfill would re-saturate with groundwater, in-pit runoff, direct precipitation, and treated process water from the WWTF, to limit the oxidation of the sulfide minerals in the pit walls and backfilled waste rock, and reduce the amount of metals leaching to the pit water. Water would be maintained within 5 ft of the backfill surface (PolyMet 2015d). During periods of high precipitation or during spring snowmelt, partial dewatering of the East Pit (to the WWTF and ultimately to the Tailings Basin) may be required to allow placement of the waste rock.

Once backfilling of the East Pit is complete, the backfill would continue to saturate and the pore water would be sent to the WWTF for treatment and returned to the pit to improve the pore water quality. When the backfill water level rises above the top of bedrock (approximately mine year 20), it would release into the East Pit – Category 2/3 Surficial Flowpath. The affected groundwater in this flowpath would migrate slowly towards the Partridge River.

The pipeline between the WWTF and the East Pit would be left in place during and after backfill re-saturation to manage the water elevation in the East Pit.

Plant Site

During operations, the primary source of process water at the Plant Site would be the Tailings Basin ponds, which would contain return water from the beneficiation plant, treated water from the Mine Site WWTF and Plant Site WWTP, and water collected from the Tailings Basin containment system. Colby Lake water would also be withdrawn. Direct precipitation and stormwater runoff from the process areas at the Plant Site would also be directed to the Tailings Basin pond.

Tailings Basin pond water would be sent to the WWTP for treatment and discharged to surface water as necessary. The purpose of the WWTP would be to treat water for discharge to the environment when the NorthMet Project Proposed Action has excess water that could not be stored in the Tailings Basin pond. The WWTP would include an RO unit or equivalent technology that would meet water quality targets.

Containment systems would be installed across the western, northwestern, northern, and eastern sides of the Tailings Basin to collect water leaving the Tailings Basin as surface and surficial groundwater flow. During operations, this water would be returned to the Tailings Basin pond for re-use. A small portion of groundwater would bypass the containment system and enter into groundwater flowpath. Groundwater would then emerge in surface waters north, northwest and west of the Tailings Basin.

On the southern side of the Tailings Basin, an existing seepage containment system would be upgraded by PolyMet to achieve 100 percent capture of tailings surface and groundwater seepage that otherwise would flow into Second Creek, a tributary of the Partridge River. Improvements to capture efficiency of the existing dam may include lining the upstream dam face with bentonite and injecting grout into the dam. A second dam could be constructed approximately 500 ft downstream of the existing dam where the geography is more constricted. This potential second dam may be earthen with a clay or concrete cutoff wall extending to bedrock (Barr 2015e).

The Tailings Basin containment systems would reduce flows to tributaries that extend from the Tailings Basin. Flow would be increased through augmentation. A portion of the water collected by the containment system and water from the Tailings Basin pond would be sent to the WWTP, treated, and discharged to Unnamed Creek, Trimble Creek, and Second Creek in order to maintain downstream hydrology and wetland function. Mud Lake Creek would be augmented via a drainage swale on the eastern side of the Tailings Basin. Augmentation would restore flow to ± 20 percent of existing or uncaptured flows to maintain existing hydrology, geomorphology, aquatic communities, connectivity, water quality, and biology (Chisholm 2006).

Tailings Basin pond elevation would be controlled by pumping any excess pond water to the WWTP. An emergency overflow channel would be constructed as a backup means of controlling pond elevation, but discharge from the emergency overflow would not be expected. The emergency overflow is provided for protection of the dams in the rare event that freeboard within the Tailings Basin is not sufficient to contain all stormwater. Such instances have the potential to occur in the event of a probable maximum precipitation rainfall event. Probable maximum precipitation rainfall events are rare.

Colby Lake water would be pumped to the Hydrometallurgical Plant. Wet hydrometallurgical residue would be pumped to the Hydrometallurgical Reside Facility. Leakage from the Hydrometallurgical Residue Facility would be collected by the leakage collection component of the double-liner system and returned to the Hydrometallurgical Residue Facility flotation pond and from there it would be returned to the Hydrometallurgical Plant.

Reject concentrate from the WWTP RO or equivalently performing system would be sent to the Mine Site WWTF for treatment by chemical precipitation.

Reclamation (Starting Year 21)

Mine Site

The backfilled East Pit would continue to saturate and excess pore water would be sent to the WWTF for treatment and returned to the pit to improve the pore water quality. A wetland would be established at the surface of the pit and water levels would be maintained by a gravity overflow structure to the West Pit.

West Pit reclamation would commence when mining activity ceases. Primary dewatering systems would no longer be operated, and the West Pit would begin to flood naturally with groundwater, precipitation, and surface runoff from the tributary watershed. Flooding would be accelerated by delivery of treated water from both the Mine Site WWTF and the Plant Site WWTP. Seepage through the Category 1 Stockpile containment system would also contribute water to the West Pit via groundwater pathways. With the addition of water pumped from the Plant Site, West Pit flooding is projected to be completed before the end of mine year 55. When the West Pit water level rises above the top of bedrock, there would be a release of pit lake water into the West Pit Surficial Flowpath. The affected groundwater in this flowpath would migrate slowly south towards the Partridge River.

Temporary stockpiles and unnecessary haul roads would be removed along with their associated process water ponds. The WWTF would also receive low flow rates from the Category 1 Stockpile surface and groundwater seepage containment system.

Reject concentrate from the Plant Site WWTP RO or equivalently performing system would be treated at the Mine Site WWTF and the resulting filtered sludge would be taken off site for disposal.

Plant Site

Plant Site reclamation would include building and structure demolition and equipment removal, Tailings Basin reclamation, and Hydrometallurgical Residue Facility reclamation.

During Tailings Basin reclamation, the pond bottom and beaches would be covered with a bentonite layer to reduce the downward percolation from the pond, which would reduce the amount of water collected by the Tailings Basin containment system. Most of the side slopes and top (non-ponded) surfaces of the Tailings Basin would be amended with bentonite to reduce meteoric infiltration and oxygen diffusion into the tailings, with the intent of reducing sulfide oxidation and associated release of soluble sulfate and metals. Tailings Basin cell 2W would be re-vegetated to reduce meteoric infiltration (PolyMet 2015d).

Water management would include maintenance of the pond and wetland within the reclaimed Tailings Basin, stormwater management, and continued operation of the WWTP and the containment systems. A wetland would be constructed on the pond perimeter.

After bentonite amendment of tailings surfaces, establishment of the wetland, and continued water treatment, the tailings pond water quality would improve over time. The pond and wetland would continue to lose water via seepage, but at a reduced rate as compared to operations. The reject concentrate stream from the WWTP would be sent to a distillation crystallizer to generate a solid residual that would be transported offsite for disposal.

Containment systems would continue to operate, although seepage rates would be progressively reduced. The collected seepage would be pumped to the WWTP. During this period, the WWTP effluent would be used for both West Pit flooding and stream augmentation (PolyMet 2015a).

The WWTP and the containment system would be periodically inspected to ensure continuing integrity. Monitoring of piezometers or other similar devices would continue for the purpose of assessing the continued effectiveness of the containment system and to inform appropriate mitigation and/or permitting of any potential release of seepage that may bypass the containment system. An NPDES permit would be required for any point source water discharge that adds pollutants to waters of the United States.

Reclamation of the Hydrometallurgical Residue Facility would include removal of ponded water from the cell surface, removal of pore water from the residue, construction of the cell cover system, and establishment of vegetation and stormwater runoff controls. Once the Hydrometallurgical Residue Facility is reclaimed, the volume of water draining from the facility would decline and nearly cease if the cover system were effective. The facility would only require periodic pumping of any remaining drainage to the WWTP and inspection of the reclaimed cell to verify integrity of the reclamation systems.

Closure and Post-Closure Maintenance (after Reclamation is Complete)

Mine Site

During this phase, the WWTF would be converted to an RO system with a distillation crystallizer to eliminate the liquid reject stream, or other membrane treatment technology that meets water quality requirements. The moist waste solids from this system would be disposed of offsite. Pilot-testing has indicated that treated effluent from this system would have sulfate concentrations less than 9 mg/L and meet water quality discharge standards for all other regulated solutes (Barr 2013f). Effluent from the WWTF RO or equivalently performing system would be discharged to the West Pit Overflow Creek shown on Figure 5.2.2-22.

Water levels in the East Pit would generally be controlled by passive wetland overflow to the West Pit. Depending on seasonal weather conditions, there could be occasional pumped flows from the wetland to the WWTF or of treated effluent from the WWTF to the wetland to further control the water levels (PolyMet 2015d). In any event, saturated backfill in the East Pit would continue to release groundwater to the East Pit – Category 2/3 Surficial Flowpath.

After the West Pit is refilled, the water level would be controlled by pumping to the WWTF to prevent surface water overflow from the pit lake. However, release of pit lake water to the West Pit Surficial Flowpath would continue. The WWTF would also receive low flow rates from the Category 1 Stockpile groundwater containment that would then be discharged to the West Pit Overflow Creek shown on Figure 5.2.2-22.

Perimeter dikes that would be no longer needed to provide access or separation from the areas outside the Mine Site would be removed. The dike located north of the East Pit would remain in place to minimize mixing of the Partridge River flows with the East Pit water and prevent gully development on the northern side of the pit in the segments not protected by ditches (see Figure 5.2.2-22). In addition, the dike located north of the Category 1 Stockpile would remain in place to allow access to groundwater monitoring locations. The Category 1 Stockpile would be inspected on a regular basis and portions of the geomembrane liner and soil cover would be replaced if necessary.

Surface runoff would be routed away from the mine pits using a combination of existing and new ditches (see Figure 5.2.2-22). Some portions of the pit rim dikes may be left in place, if needed to prevent an uncontrolled flow to or from the pits and potential erosion of the pits walls. A more detailed evaluation of this requirement would be conducted prior to mine closure.

Stormwater pond outlet control structures would remain in place as necessary to manage water resource effects. The outlet control structure on the stormwater pond located immediately north of the East Pit and the Category 1 Stockpile would remain in place to minimize the mixing of the Partridge River flows with the East Pit water and prevent gully development on the northern side of the pit. The outlet control structures on the two stormwater ponds next to Dunka Road would remain in place to direct water under the road and the railroad to a tributary to the Partridge River along natural drainage paths. As a requirement of the NPDES/SDS stormwater permit and/or Reclamation Plan for the facility, discharges from these outlet control structures would be monitored as necessary to ensure that stormwater runoff to the Partridge River would meet water quality discharge limits. For modeling purposes, it is assumed that the water quality of this stormwater runoff is the same as the non-contact water for other portions of the watershed.

The WWTF would continue to operate during closure and long-term maintenance, treating excess water from the West Pit and discharging the effluent to the West Pit Overflow Creek. The typical discharge rate from the WWTF is predicted to be about 300 gpm. The water balance model predicts periodic temporary higher treatment/discharge rates (up to about 600 gpm) to create additional freeboard prior to spring snowmelt. By pumping pit lake water to the WWTF, the pit water level would be managed to always provide sufficient freeboard to absorb extreme precipitation events without overflowing.

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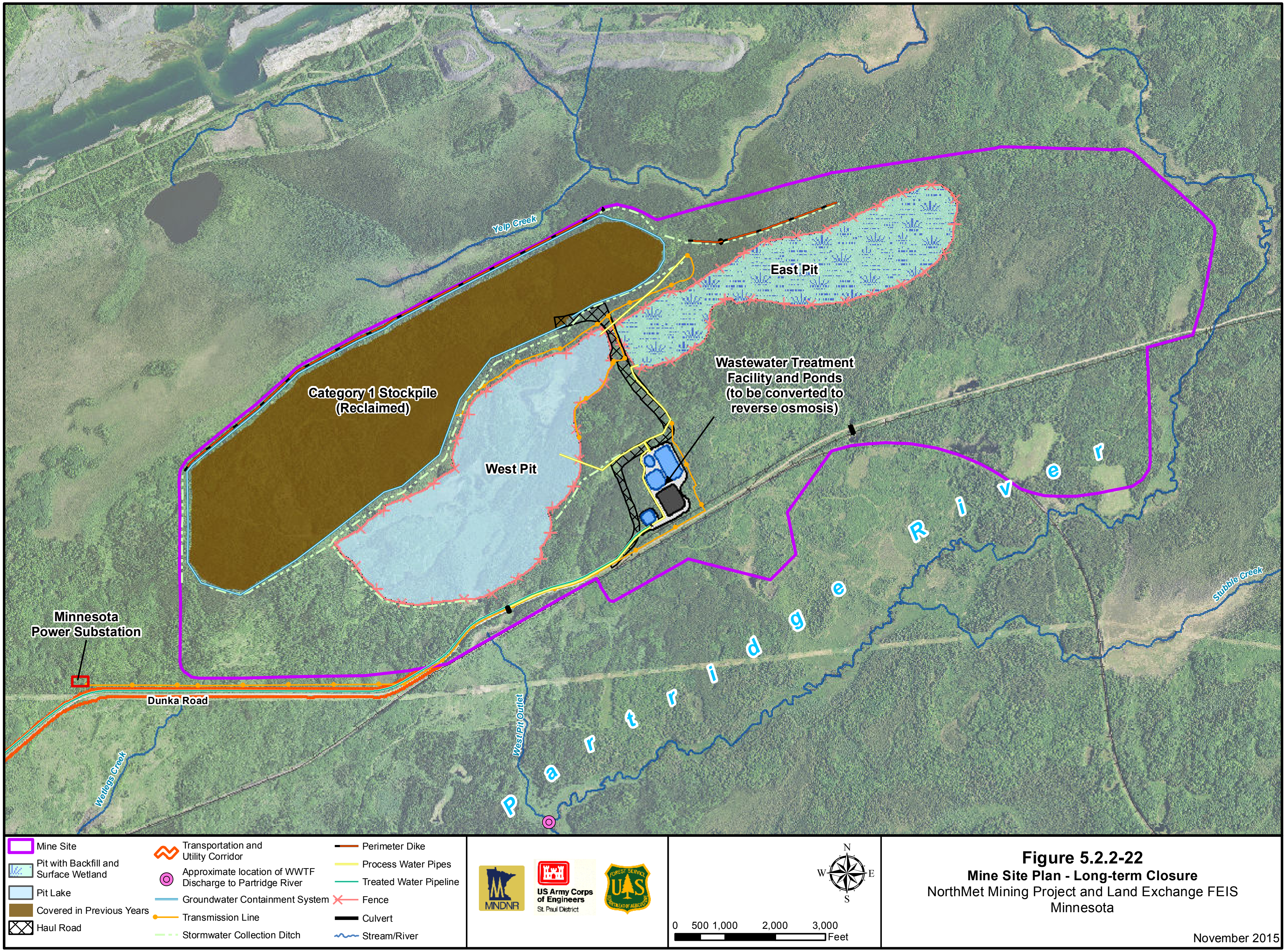

Figure 5.2.2-22

Mine Site Plan - Long-term Closure

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Plant Site

At the beginning of closure, the WWTP RO or equivalently performing system would be modified for multistage operation and use of the distillation crystallization unit to eliminate the liquid reject stream. The moist waste solids from this system would be disposed of off-site. Pilot-testing has indicated that treated effluent from this system would meet water quality discharge standards for all regulated constituents.

During closure and long-term maintenance, the WWTP would continue to treat water collected by the Tailings Basin containment systems. The treated effluent would be used for flow augmentation to Unnamed Creek, Trimble Creek, and Second Creek (PolyMet 2015a). Tailings seepage bypassing the containment system (approximately 20 gpm) would continue to enter the northern, northwestern, and western surficial flowpaths, and migrate slowly toward the Embarrass River.

Closure and Post-Closure Maintenance Objectives

The ultimate water resource closure objective is to transition from the mechanical treatment provided by the WWTF and WWTP to non-mechanical treatment. Transition to the non-mechanical treatment systems would begin after the performance of the non-mechanical treatment methods has been proven. At the Mine Site, non-mechanical treatment systems would be considered for long-term treatment of water from the Category 1 Stockpile surface and groundwater seepage containment system and West Pit overflow. At the Plant Site, non-mechanical treatment would be considered for tailings seepage collected by the Tailings Basin containment systems. Descriptions of possible non-mechanical systems are presented in PolyMet 2015d. See section 5.2.2.3.5 for more information on the transition to non-mechanical systems.

Long-term monitoring of the Hydrometallurgical Residue Facility would continue. Water collected by the leak detection system (if any water) would be sent to the WWTP for treatment. Monitoring would continue and mitigation measures would be undertaken if there was any indication of potential solute releases to groundwater or surface water.

Surface water and groundwater would be monitored as required by relevant permits. The closure and long-term maintenance activities would continue until monitoring indicated that the site water quality had met the stipulated permit conditions for discontinuing these activities.

5.2.2.3.2 Partridge River Watershed

This section discusses the potential environmental consequences of the NorthMet Project Proposed Action on groundwater and surface water hydrology and quality within the Partridge River Watershed, which includes all of the Mine Site, Transportation and Utility Corridor, processing plant and a small portion of the Tailings Basin that contributes flow via a surface seep to the headwaters of Second Creek, which is a tributary to the Partridge River.

<u>Effects on Groundwater Hydrology</u>

This section discusses the effects of the NorthMet Project Proposed Action on groundwater hydrology, specifically groundwater levels at the Mine Site. The NorthMet Project Proposed Action would not result in any measurable effects on groundwater levels along the

Transportation and Utility Corridor (other than as a result of the West Pit dewatering, which is discussed as part of the Mine Site) or at the processing plant.

The NorthMet Project Proposed Action would affect groundwater levels at the Mine Site during operations by dewatering the active mine pits and pumping water to the Plant Site (years 0 to 11) or to the East Pit and Tailings Basin (years 11 to 20). During years 20 to 52, water from the Plant Site would be pumped to the West Pit to accelerate flooding and help return groundwater levels to near pre-mining conditions.

Inflow to Mine Pits

The expected rate of groundwater inflow to the East Pit and West Pit during operations was estimated from MODFLOW modeling, similar to that performed for the DEIS. The model was updated in several ways, including the following:

- MODFLOW model was recalibrated using target groundwater baseflows of 0.41 cfs at SW-002, 0.51 cfs at SW-003, and 0.92 cfs at SW-004 to reflect revisions from the XP-SWMM model;
- Groundwater elevations at monitoring wells MW-1 through MW-18 were included as targets in the updated calibration;
- A new calibration constraint was for surficial aquifer heads not to be significantly higher than ground surface; and
- The model was calibrated using higher values of hydraulic conductivity for Virginia Formation.

These updated estimates of groundwater inflow rates to the pits were used to develop the overall water balance for the probabilistic model. Table 5.2.2-19 shows the MODFLOW-predicted inflows to the pit (years 1 to 20) as well as outflows during closure, once the pits have flooded (PolyMet 2015m).

Table 5.2.2-19 Groundwater Inflows at the Mine Pits Based on MODFLOW Results

Year	West Pit Inflow (gpm)		Central Pit Inflow (gpm)	East Pit Inflow (gpm)
1	0		0	220
2	60		0	190
3	40		0	210
4	30		0	250
5	30		0	450
6	50		0	430
7	40		0	420
8	40		0	460
9	30		0	690
10	30		0	710
11	80		30	760
12	50		20	760
13	50		10	700
14	40		10	710
15	40		10	710
16	40		10	570
17	40		10	380
18	40		10	270
19	40		10	170
20	40		10	40
	West Pit[1]		Combined East Central Pit[2]	
Closure and Long-term Maintenance	Inflow (gpm)	Outflow (gpm)	Inflow (gpm)	Outflow (gpm)
	30–40	10–20	30–40	20–50

Source: PolyMet 2015m.

Notes:
[1] Open pit lake with water-surface elevation ranging from 1,576 to 1,585 ft amsl.
[2] Combine pits backfilled and re-saturated with water-level elevation ranging from 1,592 to 1,595 ft amsl.

Extent of Groundwater Drawdown

Understanding the extent of groundwater drawdown, especially in the surficial material surrounding the NorthMet Project Proposed Action mine pits, is important in order to assess the potential effects on nearby surface water features such as wetlands. However, the complex geology with the presence of bedrock, surficial deposits, and wetland soils at the Mine Site makes it difficult to accurately quantify drawdown at any specific location. Site characterization data and MODFLOW calibration results indicate that the bulk hydraulic conductivity of bedrock is much lower than the bulk hydraulic conductivity of surficial materials. As a consequence, the bedrock tends to be saturated and overlain by a thin surficial aquifer that controls the local groundwater flow system. In a dewatering situation the lower-permeability bedrock tends to remain saturated because it is subject to downward leakage (though it may be minimal) from the overlying higher-permeability surficial aquifer (as long as the surficial aquifer contains groundwater). Unsaturated conditions in bedrock may occur very close to the pit wall, but not at moderate or large distances from the pit. Blasting during the mining operation is controlled to maintain pit wall integrity for safety considerations. Fractures and impacts to hydraulic conductivity due to blasting would not be expected to extend more than a few tens of feet from the pit walls. Water table drawdown in the surficial aquifer near the mine pits would be limited because it would be subject to meteoric aquifer recharge and has a saturated thickness on the order of only 14 ft.

Monitoring well response to pit dewatering at the Canisteo Pit, located approximately 65 miles west of the NorthMet Project Proposed Action area north of Bovey, Minnesota in similar surficial geology, indicated significant aquifer heterogeneity. The Canisteo Pit is a large lake formed by 10 inactive iron ore mine pits. Modeling of aquifer response at the Canisteo site using MODFLOW resulted in differences between simulated and measured water levels ranging from +28 ft to -4 ft (Jones 2002). The model clearly could not accurately estimate water level changes of a few feet or less as would be desirable for assessing potential effects on nearby surface water features such as wetlands. Therefore, it was concluded that it was not reasonable to attempt to quantify drawdown at the Mine Site using the MODFLOW model.

In lieu of using MODFLOW to estimate pit drawdown at the Mine Site, an analog approach was developed using available well data from the Canisteo Pit, which is the only mine pit within the Mesabi Iron Range that has an associated water balance study with well data that could be used to assess potential drawdown effects. Sixteen Canisteo wells were used for the analog evaluation. An additional shallow well near Kinney, Minnesota, adjacent to U.S. Steel Minntac’s West Pit (an active taconite pit), and one deep bedrock well, also near Kinney, were also used for the evaluation. A comparison of the hydrogeologic conditions at the Canisteo Mine Pit, the Kinney area wells, and the Mine Site concluded that the geologic and hydrogeologic settings of the Mine Site are relatively similar to the Canisteo and Minntac sites (Barr 2011i).

The Canisteo Pit is not as deep as the proposed NorthMet mine pits. However, the surficial deposits at the Canisteo site ranges from 50 to 100 ft thick, while the surficial deposits at the Mine Site average only about 14 ft thick. Also, the underlying bedrock at the Canisteo site is composed exclusively of the Biwabik Iron Formation, which generally has a higher hydraulic conductivity than the Duluth Complex, Virginia Formation, and Giants Range Granite that underlie surficial deposits at the Mine Site. Despite the difference in pit depths, it is interpreted that there is potential for greater drawdown at the Canisteo site compared to the Mine Site. Overall, the Canisteo data are believed to provide a reasonably conservative estimate of the maximum extent of surficial aquifer drawdown that would result from the proposed PolyMet mine pits.

Water level data collected from monitoring wells over several years were used to characterize the aquifer’s response to the changing Canisteo Pit water level, and response to the approaching, dewatered Minntac West Pit (ERM and MDNR 2011).

The following were conclusions of the analog study:

- Three wells within 700 ft of the Canisteo Pit showed a strong response to the rising pit water;
- Six wells within 900 to 2,625 ft of the Canisteo Pit showed a measurable, but weak, response to the rising pit water;
- Seven wells within 660 to 3,500 ft of the Canisteo Pit showed no response to the rising water;
- The deep bedrock well near Kinney showed an apparent, progressive water level drop when the dewatered Minntac West Pit approached within about 1,000 ft of the well; and

- The shallow well near Kinney did not show any measurable water level drop from June 2000 through March 2003 (when data collection stopped for safety reasons), during which time the dewatered Minntac West Pit had advanced to within 900 ft of the well.

Considering the analog site evaluation conclusions, the following guidelines for potentially measurable drawdown can be used at the Mine Site:

- 0 to 1,000 ft from the pit rim: groundwater drawdown from pit dewatering may occur and may be measurable;
- 1,000 to 1,700 ft from the pit rim: groundwater drawdown from pit dewatering may occur, but may be difficult to distinguish from natural variations in background water levels;
- 1,700 to 3,200-plus ft from the pit rim: groundwater drawdown from pit dewatering may occur, but would likely only occur under certain hydrogeologic conditions, and may not be discernible from natural variability; and
- Beyond 3,200 ft from the pit: no drawdown effects would be expected.

These guidelines are intended to help define zones of potential groundwater drawdown that could be used to estimate potential indirect effects on nearby surface water features and wetlands (see Section 5.2.3 for further discussion of this analog approach). They could also be used to design a monitoring program to quantify actual effects, which could trigger appropriate mitigation measures if warranted. Contingency mitigation options are discussed in the Water Management Plan for the Mine Site (PolyMet 2015m). These guidelines have been expanded considerably since the original analog study (see Section 5.2.3).

There are few surface waterbodies within the 0 to 1,000 ft or the 1,000 to 1,700 ft zones, where groundwater drawdown may occur and would potentially be distinguishable from natural variations that could be affected by pit drawdown. The West Pit Outlet Creek is located within these zones and would be affected by the WWTF discharge and other NorthMet Project Proposed Action activities, as well. Yelp Creek and the headwaters of the Partridge River are located to the north of the mine pits, but beyond the 0 to 1,000 ft zone. The proposed Category 1 Stockpile surface and groundwater seepage containment system, with its low-permeability cut-off wall keyed into bedrock, would minimize effects of pit drawdown on these waterbodies.

Note that these guidelines would apply during mine operations and reclamation, but groundwater drawdown associated with the mine pits should decline as the pits flood. The actual steady-state water level in the East Pit would be established by an outlet structure (invert at elevation 1,592 ft amsl) that would route surface overflows into the West Pit. The water level in the West Pit would be controlled by operation of the WWTF. Long-term change in on-site surficial aquifer groundwater levels (i.e., permanent drawdown) would be due to the fixing of head boundaries to lower surface water levels controlled by pumped discharge by the WWTF relative to existing conditions. There would be a permanent drawdown of a maximum of about 20 ft immediately surrounding the West Pit lake, resulting from a closure groundwater elevation of 1,579 ft versus existing groundwater elevation of approximately 1,600 ft, and about 10 ft immediately surrounding the East Pit, resulting from a closure groundwater elevation of 1,592 ft versus existing groundwater elevation of approximately 1,600 ft.

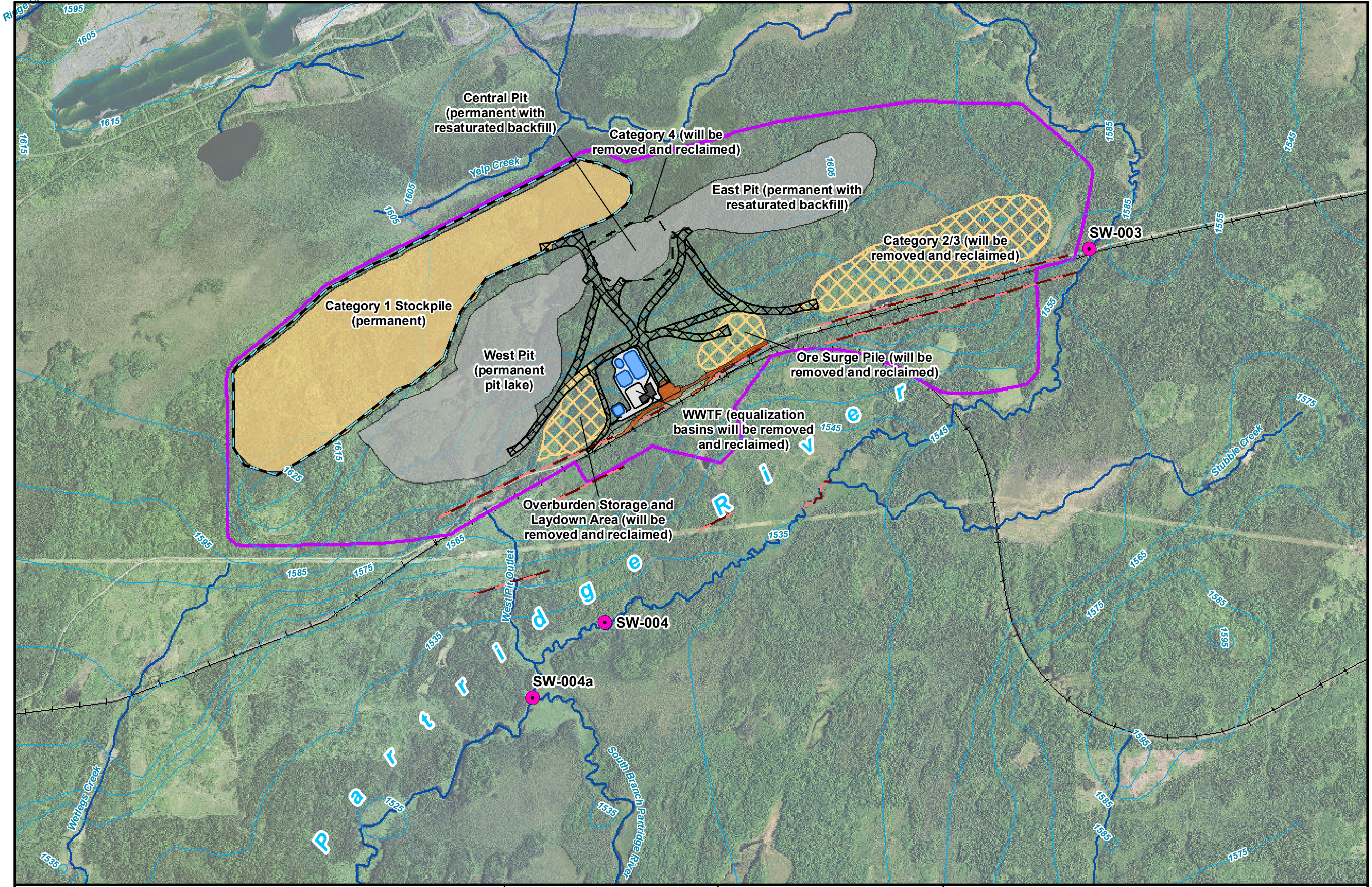
Effects on Groundwater Quality in the Surficial Aquifer

The NorthMet Project Proposed Action could affect groundwater quality at the Mine Site by leaching metals, sulfate, and other solutes from exposed waste rock, overburden, ore, WWTF ponds and unsubmerged part of pit walls. Water affected by those contaminants could enter the groundwater system and migrate from mine facilities to the Partridge River.

Potential Sources of Groundwater Impacts and Proposed Engineered Controls

The potential sources of groundwater impacts from the NorthMet Project Proposed Action within the Partridge River Watershed include the waste rock stockpiles, the Overburden Storage and Laydown Area, the Ore Surge Pile, the WWTF, and the mine pits (see Figure 5.2.2-23). Each of these sources is briefly described below and key features are summarized in Table 5.2.2-20. Note that the Category 4, Category 2/3 Stockpile, the Overburden Storage and Laydown Area, and the Ore Surge Pile, which are potential contaminant sources to groundwater, would only exist during mine operations and would cease to exist after approximately mine year 20. Another potential contaminant source, the WWTF equalization basins, would be removed at about mine year 55.

The Category 1 Stockpile would be surrounded by a groundwater containment system. Most of the water infiltrating through the stockpile would be collected by this system and conveyed to the WWTF. A portion of the infiltrating water, estimated to be less than 10 percent, would bypass the groundwater containment system and flow into the West Pit or East Pit. The quantity of water that would bypass the containment system would be largest when the stockpile is bare and the mine pits are completely dewatered. The fraction of the infiltrating water that would bypass the containment system and flow in the aquifer to the East Pit or into deep bedrock peaks at 4 percent. The aquifer and deep bedrock would each carry a peak annual average flow of 6.9 gpm in mine year 10. Flow into the East pit is negligible (modeled as zero) by mine year 20. The fraction of the infiltrating water that bypasses the containment system and flows to the West Pit is conservatively assumed to be constant through time at the maximum fraction (6 percent, representing a peak annual average flow of 22 gpm) (PolyMet 2015m). The mine pits would remain permanently and potentially serve as long-term sources of contamination. The Category 4 Stockpile would exist until about year 11 and any seepage from this stockpile would migrate as surface water or surficial groundwater to the East Pit where it would be collected as part of the pit dewatering system and pumped to the WWTF for treatment. After year 11, material in the Category 4 Stockpile would be backfilled into the combined East Central Pit.



Groundwater Evaluation Locations
Surficial Aquifer Head Contour (m) at Closure
Groundwater Containment System
Surface Water Modeling/Monitoring Location
Stream/River
Mine Site
Haul Road
Mine Pit
Permanent Stockpile
Removed and Reclaimed Stockpile
Removed Stockpile

MNDNR
US Army Corps of Engineers St. Paul District

0 1,000 2,000 4,000 Feet

Figure 5.2.2-23
Mine Site Potential Contaminant Source Areas
NorthMet Mining Project and Land Exchange FEIS
Minnesota

November 2015

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Table 5.2.2-20 Mine Site Solute Source Areas used in GoldSim

Source Area	Active Source Period (mine years)	Engineered Features	Chemical Mechanisms
Category 1 Stockpile	0+	Geomembrane cover; perimeter surface and groundwater seepage containment system. Permanent mine feature.	Most solutes released from Category 1 Stockpile material at concentration caps. Seepage collected by containment system would be sent to the WWTF or the West Pit. Seepage not collected by containment system would migrate as groundwater to West and East Pits. A very small part of it would enter bedrock.
Category 2/3 Stockpile	0–20	Geomembrane underliner with seepage collection. Solid material would be sent to East Pit as backfill. Would be removed during reclamation.	Oxidation of Category 2/3 Stockpile material. Seepage collected above liner sent to WWTF. Seepage through liner would enter the underlying groundwater system.
Category 4 Stockpile	0–11	Geomembrane underliner with seepage collection. Solid material sent to East Pit as backfill after year 11 and stockpile site reclaimed.	Oxidation of Category 4 Stockpile material. Seepage would migrate as surficial groundwater to the East Pit.
West Pit	Pit lake: 20+ Flow to groundwater flowpaths: 48+[(1)]	Dewatered during mining, followed by flooding. Water level would reach top of bedrock at year 48. Maximum flooding would occur at about year 52, after which water level would be controlled by pumping to the WWTF.	Oxidation of wall rock prior to flooding. Would receive affected water from East Pit. Receives treated (or blended) water from Plant Site WWTP during flooding period (20-52 years). Would receive treated water from Mine Site WWTF. Beginning in year 48, the West Pit water level would rise above the top of bedrock and begin to release pit lake water into the West Pit surficial groundwater flowpath.
East Pit	Flow to groundwater flowpath: 20+[(1)] Flow to West Pit: 21+[(1)]	Would merge with the Central Pit. Dewatered during mining. All Category 2, 3, and 4 waste rock, and some Category 1 waste rock, would be used as backfill. Water level in saturated backfill would reach top of bedrock at year 20. Maximum refill would occur at year 21, after which water level in saturated backfill would be controlled by overflow through a wetland to the West Pit.	Oxidation of wall rock prior to backfill saturation. Solute release from unsaturated and saturated backfill. Beginning in year 20, the water level in the East Pit saturated backfill would rise above the top of bedrock and begin release of pit water into the East Pit Cat 2/3 Surficial (groundwater) Flowpath. The East Pit would reach maximum refill at about year 21.
Overburden Storage and Laydown Area	0–20	Unlined facility, but with collection system for surface runoff. Would be removed during reclamation.	Leaching of overburden materials. Seepage would enter underlying groundwater system.

Source Area	Active Source Period (mine years)	Engineered Features	Chemical Mechanisms
WWTF Basins	0–55	Precipitation/filtration treatment plant using equalization basins with leak detection system and geomembrane underliners. Would be removed during reclamation when water treatment plant converted to RO at year 33.	Receives water from West Pit (including East Pit overflow), Category 1 Stockpile, Category 2/3 Stockpile, Overburden Storage and Laydown Area, and Ore Surge Pile. Would receive reject concentrate from Plant Site WWTP. Seepage collected from leak detection system (if any) would be sent to WWTF. Seepage through underliner would enter the underlying groundwater system.
Ore Surge Pile	0–21	Geomembrane underliner with seepage detection. Would be removed during reclamation.	Oxidation of ore. Seepage collected from leak detection system (if any) would be sent to WWTF. Seepage through underliner would enter the underlying groundwater system.

Source: PolyMet 2015d.

Note:
[1] Based on deterministic GoldSim run with P50 inputs.

All of these potential contaminant sources would be located at the Mine Site. The only potential contaminant sources along the Transportation and Utility Corridor or at the processing plant (both within the Partridge River Watershed) would be from spills, as there would be no surface stockpiles of waste rock, ore, or other potential solute sources in these areas.

No effects on groundwater quality along the Transportation and Utility Corridor are anticipated during construction, operations, or closure as part of the NorthMet Project Proposed Action.

However, in order to guard against possible adverse effects from spilled ore, monitoring and mitigation activities would be developed in permitting. Water quality monitoring is recommended downgradient from the rail line on the Partridge River tributary streams to check for any deteriorations of water quality over time from ore spillage; if detected, adaptive water management measures would be implemented.

Waste Rock Stockpiles

The NorthMet Project Proposed Action would generate about 308 million tons of waste rock over the 20 years of mine operations. This waste rock would be managed according to its geochemical properties. Four categories of waste rock were defined generally based on its sulfur content as summarized in Table 5.2.2-21.

Table 5.2.2-21 Summary of Waste Rock Stockpile Properties

Waste Rock Categorization	Sulfur Content (%S)[1]	Approximate % of Waste Rock Total Mass[4]	Max Footprint (acres)	Stockpile Duration	Waste Rock Height	Bottom Liner System	Cover System
Category 1	%S ≤ 0.12	70%	508/526[(5)]	Permanent	240 ft above ground level; 1,840 ft above sea level Maximum height based on current design: 280 ft above ground level	No liner system; a surface and groundwater seepage containment system would collect water for pumping to the WWTF.	3-ft engineered cover with a 40-mil geomembrane barrier.
Category 2[(3)]	0.12 < %S ≤ 0.31	24%	180[(3)]	Temporary	Maximum height based on current design: 200 ft above ground level; 1,770 ft above sea level Planned height based on current design: 160 ft above ground level	12-inch compacted (1 x 10^{-5} cm/s) subgrade overlaid by 80-mil LLDPE geomembrane, covered by a 24-inch overliner drainage layer	Stockpile would be completely removed and reclaimed.
Category 3[(3)]	0.31 < %S ≤ 0.6	3%	180[(3)]	Temporary	Maximum height based on current design: 200 ft above ground level; 1,770 ft above sea level Planned height based on current design: 160 ft above ground level	12-inch compacted (1 x 10^{-5} cm/s) subgrade overlaid by 80-mil LLDPE geomembrane, covered by a 24-inch overliner drainage layer	Stockpile would be completely removed and reclaimed.
Category 4[(2)]	> 0.6 %S Duluth Complex 0.4 ≤ %S ≤ 5.0 Virginia Formation	3%	57	Temporary	Maximum height based on current design: 180 ft above ground level; 1,790 ft above sea level Planned height based on current design: 80 ft above ground level	12-inch compacted (1 x 10^{-6} cm/s) subgrade overlaid by 80-mil LLDPE geomembrane, covered by a 24-inch overliner drainage layer	Stockpile would be completely removed and ore from under the stockpile would be mined (central pit).

Source: PolyMet 2015a.

Notes:
1 In general, the higher the rock's sulfur content, the higher its potential for generating acid rock drainage or leaching heavy metals.
2 Includes all Virginia formation rock.
3 Category 2/3 waste rock would be stored in one stockpile. Max footprint is total for Category 2/3 waste rock.
4 Approximately 29% of waste rock that ultimately fills the East Pit (mostly Category 2 and 3) would be sent to the pit without prior stockpiling.
5 The Category 1 waste rock stockpile has a maximum footprint of 508 acres while active. It would reach this size by mine year 6. The stockpile would be re-graded as part of reclamation with a final footprint of 526 acres in mine year 2.

As Table 5.2.2-21 above indicates, the Category 1 Stockpile would be permanent. It would not have a liner, but would be surrounded by a surface and groundwater seepage containment system consisting of a cutoff wall (i.e., low-permeability hydraulic barrier) and a sub-surface drain that would collect 90 to 94 percent of the seepage from the stockpile during mine operations and 94 percent after the mine's closure. This stockpile would be progressively reclaimed with an engineered geomembrane cover system constructed from year 14 through 21. A maximum of 8 percent of seepage is estimated to bypass the containment system, during mine operations. However, most of such uncaptured seepage would migrate with groundwater to the West Pit, where it would be collected and pumped to the WWTF for treatment. Only about 2 percent of the overall seepage during the mine operation period would bypass both the containment system and the West Pit and East Pit.

During reclamation and closure, the estimated bottom seepage from the Category 1 Stockpile would be about 3 gpm. About 94 percent of that seepage would be captured by the containment system and none of the seepage would bypass West Pit and East Pit.

The Category 2/3 and 4 stockpiles would be constructed with an underliner system including a compacted subgrade, an underdrain, an impermeable geomembrane liner, an overliner drainage layer, and a leachate collection system. Drainage from these stockpiles would be collected on the liner and routed to a lined sump for pumping to the WWTF for treatment. The GoldSim modeling assumes, however, that some leachate seeps through tears/flaws in the Category 2/3 Stockpile geomembrane liner, reaches the groundwater table, and follows what is referred to as the Category 2/3 Stockpile and East Pit Flowpath, ultimately discharging to the Partridge River. Some leachate from the Category 4 Stockpile is also assumed to seep through the liner system, but given its location adjacent to the East Pit, it is assumed that any uncollected seepage would follow the hydraulic gradient to the East Pit, where it would be collected as part of the pit dewatering system and pumped to the WWTF for treatment. Once mining of the East Pit is completed (approximately year 11), the Category 2/3 and Category 4 waste rock would be backfilled into the East Pit, the liner system would be removed, and the footprints of these stockpiles revegetated per an approved reclamation plan. Once mining ceases in the East Pit, waste rock would be directly deposited in the East Pit.

Overburden and Overburden Storage and Laydown Area

The NorthMet Project Proposed Action would strip overburden as needed for mine development, thereby minimizing the amount of exposed bedrock at any one time. About 32 percent of the overburden would be stripped in the first 2 years of the mine life, with the balance being removed by the end of year 11. Overburden present at the Mine Site is categorized into three types: unsaturated overburden, saturated overburden, and peat (organic soils). Each type of overburden would be managed in accordance with its characteristics.

Saturated overburden is material that has been below the normal water table and not exposed regularly to oxygen, so it is still potentially reactive if exposed to oxygen. Some of this material would be used for construction purposes, but only for applications where it would be placed below the water table or where any water contacting it would be collected and appropriately treated. Saturated overburden not used for construction purposes would be commingled with waste rock and placed in the temporary Category 2/3 or 4 stockpiles with a geomembrane liner.

Unsaturated overburden is above the normal water table, and waste characterization studies indicate that it has been exposed to oxygen for a sufficiently long period of time that it is now non-reactive. This material would be used for construction purposes. To the extent that unsaturated overburden exceeded immediate construction needs, it would be temporarily stored in the unlined Overburden Storage and Laydown Area. Peat would also be used for reclamation purposes, as appropriate, and any excess would be temporarily stored along with the unsaturated overburden in the unlined Overburden Storage and Laydown Area for future use during reclamation.

Surface runoff from the Overburden Storage and Laydown Area is considered "process water," and would be captured in an unlined pond (Pond PW-OSLA) and monitored for quality. If the Overburden Storage and Laydown Area water were of acceptable quality, it would be pumped to the Central Pumping Station and discharged to the East Pit or the Tailings Basin, where the destination would be based on variable project demand over time. If water in Pond PW-OSLA required treatment, it would be pumped to the WWTF for treatment prior to delivery to the Central Pumping Station.

Since the Overburden Storage and Laydown Area would be unlined, the GoldSim model assumes meteoric water would seep into the groundwater below the Overburden Storage and Laydown Area and follow the Overburden Storage and Laydown Area Flowpath ultimately discharging to the Partridge River. During operations, the estimated bottom seepage from the Overburden Storage and Laydown Area would be about 14 gpm. The water quality of this seepage was estimated based on the results of the Meteoric Water Mobility Procedures test for peat and unsaturated overburden (PolyMet 2015q).

Ore Surge Pile

An Ore Surge Pile would be constructed near the Rail Transfer Hopper to allow for temporary storage of ore and a steady flow and uniform grade of ore to the processing plant. Ore would pass into and out of this pile during operations to meet plant needs for efficient processing. The Ore Surge Pile would have a geosynthetic underliner system identical in design to that for the Category 4 Stockpile. Drainage from the Ore Surge Pile would be collected on the liner and routed to a lined sump for pumping to the WWTF for treatment. The Ore Surge Pile, including the liner system, would be removed at the completion of mining activities (at mine year 20) and reclaimed.

The GoldSim modeling assumes that a small volume of leachate would seep through flaws in the geomembrane liner, reach the groundwater table, and migrate along the Ore Surge Pile Flowpath, ultimately discharging to the Partridge River.

East Pit

During mining, the East Pit would be dewatered. In approximately year 10, mining of the East Pit would be completed and backfilling would begin with stockpiled Category 2/3 and 4 waste rock, and fresh waste rock (all categories) from the West Pit. During backfilling, natural groundwater inflow to the pit would saturate the backfill. The pore water in the initially saturated backfill would have relatively high solute concentrations (see Figure 5.2.2-24 for a representative example based on sulfate), but once submerged, oxygen transport would be limited and there would be a systematic decrease in oxidation and associated dissolution of sulfide minerals.

Additional concentration reduction would be accomplished by pumping the East Pit backfill pore water through the WWTP and re-injecting the treated effluent back into the backfill.

Once the saturated water level in the backfill reaches the top of bedrock along the pit rim (approximate elevation of 1,577 ft at year 20), some backfill pore water would begin to flow from the pit into the surficial aquifer. The quality of the aquifer inflow would reflect the quality of the pit lake water, which would gradually improve over time due to reclamation activities at the Mine Site. This groundwater inflow would migrate south through the East Pit Category 2/3 Surficial Flowpath and ultimately release to the Partridge River. Since both the Category 2/3 Stockpile and the East Pit would share the same flowpath, the flowpath would experience two concentration peaks, the first representing the arrival of solutes from the Category 2/3 Stockpile, which would reach the Partridge River around year 35 and would peak around year 55, and the second from the arrival of aquifer inflow from the East Pit, which would reach the Partridge River around year 100 and peak around year 150. For cobalt, Figure 5.2.2-25 shows the dual peak that would occur in the East Pit Cat 2/3 Surficial Flowpath at the Partridge River and compares this response with peaks that would occur in the other surficial flowpaths.

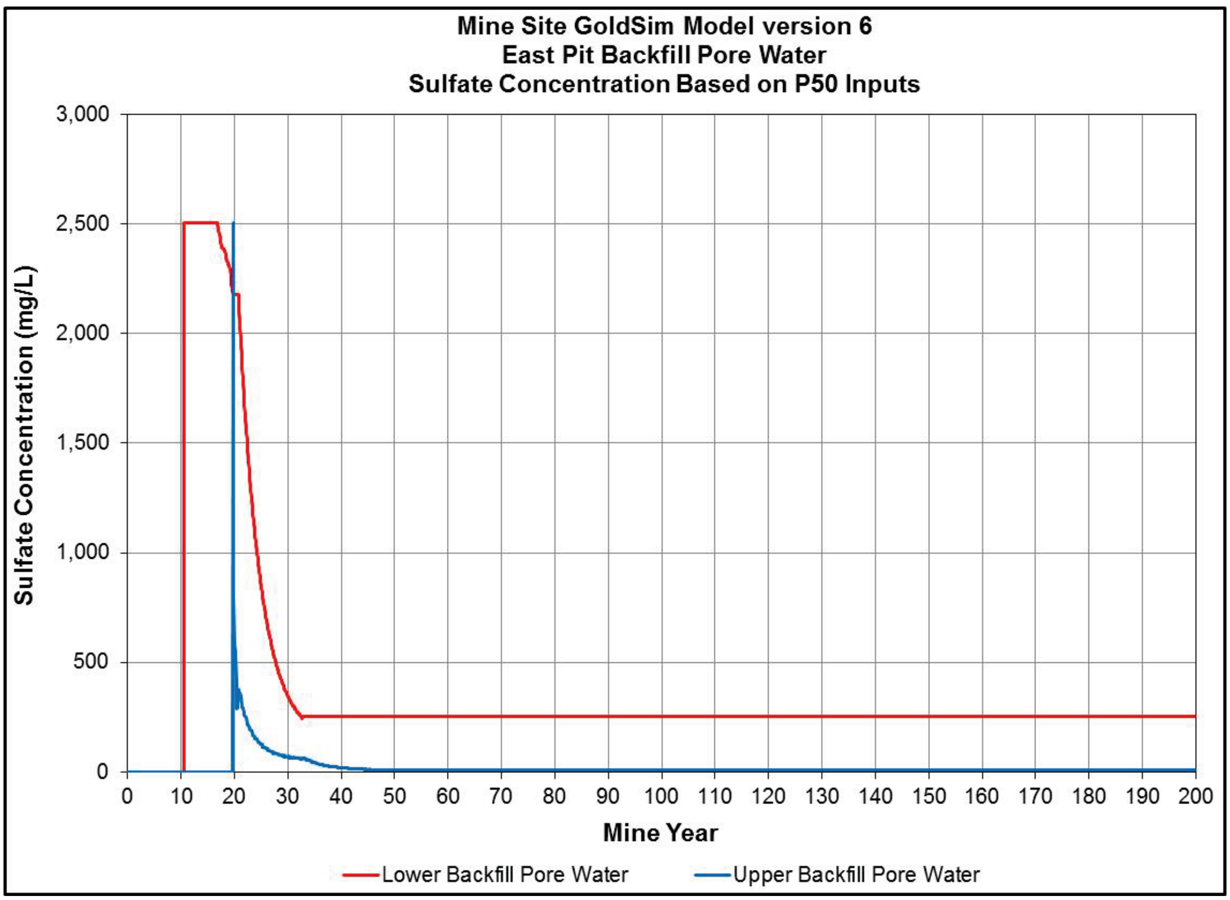


Figure 5.2.2-24 Sulfate Concentrations in East Pit Backfill Based on GoldSim Deterministic Run with P50 Inputs

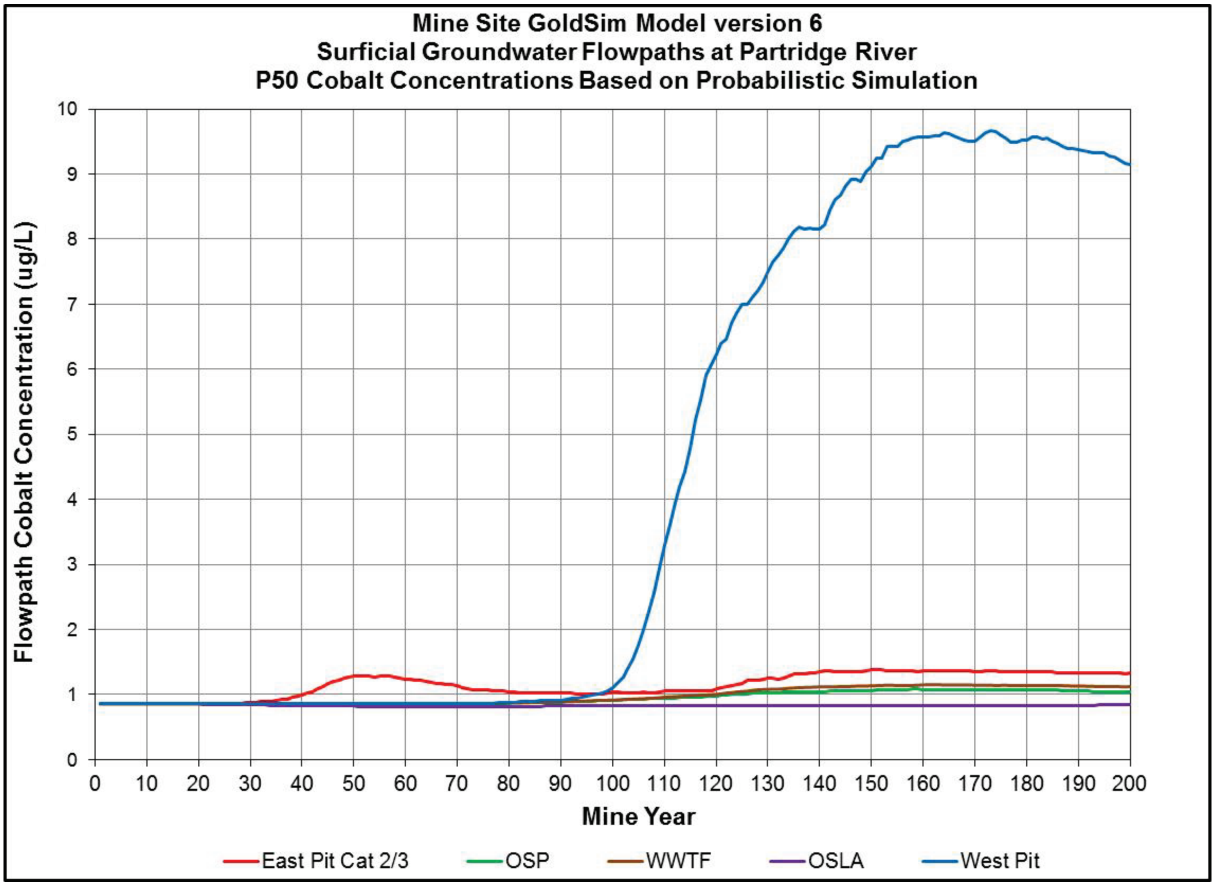


Figure 5.2.2-25 P50 Cobalt Concentrations in Surficial Groundwater Flowpaths at the Partridge River Based on GoldSim Probabilistic Simulation

<u>West Pit</u>

Flooding of the West Pit would begin after the completion of mining in year 21. The water in the West Pit is expected to contain dissolved oxygen with initial concentrations as high as 15 mg/L. This oxygen would be initially reactive with the pit wall rock, but the reactivity would decrease over time as the material exposed to water oxidizes. Groundwater flow in bedrock would be towards the pit, so the only mechanism for oxygen to reach unoxidized rock beyond the pit wall would be diffusion, and this would limit the rate of wall rock chemical reactions.

Once the water in the flooded pit reaches the top of bedrock along the pit rim (at an approximate elevation 1,550 ft at year 48), some of the pit lake water would begin to flow into the surficial aquifer. The quality of this aquifer inflow would reflect the quality of the pit lake water, which is predicted by GoldSim to improve over time due to: 1) dilution from rainfall and surface runoff into the pit, and 2) submergence of pit walls with an associated decrease in the oxidation of sulfide minerals. The groundwater inflow would migrate south along West Pit Surficial Flowpath and ultimately release to the Partridge River. The initial arrival of West Pit solutes at the Partridge River would occur at about year 105, and peak concentrations in groundwater discharging to the river would occur at about year 160.

Wastewater Treatment Facility

The WWTF would treat influent water from a variety of sources (e.g., pit dewatering, stockpile leachate collection, contact surface water, Plant Site RO concentrate). The only potential source of groundwater contamination at the WWTF would be leakage from the two equalization basins and from the Central Pumping Station. The equalization basin would have a geomembrane liner system and would be designed to have a minimum of 3 ft of freeboard, in accordance with the MPCA guidance (Meyer et al. 2009). Leakage from these basins through the liner system is calculated differently than for the waste rock stockpile liner systems because these ponds would have standing water above the underliner. Therefore, the hydraulic pressure on the liners would be greater, and, in turn, more water would be expected to leak on a per-acre basis (i.e., approximately 5 gallons per acre per day) (PolyMet 2015m). The total volume of leakage from the equalization basins, however, would be less than from the stockpiles, as the footprint of the equalization basins would be smaller. This leakage would reach the groundwater table and follow the WWTF Flowpath ultimately to the Partridge River.

Groundwater Transport and Evaluation Locations

Solutes from each source area described above would be transported by groundwater along its associated flowpath (see Figure 5.2.2-7). Each of these flowpaths has a groundwater evaluation location where the GoldSim model predicts groundwater quality (see Figure 5-2.2-7). At each evaluation location, the predicted water quality for the NorthMet Project Proposed Action is compared with both the evaluation criteria and the predicted water quality for the CEC scenario. See Table 5.2.2-22 for a summary of solute fate and transport.

The time at which contaminants leached from the Mine Site would begin to affect water quality at the downgradient evaluation locations depends on the following four variables:

- The time (i.e., year) when the source facility was constructed or began leaching contaminants;
- The rate at which contaminants move in groundwater (assumed to equal the groundwater flow rate for all constituents except the four attenuated contaminants (arsenic, antimony, copper, and nickel), which are assumed to migrate more slowly than the groundwater);
- The distance between the source and the evaluation location; and
- Mechanical dispersion, which tends to spread out the solute plume.

Cobalt was generally used to illustrate groundwater transport at the Mine Site because the model did not account for attenuation and it would enter the surficial flowpaths at concentrations higher than baseline groundwater. As a consequence, the movement of solute fronts associated with this solute is readily discernible on concentration-versus-time and concentration-versus-distance plots for the modeled flowpaths. Transport of other non-attenuated solutes should be similar to cobalt, but the changes in concentrations are not as visually noticeable as it is for cobalt.

The estimated migration times for contaminant plumes to reach the evaluation locations are presented in Table 5.2.2-22.

Table 5.2.2-22 P50 Solute Migration Times for Mine Site Groundwater Flowpaths Based on GoldSim Probabilistic Simulation

	Solute Source Times		Solute Migration Times to Groundwater Evaluation Location[1]		Solute Migration Times to Partridge River[1]	
Surficial Groundwater Flowpath	**Start Mine Year**	**Stop Mine Year**	**Initial Concentration Increase Mine Year**	**Peak Concentration[5] Mine Year**	**Initial Concentration Increase Mine Year**	**Peak Concentration[5] Mine Year**
Category 2/3 Stockpile	0	20	15	30	35	55
East Pit	20[(4)]	Continuous	95	135	100	150
Ore Surge Pile [6]	0	21	90	155	90	155
WWTF	0	33	80	130	85	160
Overburden Storage and Laydown Area	0	20	8[(2)]	20[(3)]	30[(2)]	60[(3)]
West Pit	48[(4)]	Continuous	85	135	105	160

Source: PolyMet 2014v.

Notes:
1 Arsenic, copper, nickel, and antimony, are modeled with adsorption coefficients that greatly increase solute migration times.
2 Concentration decrease for most constituents.
3 Minimum concentration for most constituents.
4 Time when pit water level would rise above the top of bedrock and begin to release pit water into the adjacent surficial (groundwater) flowpath.
5 All modeled peak concentrations are below evaluation criteria.
6 River location used for groundwater evaluation location.

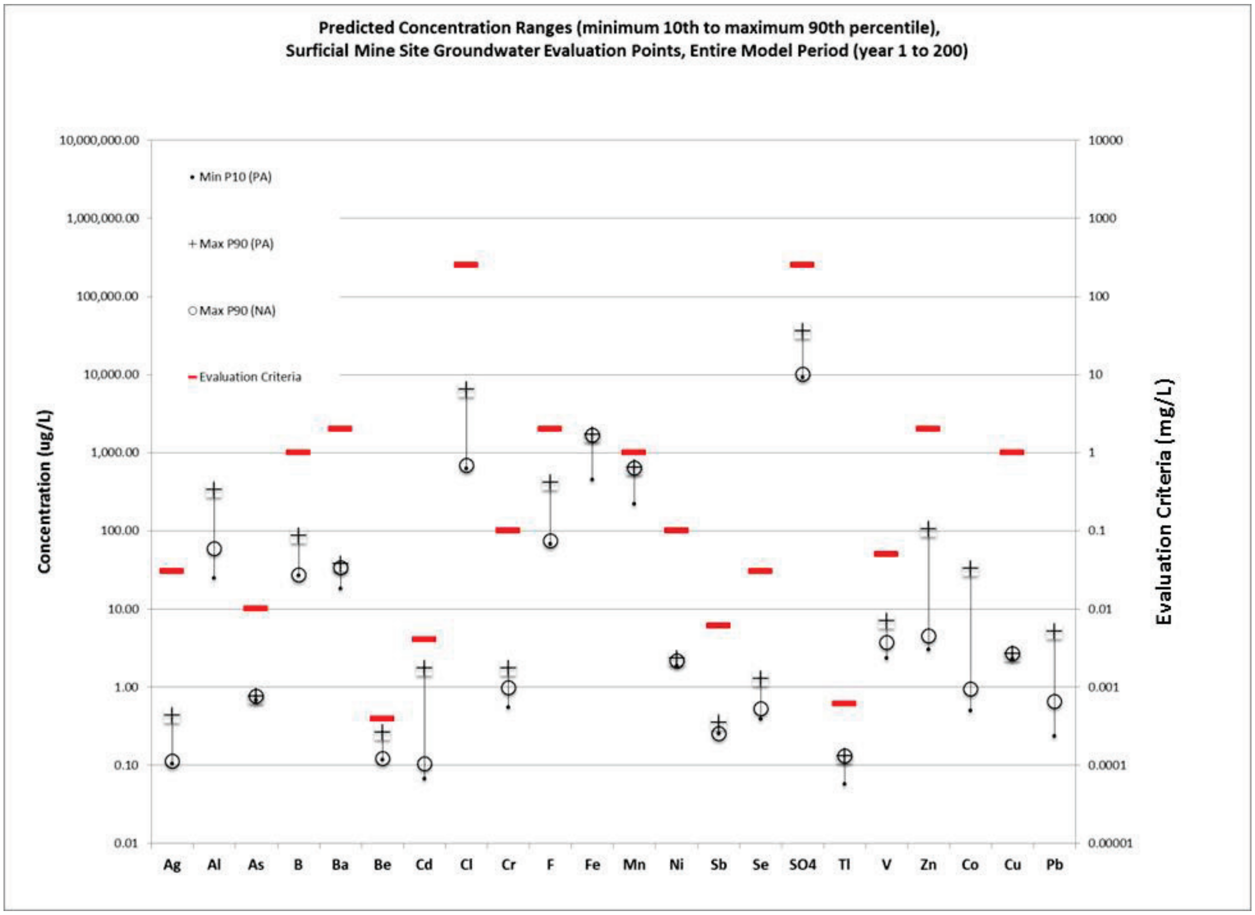
Table 5.2.2-22 indicates that all of the contaminant plumes would reach the Partridge River within the 200-year modeled duration.

Surficial Groundwater Quality at the Evaluation Locations

Model results were reviewed for all 29 solutes at the evaluation location within each of the five surficial flowpaths. A screening process was used to identify any constituents and locations that warranted a more robust examination because some modeled concentrations were above or equal to water quality evaluation criteria. The initial screening process involved comparing the single-highest monthly P90 water quality prediction from among the 2,388 months covered by the simulation (i.e., 12 months times 199 years, with the first year of simulation excluded for screening review due to potential numerical artifacts in the model results) for each constituent at each of the five evaluation locations. These NorthMet Project Proposed Action modeled values were compared with both the CEC scenario modeled values and the evaluation criteria discussed previously.

The screening of maximum P90 groundwater concentrations of all modeled solutes indicated that none of the solutes at any of the five flowpaths were predicted to ever exceed the evaluation criteria. These results are shown in Table 5.2.2-23, which lists the maximum P90 values for each modeled constituent. These results are illustrated, along with the maximum P90 concentrations for the CEC scenario and the range in NorthMet Project Proposed Action model concentrations (lowest P10 to the highest P90 value over 200-year simulation and across all groundwater model-reporting points), in Figure 5.2.2-26. The proportional increase in the concentrations of each solute (i.e., the ratio of the maximum P90 value under the NorthMet Project Proposed Action scenario to the maximum P90 value under the CEC scenario) are listed in Table 5.2.2-24 and illustrated graphically in Figure 5.2.2-27. Note that if the values are the same, the relative change ratio would be 1; values greater than 1 indicate the ratio at which the NorthMet Project Proposed Action would result in an increase in solute concentrations relative to the CEC scenario model results.

When groundwater affected by mining reaches the Partridge River, the concentration of groundwater that exits from the flowpath into the river would be a mixture of water that entered the upgradient end of the flowpath, meteoric aquifer recharge along the flowpath, and background groundwater into which the contaminant front disperses. For most constituents both the meteoric and background groundwater concentrations are lower than the source concentration. This means there would be a reduction in concentration of these constituents by the time the original source water arrived at the Partridge River (PolyMet 2015m).



Note: Groundwater evaluation criteria plotted are listed in Table 5.2.2-2.

Figure 5.2.2-26 Predicted Maximum P90 Concentrations of Each Solute versus Evaluation Criteria, Mine Site Surficial Groundwater Evaluation Locations

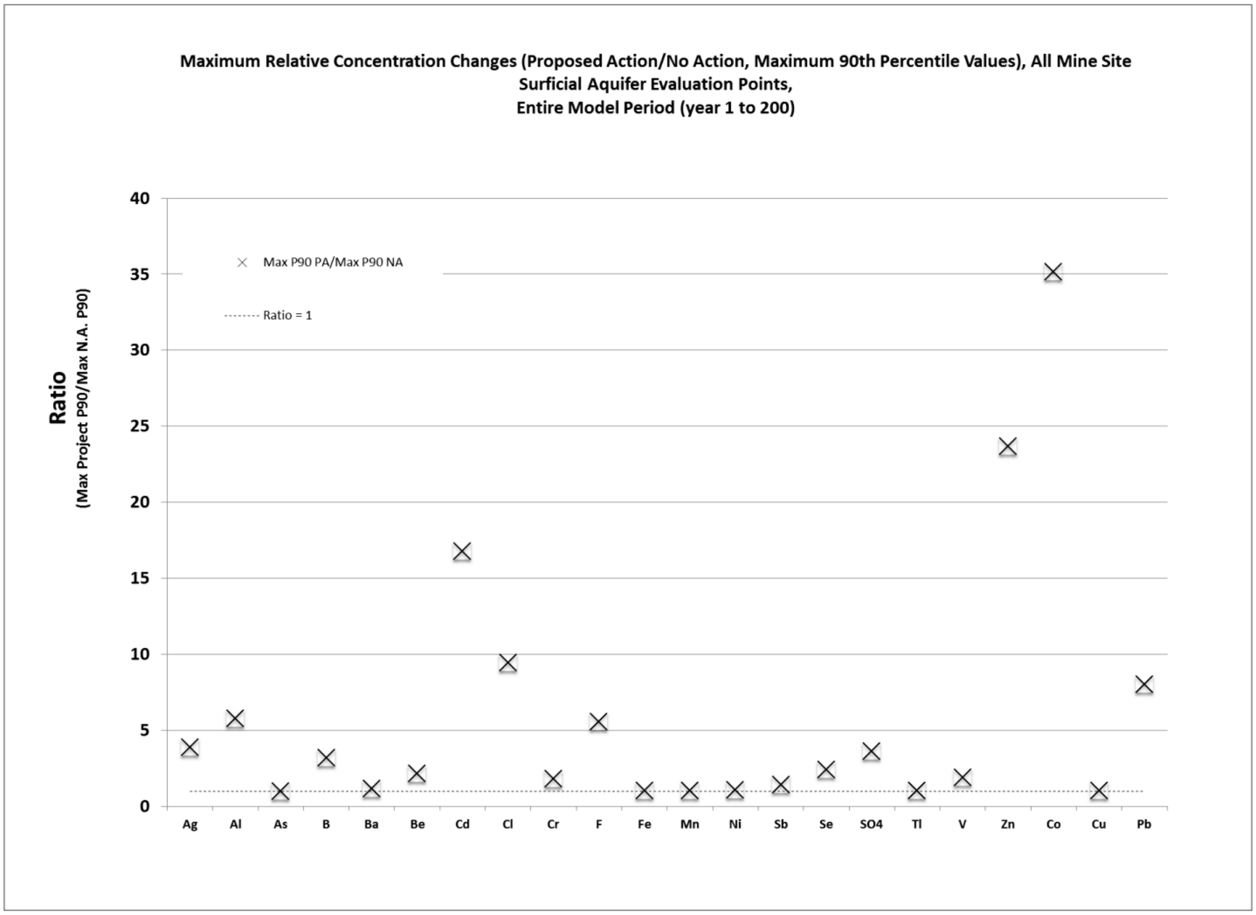


Figure 5.2.2-27 Relative Maximum P90 Concentration Differences (Proposed Action vs CEC), Over the 200-year Simulation Period at a Mine Site All Surficial Aquifer Evaluation Locations

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Table 5.2.2-23 Mine Site Groundwater – Maximum P90 Solute Concentration Over Entire 200-Year Simulation at Each Evaluation Location Based on the GoldSim Probabilistic Model

	FEIS Groundwater Evaluation Criterion			East Pit Category 2/3 Surficial Flowpath at Property Boundary		Overburden Storage and Laydown Area Surficial Flowpath at Old Property Boundary		Ore Surge Pile Surficial Flowpath at Partridge River		WWTF Surficial Flowpath at Property Boundary		West Pit Surficial Flowpath at Property Boundary	
Parameter	**Concentration**	**Units**	**Reference Table**	**PA**	**CEC Scenario**	**PA**	**CEC Scenario**	**PA**	**CEC Scenario**	**PA**	**CEC Scenario**	**PA**	**CEC Scenario**
General													
Alkalinity	--	mg/L	5.2.2-2	67.5	67.5	67.5	67.5	67.5	67.5	67.5	67.5	67.5	67.5
Calcium	--	mg/L	5.2.2-2	18.1	16.1	16.1	16.1	16.1	16.1	16.1	16.1	29.0	16.1
Chloride	250	mg/L	5.2.2-2	3.5	0.69	3.7	0.69	0.69	0.69	0.69	0.69	6.5	0.69
Fluoride	2	mg/L	5.2.2-2	0.13	0.08	0.42	0.08	0.08	0.08	0.08	0.08	0.17	0.08
Hardness	--	mg/L	5.2.2-2	77.6	69.9	69.9	69.9	70.0	69.9	70.2	69.9	120	69.9
Sulfate	250	mg/L	5.2.2-2	18.6	10.1	36.2	10.1	10.2	10.1	10.5	10.1	34.0	10.1
Magnesium	--	mg/L	5.2.2-2	7.9	7.3	7.3	7.3	7.3	7.3	7.3	7.3	11.7	7.3
Potassium	--	mg/L	5.2.2-2	4.7	1.7	2.6	1.7	1.7	1.7	1.8	1.7	6.4	1.7
Sodium	--	mg/L	5.2.2-2	16.2	5.6	16.1	5.6	5.6	5.6	5.6	5.6	23.9	5.6
TDS[1]	500	mg/L	5.2.2-2	109	82.0	122.8	82.0	82.2	82.0	82.6	82.0	152	82.0
Metals													
Aluminum	--	µg/L	5.2.2-2	339	58.9	139	58.9	70.1	58.9	79.0	58.9	58.9	58.9
Antimony	6	µg/L	5.2.2-2	0.35	0.25	0.29	0.25	0.25	0.25	0.25	0.25	0.27	0.25
Arsenic	10	µg/L	5.2.2-2	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.76
Barium	2,000	µg/L	5.2.2-2	34.8	33.4	33.4	33.4	33.4	33.4	33.4	33.4	38.1	33.4
Beryllium[2]	0.39	µg/L	5.2.2-1[(2)]	0.15	0.12	0.16	0.12	0.12	0.12	0.12	0.12	0.27	0.12
Boron	1,000	µg/L	5.2.2-2	30.6	27.5	87.3	27.5	27.5	27.5	27.5	27.5	65.7	27.5
Cadmium	4	µg/L	5.2.2-2	0.28	0.10	0.10	0.10	0.11	0.10	0.11	0.10	1.7	0.10
Chromium III	100	µg/L	5.2.2-2	1.1	0.98	0.98	0.98	0.98	0.98	0.98	0.98	1.8	0.98
Cobalt	--	µg/L	5.2.2-2	10.5	0.94	0.94	0.94	1.7	0.94	1.8	0.94	33.1	0.94
Copper	1,000	µg/L	5.2.2-2	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7
Iron	--	µg/L	5.2.2-2	1,721	1,673	1,673	1,673	1,676	1,673	1,681	1,673	1,673	1,673
Lead	--	µg/L	5.2.2-2	0.86	0.65	0.65	0.65	0.65	0.65	0.66	0.65	5.2	0.65
Manganese[2]	1,002	µg/L	5.2.2-1[(2)]	645	635	635	635	636	635	636	635	635	635
Nickel	100	µg/L	5.2.2-2	2.3	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2
Selenium	30	µg/L	5.2.2-2	0.72	0.53	0.61	0.53	0.53	0.53	0.54	0.53	1.3	0.53
Silver	30	µg/L	5.2.2-2	0.14	0.11	0.44	0.11	0.11	0.11	0.11	0.11	0.16	0.11
Thallium[2]	0.6	µg/L	5.2.2-2	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
Vanadium	50	µg/L	5.2.2-2	4.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7	7.0	3.7
Zinc	2,000	µg/L	5.2.2-2	19.2	4.5	4.5	4.5	4.8	4.5	5.2	4.5	106	4.5

Source: PolyMet 2014v.

Notes:
CEC = Continuation of Existing Conditions
PA = NorthMet Project Proposed Action
1 Groundwater evaluation criteria.
2 Surficial groundwater.

Table 5.2.2-24 Relative Difference in Maximum P90 Concentrations (NorthMet Project Proposed Action/CEC Scenario) for Mine Site Surficial Flowpath

Parameter	Units	East Pit-Category 2/3 Flowpath at the Property Boundary[1]	East Pit-Category 2/3 Flowpath at the Partridge River	Overburden Storage and Laydown Area Flowpath at the Property Boundary[1]	Overburden Storage and Laydown Area Flowpath at the Partridge River	Ore Surge Pile Flowpath at the Partridge River[1]	WWTF Flowpath at the Property Boundary[1]	WWTF Flowpath at the Partridge River	West Pit (Surficial) Flowpath at the Property Boundary[1]	West Pit (Surficial) Flowpath at the Partridge River
General										
Alkalinity	Unitless	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Calcium	Unitless	1.1	1.1	1.0	1.0	1.0	1.0	1.0	1.8	1.5
Chloride	Unitless	5.1	3.6	5.3	2.4	1.0	1.0	1.0	9.4	6.9
Fluoride	Unitless	1.7	1.4	5.6	2.4	1.0	1.0	1.0	2.2	1.9
Hardness	Unitless	1.1	1.1	1.0	1.0	1.0	1.0	1.0	1.7	1.5
Sulfate	Unitless	1.8	1.5	3.6	1.8	1.0	1.0	1.0	3.4	2.7
Magnesium	Unitless	1.1	1.0	1.0	1.0	1.0	1.0	1.0	1.6	1.4
Potassium	Unitless	2.7	2.0	1.5	1.1	1.0	1.0	1.0	3.7	2.8
Sodium	Unitless	2.9	2.1	2.9	1.6	1.0	1.0	1.0	4.3	3.3
TDS	Unitless	1.3	1.2	1.5	1.1	1.0	1.0	1.0	1.85	1.5
Metals										
Aluminum	Unitless	5.8	2.9	2.4	1.4	1.2	1.3	1.3	1.0	1.0
Antimony	Unitless	1.4	1.0	1.1	1.0	1.0	1.0	1.0	1.0	1.0
Arsenic	Unitless	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Barium	Unitless	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.1	1.1
Beryllium	Unitless	1.3	1.2	1.3	1.1	1.0	1.0	1.0	2.2	1.8
Boron	Unitless	1.1	1.1	3.2	1.7	1.0	1.0	1.0	2.4	2.0
Cadmium	Unitless	2.7	2.0	1.0	1.0	1.0	1.1	1.1	16.8	12.2
Chromium III	Unitless	1.1	1.1	1.0	1.0	1.0	1.0	1.0	1.8	1.5
Cobalt	Unitless	11.2	4.6	1.0	1.0	1.8	1.9	1.7	35.2	24.3
Copper	Unitless	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Iron	Unitless	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Lead	Unitless	1.3	1.2	1.0	1.0	1.0	1.0	1.0	8.0	5.8
Manganese	Unitless	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Nickel	Unitless	1.1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Selenium	Unitless	1.3	1.2	1.1	1.0	1.0	1.0	1.0	2.4	2.0
Silver	Unitless	1.2	1.1	3.9	1.9	1.0	1.0	1.0	1.4	1.3
Thallium	Unitless	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Vanadium	Unitless	1.2	1.1	1.0	1.0	1.0	1.0	1.0	1.9	1.6
Zinc	Unitless	4.3	3.0	1.0	1.0	1.1	1.2	1.1	23.7	17.0

Source: PolyMet 2014v.

Note:
[1] Evaluation location

Effects on Bedrock Groundwater Quality

At the Mine Site, the only mine-related solute sources to bedrock groundwater are flooded backfill in the East Pit, ponded water in the West Pit, and seepage from the Category 1 Stockpile. These waters are carried by three flowpaths to the south to the Partridge River. It is uncertain if a north bedrock groundwater flowpath from the Mine Site would develop naturally. If monitoring indicates a potential northern flowpath, mitigation measure(s) would be employed to prevent impacted bedrock groundwater flow to the north (MDNR et al. 2015).

The East Pit bedrock evaluation location is the property boundary, and the West Pit evaluation location is the Mine Site project boundary.

Predicted water quality in the bedrock south of the Mine Site was reviewed, but the solute load from these sources did not reach the evaluation locations at the end of the 200-year model simulation because the estimated travel time for groundwater between the mine pits and the bedrock evaluation locations would be much longer (greater than 1,000 years). The effect of the NorthMet Project Proposed Action on bedrock groundwater is considered negligible at the bedrock evaluation locations.

Saline Groundwater

Saline groundwater is known to occur in bedrock across the Canadian Shield (Fritz and Frape 1987; Morton and Ameel 1985). In general, the potential for encountering saline water increases with depth, such that briny groundwater (defined as TDS greater than 35,000 mg/L) may be nearly ubiquitous in bedrock at depths greater than approximately 3,000 ft throughout the Lake Superior Basin in northeastern Minnesota (Morton and Ameel 1985), including the Duluth Complex (Rouleau et al. 2003; Bottomley 1996). Brackish to saline groundwater is encountered sporadically in deep (greater than 1,000 ft) bedrock wells in northeastern Minnesota and on the Keweenaw Peninsula and in shallow (less than 300 ft) bedrock wells near Lake Superior (Morton and Ameel 1985). Elevated salinity at depth does not appear to be caused by the bedrock itself, as studies have found no particular relationship with rock type (Morton and Ameel 1985). One study concluded that these “brines” were likely formed by the evaporation of seawater during Devonian time about 359 to 419 million years ago (Bottomley 1996).

The concern for water quality is whether excavation of the East Pit and West Pit could penetrate zones of saline or briny groundwater or otherwise draw these waters to the surface, thereby increasing the salinity of the pit water.

The closest wells to the NorthMet Project Proposed Action area that are known to have encountered saline groundwater are located 3.2 miles to the northeast of the East Pit at the former AMAX test shaft at depths of approximately 1,200 to 1,400 ft bgs (elevation 200 to 400 ft amsl) (Barr 2012m). The maximum depths of the East Pit and West Pit, however, are approximately 630 and 700 ft bgs (elevation 800 to 900 ft amsl) or a minimum of 400 ft above the elevation where saline water was observed.

Bedrock groundwater sampling from the Mine Site also suggests that the pit excavations would not encounter saline groundwater. Sampling from two exploratory boreholes, a water supply well, and nine groundwater monitoring wells drilled at the Mine Site found a maximum chloride concentration of 15.7 mg/L (this excludes a value of 93.1 mg/L from the initial sampling of

Observation Well-3, where the maximum value detected in subsequent monitoring was 0.81 mg/L) (Barr 2012m).

Despite the absence of brine in current wells, the excavation and dewatering of the mine pits would likely draw water up from deeper bedrock below the pits, which could contain elevated chloride concentrations. Bedrock conductivity, however, is much lower than the surficial aquifer, and hydraulic analyses indicate that groundwater inflow to the West Pit would be dominated by water from the surficial aquifer, which is predicted to comprise 64 percent of groundwater inflow at end of mining and increase to 98 percent of inflow after the pit is fully flooded (PolyMet 2015m, Table 1-22b).

Regionally, the Federal Hardrock Mineral Prospecting Permits Project ROD recognizes this as a potential risk from exploration drilling (USFS 2012b), noting the possibility that "exploratory drilling could cause pockets of brackish (i.e., salty) groundwater to reach freshwater supplying drinking water wells." This ROD concluded, in consultation with the MDH, that "this scenario is considered unlikely," but "that the risk is not zero" (USFS 2012b).

Given that bedrock groundwater monitoring from 12 wells with depths up to 600 ft bgs at the Mine Site did not reveal any elevated chloride concentrations, that the nearest known occurrence of saline water is 3.2 miles from the Mine Site, and that the proposed pit floors would be at least 400 ft above the elevation where saline water is known to occur, the risk of encountering saline water is considered low. If encountered, saline bedrock groundwater inflow to the pits would be diluted by other water sources (surficial aquifer, and precipitation). In addition, any groundwater inflow to the pit during operations would be collected as part of pit dewatering and pumped to the WWTF for treatment. Finally, the chances of a perpetual elevated saline condition is considered small because the pits would flood in closure, producing hydraulic head that would inhibit groundwater upwelling.

Effects on Surface Water Hydrology in the Partridge River Watershed

This section describes the effects of the NorthMet Project Proposed Action on the surface water hydrology of the Partridge River and its tributaries (see Figure 5.2.2-28). The NorthMet Project Proposed Action could affect flows in the Partridge River and its tributaries by changing drainage areas (e.g., alteration or reduction in watershed area), reducing groundwater baseflow contributions during the dewatering and flooding of the East Pit and West Pit, and withdrawing water from Colby Lake occasionally for use as makeup water at the processing plant during operations.

Changes in Drainage Area

The NorthMet Project Proposed Action would result in changes to drainage areas in some locations that would, in turn, affect streamflows. These changes would primarily include the capture and retention of contact water at the Mine Site and during reclamation the use of this water to flood the West pit. During mine operations and reclamation, surface water runoff from much of the Mine Site would be retained within the site until the West Pit floods. This would reduce the effective drainage area that currently provides surface water runoff to the Partridge River. Table 5.2.2-25 shows the total watershed area and percent watershed area reduction at each surface water evaluation location for selected time periods.

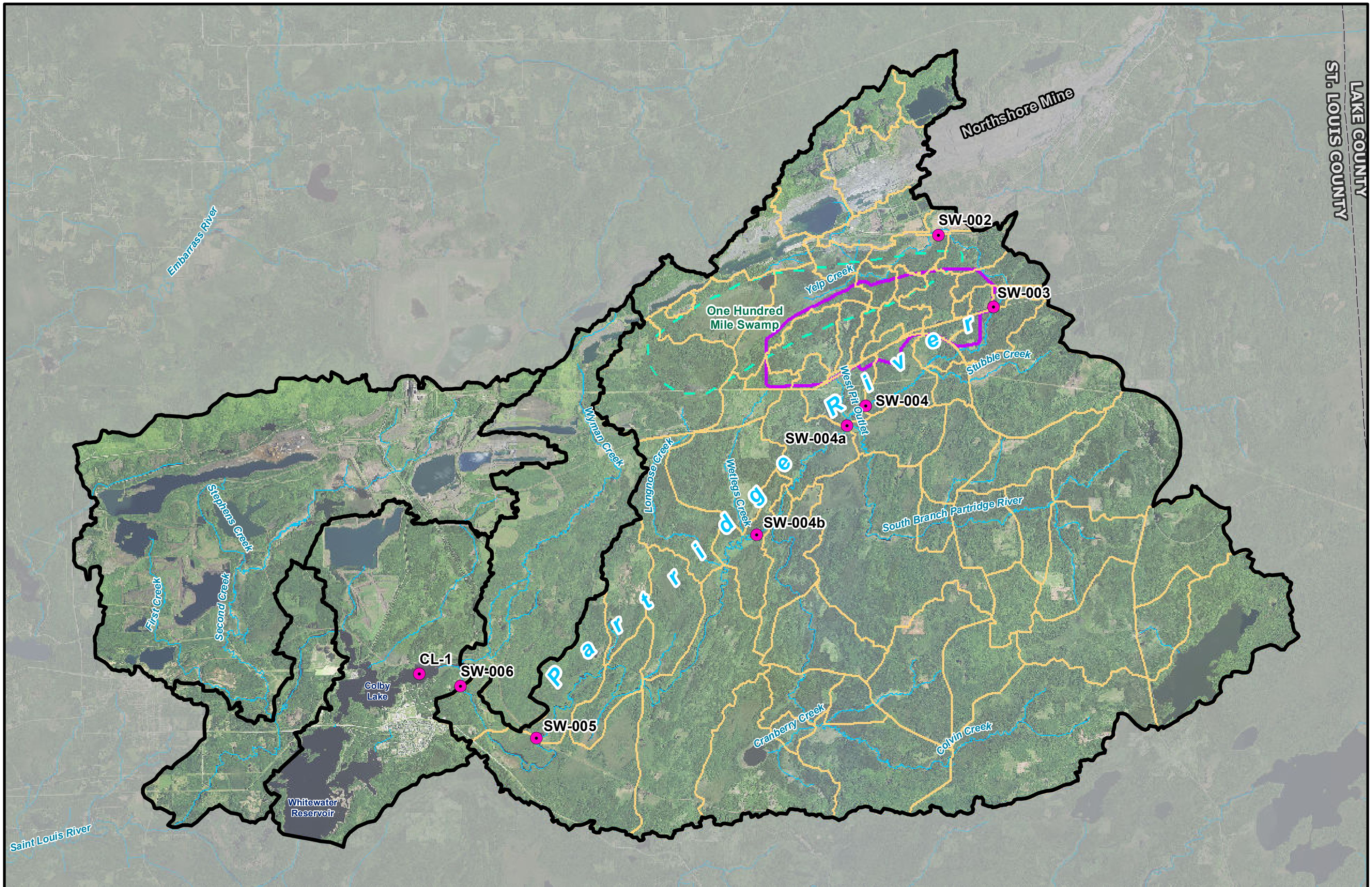

Figure 5.2.2-28

Partridge River Subwatersheds and Surface Water Evaluation Locations

NorthMet Mining Project and Land Exchange FEIS

Minnesota

November 2015

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Table 5.2.2-25 Total Watershed Area (acres) and Percent Watershed Area Reduction for the Partridge River Resulting from the NorthMet Project Proposed Action

Location/ Year	SW-001[(1)]	SW-002	SW-003	SW-004	SW-004a	SW-004b	SW-005	SW-006	Colby Lake
Existing Conditions	670	4,508	5,550	10,566	30,557	45,665	59,065	62,056	74,636
Operations Mine Year 11	670 0%	4,264 5.4%	5,301 4.5%	9.907 6.2%	29,041 5.0%	44,149 3.3%	57,549 2.6%	60.540 2.4%	73,120 2.0%
End of Operations Mine Year 20	670 0%	4,484 0.5%	5,521 0.5%	10,126 0.4%	29,504 3.4%	44,612 2.3%	58,012 1.8%	61,003 1.7%	73,583 1.4%
Closure and Post-closure Maintenance	670 0%	4,462 1.0%	5,504 0.8%	10,397 1.6%	29,903 2.1%	45,011 1.4%	58,411 1.1%	61,402 1.1%	73,982 0.9%

Source: PolyMet 2015m, Attachment C.

Note:
[1] Station SW-001 is upstream from the NorthMet Project Proposed Action area, and is thus unaffected by the NorthMet Project Proposed Action. Data from this station are used in the hydrologic modeling, but this FEIS does not estimate water quality at this station.

The maximum watershed area reduction for any modeled location along the Partridge River would be 6.2 percent at SW-004, during year 11 of operations. A maximum long-term watershed area reduction of 2.1 percent would occur at SW-004a. Mine year 11 is presented as it is the predicted time of maximum change in watershed area. It represents the time when the combined East Central Pit has reached maximum areal extent (and has not been backfilled), and when the West Pit is open and approaching maximum areal extent.

The reduced drainage areas were taken into consideration in the XP-SWMM modeling and are presented in the Mine Site Data Package (PolyMet 2015m) with key values presented in Table 5.2.2-26 of this FEIS.

XP-SWMM Modeling Results for the Partridge River

The flow parameters and water resources evaluation criteria, established in Section 5.2.2.1.2, were used to evaluate the effects on surface water hydrology in the Partridge River Watershed. The XP-SWMM model was run for the NorthMet Project Proposed Action and the CEC scenarios for selected years during operations, and reclamation and closure, to determine the changes to each parameter at each stream location. Given the relatively small watershed area changes (watershed area reductions would approximate flow reductions), only selected modeling results are presented here to demonstrate the range of potential hydrologic effects. Effects on Colby Lake were not evaluated with the XP-SWMM model; however, water-level changes to Colby Lake and Whitewater Reservoir are addressed in a subsequent section of this FEIS. Table 5.2.2-26 summarizes the XP-SWMM results for selected flow parameters and stream locations. Modeled annual daily mean flow is also shown as a percentage of existing conditions in Figure 5.2.2-29.

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Table 5.2.2-26 Modeled Percent Change in Selected Streamflow Parameters at Selected Locations in the Partridge River

Location/Flow Parameter	SW-002				SW-004				SW-004a				SW-006			
	Year 11 Change in Flow	Mine Year 11 Percent Change	Long-Term Closure Change in Flow	Long-Term Closure Percent Change	Year 11 Change in Flow	Mine Year 11 Percent Change	Long-Term Closure Change in Flow	Long-Term Closure Percent Change	Year 11 Change in Flow	Mine Year 11 Percent Change	Long-Term Closure Change in Flow	Long-Term Closure Percent Change	Year 11 Change in Flow	Mine Year 11 Percent Change	Long-Term Closure Change in Flow	Long-Term Closure Percent Change
Annual Daily Mean (cfs)	-0.30	-4.9%	0.00	NC	-0.60	-4.3%	0.10	NC	-1.67	-4.4%	0.39	1.0%	-1.33	-1.7%	0.68	NC
February Mean (cfs)	-0.06	-5.7%	-0.01	NC	-0.10	-4.2%	0.02	NC	-0.30	-4.6%	0.43	6.5%	-0.24	-1.8%	0.50	3.7%
Average Annual 3-day Min (cfs)	-0.02	-5.1%	0.00	NC	-0.06	-7.1%	-0.03	-3.6%	-0.16	-7.8%	0.78	38.0%	-0.16	-3.4%	0.71	15.3%
Average Annual 30-day Min (cfs)	-0.03	-7.3%	-0.01	-2.4%	-0.07	-7.6%	-0.03	-3.3%	-0.14	-5.7%	0.54	22.1%	-0.14	-2.7%	0.49	9.3%
Mean Duration of Low Pulses (days)	0.02	NC	0.02	NC	0.83	3.2%	0.00	NC	0.07	NC	-0.24	NC	-2.20	-5.9%	-2.57	-6.9%
April Mean (cfs)	-1.62	-5.3%	-0.16	NC	-3.37	-4.7%	0.17	NC	-9.02	-4.5%	-1.70	NC	-8.25	-2.0%	-0.84	NC
Average Annual 3-day Max (cfs)	-3.33	-4.7%	0.20	NC	-4.21	-2.8%	3.91	2.6%	-14.75	-3.5%	-1.03	NC	-15.99	-2.1%	-1.21	NC
Mean Duration of High Pulses (days)	-0.09	-1.8%	-0.09	-1.8%	-0.07	-2.4%	-0.03	-3.3%	-0.25	-3.0%	-0.17	-2.0%	0.00	NC	-0.16	-1.3%

Source: PolyMet 2015m, Attachment J.

NC: Indicates modeled change less than 1 percent.

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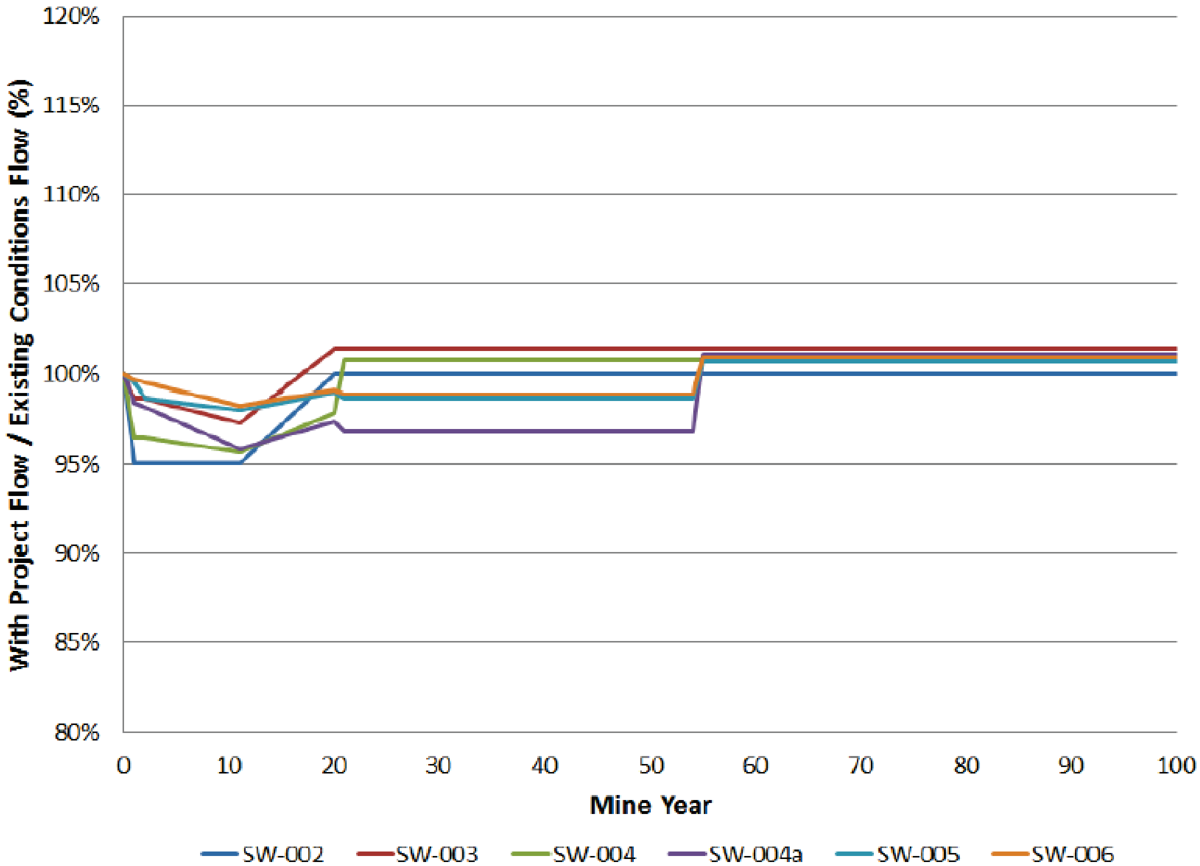

Source: Barr 2015i

Figure 5.2.2-29 Project Impact on Partridge River Annual Daily Mean Flow, shown as Modeled Flows Over Time as a Percent of Existing Conditions

It is apparent from Table 5.2.2-26 that almost all effects on streamflow during the year of maximum watershed reduction (mine year 11) would be in the form of streamflow reductions. The largest modeled effect, about an 8 percent reduction, would occur during low-flow conditions. After the West Pit is filled with water, discharge from the WWTF to the West Pit Outlet Creek would more than compensate for the reduced low flows at some locations. The maximum modeled effect is at location SW-004a, just downstream of where the WWTF discharge would enter the Partridge River. Here, the annual minimum 3-day flow and average annual 30-day low flow would increase by about 38 and 22 percent, respectively. The actual flow increases would be on the order of 0.78 and 0.54 cfs, respectively. The NorthMet Project Proposed Action would have little effect on high flows, as shown for the mean April flows and the annual maximum 3-day flows.

Modeling predicts that annual daily mean flow would change by 5 percent or less during operations and reclamation, and return to within approximately 1 percent of existing flow conditions in closure and long-term maintenance, as shown in Figure 5.2.2-29.

Changes in hydrology can affect stream geomorphology. PolyMet conducted a Level I Geomorphic Survey of the Partridge River from its headwaters to Colby Lake (Barr 2005) to determine the stability of the river under existing conditions, evaluate its sensitivity to hydrologic change, and indicate how restoration may be approached if a portion of the stream becomes unstable. The Geomorphic Survey found the Upper Partridge River to be stable, with no evidence of erosion except in its headwaters (see Figure 4.2.2-9). Its steep reaches are well-armored and the flatter reaches tend to have well-vegetated shorelines. As indicated in Table 5.2.2-26, the NorthMet Project Proposed Action would reduce flow in the Upper Partridge River during mine operations by 1.8 to 7.8 percent depending on evaluation location and flow parameter, with less of an effect (2.0 to 5.3 percent) on higher flows. Flows would return to nearly pre-NorthMet Project Proposed Action conditions during closure, except at surface water stations downstream of WWTF discharge points where river flows would be higher.

No erosion or significant geomorphic changes are expected in the Upper Partridge River due to the NorthMet Proposed Action for the following reasons:

- The Geomorphic Survey of the Upper Partridge River found it to be stable;
- The NorthMet Project Proposed Action would not directly disturb the river banks;
- High flows (e.g., bank-full flows), which are important in shaping geomorphic processes, would only be reduced by a maximum of five percent during operations which is within the range of natural variability; and
- Most streamflows would return to near pre-NorthMet Project Proposed Action conditions after closure.

Effects on the Hydrology of the Partridge River Tributary Streams

The NorthMet Project Proposed Action is not expected to have any measurable effects on surface water hydrology of the tributary streams along the Transportation and Utility Corridor. Flow data collection and monitoring of the Partridge River tributary streams would be conducted for permitting.

Flow in the West Pit Outlet Creek would be modified due to reduction of drainage area, interception of groundwater by the West Pit, and discharge of the WWTF effluent during closure and long-term maintenance. The XP-SWMM model estimates an average annual flow of 1.2 cfs at the approximate location of the future WWTF discharge under existing conditions. The estimated average annual flow at this location in closure and long-term maintenance is increased to 1.4 cfs primarily due to the WWTF discharge (PolyMet 2015m).

A geomorphic survey of the West Pit Outlet Creek between Dunka Road and the Partridge River found no evidence of erosion, downcutting, or channel widening. The survey concluded that because the creek has a well-developed floodplain and substantial and continuous bank vegetation, it would be tolerant to moderate changes in hydrology (Barr 2005).

Effects on Colby Lake and Whitewater Reservoir Water Levels

The effect of the NorthMet Project Proposed Action on water levels in Colby Lake is related to changes in Partridge River inflow and water withdrawals to the Plant Site during operations.

The XP-SWMM modeling for SW-006, just upstream of Colby Lake, shows minor reductions in Partridge River low flows during operations (2.7 percent reduction in the 30-day low flow, which is equivalent to about 0.14 cfs). On an annual average basis, inflow to Colby Lake would be reduced about 1.7 percent during operations (in mine year 11) and have virtually no change during closure (see Table 5.2.2-26 for SW-006) (PolyMet 2015m).

NorthMet Project Proposed Action makeup water demand from Colby Lake during operations would vary between 260 and 1,760 gpm (0.6 and 3.9 cfs) with an average annual demand of 760 gpm (1.7cfs). After operations complete, makeup water from Colby Lake would no longer be withdrawn (PolyMet 2015a).

Combining the flow reduction at SW-006 with the rate of process makeup water removed from Colby Lake provides an estimate of the total reduction in flow to Colby Lake. The maximum predicted reduction to average annual flow due to the NorthMet Project Proposed Action at SW-006 is 1.7 percent, occurring during mine year 11, which corresponds to an average annual flow reduction of 600 gpm (1.3 cfs) (Table 5.2.2-26). The average and maximum Colby Lake annual withdrawal rates during operations are 760 gpm (1.7 cfs) and 1,750gpm (3.9 cfs). Therefore, the estimated annual average reduction in flow to Colby Lake is 1,360 gpm (3.0 cfs) with a maximum withdrawal rate of 2,350 gpm (5.2 cfs). The NorthMet Project Proposed Action DEIS (MDNR and USACE 2009) evaluated two potential Colby Lake withdrawal rates, 3,500 gpm and 5,000 gpm. The model assumed transfer of water from Whitewater Reservoir in order to maintain water levels above the critical outflow elevation of 1,439 ft at all times in Colby Lake, which is required under MDNR Water Appropriation Permit 1949-0135.

The evaluation criterion for Colby Lake and Whitewater Reservoir is an assessment of the annual mean, maximum, and minimum lake level changes from existing conditions. At a 3,500 gpm withdrawal rate and average flow conditions, the average Colby Lake drawdown over the modeled period was 0.01 ft, with an average annual water level fluctuation of about 3.6 ft, compared to 3.9 ft for zero withdrawal. Whitewater Reservoir would also be affected by water withdrawals, as it is used to help maintain water levels in Colby Lake. Under this 3,500 gpm withdrawal and average flow conditions scenario, drawdown on Whitewater Reservoir was predicted to be about 0.4 ft with a maximum annual fluctuation of about 4.2 ft, compared to about 2.9 ft for zero withdrawal (PolyMet 2015m). Environmental consequences of the drawdown on wetlands and aquatic resources are discussed in Sections 5.2.3 and 5.2.6, respectively.

It is reasonable to assume that the effects of PolyMet's proposed withdrawal of less than 3,500 gpm would be no worse on Colby Lake and Whitewater Reservoir water levels than this modeled 3,500 gpm withdrawal. These anticipated effects on water levels are well within the range experienced during the former LTVSMC taconite mining operations.

Effects on the Hydrology of the Lower Partridge River

Existing flow conditions in the Lower Partridge River can be estimated by examining the flow record (i.e., 1942 to 1982) at USGS gaging station 04016000, which was located approximately 1.5 miles downstream of Colby Lake. Historic hydrologic alterations to Partridge River watershed area caused by former LTVSMC operations are likely present in the USGS flow data, while alterations from the present Mesabi Nugget operations are not considered. Notwithstanding these effects, the historic flow records can be used to provide a reasonable estimate of NorthMet Project Proposed Action effects on the Lower Partridge River.

The record shows average monthly flows varying from about 17 cfs during February to about 333 cfs during May, with an average annual flow of about 112 cfs. As described above, the maximum effect of the NorthMet Project Proposed Action on streamflow into Colby Lake would be a net reduction in flow of about 3.0 to 4.2 cfs during operations, which would represent about a 2.7 to 3.8 percent decrease in the average annual flow at the gage site. This withdrawal cannot simply be subtracted from each month to estimate effects on low or high flows because of required transfer of water from Whitewater Reservoir when Colby Lake drops to elevation 1,439.0. Given this requirement to supplement low flows by transferring water from the reservoir, it is expected that effects on low flows at the gage station would be negligible. Effects on high flows would be less than on average flows, and would proportionately diminish as the flow increases. Note that high flows downstream of Colby Lake would also be substantially reduced because of water transfers to the reservoir during high runoff periods, which reflects existing operating procedures. Therefore, the NorthMet Project Proposed Action is expected to have negligible effects on flow in the Lower Partridge River. Note that during closure, once the West Pit floods, the hydrology of the Partridge River is expected to return to relatively normal conditions with no net change in average annual flow at SW-006 (Table 5.2.2-26).

Effects on the Hydrology of Second Creek

Second Creek is the only Lower Partridge River tributary stream that could be notably affected by the NorthMet Project Proposed Action. The current estimated average seepage rate is about 230 gpm (see Table 5.2.2-37). Historically, seepage from the southern side of the Tailings Basin entered the headwaters of Second Creek. In July 2011, a seepage collection system was installed, which returned most of the south-side seepage to the Tailings Basin pond. Under the NorthMet Project Proposed Action, the seepage collection system would be upgraded to ensure essentially 100 percent capture of the southern side surface seepage. If seepage were observed to bypass the existing dam, a second dam could be constructed approximately 500 ft downstream of the existing system, in an area where the Second Creek headwaters valley is more constricted and any remaining subsurface seepage would have come to the surface. This potential second dam could be constructed as an earthen dam with a clay or concrete cutoff wall (extending to bedrock if necessary) in order to achieve 100 percent capture of the surface seepage (Barr 2015e). As part of its streamflow augmentation plan (PolyMet 2015j), PolyMet would discharge WWTP effluent to the headwaters of Second Creek at a rate equal to a minimum of 80 percent of the uncaptured south-side seepage rate, or at least 184 gpm, to compensate for interception of the south-side seepage. The effects of the NorthMet Project Proposed Action on Second Creek streamflow would be minimal.

Effects on Surface Water Quality

The NorthMet Project Proposed Action would affect the water quality of the Partridge River and its tributaries that drain the Mine Site, Transportation and Utility Corridor, and the processing plant area. PolyMet proposes to treat and re-use water, resulting in no direct surface water discharges to the Partridge River until the West Pit completely refills by approximately year 52. The West Pit would not be allowed to overflow until its water quality meets water quality based effluent limits. During operations, reclamation, and closure and post-closure maintenance there would be continuous augmentation at the Plant Site to Second Creek, which is a tributary of the Partridge River. Several other potential pathways for surface water quality effects include domestic wastewater, non-contact stormwater runoff, and seepage from waste rock stockpiles.

PolyMet proposes to manage domestic wastewater by providing portable facilities serviced by a supplier at the Mine Site. These portable facilities would be designed to adequately manage the domestic wastewater requirements of the NorthMet Project Proposed Action, so this potential contaminant source is not discussed further.

The other predicted effects of the NorthMet Project Proposed Action on surface water quality in the Upper Partridge River, Colby Lake, and the Lower Partridge River are discussed below.

Effects on the Upper Partridge River

Water quality in the Upper Partridge River (upstream of Colby Lake) is already affected by discharges from the Northshore Mine. For purposes of estimating water quality impacts, a 2.6 cfs constant discharge from Northshore is used in modeling. This is a best estimate flow rate determined through a sensitivity analysis (MDNR et al. 2015a). As mentioned above, PolyMet does not propose any surface water discharges to the Upper Partridge River until the West Pit floods around mine year 52. However, non-contact stormwater runoff, unrecoverable groundwater seepage from the five groundwater flowpaths (i.e., from the waste rock stockpiles, pits, Ore Surge Pile, WWTF, and Overburden Storage and Laydown Area), and the WWTF discharge would all serve as contaminant sources to the Upper Partridge River. Each of these sources is discussed below and then the predicted overall effect of these sources on water quality in the Upper Partridge River is evaluated.

<u>*Non-contact Stormwater Runoff*</u>

PolyMet proposes to collect non-contact stormwater runoff from undisturbed and reclaimed vegetated areas within the Mine Site and route it to the Partridge River via existing drainage patterns to the extent possible. Stormwater quality is not expected to differ significantly from existing conditions because it would not contact any reactive rock, but there would be the potential for increased suspended solids. PolyMet would provide sedimentation ponds at the outlet locations to manage suspended solids prior to discharge to surface waterbodies (see Figures 3.2-5, 3.2-6, 3.2-7, and 3.2-8). These sedimentation ponds should be adequate to manage suspended solids, but monitoring of the discharge is recommended as part of any NPDES/SDS permit (see Section 4.1.3.5 for a discussion of recommended monitoring measures).

<u>*Unrecovered Groundwater Seepage from Liner Leakage and Pit Seepage*</u>

The WWTF equalization basins, Ore Surge Pile, Category 2/3 Stockpile, and Category 4 Stockpile would all have compacted soil and geomembrane liners. Percolating water above the liner would be collected and pumped to the WWTF for treatment.

Some water is predicted to leak through the liners as a result of tears or defects in the geomembrane liners and this effect is included in the GoldSim model. The quantity of water leaking through the liners is determined by the liner design and effectiveness. The Hydrologic Evaluation of Landfill Performance model was used to help estimate liner leakage, including the use of uncertainty analysis for three key input variables (i.e., liner slope, subgrade permeability, and frequency of liner defects) (PolyMet 2015m).

The proposed liner systems would be installed in accordance with the proposed design using rigorous quality control measures consistent with industry standards. Current construction practices and improvements in electrical leak detection surveys should be able to achieve the proposed design criteria (i.e., defects/acre, overliner slope, and subgrade permeability). Concerns regarding geomembrane liners primarily relate to the potential for differential settlement to cause tears and for it to degrade over time. These concerns are tempered by the fact that all of the proposed liner systems would be temporary. The Ore Surge Pile and Category 2/3 and 4 stockpiles would be removed, including the liners, by year 21. The WWTF equalization basins would remain in use while the East Pit is being treated in reclamation and closure and post-closure maintenance until approximately year 33.

Because the Category 4 waste rock stockpile would be surrounded by mine pits and its footprint later becomes the Central Pit, any liner leakage from the stockpile would not enter a groundwater flowpath, and would instead be assumed to enter the East Pit and contribute to the flow that must be dewatered from the pit during operations.

During reclamation and closure and post-closure maintenance, small volumes of water are predicted to flow from the pits into the downgradient surficial groundwater. These untreated pit releases would include East Pit backfill pore water into the East Pit Category 2/3 Surficial Flowpath (beginning year 20) and West Pit lake water into the West Pit Surficial Flowpath (beginning year 48). These releases to surficial groundwater would continue in perpetuity. Groundwater in these flowpaths would flow downgradient and eventually reach the Partridge River.

Liner leakage from the Overburden Storage and Laydown Area, WWTF, Ore Surge Pile, and Category 2/3 Stockpile would also follow groundwater flowpaths that eventually reach the Partridge River. These would be temporary sources where solute leakage/seepage flow rates are generally low and are summarized in Table 5.2.2-27. For P50 inputs, depending on the flowpath, the initial concentration change in groundwater as it discharges to the Partridge River would occur at 30 to 105 years after the start of mining, and peak concentrations at the Partridge River would occur in the range of 55 to 160 years after the start of mining (see Table 5.2.2-22). After peak concentrations were achieved, the groundwater concentrations would gradually decrease over many tens to hundreds of years. Note that for the Overburden Storage and Laydown Area flowpath, most solutes would experience a decrease in concentration downgradient of the source.

Table 5.2.2-27 Pit Outflow and Liner/Equalization Basin Leakage into Groundwater Flowpaths (Based on GoldSim Deterministic Run with P50 Inputs)

Contaminant Source	Flow Rate (gpm)	Duration of Source (Mine Years)	Mine Year when Solute Plume First Arrives at Partridge River
East Pit	3.75[(1)]	20+	100
Category 2/3 Stockpile	0.0193	0–20	35
Ore Surge Pile	0.00116	0–21	90
WWTF Equalization Basins	0.0138	0–33	85
Overburden Storage and Laydown Area	14.0	0–20	30[(2)]
West Pit	6.09[(1)]	48+	105

Notes:
1 Pit water into groundwater flowpath.
2 Concentration decrease.

Category 1 Stockpile Seepage

The Category 1 Stockpile would have a permanent cover consisting of a synthetic (geomembrane) overlain by a compacted soil and vegetated growth medium, which would be installed progressively during operations, starting in mine year 13 and completed during mine year 22.

Infiltration passing through covered and uncovered portions of the top surface would percolate to the bottom of the stockpile, and most would be collected by the groundwater seepage containment system. For best estimate parameters, the seepage rate reporting to the bottom of the stockpile depends on the stockpile footprint and the proportion of the stockpile that is reclaimed (covered). From the beginning of operations to mine year 7, the annual average flow rate is predicted to progressively increase from 150 to 360 gpm. From mine year 7 to 12, the annual average flow rate is relatively constant at 360 gpm. From mine year 12 to 22, the annual average flow rate progressively decreases from 360 to 2.8 gpm and then remains constant at 2.8 gpm after mine year 22.

Relatively small amounts of the infiltration seepage would not be collected by the containment system and would migrate via bedrock to the West Pit. From the beginning of operations to mine year 7, this annual average flow rate is predicted to progressively increase from 9 to 22 gpm. From mine year 7 to 12, the annual average flow rate is relatively constant at 22 gpm. From mine year 12 to 22, the annual average flow rate progressively decreases from 22 to 0.16 gpm and then remain at near zero after mine year 22.

A very small amount of the stockpile seepage would by-pass the containment system and slowly migrate to the Partridge River via bedrock flowpaths. For best estimate parameters, this flow rate is estimated to progressively increase from zero to 6.8 gpm from mine year zero to 11 and then progressively decrease to zero at mine year 20.

Note that none of the Category 1 Stockpile seepage is predicted to flow into any of the surficial groundwater flowpaths.

Wastewater Treatment Facility Discharges

PolyMet proposes a WWTF at the Mine Site to treat affected water from the sources summarized in Table 5.2.2-28. This table presents P90 (high-end) estimated average Mine Site process water flow rates by source for the indicated design year (which are years 14, 25, and 75 for operations, reclamation, and closure and post-closure maintenance, respectively). Details regarding some of these WWTF influent sources are discussed below. The process water at the Mine Site would be combined into three waste streams for treatment at the WWTF. Construction water would be treated in a construction water stream and would only be needed through approximately year 11. Process water containing relatively high levels of metals and sulfate (drainage from the temporary Category 2/3 Stockpile and Category 4 Stockpile liners and the temporary Ore Surge Pile liner) would be stored in the West Equalization Basin and routed to the chemical precipitation treatment train. Process water containing relatively low concentrations of metals and sulfate (drainage from haul roads, the Rail Transfer Hopper, pit dewatering, and Category 1 Stockpile drainage) would be stored in the East Equalization Basin and routed to the filtration treatment train. The WWTF effluent would be conveyed to the Central Pumping Station pond to be blended with the Overburden Storage and Laydown Area runoff prior to being pumped through the Treated Water Pipeline for use at the Tailings Basin or used to supplement flooding of the East Pit after approximately year 11 (PolyMet 2015r).

Table 5.2.2-28 P90 Mine Site Process Water Flows to the Wastewater Treatment Facility

	90th Percentile Estimated Average Annual Flow (gpm)		
Source	**Operations[2]**	**Reclamation[3]**	**Closure and Post-Closure Maintenance[4]**
East Pit	1,035	1,750[(5)]	--
Central Pit	55	--	--
West Pit	365	--	400
Haul Roads and Rail Transfer Hopper	65	--	--
Category 1 Stockpile	375	10	10
Category 2/3 Stockpile	145	--	--
Ore Surge Pile	25	--	--
Category 4 Stockpile	0	--	--
WWTP Reject Concentrate	145	175	--
Total[1]	2,065	1,925	405

Source: PolyMet 2015d, Table 2-1.

Notes:
1 Flows are rounded to the nearest 5 gpm; column values do not sum to 90th percentile total value due to probabilistic modeling (P90 of totals is not equivalent to the total of the P90s).
2 Estimates based on PolyMet 2015m for mine year 14, 90th Percentile.
3 Estimates based on PolyMet 2015m for mine year 25, 90th Percentile.
4 Estimates based on PolyMet 2015m for mine year 75, 90th Percentile.
5 Flow value is total of East Pit and Central Pit.

Actual flow rates would vary both daily and seasonally throughout the 20 years of mine operations. Peak influent flows to the WWTF are anticipated to occur during spring snowmelt. Because influent flow rates to the WWTF would vary significantly over the life of the NorthMet Project Proposed Action and within any given year, the WWTF design includes two equalization basins that would store influent when flows exceed the WWTF's treatment capacity. The WWTF equalization basins are designed for the spring snowmelt, when the Mine Site would be at its maximum area. In the event of an extreme event (e.g., 100-year storm), excess water would remain in the initially dewatered mine pits, which essentially have unlimited storage capacity, with mine operations in the pits temporarily shut down (see PolyMet 2015r). Even during an extreme event, no untreated water would be discharged to a natural water body.

The WWTF process design for operations and reclamation includes chemical precipitation and nano-membrane separation. During mine operations, the treated effluent from the WWTF would be mixed with the runoff collected from the Overburden Storage and Laydown Area in the Central Pumping Station pond, where it would be pumped either to the Tailings Basin pond (for re-use as process water at the Beneficiation Plant) or to help re-saturate the East Pit backfill (after mining would be completed in year 11). During mine reclamation, the WWTF would primarily be used for treating East Pit backfill surface water and to accelerate flooding of the West Pit.

During mine closure and post-closure reclamation, the WWTF would be used to treat water collected from the Category 1 Stockpile containment system and pumped water from the West Pit. Since the West Pit would now be flooded, the WWTF would begin in closure and post-closure maintenance to discharge effluent to the West Pit Outlet Creek, a natural intermittent stream that flows to the Partridge River just upstream of SW-004a. The treated effluent would need to meet applicable effluent limits. During closure and post-closure maintenance, the existing WWTF nano-membrane system would be converted to an RO system with an evaporator/spray dryer or equivalent unit. Reject concentrate from the primary membrane separation unit would continue to be treated with existing secondary membrane separation and chemical precipitation equipment, or would be evaporated and the residual solids disposed offsite.

Table 5.2.2-29 presents the target WWTF effluent concentrations for the different mine phases. Pilot-testing of a WWTF with RO demonstrated that all of the target closure effluent concentrations could be achieved with the planned WWTF design (Barr 2013f).

Table 5.2.2-29 Wastewater Treatment Facility Preliminary Water Quality Targets

	Targets			
Parameter[1]	**Operations**	**Reclamation**	**Closure and Post-Closure Maintenance**	**Basis**
Metals (µg/L)				
Aluminum	125	125	125	M.R., part 7050.0222 Class 2B (chronic standard)
Antimony	31	31	31	M.R., part 7050.0222 Class 2B (chronic standard)
Arsenic	10	10	4	Federal Standard (pMCLs)
Barium	2,000	2,000	2,000	Minn. Groundwater (HRL, HBV5, or RAA)
Beryllium	4	4	4	Federal Standard (pMCLs)
Boron	500	500	500	M.R., part 7050.0224 Class 4A (chronic standard)
Cadmium[2]	5.1	4.2	2.5	M.R., part 7052.0100 Class 2B (chronic standard)
Chromium III[2]	86	86	86	M.R., part 7052.0100 Class 2B (chronic standard)
Cobalt	5	5	5	M.R., part 7050.0222 Class 2B (chronic standard)
Copper[2]	20	17	9.3	M.R., part 7052.0100 Class 2B (chronic standard)
Iron	300	300	300	Federal Standard (sMCLs)
Lead[2]	10.2	7.7	3.2	M.R., part 7050.0222 Class 2B (chronic standard)
Manganese	50	50	50	Federal Standard (sMCLs)
Nickel[2]	113	94	52	M.R., part 7052.0100 Class 2B (chronic standard)
Selenium	5	5	5	M.R., part 7052.0100 Class 2B (chronic standard)
Silver	1	1	1	M.R., part 7050.0222 Class 2B (chronic standard)
Thallium	0.56	0.56	0.56	M.R., part 7050.0222 Class 2B (chronic standard)
Zinc[2]	260	216	120	M.R., part 7050.0222 Class 2B (chronic standard)
General Parameters (mg/L)				
Chloride	230	230	230	M.R., part 7050.0222 Class 2B (chronic standard)
Fluoride	2	2	2	Federal Standard (sMCLs)
Hardness[3]	250	200	100	Hardness PWQT chosen to establish PWQTs for metals with a hardness based standard
Sodium	60% of cations	60% of cations	60% of cations	M.R., part 7050.0224 Class 4A (chronic standard)
Sulfate	250	150	9	Operations: Federal Standard (sMCLs) Long-term closure: M.R., part 7050.0224 Class 4A

Source: PolyMet 2015d; Barr 2013f, Table 3.

Notes:
M.R. = Minnesota Rules
1 The Process Water Quality Targets parameter list has been updated from RS29T to include only the parameters modeled in GoldSim.
2 Standard based on hardness.
3 *Minnesota Rules,* part 7050.0223 Class 3C standard for hardness is 500 mg/L.

Comparison of Contaminant Sources

The GoldSim model enables the identification of "culpability," or the relative contribution of various contaminant sources to the overall contaminant load at a specific evaluation location. Table 5.2.2-30 presents an illustrative example of the culpability analysis using two representative solutes of interest (copper and sulfate) at evaluation location SW004a during representative years for operations, reclamation, and closure and post-closure maintenance periods. The culpability identifies 11 sources of copper and sulfate at this evaluation location. In addition to the eight NorthMet Project Proposed Action-related sources (i.e., five surficial aquifer flowpaths, two bedrock flowpaths, and the WWTF discharge), three non-NorthMet Project Proposed Action-related sources are identified (i.e., background groundwater, non-contact stormwater runoff, and the Northshore Mine discharge).

Table 5.2.2-30 Culpability Analysis for Copper and Sulfate at SW-004a Based on GoldSim P50 Results

	Copper Load (% of total)			Sulfate Load (% of total)		
Contaminant Source	**Operations Year 12**	**Reclamation Year 25**	**Closure and Post-Closure Maintenance Year 200**	**Operations Year 12**	**Reclamation Year 25**	**Closure and Post-Closure Maintenance Year 200**
Background Groundwater	17.9%	19.1%	16.5%	9.1%	9.5%	13.9%
Non-contact Stormwater	72.1%	70.2%	64.0%	56.6%	55.5%	80.6%
Northshore Mine Discharge	8.8%	9.4%	0.0%	33.7%	34.3%	0.0%
East Pit Category 2/3 Surficial GW Flowpath[1]	0.6%	0.8%	0.7%	0.3%	0.4%	0.7%
East Pit Bedrock GW Flowpath	0.0%	0.002%	0.002%	0.0%	0.005%	0.007%
Ore Surge Pile Surficial GW Flowpath[1]	0.1%	0.2%	0.1%	0.1%	0.1%	0.1%
WWTF Surficial GW Flowpath[1]	0.1%	0.1%	0.1%	0.04%	0.04%	0.1%
Overburden Storage and Laydown Area Surficial GW Flowpath[1]	0.5%	0.3%	0.2%	0.2%	0.1%	0.2%
West Pit Surficial GW Flowpath[1]	0.0%	0.0%	0.3%	0.0%	0.0%	0.5%
West Pit Bedrock GW Flowpath	0.0%	0.0%	0.0%	0.0%	0.0%	0.004%
WWTF discharge	0.0%	0.0%	18.1%	0.0%	0.0%	4.0%

Source: PolyMet 2014v

Notes:
GW = Groundwater.
[1] Includes NorthMet Project Proposed Action-related loading and loading associated with meteoric aquifer recharge into the flowpath.

As Table 5.2.2-30 indicates, the primary source of load for both copper and sulfate at SW-004a for operations, reclamation, and closure and post-closure maintenance phases are the non-NorthMet Project Proposed Action-related sources (background groundwater, surface water, and Northshore Mine discharge). In addition, the WWTF discharge represents an important source of copper in closure and post-closure maintenance, and a minor source of sulfate.

Evaluation of Surface Water Quality for the Upper Partridge River

Results of the GoldSim water quality modeling were reviewed for 29 constituents at the seven Partridge River surface water evaluation locations listed in Table 5.2.2-31. Station SW-001, upstream of SW-002, is not an evaluation location because its water chemistry is essentially the same as that of the Northshore Mine discharge. The initial screening process described previously for constituents without hardness-based evaluation criteria (see Section 5.2.2.2.3) was applied to 23 constituents to identify constituents and locations that warranted a more robust examination. The screening process involved comparing the single-highest monthly P90 water quality prediction (maximum P90 concentration) for the NorthMet Project Proposed Action to the associated evaluation criterion, excluding the first year of simulation as discussed previously. The bold entries in Table 5.2.2-31 identify constituents and locations with maximum P90 values that exceed the associated evaluation criterion and where NorthMet Project Proposed Action concentrations are greater than CEC concentrations. This subset is retained for further evaluation and includes sulfate and aluminum.

Table 5.2.2-31 shows that the maximum P90 solute concentrations for the NorthMet Project Proposed Action are similar to the corresponding CEC scenario modeled values for most of the constituents. Some of the NorthMet Project Proposed Action maximum P90 values—such as those for antimony, cadmium, cobalt, copper, nickel, vanadium, and zinc at SW-004a, SW-004b, SW-005, and SW-006, and sulfate and lead at SW-004a and SW-004b—are noticeably higher than the CEC scenario maximum P90 values. If the maximum P90 concentration exceeded the evaluation criteria and the NorthMet Project Proposed Action P90 concentration was greater than the CEC scenario concentration, the screening process identified it for secondary screening and further analysis. Aluminum at SW-002, SW-003, and SW-004 and Sulfate at SW-005 did not pass initial screening and therefore were retained for further evaluation through secondary screening.

While listed in Table 5.2.2-31, six constituents with hardness-based evaluation criteria (cadmium, chromium III, copper, lead, nickel, and zinc) were screened using a different methodology (secondary screening) because the associated evaluation criteria could not be described by single values. This methodology was discussed in Section 5.2.2.2.3. Using this secondary screening methodology, Table 5.2.2-32 summarizes the Mine Site surface water constituents that have hardness-based evaluation criteria as well as those that did not pass initial screening identified above. For the secondary screening method, a constituent was retained for further evaluation if there was a 10 percent probability that either event (A or B described previously) would occur more than 10 percent of the time and there was a 10 percent probability that the event magnitude was more than 5 percent of the applicable NorthMet Project Proposed Action evaluation criteria (see section 5.2.2.2.3 for a more detailed explanation). As shown, for the Partridge River no constituent met both of these conditions. As a consequence, Mine Site water quality impacts from the NorthMet Project Proposed Project are not considered significant. Additional discussion is offered below on selected constituents of interest.

Table 5.2.2-31 Mine Site Surface Water – Maximum P90 Solute Concentration Over Entire 200-Year Simulation with Initial Screening of Constituents without Hardness-Based Evaluation Criteria

			SW-002		SW-003		SW-004		SW-004a		SW-004b		SW-005		SW-006	
Parameter	**Partridge Evaluation Criteria**	**Units**	**NorthMet Project Proposed Action**	**CEC Scenario**	**NorthMet Project Proposed Action**	**CEC Scenario**	**NorthMet Project Proposed Action**	**CEC Scenario**	**NorthMet Project Proposed Action**	**CEC Scenario**	**NorthMet Project Proposed Action**	**CEC Scenario**	**NorthMet Project Proposed Action**	**CEC Scenario**	**NorthMet Project Proposed Action**	**CEC Scenario**
General																
Alkalinity	NA	mg/L	152.7	152.4	150.8	150.7	150.6	150.6	152.4	152.9	150.5	150.8	147.4	147.9	145.8	146.3
Calcium	NA	mg/L	38.0	38.0	37.9	37.8	37.9	37.8	38.0	38.0	37.9	37.9	36.9	36.9	36.7	36.7
Chloride	230	mg/L	16.9	16.9	16.8	16.8	16.8	16.7	16.8	16.9	16.8	16.8	16.4	16.4	16.4	16.4
Fluoride	NA	mg/L	0.21	0.21	0.21	0.20	0.21	0.21	0.21	0.21	0.21	0.21	0.20	0.20	0.20	0.20
Hardness	500	mg/L	135.9	135.8	133.9	132.9	133.3	132.6	134.7	135.2	134.4	134.4	131.7	131.7	131.4	131.4
Magnesium	NA	mg/L	15	15	14.9	14.9	14.6	14.5	14.4	14.5	14.3	14.3	13.9	13.9	13.9	14
Potassium	NA	mg/L	5.01	5.01	4.98	4.97	5.03	4.97	4.98	5.02	4.96	4.98	4.86	4.88	4.83	4.84
Sodium	NA	mg/L	13.2	13.1	13.1	13	13.1	12.9	23.8	13.2	15.9	13.1	13.2	12.8	13.3	13
Sulfate	NA / 10[1]	mg/L	27.3	27.3	27.1	27.1	26.4	26.3	24.3	24.2	22.1	22	**18.3**	**18.2**	17.6	17.6
TDS	700	mg/L	207	207	205	205	204	204	214	204	202	200	192	192	190	191
Metals Total																
Aluminum	125	µg/L	**313.3**	**313.1**	**312.1**	**311.6**	**311.8**	**311.5**	310.2	314.9	310.1	312.6	307.5	308.8	305.6	308.0
Antimony	31	µg/L	0.25	0.25	0.25	0.25	0.26	0.25	4.15	0.25	2.59	0.25	1.39	0.25	1.13	0.25
Arsenic	53	µg/L	2.59	2.59	2.58	2.58	2.59	2.59	2.69	2.64	2.62	2.62	2.62	2.61	2.61	2.59
Barium	NA	µg/L	31.1	31.2	29.9	30.0	28.3	28.5	34.8	30.5	31.4	29.0	25.8	23.9	24.7	22.8
Beryllium	NA	µg/L	0.12	0.12	0.12	0.12	0.12	0.12	0.25	0.12	0.20	0.12	0.15	0.11	0.14	0.11
Boron	500	µg/L	199.7	199.4	197.8	196.4	197.5	196.7	199.7	201.7	198.2	199.3	195.3	195.5	192.8	193.1
Cadmium	NA[2]	µg/L	0.17	0.17	0.16	0.16	0.16	0.16	0.93	0.17	0.57	0.16	0.34	0.16	0.28	0.16
Chromium III	NA[2]	µg/L	1.44	1.44	1.44	1.44	1.44	1.44	1.74	1.47	1.48	1.48	1.46	1.46	1.44	1.45
Cobalt	5	µg/L	1.29	1.29	1.29	1.29	1.29	1.28	3.11	1.29	2.21	1.29	1.58	1.25	1.44	1.27
Copper	NA[2]	µg/L	3.48	3.48	3.44	3.44	3.42	3.41	5.79	3.48	4.47	3.44	3.40	3.34	3.36	3.32
Iron	NA	µg/L	5,917	5,913	5,858	5,845	5,850	5,843	5,864	5,933	5,824	5,890	5,746	5,765	5,710	5,728
Lead	NA[2]	µg/L	0.94	0.94	0.92	0.92	0.92	0.92	1.85	0.97	1.37	1.03	1.06	1.05	1.05	1.05
Manganese	NA	µg/L	575.2	575.4	548.2	549.0	523.2	522.9	443.6	568.0	452.1	533.7	403.9	442.4	395.0	419.3
Nickel	NA[2]	µg/L	4.35	4.34	4.31	4.29	4.27	4.26	26.7	4.36	16.9	4.31	9.17	4.15	7.77	4.09
Selenium	5	µg/L	1.53	1.53	1.52	1.52	1.51	1.51	1.54	1.54	1.53	1.52	1.49	1.49	1.50	1.49
Silver	1	µg/L	0.11	0.11	0.11	0.11	0.11	0.11	0.16	0.11	0.14	0.11	0.12	0.11	0.12	0.11
Thallium	0.56	µg/L	0.12	0.12	0.12	0.12	0.11	0.11	0.11	0.12	0.11	0.11	0.09	0.09	0.09	0.09
Vanadium	NA	µg/L	3.57	3.57	3.47	3.47	3.38	3.34	6.72	3.51	5.28	3.40	3.87	2.92	3.62	2.82
Zinc	NA[2]	µg/L	25.4	25.4	25.6	25.5	25.5	25.4	48.7	25.4	32.7	25.6	25.9	25.5	27.0	25.9

Source: PolyMet 2015m and PolyMet 2014v

Notes:
CEC = Continuation of Existing Conditions
Bold value indicates non-hardness based constituent was retained for secondary screening.
1 Sulfate 10 mg/L wild rice evaluation criterion applies at SW-005 and SW-006
2 Parameter has a hardness-based evaluation criterion and is screened using the secondary screening procedure (see Table 5.2.2-32)

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Table 5.2.2-32 Secondary Screening for Partridge River Watershed

Evaluation Location	Constituent	Events A or B[1,2] - Data Used for Secondary Screening: Occurrence (%)[3]				Magnitude of Concentration Increase (%)[4]				Magnitude of Concentration Increase (µg/L)[5]				Mine Years
		1-55		56-200		1-55		56-200		1-55		56-200		
		50%	90%	50%	90%	50%	90%	50%	90%	50%	90%	50%	90%	Percentile
SW-002	Cd	0	0	0	0	NA	NA	NA	NA	NA	NA	NA	NA	Constituents with Hardness-Based Evaluation Criteria
	Cr III	0	0	0	0	NA	NA	NA	NA	NA	NA	NA	NA	
	Cu	0.2	0.5	1.4	1.8	<0.05	0.1	0	0.3	0	0	0	0	
	Ni	0	0.2	0.1	0.2	0	0.1	0.1	0.4	0	0.1	0	0.2	
	Pb	0.8	1.2	2.8	3.4	0.1	0.2	0.1	0.6	<0.05	0	0	0	
	Zn	0.2	0.3	0.7	1	<0.05	0.1	0.1	0.4	0.1	0.2	0.1	0.5	
SW-003	Cd	0	0	0	0	NA	NA	NA	NA	NA	NA	NA	NA	
	Cr III	0	0	0	0	NA	NA	NA	NA	NA	NA	NA	NA	
	Cu	0.3	0.6	1.3	1.7	0.3	0.8	0.2	1	<0.05	0.1	0	0.1	
	Ni	0	0.2	0.1	0.2	0.4	0.8	0.3	1.3	0.2	0.5	0.1	0.6	
	Pb	0.9	1.5	2.7	3.2	0.4	1.6	0.3	2.1	0	0.1	0	0.1	
	Zn	0.2	0.5	0.7	1	0.3	1.1	0.3	1.5	0.4	1.7	0.3	1.8	
SW-004	Cd	0	0	0	0	NA	NA	NA	NA	NA	NA	NA	NA	
	Cr III	0	0	0	0	NA	NA	NA	NA	NA	NA	NA	NA	
	Cu	0.3	0.6	1.3	1.7	0.1	0.4	0.1	0.6	<0.05	0	0	0.1	
	Ni	0	0.2	0.1	0.2	0.2	0.6	0.2	0.8	0.1	0.3	0.1	0.4	
	Pb	1.1	1.5	2.8	3.5	0.2	1	0.2	1.5	<0.05	0.1	0	0.1	
	Zn	0.2	0.5	0.7	1	0.2	0.6	0.2	1.1	0.2	0.9	0.2	1.3	
SW-004a	Cd	0	0	0	0	0	0	0.5	1.2	0	0	0	0	
	Cr III	0	0	0	0	NA	NA	NA	NA	NA	NA	NA	NA	
	Cu	0.2	0.3	1.2	1.5	0.1	0.7	0.8	3.9	<0.05	0	0	0.2	
	Ni	0	0.2	0.1	0.2	0	0.6	0.7	3.6	0	0.2	0.2	1.1	

Evaluation Location	Constituent	Events A or B[1,2] - Data Used for Secondary Screening												
		Occurrence (%)[3]				Magnitude of Concentration Increase (%)[4]				Magnitude of Concentration Increase (µg/L)[5]				
		1-55		56-200		1-55		56-200		1-55		56-200		Mine Years
		50%	90%	50%	90%	50%	90%	50%	90%	50%	90%	50%	90%	Percentile
	Pb	0.5	0.9	1.8	2.2	0.1	1.3	1.4	7.8	<0.05	0.1	0	0.1	
	Zn	0.2	0.3	0.3	0.6	0.1	0.4	0.5	2.3	0.1	0.5	0.3	1.4	
SW-004b	Cd	0	0	0	0	0	0	0.4	0.8	0	0	0	0	
	Cr III	0	0	0	0	NA	NA	NA	NA	NA	NA	NA	NA	
	Cu	0.3	0.6	1.2	1.5	0	0.4	0.6	2.7	0	0	0	0.1	
	Ni	0	0.2	0.1	0.2	0	0.3	0.5	2.3	0	0.1	0.2	0.7	
	Pb	1.1	1.7	1.9	2.4	0.1	0.8	1	5.3	<0.05	0	0	0.1	
	Zn	0.3	0.6	0.3	0.6	0	0.3	0.3	1.6	0	0.4	0.2	1.1	
SW-005	Cd	0	0	0	0	NA	NA	NA	NA	NA	NA	NA	NA	
	Cr III	0	0	0	0	NA	NA	NA	NA	NA	NA	NA	NA	
	Cu	0.2	0.5	1	1.4	0	0.5	0.5	1.9	0	0	0	0.1	
	Ni	0	0.2	0.1	0.1	0	0.4	0.4	1.9	0	0.2	0.1	0.6	
	Pb	0.9	1.5	1.9	2.4	0.2	0.9	0.8	3.7	<0.05	0	0	0.1	
	Zn	0.2	0.5	0.3	0.6	0	0.4	0.3	1.3	0	0.4	0.2	0.9	
SW-006	Cd	0	0	0	0	NA	NA	NA	NA	NA	NA	NA	NA	
	Cr III	0	0	0	0	NA	NA	NA	NA	NA	NA	NA	NA	
	Cu	0.3	0.6	1	1.3	0	0.3	0.5	1.8	0	0	0	0.1	
	Ni	0	0.2	0.1	0.1	0	0.3	0.4	1.9	0	0.1	0.2	0.6	
	Pb	1.2	2	2	2.4	0.1	0.8	0.7	3.5	<0.05	0	0	0.1	
	Zn	0.2	0.5	0.3	0.6	0	0.3	0.3	1.2	0	0.4	0.2	1	
Colby Lake	Cd	0	0	0	0	NA	NA	NA	NA	NA	NA	NA	NA	
	Cr III	0	0	0	0	NA	NA	NA	NA	NA	NA	NA	NA	
	Cu	1.1	2	2.5	3.3	0.1	0.3	0.4	1.2	<0.05	0	0	0.1	
	Ni	0	0	0	0.1	0.1	0.3	0.3	0.8	<0.05	0.1	0.1	0.4	

Evaluation Location	Constituent	Events A or B[1,2] - Data Used for Secondary Screening: Occurrence (%)[3]				Magnitude of Concentration Increase (%)[4]				Magnitude of Concentration Increase (µg/L)[5]				Mine Years
		1-55		56-200		1-55		56-200		1-55		56-200		
		50%	90%	50%	90%	50%	90%	50%	90%	50%	90%	50%	90%	Percentile
	Pb	0.8	1.8	1.2	1.7	0.2	0.6	0.3	1.1	<0.05	0	0	0	
	Zn	0	0.2	0.1	0.3	0.1	0.4	0.2	0.6	0.2	0.5	0.2	0.6	
SW-002	Al	9.9	11.2	29	30.5	0.1	0.2	0.1	0.5	0.1	0.4	0.2	1	**Constituents with *Non*-Hardness-Based Evaluation Criteria**
SW-003	Al	12.9	14.6	29	30.4	0.4	1.3	0.3	1.7	0.9	2.7	0.6	3.3	
SW-004	Al	12.7	14.3	31.2	32.9	0.3	1	0.3	1.5	0.5	1.9	0.5	2.9	
SW-005	SO_4 (mg/L)	37.9	42	2.4	4.5	0.2	0.3	0.1	0.8	0.02	0.05	0.02	0.09	
Colby Lake	Fe	61.7	69.2	0.8	1.3	0.1	0.3	0.3	1.1	1.7	6.5	3.7	20.1	
	Al	24.2	29.6	0	0.2	0.1	0.3	0.1	0.6	0.2	0.5	0.2	1.1	
	Mn	2.6	4.4	11.2	12.7	0.2	0.6	0.7	2.4	0.2	1.5	0.6	2.1	
	As	4.4	6.5	7.5	8.9	0.1	0.5	0.5	1.6	<0.05	0	0	0	

Notes:

- (yellow) 90th percentile of the percent of time is greater than 10%
- (light blue) 90th percentile of the magnitude of events is greater than 5% of NorthMet Project Propoed Action evaluation criterion
- (red) Constituent/Evaluation Location is characterized by both of the above for the same time period (none this table)

CEC = Continuation of Existing Conditions
PA = NorthMet Project Proposed Action
[1] Event A is when PA>Evaluation Criterion and CEC<Evaluation Criterion; Event B is when PA>CEC and CEC>Evaluation Criterion
[2] For Event A, the magnitude of exceedance (in µg/L) equals the PA concentration minus the PA water quality evaluation criterion. For Event B, the magnitude of exceedance (in µg/L) equals the PA concentration minus the CEC concentration.
[3] As a percent of time
[4] As a percent of PA evaluation criterion
[5] Unless otherwise noted

Table 5.2.2-33 below compares the maximum P50 and P90 for NorthMet Project Proposed Action and the CEC scenario modeled concentrations for selected solutes during mine operations, reclamation, and closure and post-closure maintenance at SW-004a, which is the evaluation location where the NorthMet Project Proposed Action would have its greatest effects on water quality for most constituents. As these data show, the water quality is predicted to be essentially the same for the CEC scenario and the NorthMet Project Proposed Action modeled values for operations and reclamation. This result is not unexpected, as most of the groundwater contaminant source loads would not reach the Partridge River at the end of the reclamation period, and WWTF effluent discharge to the Partridge River would not begin until about year 52. By year 2020 in closure and post-closure maintenance, which reflects the time period when effects would have peaked and would be decreasing, the WWTF would be discharging and all groundwater contaminant source loads would have reached the Partridge River (except negligible contributions from the bedrock flowpaths), the predictions for the NorthMet Project Proposed Action for some constituents (e.g., nickel and zinc) are higher than for the CEC scenario, but remain below applicable evaluation criteria.

Table 5.2.2-33 Comparison of the Maximum P50 and P90 Values for NorthMet Project Proposed Action and CEC Scenario Concentrations at SW-004a for Selected Key Constituents, by Phase

Parameter	Units	Maximum P50 Operations (Mine Years 2-20)		Maximum P50 Reclamation (Mine Years 21-55)		Maximum P50 Closure & Post-Closure Maintenance (Mine Years 56-200)		Maximum P90 Operations (Mine Years 2-20)		Maximum P90 Reclamation (Mine Years 21-55)		Maximum P90 Closure & Post-Closure Maintenance (Mine Years 56- 200)	
		PA	**CEC**	**PA**	**CEC**	**PA**	**CEC**	**PA**	**CEC**	**PA**	**CEC**	**PA**	**CEC**
Sulfate	mg/L	21.9	21.7	21.8	21.7	15.8	16.4	24.2	24.1	24.3	24.2	20.1	21.6
Aluminum	µg/L	113.6	113.7	111.1	111.2	115.8	118.3	276.1	276.3	295.6	295.6	310.2	314.9
Arsenic	µg/L	1.1	1.1	1.4	1.1	2.0	1.0	2.6	2.6	2.4	2.4	2.7	2.6
Copper	µg/L	1.5	1.5	2.5	1.5	4.7	2.2	3.0	3.0	3.2	3.2	5.8	3.5
Lead	µg/L	0.4	0.4	0.7	0.4	1.5	0.5	0.9	0.9	1.0	1.0	1.9	0.9
Nickel	µg/L	1.2	1.3	6.4	1.3	19.8	1.8	3.9	3.9	9.0	3.7	26.7	4.4
Zinc	µg/L	5.7	5.7	14.2	5.7	29.8	5.4	22.4	22.4	22.5	21.9	48.7	25.4

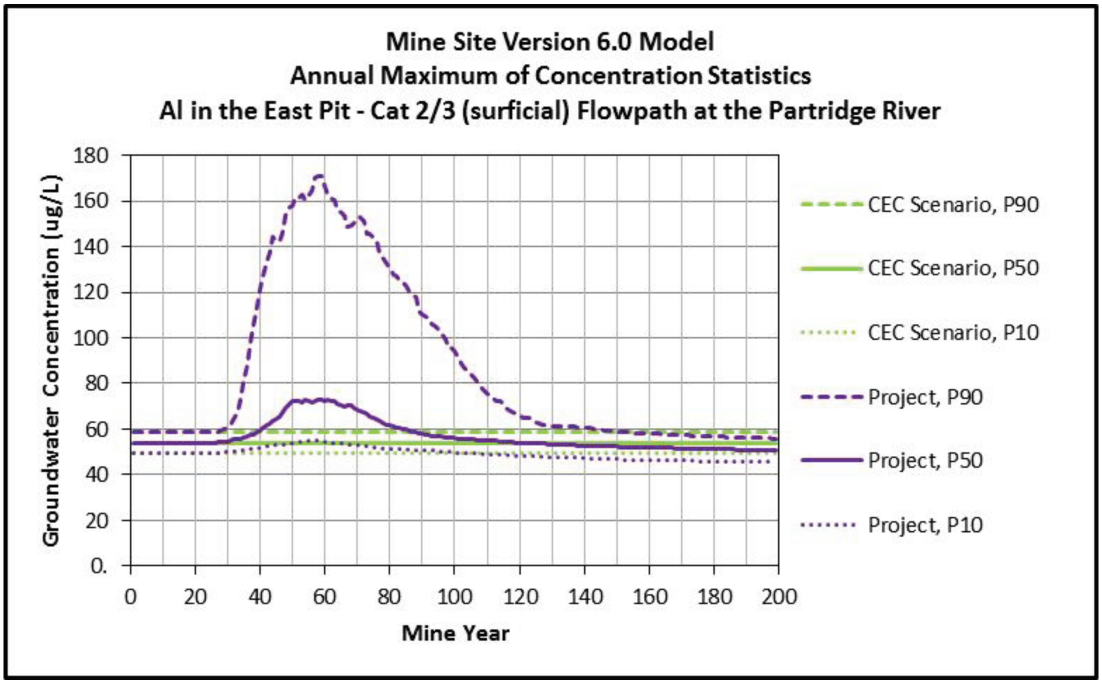
Source: PolyMet 2014v.

Notes:
CEC = Continuation of Existing Conditions
PA = NorthMet Project Proposed Action

Aluminum in the Partridge River

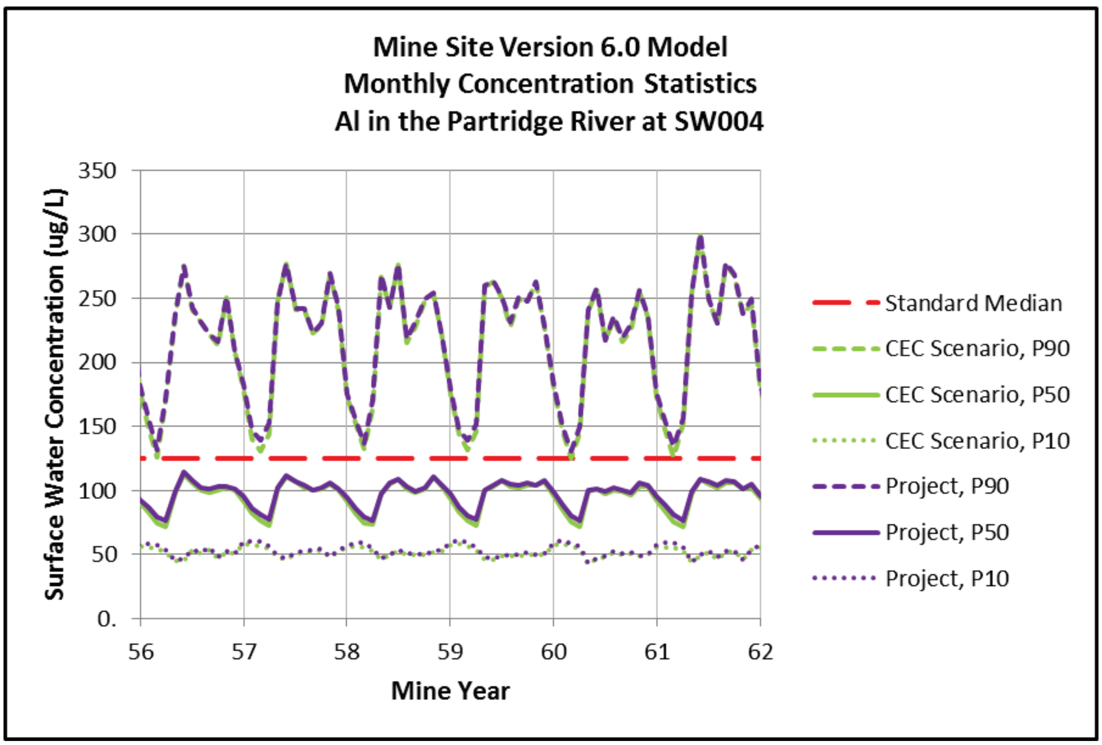
Initial screening model results indicate that the maximum P90 concentration of aluminum for the modeled NorthMet Project Proposed Action would exceed the evaluation criterion (125 µg/L) at all seven evaluation locations along the Upper Partridge River. Aluminum maximum P90 concentrations for NorthMet Project Proposed Action conditions range from 305.6 to 313.3 µg/L at the various evaluation locations (see Table 5.2.2-31). Secondary screening identified that it was likely that when Event A or B occured, the magnitude of the events is small (see Table 5.2.2-32).

Potential sources of aluminum from the NorthMet Project Proposed Action include the East Pit – Category 2/3 Stockpile, the Ore Surge Pile, the WWTF Equalization Basins, the Overburden Storage and Laydown Area, and the West Pit. For each Mine Site contaminant source, the primary constituent migration pathway would be transported as groundwater in the surficial aquifer and eventual release of affected groundwater to the Partridge River. The groundwater flowpath that provides groundwater release to the Partridge River with P90 aluminum concentrations above the surface water quality evaluation criterion of 125 µg/L is the East Pit – Category 2/3 Stockpile flowpath, which shows a "pulse" in aluminum concentrations that would peak at about 175 µg/L between years 25 and 125 (see Figure 5.2.2-30). As the 125 µg/L surface water evaluation criterion is not applicable to groundwater, this pulse in aluminum concentrations would only be a concern if it was measurable upon release to the Partridge River. Figure 5.2.2-31 shows the modeled monthly aluminum concentration for years 56 to 62 at SW-004, the first surface water evaluation location downstream of the East Pit – Category 2/3 Stockpile flowpath contribution, and captures the peak of the pulse shown in Figure 5.2.2-30. As evidenced by the CEC scenario and the NorthMet Project Proposed Action modeled concentrations being coincident in Figure 5.2.2-31, groundwater flow from the East Pit – Category 2/3 Stockpile is sufficiently diluted upon reaching the Partridge River and the flow rates small enough (see Table 5.2.2-27) such that effects from the NorthMet Project Proposed Action are not discernible.



Source: PolyMet 2014v

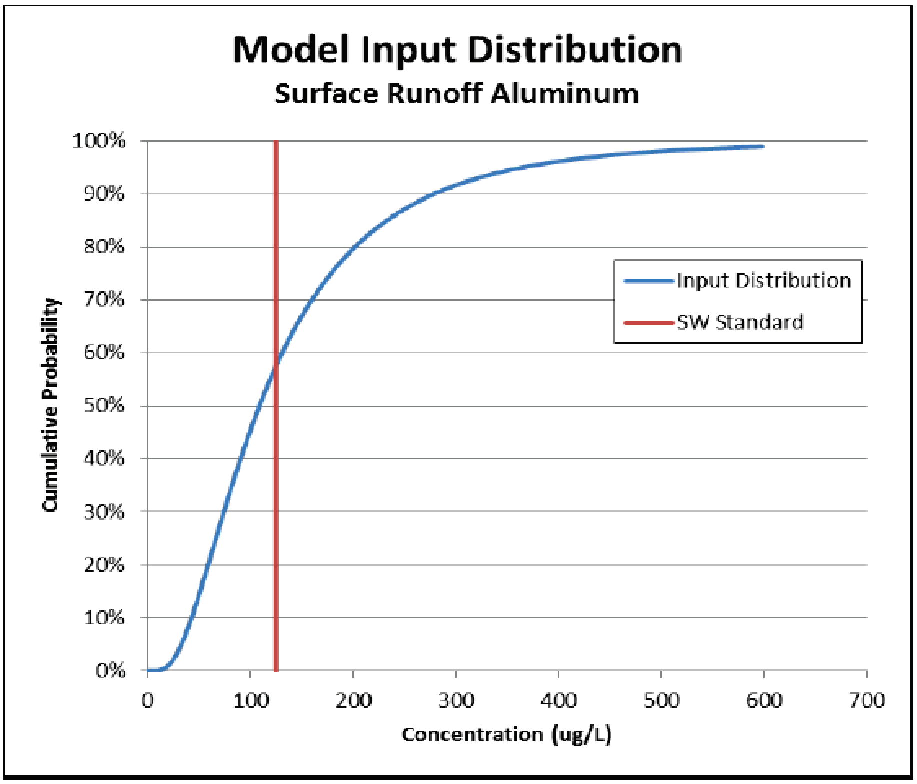
Figure 5.2.2-30 Annual Maximum Aluminum Concentrations Along the Groundwater Flowpath from the East Pit - Category 2/3 Stockpile



Source: PolyMet 2014v.

Figure 5.2.2-31 Monthly Aluminum Concentrations at SW-004

As shown in Table 5.2.2-31 comparing the modeled CEC scenario concentrations in the Upper Partridge River with the modeled NorthMet Project Proposed Action concentrations indicates that although aluminum concentrations in the Upper Partridge River would exceed the evaluation criterion, the concentrations are predicted to be about the same as they would be under the CEC scenario. Therefore, it is predicted that the NorthMet Project Proposed Action would not have a measurable adverse effect on aluminum concentrations in the Upper Partridge River. In addition, as indicated in Figure 5.2.2-32, the concentrations of aluminum in background surface runoff (i.e., non-contact water) exceed the evaluation criterion of 125 µg/L approximately 20 percent of the time. This suggests that the modeled aluminum exceedances are attributable to background surface runoff, which is naturally high in aluminum, and not to effects related to the NorthMet Project Proposed Action.



Source: PolyMet 2015m

Figure 5.2.2-32 GoldSim Input – Cumulative Probability Distribution for Aluminum in Surface Runoff

Sulfate in the Partridge River

Evaluation locations SW-005 and SW-006 are located in portions of the Partridge River that the MPCA staff has previously recommended as being waters used for production of wild rice, and therefore subject to the 10 mg/L wild rice sulfate evaluation criterion. As shown in Table 5.2.2-31, the maximum P90 sulfate concentrations at SW-005 and SW-006 for the NorthMet Project Proposed Action are 18.3 and 17.6 mg/L, respectively, which exceed the 10 mg/L criterion. The CEC scenario, however, would also exceed the wild rice evaluation criterion. The analysis below focuses on SW-005 because the NorthMet Project Proposed Action would have greater effects (higher sulfate concentrations) at this location compared to SW-006. Inspection of the GoldSim outputs verifies that predicted sulfate concentrations at SW-006 are always slightly lower than at SW-005 due to dilution effects.

SW-005 shows a dramatic reduction in sulfate concentration after mine year 55 (see Figure 5.2.2-33). Up to this time, the Northshore Mine is modeled as continuously discharging 2.6 cfs of mine water to the Partridge River with a sulfate concentration of 28 mg/L. After mine year 55, there would no longer be a Northshore Mine discharge, but the WWTF would have begun to discharging approximately 0.67 cfs to the West Pit Overflow Creek with a sulfate concentration of 9 mg/L. As a consequence, the sulfate chemical load from affected water discharged to the river would decrease after mine year 55, but P90 sulfate concentrations would still exceed the evaluation criterion.

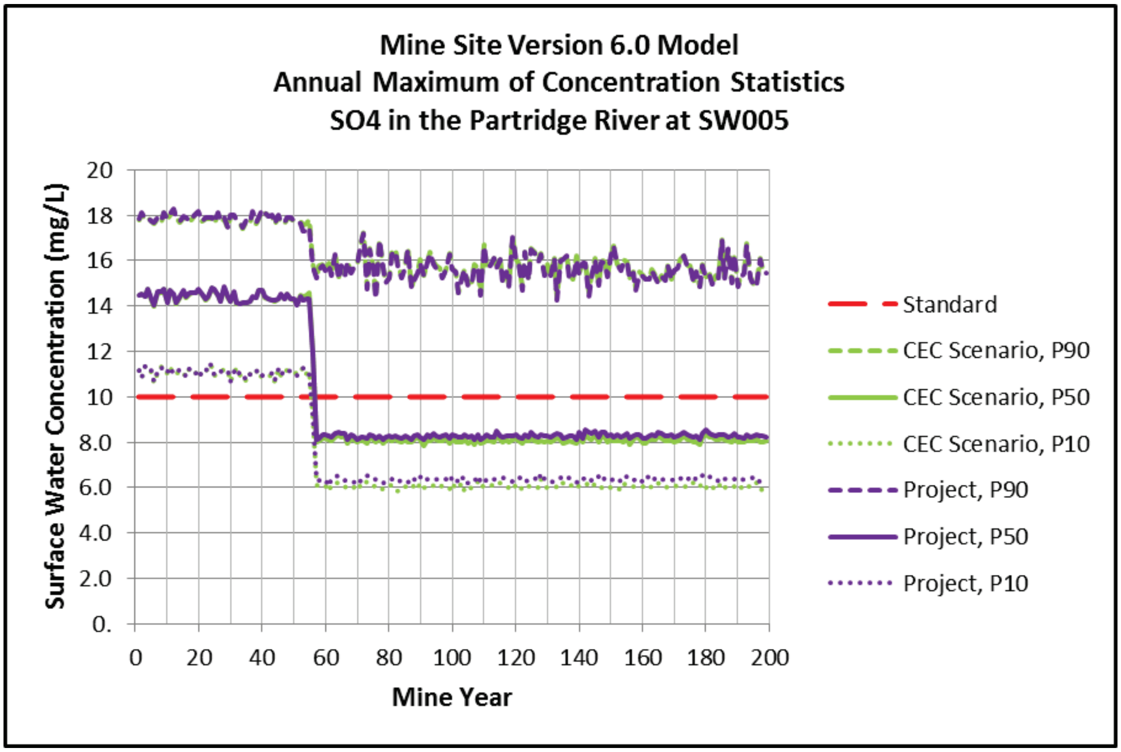


Figure 5.2.2-33 Maximum P90 of Annual Sulfate Concentration at SW-005

Monthly sulfate concentrations in the Partridge River would fluctuate with higher concentrations tending to occur during winter low flows as well as lower concentrations during the spring and summer when increased runoff occurs. For example, Figure 5.2.2-34 shows monthly sulfate concentrations for a representative time period (mine years 30-50) when the Northshore Mine discharges to the Partridge River and the WWTF discharges to the West Pit, but not to the river. Figure 5.2.2-35 is plotted for mine years 140-160 when the WWTF discharges to the Partridge River, all groundwater plumes have reached the river, and the Northshore Mine no longer discharges to the river. As can be seen on both figures, sulfate concentrations fluctuate on an annual basis, with highest concentrations during low-flow conditions (typically January and February) when there is less dilution from surface runoff, which typically has low sulfate concentrations.

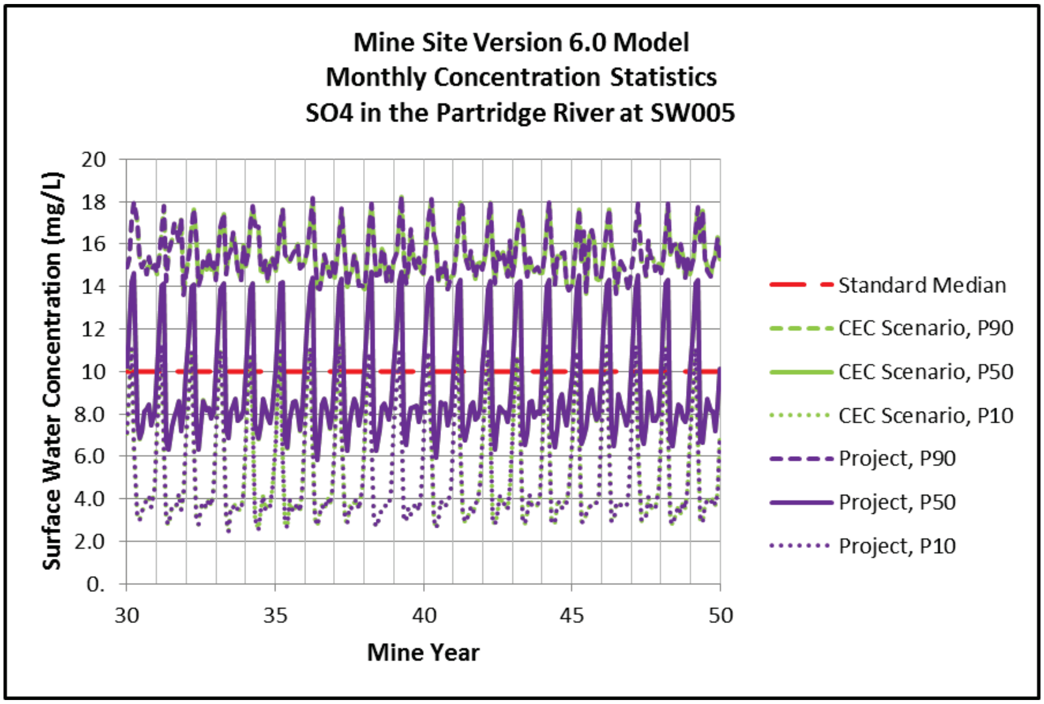


Figure 5.2.2-34 GoldSim-Predicted Sulfate Concentrations at SW-005 for Mine Years 30-50, when Northshore Mine Discharges to the Partridge River and the WWTF Discharges to the West Pit (and not to the River)

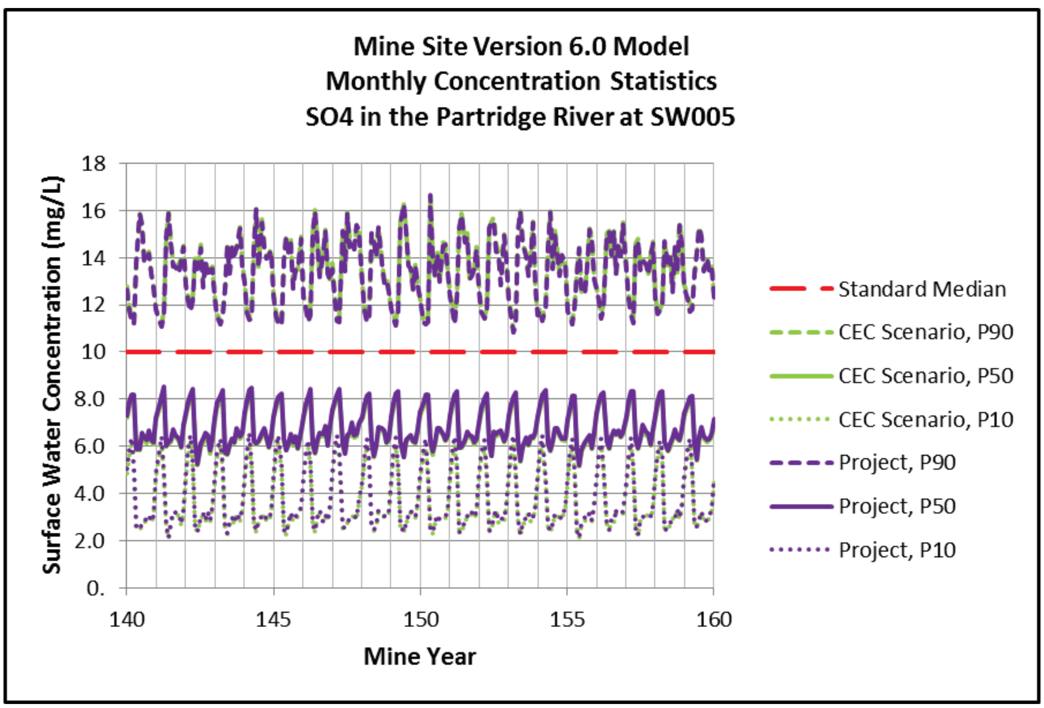


Figure 5.2.2-35 GoldSim-Predicted Sulfate Concentrations at SW-005 for Mine Years 140 -160 when the WWTF Discharges to the Partridge River, Groundwater Plumes have Reached the River, and Northshore No Longer Discharges to the River

To investigate sulfate at SW-005 in more detail, GoldSim results were evaluated on a timestep-by-timestep basis for both P50 concentrations and P90 concentrations.

Time period 0 to 55 years: During this period, sulfate concentrations at SW-005 would always exceed the evaluation criterion at the P90 level for both the CEC and NorthMet Project Proposed Action scenarios, but under both scenarios this is attributable to background runoff, background groundwater, and the Northshore Mine discharge. The NorthMet Project Proposed Action would have negligible effect on sulfate concentrations in the Partridge River during this period because it would not have any surface discharges and only groundwater from the Overburden Storage and Laydown Area and Category 2/3 Stockpile flowpaths would have reached the Partridge River (initially contributing sulfate load to the river in years 30 and 35, respectively). At SW-005, it is likely that the NorthMet Project Proposed Action would not increase the magnitude of events A or B by greater than 0.3 percent in the Partridge River (see Table 5.2.2-32).

Time period 55 to 200 years: During this period, sulfate concentrations at SW-005 would still always exceed the evaluation criterion at the maximum P90 level for both the CEC and NorthMet Project Proposed Action scenarios, but would be at lower concentrations than during the Year 0 to 55 period because Northshore Mine's discharge would cease. The NorthMet Project Proposed Action's contribution to the sulfate loading increases noticeably because the WWTF begins discharging in Year 52 and the NorthMet Project Proposed Action groundwater from other flowpaths (in addition to the OSLA and East Pit-Category 2/3 Stockpile flowpaths) begins to reach the Partridge River. The WWTF would discharge at a sulfate effluent target of 9 mg/L so it would not add to any exceedances of the evaluation criterion, rather it would provide dilution. The groundwater flowpaths would contribute small volumes (see Table 5.2.2-27), but higher sulfate concentrations to the Partridge River.

Overall, the NorthMet Project Proposed Action would account for approximately 3 percent of the sulfate loadings to the Partridge River at SW-005. The primary sources of sulfate loads would continue to be background runoff and background groundwater. At SW-005, it is likely that the NorthMet Project Proposed Action would not increase the magnitude of events A or B by greater than 1.0 percent in the Partridge River (see Table 5.2.2-32). It should be noted that the GoldSim results show that the evaluation criterion would be met essentially all the time under the NorthMet Project Proposed Action Scenario at the P50 level. A practical consequence of this result is that the effects of the NorthMet Project Proposed Action would likely not be identifiable by the proposed post-operations field monitoring program.

The small sulfate increases are explained by the small amounts of impacted and untreated water leaving the Mine Site, which only occur as groundwater. For P50 predictions during all phases of the NorthMet Project Proposed Action, the maximum amount of impacted and untreated groundwater leaving the site is 0.031 cfs (14 gpm). The maximum impact to the Partridge River would occur when this affected groundwater is released to the Partridge River during low-flow conditions. At SW-005, the average annual 1-day low flow is estimated to be 6.9 cfs (3,100 gpm) when Northshore is discharging (up to year 55) and 5.0 cfs (2,240 cfs) when only the WWTF discharges to the Partridge River (after year 52). Given the contrast between groundwater and river flows, it is apparent that the mass loading associated with groundwater flow from the Mine Site is far too small to impart a noticeable impact on sulfate concentrations in the Partridge River.

Nevertheless, a number of contingency measures could be implemented and adapted as necessary to decrease NorthMet Project Proposed Action effects on the Partridge River. As discussed in Section 5.2.2.3.5, these mitigation measures could include: 1) changes in WWTF effluent sulfate concentration and flow rate, 2) installation of surface and groundwater seepage containment systems, and 3) installation of non-mechanical groundwater treatment systems.

Effects on Surface Water Quality in the Upper Partridge River Tributary Streams

This section discusses the effects on surface water quality in the four Upper Partridge River tributary streams: West Pit Outlet Creek, Wetlegs Creek, Longnose Creek, and Wyman Creek. Surface water quality in these creeks would be affected by ore spillage from the rail cars that would transport ore from the Mine Site to the processing plant during operations. Ore would range in size from 48 inches down to small gravel and dust.

Based on observations at other mining operations using similar side-dump rail cars, it is assumed that spillage is most likely to occur along the first 1,000 meters of rail from the Rail Transfer Hopper (PolyMet 2015q). The railway does not cross any streams along this stretch. Rainfall contacting the spilled ore would have the potential to release contaminants, but the relatively small volume of material and dilution from other sources are expected to result in surface water quality meeting the evaluation criteria (PolyMet 2015q). During closure, there may be residual effects on surface water quality from the spilled ore, although the small quantity of expected spilled material would become rapidly depleted of sulfide materials compared to the much larger waste rock stockpiles (PolyMet 2015q).

Three potential ways that ore could be released to the environment during transport via rail car include: 1) ore spillage through the hinge gap, 2) ore spillage through the door gap, and 3) dust from the top of the car. To guard against possible adverse effects from spilled ore, PolyMet plans to refurbish the ore cars, tightening or replacing the couplings and linkages to minimize gaps along the hinges and joint areas where spillage could occur (PolyMet 2014a). The quantity of ore that could potentially spill through the door and hinge gaps of a single refurbished ore car is estimated to be 0.20 tons per year. This is a 97 percent reduction from the originally calculated value of 6.14 tons per year of unrefurbished cars (PolyMet 2015q).

Water quality monitoring is recommended downstream from the rail line on the Partridge River tributary streams to check for any potential deteriorations of water quality over time from ore spillage, and, if detected, adaptive water management measures would be implemented. Dust could be mitigated by spraying water on the loaded ore prior to transport. If significant accumulation of ore spillage occurs, it would be removed.

The West Pit Outlet Creek would also receive effluent from the WWTF during closure, which is estimated at an annual average discharge rate of 0.65 cfs. The WWTF is designed to meet all surface water quality standards with its discharge.

Effects on Surface Water Quality in Colby Lake and Whitewater Reservoir

Secondary screening for Colby Lake constituents with hardness-based evaluation criteria is shown in Table 5.2.2-32. As indicated on the table, there are no hardness-based constituents that exceed screening evaluation thresholds for frequency and magnitude of potential impacts. Table 5.2.2-34 provides maximum P90 concentrations for Colby Lake along with the initial screening results for constituents that do not have hardness-based evaluation criteria. As indicated in Table

5.2.2-34, aluminum, arsenic, iron, and manganese have maximum P90 concentrations that exceed their associated evaluation criteria. However, only arsenic has a maximum P90 NorthMet Project Proposed Action concentration greater than corresponding CEC concentration; therefore, it is retained for further evaluation in secondary screening (Table 5.2.2-32).

Table 5.2.2-34 Colby Lake – Maximum P90 Solute Concentration Over Entire 200-Year Simulation with Initial Screening of Constituents without Hardness-Based Evaluation Criteria

Parameter	Colby Lake Evaluation Criteria	Units	CEC Scenario	PA	% Change from CEC Scenario
General					
Alkalinity	NA	mg/L	130	129	-0.3%
Calcium	NA	mg/L	35.1	35.1	0%
Chloride	230	mg/L	15.3	15.3	-0.2%
Fluoride	4	mg/L	0.19	0.19	0.2%
Hardness	500	mg/L	133	133	-0.3%
Magnesium	NA	mg/L	14.0	14.0	0%
Potassium	NA	mg/L	4.00	3.97	-0.6%
Sodium	NA	mg/L	12.0	12.0	0.1%
Sulfate	250	mg/L	69.8	69.3	-0.9%
TDS	500	mg/L	150	150	-0.1%
Metals Total					
Aluminum[2]	125	µg/L	266	266	-0.3%
Antimony	5.5	µg/L	0.26	0.48	85.9%
Arsenic	2	µg/L	2.44	**2.46**	0.9%
Barium	2,000	µg/L	16.7	16.9	1.1%
Beryllium	4	µg/L	0.11	0.12	6.7%
Boron	500	µg/L	167	167	-0.2%
Cadmium	NA[1]	µg/L	0.17	0.20	18.5%
Chromium III	NA[1]	µg/L	1.28	1.28	-0.1%
Cobalt	2.8	µg/L	1.22	1.26	3.3%
Copper	NA[1]	µg/L	9.83	9.88	0.5%
Iron[2]	300	µg/L	5,043	5,034	-0.2%
Lead	NA[1]	µg/L	1.26	1.31	3.4%
Manganese[2]	50	µg/L	207	202	-2.2%
Nickel	NA[1]	µg/L	4.42	5.43	22.9%
Selenium	5	µg/L	1.29	1.29	0.3%
Silver	1	µg/L	0.11	0.11	0.9%
Thallium	0.28	µg/L	0.07	0.08	0.5%
Vanadium	NA	µg/L	1.83	2.03	11.3%
Zinc	NA[1]	µg/L	26.7	27.6	3.6%

Source: PolyMet 2014v.

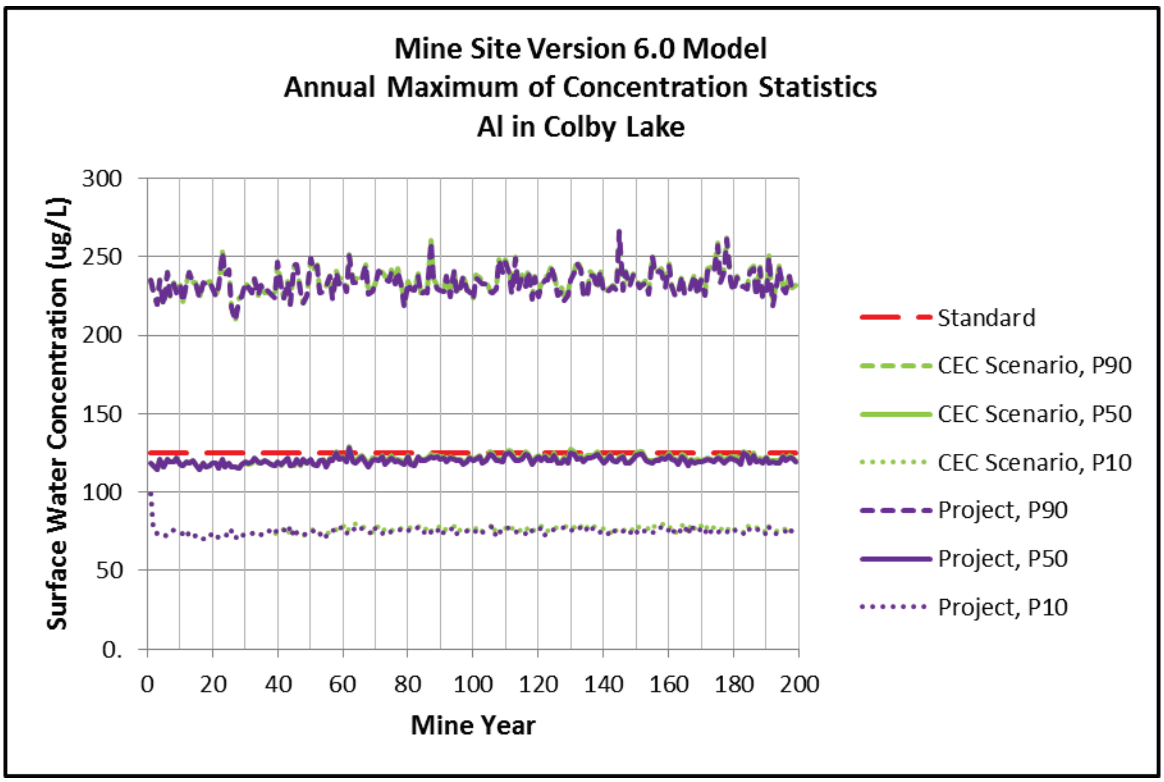
Notes:
CEC = Continuation of Existing Conditions
PA = NorthMet Project Proposed Action
Bold value indicates the constituent is retained for secondary screening
[1] Parameter has a hardness-based evaluation criterion and is screened using the secondary screening procedure (see Table 5.2.2-32).
[2] Carried forward to secondary screening because it is a constituent of interest.

Table 5.2.2-34 above also shows the percent change from the CEC scenario model results. The percent change can appear quite large, but the absolute change is quite small, especially when compared with the evaluation criteria. A good example is nickel, which has a maximum P90 value that increases 22.9 percent, but the absolute increase is approximately 1 µg/L, and the NorthMet Project Proposed Action maximum P90 value (5.43 µg/L) is still well below the evaluation criteria (43.3 µg/L). Note that for aluminum, iron, and manganese, the maximum P90 concentration for CEC is lower than the comparable value for the NorthMet Project Proposed Action. For arsenic, the CEC value is lower by 0.9 percent.

All constituents evaluation for Colby Lake passed secondary screening, so no further analysis is required. However, four constituents were evaluated further because they are of interest.

Aluminum

Model results indicate that the maximum P90 concentration of aluminum (266 µg/L) would exceed the evaluation criteria (125 µg/L) in Colby Lake, just as it is predicted to exceed along most of the Partridge River (see Figure 5.2.2-36). Though intial screening shows a slight decrease in concentraions, this constituent was retained for secondary screening (see Table 5.2.2-32) and is discussed further below.



Source: PolyMet 2014v.

Figure 5.2.2-36 Colby Lake Annual Maximum Aluminum Concentrations

Higher aluminum concentrations would typically occur between April and November, when surface runoff would contribute proportionately more to river flow than groundwater baseflow. Concentrations of aluminum in background surface non-contact water would exceed the water quality evaluation criteria approximately 20 percent of the time, whereas aluminum in groundwater would almost never exceed the evaluation criteria.

As indicated in Table 5.2.2-34 and Figure 5.2.2-36, the NorthMet Project Proposed Action would not cause Colby Lake aluminum to increase in comparison to the CEC scenario. For P10, P50, and P90 annual maximum curves on Figure 5.2.2-36, the NorthMet Project Proposed Action curves are nearly identical to the CEC curves. In Table 5.2.2-33, the maximum P90 concentration for the Proposed Action (310.2 µg/L) is slightly less than the comparable P90 for CEC (314.9 µg/L). The conclusion is that aluminum would likely exceed the evaluation criterion in Colby Lake, but the NorthMet Project Proposed Action would not cause concentrations to be noticeably higher than what would occur without the NorthMet Project Proposed Action.

Further, aluminum has not been an issue for the City of Hoyt Lakes. For municipal drinking water, the City currently treats raw water from Colby Lake with alum and produces drinking water that meets applicable regulatory standards. The City is not required to monitor for aluminum, as there is no human health-based drinking water standard for aluminum.

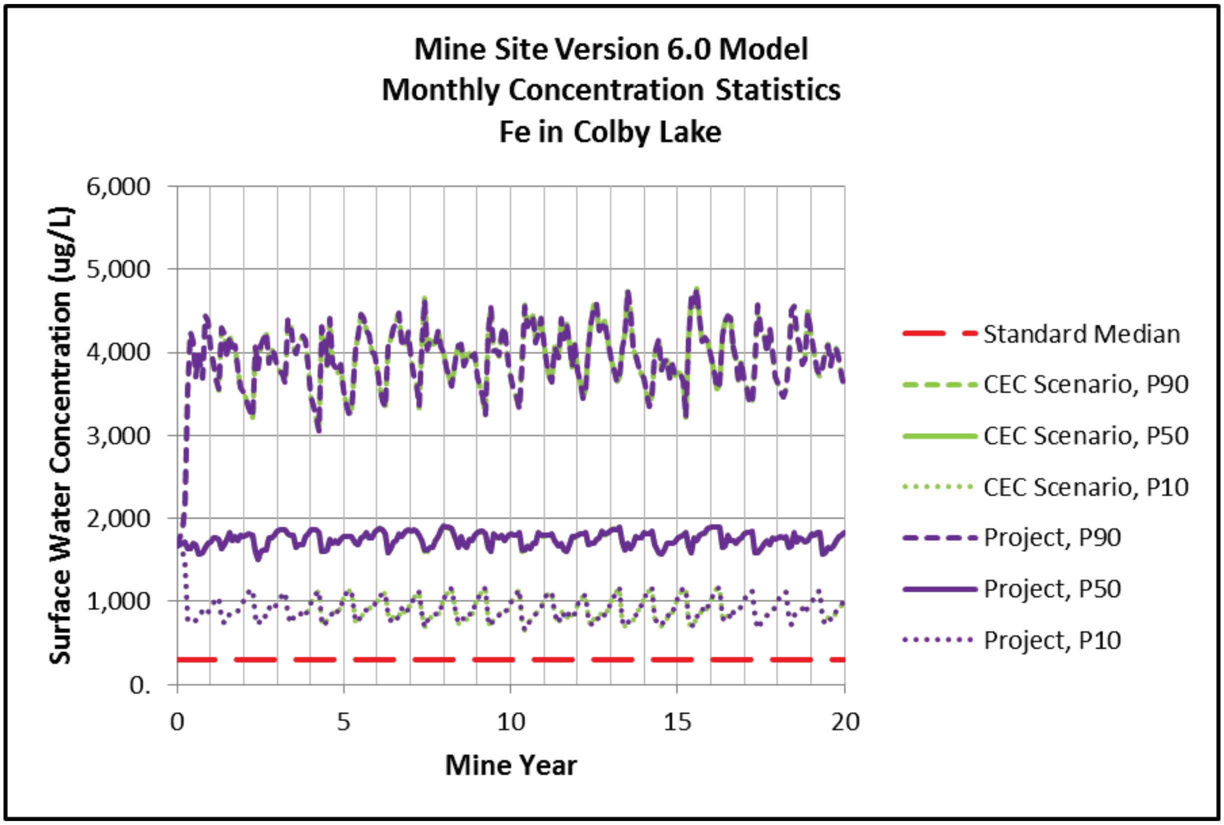
Iron and Manganese

Because Colby Lake is used as a drinking water source by the City of Hoyt Lakes, the USEPA sMCL evaluation criteria apply: 300 µg/L for iron and 50 µg/L for manganese. Measured background iron and manganese concentrations in Colby Lake are high and usually exceed their respective evaluation criteria. Over 90 percent of the background iron samples exceed the iron evaluation criteria and approximately 80 percent of the manganese samples exceed the manganese evaluation criteria.

As shown in the initial screening Table 5.2.2-34 for Colby Lake, the GoldSim-predicted maximum P90 concentrations for iron and manganese exceed the applicable evaluation criterion and therefore require further evaluation. Table 5.2.2-35 shows GoldSim-predicted maximum P50 and maximum P90 concentrations for three NorthMet Project Proposed Action phases; operations, reclamation, as well as closure and long-term maintenance. The following observations are made from this table:

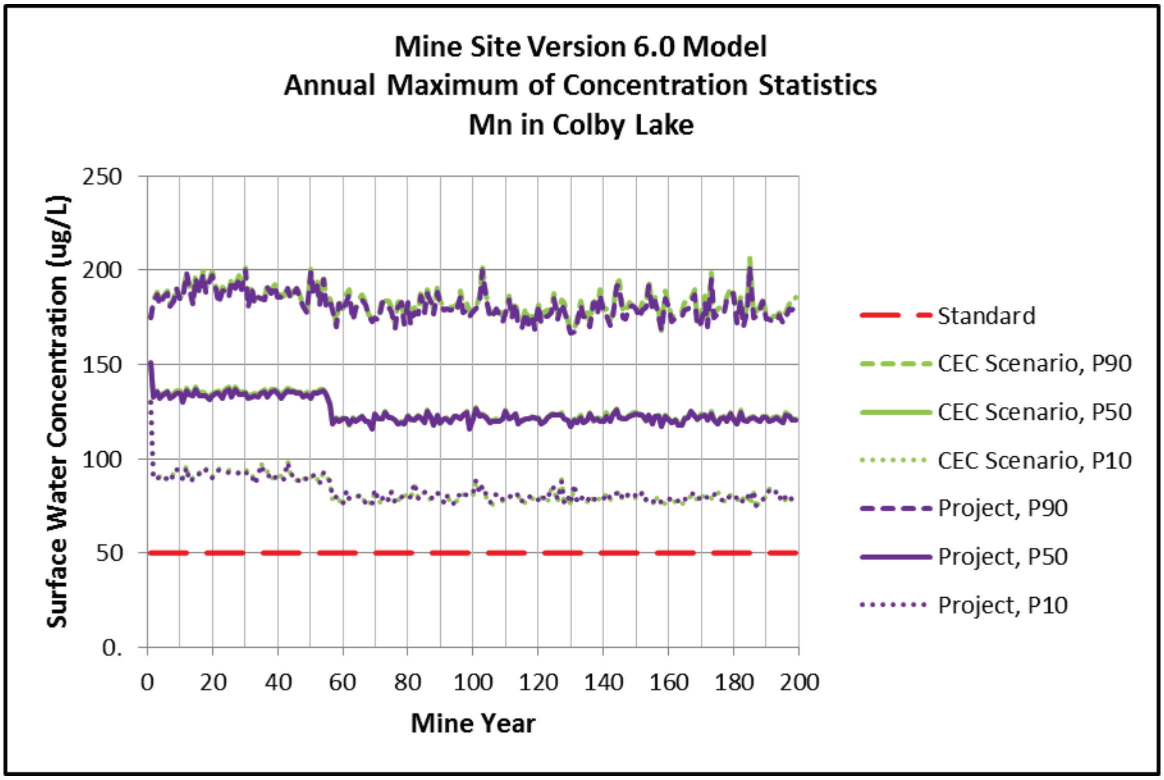
- All maximum P50 and maximum P90 values for iron and manganese exceed the applicable evaluation criterion for both the NorthMet Project Proposed Action and CEC scenarios.
- For manganese, all maximum P50 and maximum P90 values for the NorthMet Project Proposed Action are lower than the comparable CEC scenario (see Figure 5.2.2-38). It is therefore concluded that the NorthMet Project Proposed Action would not cause a manganese impact to Colby Lake above and beyond what would occur without the NorthMet Project Proposed Action.
- For iron, the maximum P50 and maximum P90 values for the NorthMet Project Proposed Action are lower than the comparable CEC scenario for the reclamation phase and the closure and long-term maintenance phase, but not for the operations phase. Iron for the operations phase therefore requires further evaluation.

Figure 5.2.2-37 is a plot of GoldSim-predicted monthly P10, P50, and P90 iron concentrations for iron in Colby Lake during the operations phase (mine years 0 to 20). Inspection of this figure shows that the P10, P50, and P90 lines for the NorthMet Project Proposed Action are either identical or extremely close to the comparable lines for the CEC scenario. Given this result and the observations made in Table 5.2.2-35, it is concluded that the NorthMet Project Proposed Action would not cause an iron impact to Colby Lake above and beyond what would occur without the NorthMet Project Proposed Action.



Source: PolyMet 2014v.

Figure 5.2.2-37 Monthly Iron Concentration in Colby Lake for the Operations Phase (Mine Years 0 to 20)



Source: PolyMet 2014v.

Figure 5.2.2-38 Colby Lake Annual Maximum Manganese Concentrations

Table 5.2.2-35 GoldSim-Predicted Maximum P50 and Maximum P90 Concentrations of Iron and Manganese in Colby Lake for Different Project Phases

Parameter	Evaluation Criterion	Operations (years 2-20)		Reclamation (years 21-55)		Post-Closure Maintenance (years 56-200)	
		PA	CEC	PA	CEC	PA	CEC
a. Maximum P50 of Annual Concentrations from GoldSim Output							
Iron	300	1,904	1,898	1,952	1,953	1,903	1,932
Manganese	50	136	138	137	138	129	130
b. Maximum P90 of Annual Concentrations from GoldSim Output							
Iron	300	4,771	4,763	4,931	4,932	5,034	5,043
Manganese	50	198	200	200	202	202	207

Notes:
CEC = Continuation of Existing Conditions
PA = NorthMet Project Proposed Action
Highlighted values indicate that the PA > CEC and both concentrations are above the evaluation criterion.

<u>*Arsenic*</u>

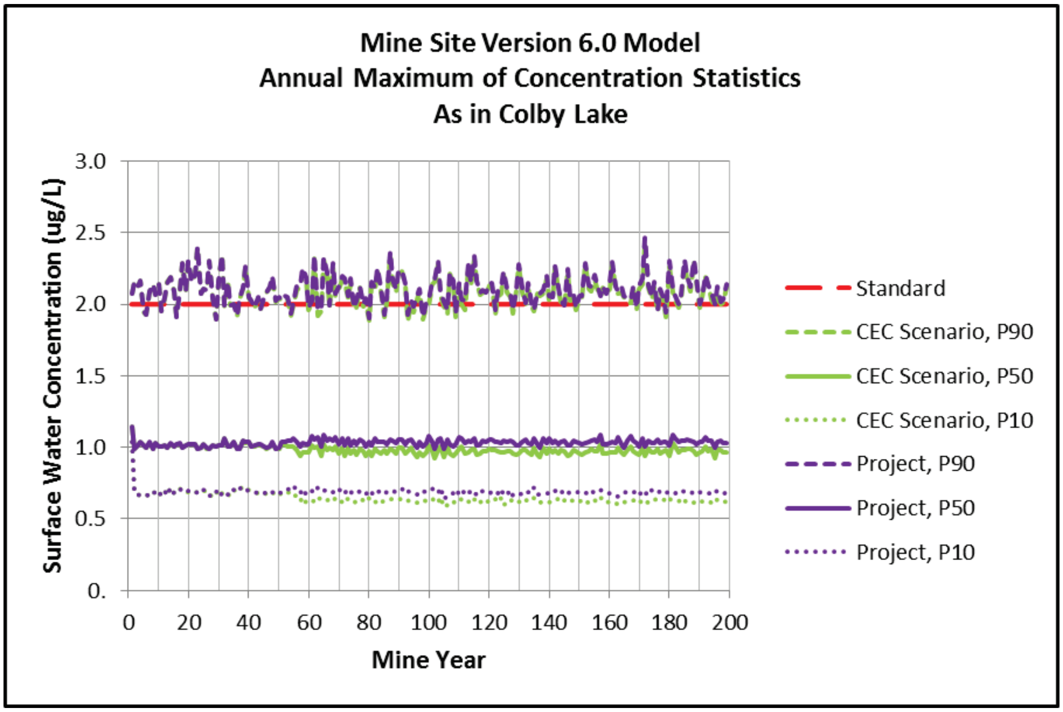
As shown by bold font in Table 5.2.2-34, the maximum P90 concentration for arsenic in Colby Lake (2.46 µg/L) exceeds the evaluation criterion (2 µg/L). As a consequence, the GoldSim-predicted arsenic in Colby Lake was identified as requiring secondary screening. Though it passed secondary screening, additional details are provided below because it is a constituent of interest.

GoldSim model output indicates that the dominating chemical controls on arsenic concentrations in Colby Lake are natural surface runoff, natural groundwater baseflow, and contaminant sources contributing directly to Colby Lake, all of which are not related to the NorthMet Project Proposed Action. While much less important, other sources include Northshore discharge which operates for mine years 0 to 55 and WWTF discharge to the Partridge River, which begins about mine year 52.

To investigate the source and significance of arsenic in more detail, Figure 5.2.2-39 is a plot of the predicted P10, P50, and P90 of annual maximum arsenic concentrations for years 0 to 200 (purple lines). Also shown (in red) is the Colby Lake arsenic evaluation criterion of 2 µg/L. As observed on the plot, the NorthMet Project Proposed Action concentrations are virtually identical to CEC concentrations up to mine year 52. After that time, the NorthMet Project Proposed Action concentrations are slightly higher than the CEC concentrations; however, the difference is less than about 0.05 µg/L. The slight increase in NorthMet Project Proposed Action concentrations after mine year 52 results from the partially offsetting effects of: 1) ending of low-concentration (1.33 µg/L) Northshore discharge to the Partridge River that provides a dilution effect in the Lake; and 2) the beginning of WWTF discharge to the Partridge River with an arsenic concentration of 4 mg/L, which increases the arsenic concentration in the Lake. This increase in loading from the WWTF is only partially offset by the decrease from the cessation of the Northshore discharge, so the overall result is a slight increase in Colby Lake arsenic concentrations after year 52. Also observed on Figure 5.2.2-39 is that only the annual maximum P90 concentrations exceed the standard.

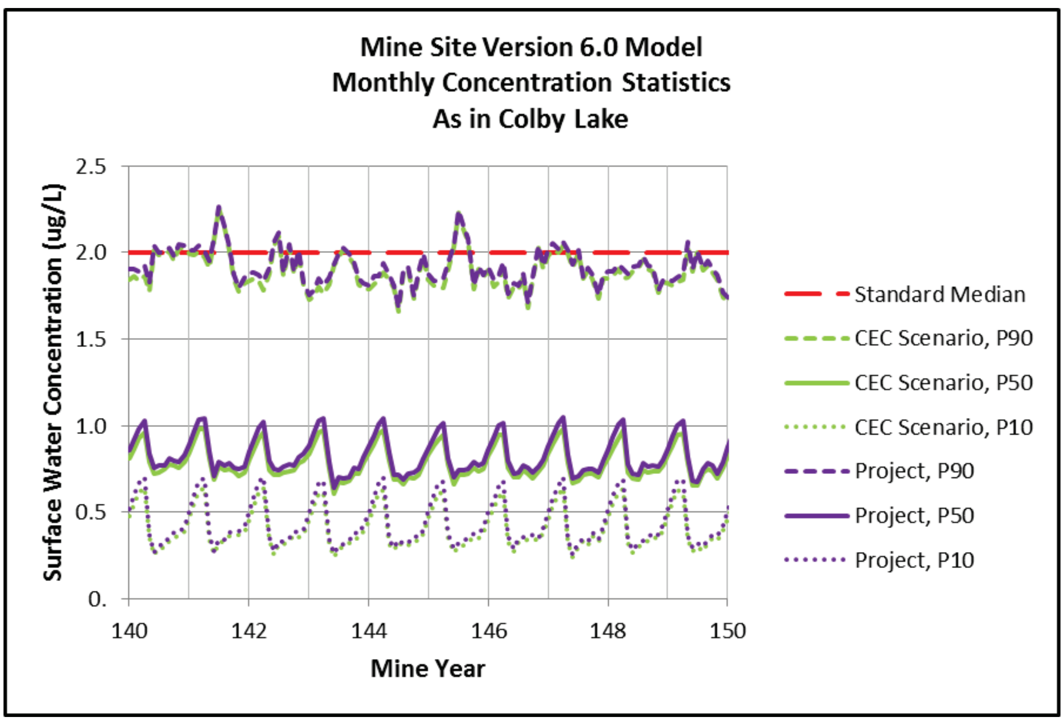
Figure 5.2.2-40 compares *monthly* P10, P50, and P90 concentrations with the evaluation criteria for a representative time period after the beginning of mine-affected groundwater emerge in the Partridge River. As can be seen on the graph, when the P90 concentrations are predicted to exceed the standard (most notably during mine years 141 and 145), the NorthMet Project Proposed Action concentrations are virtually identical to the CEC scenario concentrations. An analysis of other time periods showed a similar result. This observation indicates that for conditions where the arsenic standard would be exceeded in Colby Lake, the NorthMet Project Proposed Action would not cause higher concentrations compared to what would occur for the CEC scenario. It is therefore concluded that the NorthMet Project Proposed Action would not cause arsenic exceedances in Colby Lake above and beyond what would occur without the NorthMet Project Proposed Action.

Finally, pilot testing of RO treatment concluded that arsenic is effectively removed by the greensand filter which produces filter effluent with arsenic concentrations that were well below the Class 2Bd water quality standard for all three sampling events (Barr 2013f) as well as the drinking water standard for Colby Lake (2 µg/L). Therefore, the assumed modeled effluent concentrations of the WWTF may be higher than what would actually be produced.



Source: PolyMet 2014v.

Figure 5.2.2-39 Colby Lake Annual Maximum Arsenic Concentrations



Source: PolyMet 2014v.

Figure 5.2.2-40 Colby Lake Monthly Arsenic Concentration Statistics

<u>*Whitewater Reservoir*</u>

The NorthMet Project Proposed Action is predicted to have negligible effects on water quality in Whitewater Reservoir because only high Partridge River flows would be diverted into the reservoir from Colby Lake, which would coincide with the periods when any contaminants from the NorthMet Project Proposed Action would be diluted and because the water quality of Colby Lake is predicted to meet evaluation criteria, prior to dilution, except for the four parameters (i.e., aluminum, arsenic, iron, and manganese) that are explained above.

Water Quality Effects in the Lower Partridge River

Although not specifically modeled, water quality in the Lower Partridge River would be expected to reflect the water quality condition of water flowing out of Colby Lake. As discussed above, under the NorthMet Project Proposed Action Colby Lake water is predicted to meet all water quality evaluation criteria other than for aluminum, arsenic, iron, and manganese, which are attributable to natural background conditions. The contaminant load in flow from Colby Lake attributable to the NorthMet Project Proposed Action would be further diluted downstream as the watershed area increases. The NorthMet Project Proposed Action would not result in any new surface water discharges (other than stormwater runoff from the processing plant area and Second Creek flow augmentation) or groundwater seepage that would affect the water quality of the Lower Partridge River that are not already accounted for in predicted upstream water quality.

These contaminant loads from the NorthMet Project Proposed Action, however, could contribute to cumulative effects in combination with contaminant loading from other projects. See Section 6.2.2.

Surface water currently seeps at a rate of approximately 227 gpm from the existing LTVSMC Tailings Basin to the headwaters of Second Creek. This seepage is currently partially blocked by a cutoff berm and trench and collected in a sump and pumped back to the Tailings Basin pond. Under the NorthMet Project Proposed Action, this seepage is predicted to continue during mine operations (550 gpm), reclamation, and closure and long-term maintenance (80 gpm). The NorthMet Project Proposed Action would install an engineered containment system south of the Tailings Basin designed to ensure that 100 percent of the seepage is captured during operations and closure and post-closure maintenance, this seepage would continue to be pumped to either the Tailings Basin pond or the WWTP. To mitigate the reduction of flow to Second Creek, under the NorthMet Project Proposed Action, WWTP effluent would be used to augment flow to Second Creek in closure at a minimum flow rate equal to about 80 percent of the uncaptured flow rate (or about 184 gpm). Since the effluent from the WWTP is designed to meet surface water quality standards, this discharge is not expected to cause any exceedance of water quality evaluation criteria.

NorthMet Project Proposed Action Solute Contribution Over Time

The NorthMet Project Proposed Action is predicted to meet most groundwater and surface water quality evaluation criteria at evaluation locations for all mine phases (operations, reclamation, and closure and post-closure maintenance). There is value, however, in understanding how the NorthMet Project Proposed Action would contribute to the solute load in the Partridge River over time.

The NorthMet Project Proposed Action would contribute contaminant loads to the Partridge River from seven groundwater sources: Overburden Storage and Laydown Area, Ore Surge Pile, Category 2/3 Stockpile, WWTF equalization basins, East Pit, West Pit, and the Category 1 Stockpile (which provides seepage to the West Pit and bedrock flowpaths). As shown in Table 5.2.2-36, four of these sources are temporary and would not be present during closure. The loadings from these features would not occur after the feature is removed and the associated peak concentrations in groundwater reaching the Partridge River would occur before 200 years. The East Pit, West Pit, and Category 1 Stockpile are permanent features that would continue to provide contaminant loading for a minimum of 200 years. Also contributing contaminant loads to the Partridge River would be the WWTF effluent discharge, which would continue to operate during closure and post-closure maintenance.

Table 5.2.2-36 Estimated Times for Affected Water to Reach the Partridge River

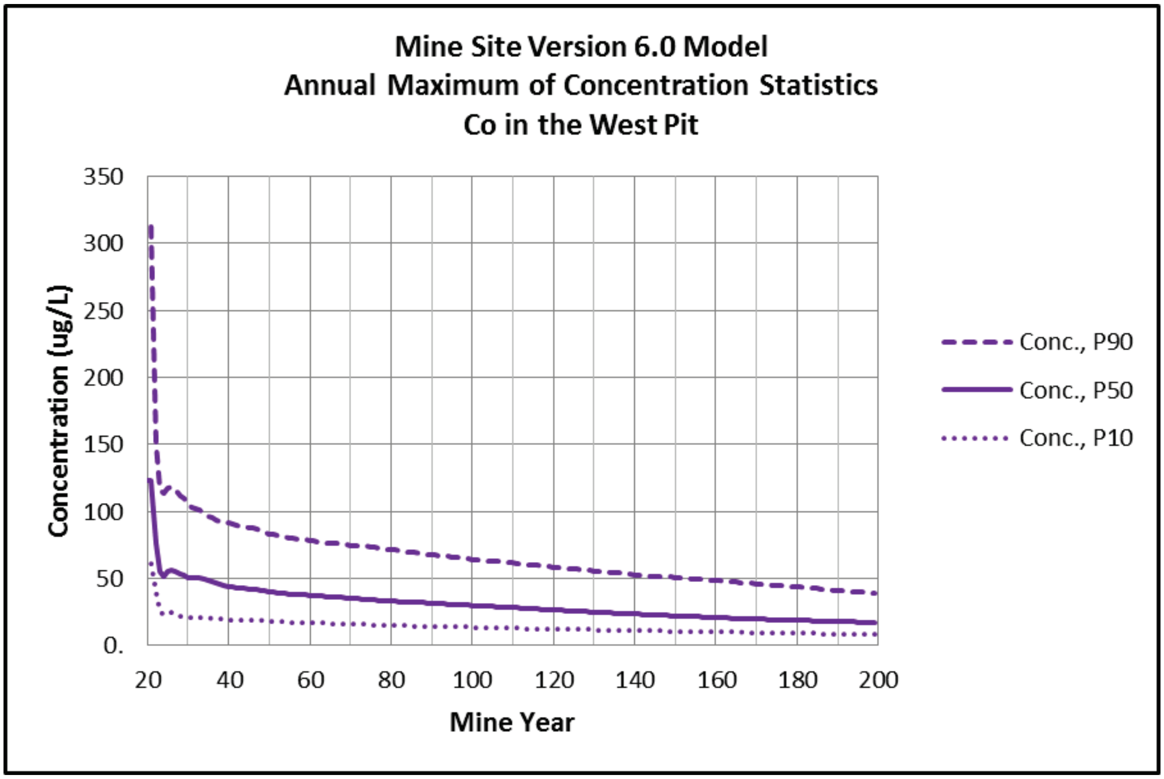
Source	Flow Rate from Source into Surficial GW Flowpath[3] (gpm)	Time Period that Source is Active[3] (Mine Year)	Time for Peak Loading at Partridge River[4] (Mine Year)
Overburden Storage and Laydown Area	14.0	0 to 20	60[(1)]
Ore Surge Pile	0.00116	0 to 21	155
Category 2/3 Stockpile	0.0194	0 to 20	55
WWTF Pond leakage	0.0135	0 to 52	160
East Pit	3.75	20 onward	150
West Pit (receives seepage from Category 1 Stockpile)	6.09	48 onward	160
WWTF discharge[2] (receives seepage from Category 1 Stockpile)	290	52 onward	52 onward

Notes:
GW = Groundwater
1 For most constituents, source causes a concentration decrease in the flowpath; reported time is for minimum river loading.
2 Discharge of WWTF effluent directly into the river.
3 Based on GoldSim deterministic run with P50 inputs.
4 Based on P50 results for GoldSim probabilistic run.

The backfilled East Pit, Category 1 Stockpile, and flooded West Pit would be the only permanent mine features and would continue to contribute solute load to the surficial aquifer that eventually releases to the Partridge River. The small volume of seepage from the Category 1 Stockpile that would not be captured by the containment system would contribute solutes to the West Pit. This seepage would be expected to reduce in quantity over time as the Category 1 Stockpile geomembrane and vegetative cover is established, although concentrations are not expected to improve because most solutes are at their concentration caps.

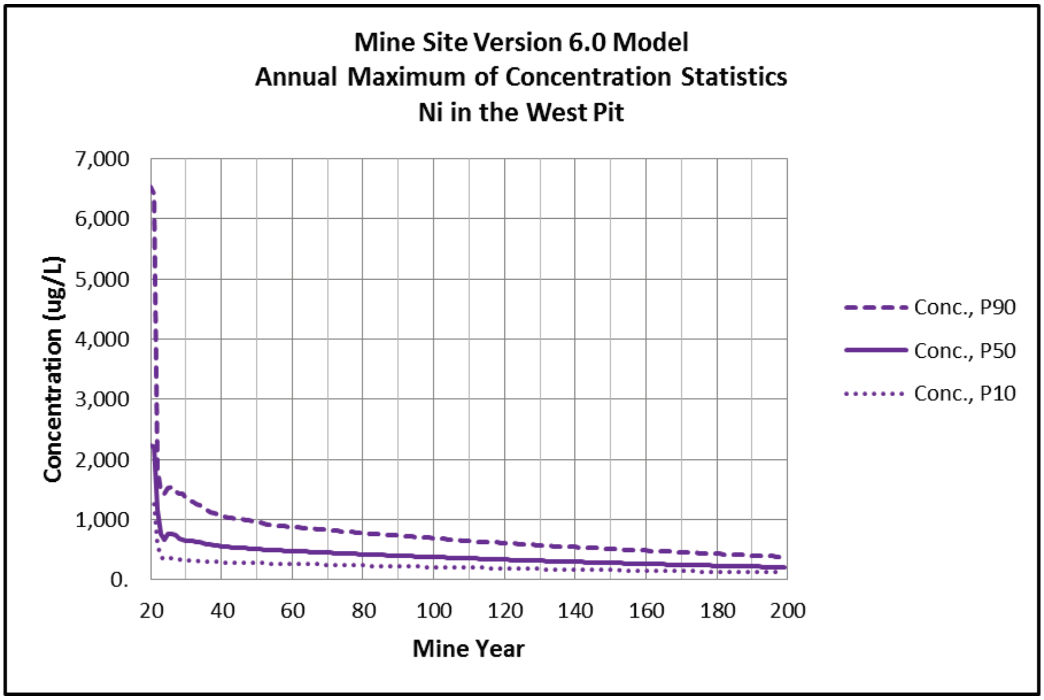
Under the NorthMet Project Proposed Action, the water levels in the West Pit would be controlled by water pumped to the WWTF for treatment. The WWTF is considered a long-term facility that would require ongoing maintenance.

The water quality of both mine pits, however, is predicted to improve over time as the pits become flooded, thereby effectively eliminating oxidation of the pit walls, the primary source of solutes, except for the upper few feet where water levels may fluctuate. Figures 5.2.2-41, 5.2.2-42, and 5.2.2-43 show how the water quality in the West Pit is predicted to improve over time for three representative solutes: cobalt, nickel, and sulfate. It is expected that eventually the solute concentrations in the pits would stabilize to more or less steady-state values, although the timeframe for this would likely be greater than 200 years as indicated by Figures 5.2.2-41 to 5.2.2-43, which show solute concentrations continuing to decrease at year 200, although still above the evaluation criterion. These predicted improvements in water quality suggest that the WWTF may not need to operate permanently, but that at some point, non-mechanical treatment systems may be sufficient to meet water quality based effluent limits.



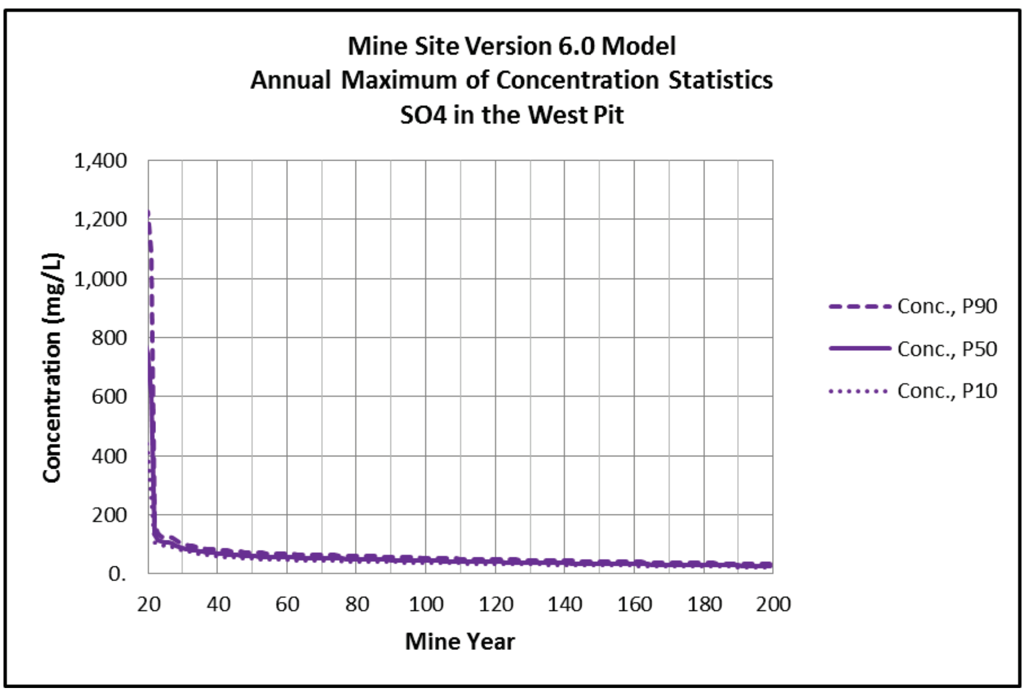
Source: PolyMet 2014v.

Figure 5.2.2-41 Cobalt Concentration in the West Pit during Reclamation, Closure, and Post-Closure Maintenance



Source: PolyMet 2014v.

Figure 5.2.2-42 Nickel Concentration in the West Pit during Reclamation, Closure, and Post-Closure Maintenance



Source: PolyMet 2014v.

Figure 5.2.2-43 Sulfate Concentration in the West Pit during Reclamation, Closure, and Post-Closure Maintenance

The only long-term sources of solutes from the NorthMet Project Proposed Action would be groundwater seepage from the East Pit and West Pit (which includes Category 1 Stockpile seepage), with a combined total flow rate of about 10 gpm and the WWTF effluent discharge of about 290 gpm.

Sensitivity of Model Predictions to Hydrologic Inputs

The sensitivity of the GoldSim model was evaluated for changes to groundwater baseflow rates and climate change to determine what effect they have on model predictions. The following sections summarize the sensitivity analysis findings for the Mine Site.

High Groundwater Baseflow Scenario

An analysis of 2 years of stream flow data collected at SW-003 gave low-flow values of 1.2 to 1.8 cfs (MDNR 2013i), which are higher than the groundwater baseflow used in GoldSim at that location (0.51 cfs). Upon additional evaluation, the Co-lead Agencies concluded that the low-flow values determined from the SW-003 gaging data could not be used to reliably estimate groundwater baseflow due to the complicating effects of Northshore discharges that assuredly affected the SW-003 stream flows (MDNR et al. 2014b).

However, to investigate the theoretical effects of higher groundwater baseflows on model predictions, the Co-lead Agencies directed PolyMet to perform a high groundwater baseflow (HGB) scenario that increased groundwater baseflows at all locations in the Partridge River to 4 times higher than the values used to inform this FEIS. While this increase was not considered physically realistic, it provided an HGB scenario that could be used to assess FEIS model sensitivity to groundwater baseflow. The HGB scenario included a complete recalibration of the Mine Site MODFLOW model and recalibration of surface runoff concentrations using the current-conditions Goldsim model. Compared to the FEIS MODFLOW model, the HGB MODFLOW model (Barr 2015d, Appendix K) generally predicted:

- Faster groundwater migration in the surficial flowpaths and shorter travel times to evaluation locations;
- Slightly higher groundwater inflow rates into the West Pit and associated faster pit flooding; and
- Moderately higher groundwater inflow rates into the East Pit and associated faster backfill saturation.

The recalibrated HGB MODFLOW model did not predict a groundwater flow rate between the Central and West Pit via bedrock that is significantly different from the predictions of the FEIS model.

To evaluate water quality predictions, the results of the recalibrated MODFLOW model simulations were used as inputs to the HGB version of the GoldSim model. Because the adjustment of the estimated groundwater baseflow in the Partridge River changed the ratio of groundwater to surface water runoff in the river, the calibration process for estimating surface runoff chemical concentrations was repeated for HGB analysis as well.

Results of the HGB scenario were compared with the FEIS model results to evaluate the degree to which predicted the NorthMet Project Proposed Action impacts are sensitive to baseflow and related model inputs.

The HGB Goldsim model run predicted generally higher NorthMet Project Proposed Action-related chemical concentrations that would occur sooner than what was predicted in the FEIS model for some constituents. However, peak concentrations remained below evaluation criteria for most parameters. The HGB results showed that, although the estimated concentrations in the groundwater and surface water are moderately sensitive to Partridge River baseflows, the NorthMet Project Proposed Action's ability to comply with the applicable groundwater and surface water evaluation criteria is not a concern.

The comparison of the FEIS and HGB models indicate increased chemical loadings at the upgradient end of the flowpaths (due to higher groundwater flow rates). However, concentration increases due to the increased loading are offset by: 1) increased dilution from aquifer recharge water along the flowpath, and 2) increased dilution in the river from higher baseflows during winter low-flow conditions. In other words, for low (i.e., winter) streamflow conditions, the higher contaminant mass loading into the river was offset by dilution associated with the higher river groundwater baseflows.

Despite the conservative nature of this HGB GoldSim model, its predicted chemical concentrations remained below the applicable groundwater and surface water quality evaluation criteria (Barr 2015d, Appendix K).

Climate Change Sensitivity Analysis

The potential effects of a climate change upon the predictions of a GoldSim probabilistic model (the Project Model) were evaluated by running the "climate change sensitivity analysis." The ranges of precipitation and temperature input parameters were varied following the guidance provided by the Co-lead Agencies (Kellogg 2011). In summary, the Climate Change Sensitivity Analysis Model was set by increasing: 1) the mean annual temperature by 2.0 to 5.2 degrees Celsius, 2) the mean annual precipitation from 28.1 to 29.8 in/yr, and 3) the mean annual open water evaporation by 6.5 percent. The parameter values were linearly increased from mine year 1 to mine year 60 and, then, were kept constant. Such a modified model was used to run 200-year predictive simulations, similar to the Project Model.

The impacts of the modeled changes upon chemical concentrations in the East Pit pore water and West Pit Lake were analyzed for lead, sulfate, copper, and iron. The simulation results showed that the greatest changes would occur during closure and long-term maintenance (approximately mine year 45 and beyond). Lead concentrations in East and West Pits would change very little. The largest increase in sulfate concentration of 10.3 percent would occur in the East Pit wetland, but would change little outside of that wetland. The pattern of simulated changes in concentration for copper is similar to sulfate with the maximum change of 15 percent for the East Pit wetland. No significant changes in iron concentrations were simulated for any part of the modeled domain (Barr 2015d).

Climate change would affect water quality in the stockpile drainage in similar ways to the mine pit water. The largest simulated change in concentration was 5.1 percent for lead, 0.9 percent for sulfate, 0.3 percent for copper, and 0.2 percent for iron.

The changes in dewatering volumes for the Pits were simulated to be very small, the largest for the period of closure and long-term maintenance: 5.2 gpm. This would slightly increase the amount of water that would be treated. Likewise, the simulated changes in leakage flows from the stockpiles were very small; the largest flow for the period of closure and long-term maintenance is 0.014 gpm for the Category 1 Stockpile (Barr 2015d).

Flow rates from the Pits to bedrock or surficial aquifers were not affected by the climate change simulation as this is controlled by pit water levels. Surface water quality also did not change much because all surface water discharged from the Mine Site would be treated by the WWTF.

5.2.2.3.3 Embarrass River Watershed

This section discusses potential environmental effects of the NorthMet Project Proposed Action on groundwater and surface water hydrology and quality within the Embarrass River watershed. The solute-generating NorthMet Project Proposed Action features in the Embarrass River Watershed are the Tailings Basin, the WWTP discharge, the Hydrometallurgical Residue Facility, and (much less significantly) domestic sewage treatment systems and/or potable water treatment backwash systems. These potential hydrologic and contaminant sources and their predicted effects on groundwater and surface water hydrology and quality are evaluated below.

Hydrometallurgical Residue Facility

PolyMet expects that the Hydrometallurgical Plant would begin operation between mine years 3 to 5. Residue would be transported to the Hydrometallurgical Residue Facility as a mixture of solids and water. The solids would settle out into the Hydrometallurgical Residue Facility, and the water would be returned to the Hydrometallurgical Plant for reuse. However, losses would occur during processing and through evaporation or storage within the pores of the deposited residue. The discharge from the Hydrometallurgical Plant to the pond is expected to be a constant 223 gpm through operations. Average annual flows from the Hydrometallurgical Residue Facility to the Hydrometallurgical Plant during operations range from 182 to 219 gpm (PolyMet 2015i). Precipitation falling within the drainage area of the Hydrometallurgical Residue Facility pond would be managed as process water.

The design of the Hydrometallurgical Residue Facility is based on State of Minnesota Rule requirements, expected residue generation rates, hydrology within the Hydrometallurgical Residue Facility, geotechnical considerations and Hydrometallurgical Residue Facility operating plans. Additional design considerations include the potential for water treatment plant solids (gypsum) to be disposed of within the Hydrometallurgical Residue Facility and the relocation of coal ash from the existing closed Coal Ash Landfill near the Tailings Basin (PolyMet 2014c).

The Hydrometallurgical Residue Facility would have a double geomembrane liner with a leachate collection system between the liners. The upper liner would consist of an 80-mil Linear Low Density Polyethylene geomembrane. This liner would serve as the primary barrier to leakage from the Hydrometallurgical Residue Facility. Its thickness was selected by PolyMet for durability and to resist ice impacts in the event of any temporary shutdowns of the hydrometallurgical process in winter months. The leakage collection layer would consist of a continuous layer of Geocomposite Drainage Net. The leakage collection layer would collect any leakage that passes through defects in the upper liner. The leakage collection layer is included in the liner system because even with application of industry-standard quality control procedures during installation of the upper liner, some installation defects can remain. The leakage collection layer directs leakage to a sump which then pumps it back to the Hydrometallurgical Residue Facility pond. The lower liner would consist of 60-mil Linear Low Density or High Density Polyethylene above a Geosynthetic Clay Liner. The lower composite liner would provide a virtually leak-free barrier to prevent leakage that may pass through the upper liner from leaving the Hydrometallurgical Residue Facility (PolyMet 2014c).

The amount of water pumped from the leak collection system would be monitored on a long-term basis. For this reason, if the amount of pumping were to increase or if there were any other indications of increased leakage, appropriate repairs and mitigation measures would be undertaken. For these reasons, it is assumed for purposes of this FEIS that the leakage from this facility into underlying groundwater or adjacent surface water would be negligible and therefore is not further evaluated. Details on the design and operation of this facility are in Chapter 3. A detailed Residue Management Plan for this facility would be required during permitting (PolyMet 2014r).

Effects on Groundwater Hydrology

This section discusses the environmental consequences of the NorthMet Project Proposed Action on groundwater hydrology within the Embarrass River Watershed, specifically from the Tailings Basin and associated engineering controls. There are no other NorthMet Project Proposed Action area facilities within the Embarrass River Watershed that would affect groundwater hydrology.

As discussed in Chapter 3, PolyMet proposes to re-use the existing LTVSMC Tailings Basin. Seepage from the existing LTVSMC Tailings Basin has decreased since LTVSMC operations ended in 2001, reaching a current steady state of approximately 2,820 gpm with 2,590 gpm seeping from the Tailings Basin. Once the seepage reaches the toe of the Tailings Basin, it divides between flow that remains as groundwater (referred to as groundwater seepage) and flow that exceeds the hydraulic capacity of the aquifer and upwells to the surface (referred to as surface seepage). Under existing conditions, about 200 gpm of Tailings Basin seepage remains as groundwater and about 2,390 gpm upwells to the surface and ultimately contributes to surface water flow in the Embarrass River. The Tailings Basin seepage reaches the Embarrass River via its tributaries (Mud Lake Creek, Trimble Creek, and Unnamed Creek) and by flow through wetlands. On the southern side of the Tailings Basin, most of the seepage is collected and returned to the Tailings Basin. Some of this seepage is not captured and migrates to the Second Creek, a tributary of the Partridge River (PolyMet 2015j).

Groundwater seepage from the Tailings Basin flows into three flowpaths to the Embarrass River identified as the north, northwest, and west flowpaths (see Figure 5.2.2-9). On the eastern side of the Tailings Basin, because of the presence of bedrock outcrops, natural groundwater flow is toward the Tailing Basin. Essentially all of the groundwater that flows south toward Second Creek in the Partridge River Watershed would be captured and pumped back into the Tailings Basin.

The addition of tailings and changes in water management due to the NorthMet Project Proposed Action would result in increased seepage from the Tailings Basin relative to existing legacy LTVSMC seepage. As Table 5.2.2-37 indicates, seepage is predicted to increase from the current approximately 2,820 gpm to a maximum of 3,880 gpm during operations. Most of this seepage would travel to the north, northwest, and west of the Tailings Basin and could affect groundwater levels in those areas.

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Table 5.2.2-37 Tailings Basin Seepage

TB Toe	Continuation of Existing Conditions				Maximum Rates for Mine Years 0–25[1]					Long-Term Maintenance				
	TB Seepage	Seepage to GW	Surface Seepage	Collected Seepage	TB Seepage	Seepage to GW	Surface Seepage	Bypass to GW Flowpath	Collected Seepage	TB Seepage	Seepage to GW	Surface Seepage	Bypass to GW Flowpath	Collected Seepage
North	1,540	40	1,500	0	2,160	40	2,120	4	2,156	450	40	410	4	446
Northwest	440	50	390	0	680	50	630	5	675	400	50	350	5	395
West	610	110	500	0	880	110	770	11	869	670	110	560	11	659
South	230	0	0	230	550	0	550	0	550	80	0	80	0	80
East	0	0	0	0	310	0	310	0	310	20	0	20	0	20
Total	2,820	200	2,390	230	3,880[4,7]	200	3,680[5,7]	20	3,860[6,7]	1,620	200	1,420	20	1,600
To Embarrass River	2,590[2]				20[3]					20[3]				

Source: PolyMet 2015j.

Notes:
All flows in gpm.
1 Maximum rates occur at different times at different toes.
2 Combination of surface seepage and groundwater.
3 Groundwater only.
4 Maximum total for single month within the time range of 0–25 years.
5 Maximum total minus seepage to groundwater.
6 Maximum total minus bypass to groundwater flowpaths.
7 Not a summation of values above.

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The NorthMet Project Proposed Action would increase Tailings Basin seepage rates by 1,060 gpm from existing conditions. The hydraulic capacity of the surficial aquifer would not change. This increase in upwelling could have a significant effect on downgradient wetlands and waterways. Therefore, PolyMet proposed that the containment system would wrap around the northern, northwestern, and western sides of the Tailings Basin. This system is designed to capture 100 percent of the surface seepage and 100 percent of the groundwater seepage, but is conservatively modeled to collect 100 percent of surface seepage and only 90 percent of the groundwater seepage to account for possible construction flows and by-pass in deeper bedrock. Another containment system, assumed to have 100 percent capture efficiency, would be constructed along a portion of the eastern side of the Tailings Basin. Figure 5.2.2-14 and Figure 5.2.2-15 show the capture system hydraulics. As Table 5.2.2-37 indicates, the net effect of the containment system would be to decrease groundwater seepage from the Tailings Basin downgradient of the containment system from approximately 200 to 20 gpm. This decrease in groundwater seepage would be mitigated by a proposed flow augmentation program, which is described later in this section.

As Table 5.2.2-37 indicates, seepage from the Tailings Basin to the Embarrass River Watershed is predicted to decrease from the estimated current rate of 2,820 gpm to about 1,620 gpm at closure under the NorthMet Project Proposed Action, which is approximately a 42 percent decrease. The surface and groundwater seepage containment system would remain in place, which would capture all but an estimated 20 gpm of Tailings Basin seepage. The decrease in groundwater seepage would not be expected to have a significant effect on wetlands or tributaries downgradient of the surface and groundwater seepage containment system because of proposed flow augmentation, which would maintain surface flows within ± 20 percent of existing conditions. There would be sufficient natural aquifer recharge to maintain saturation in the surficial (unconsolidated) unit. The effects of the containment system on surface water hydrology are discussed later in this section.

Effects on Groundwater Quality

The NorthMet Project Proposed Action could affect surficial groundwater quality within the Embarrass River Watershed by leaching metals, sulfate, and other solutes from the NorthMet Tailings Basin. However, current conditions at the Tailings Basin are already affecting the groundwater. The following two subsections offer a summary comparison between the current conditions and the conditions projected to take effect as a result of the NorthMet Project Proposed Action.

Current Conditions

Under current conditions, the seepage emerging from the LTVSMC Tailings Basin at its northern, northwestern, and western toes feeds groundwater (at a rate of about 200 gpm) and surface waters at a rate of about 2,390 gpm). All the seepage-affected groundwater and surface water migrates to the Embarrass River via its tributaries, through wetlands and via groundwater migration along the northern, northwestern, and western groundwater flowpaths (see Figure 5.2.2-9). Tailings seepage from its southern toe is partially collected and returned to the Tailings Basin. Groundwater flows toward the Tailings Basin at its eastern toe, so the seepage in that part of the toe does not affect the environment either.

Proposed NorthMet Project Proposed Action Conditions

The only untreated Tailing Basin water entering the surrounding environment would be groundwater bypassing the northern, northwestern, and western parts of the containment system at a rate of 20 gpm. This 20 gpm represents a conservative engineering assumption (actual rate may be lower). This signifies a 90 percent reduction of the groundwater flow rates occurring under current conditions (20 gpm vs. 200 gpm). Most of the seepage-affected groundwater bypassing the containment system would flow along the north, northwest, and west flowpaths towards the Embarrass River and would affect downgradient groundwater quality (see Figure 5.2.2-9).

Several sources would contribute solutes to the Tailings Basin, including both the existing LTVSMC tailings and NorthMet Project Proposed Action tailings themselves, Mine Site process water (which could be pumped to the Tailings Basin through year 11, and possibly through year 20 depending on the NorthMet Project Proposed Action water budget), Colby Lake makeup water, and a negligible amount of watershed runoff.

The contribution from the Mine Site (to the Tailings Basin's water quality) would be influenced by the predictions of stockpile leachate and mine pit water quality and the ability of the WWTF to achieve design effluent concentrations prior to pumping to the Tailings Basin.

Some solutes can be released from tailings by direct dissolution of minerals, but solutes of concern are primarily released by oxidation of sulfide minerals in the tailings. The oxidation rate in tailings, and thus the rate of solute release, is typically limited by the rate that atmospheric oxygen can diffuse into the facility. The diffusion of oxygen and the rate of oxidation and associated solute release would depend strongly on the tailing's moisture content, where higher moisture content corresponds to lower rates of oxygen diffusion and associated oxidation and contaminant release. Thus, the unsaturated tailings in the embankment and beach areas are expected to have higher oxidation rates than the saturated tailings below the pond.

Laboratory testing indicated that average sulfur concentration in the NorthMet tailings would be 0.12 percent, which is low enough to ensure that the tailings would not produce acidic leachate. Pore water metal concentrations could increase dramatically if pH were to decrease, especially for nickel and cobalt (SRK 2007c). The oxyanions (arsenic, antimony, and selenium), however, tend to have increasing solubility with higher pHs.

Testing of tailings containing 0.2 percent sulfur by the MDNR from the nearby Babbitt prospect within the Duluth Complex did not result in acidic leachate because silicate weathering was sufficient to neutralize the acid produced. Humidity cell test results for NorthMet Project Proposed Action tailings have tended to support the research by the MDNR and the results from the Babbitt Deposit (Day 2008). Leachate showed an initial decline in pH, but has subsequently remained between 6.0 and 7.8 with no trend toward lower pHs.

Solutes released by oxidation (primarily sulfate and metals) would be mobilized and flushed from the tailings by percolating water. The rate of percolation would depend on the net infiltration of meteoric water at the tailing's surface and the rate of pond leakage. The seepage from the NorthMet Project Proposed Action tailings would pass through the underlying existing LTVSMC tailings (i.e., previous taconite tailings). These underlying tailings may attenuate to some extent the metals leached from the NorthMet Project Proposed Action tailings, or may contribute additional solutes to seepage, or both.

The Tailings Basin pond would receive: 1) treated Mine Site process water (during mine operations); 2) tailings slurry water from Processing Plant (during mine operations); 3) captured untreated seepage from Tailings Basin's toes; 4) rainfall, snowmelt, and local storm runoff; 5) filtered backwash from the WWTP; 6) sewage treatment effluent; and 7) treated water from WWTP.

The Tailings Basin pond, in turn, would become a primary source of contaminants due to the pond's infiltration into the tailings. Therefore, the chemical composition of the Tailings Basin's pond water (becoming a permanent feature of the Tailings Basin) would be an important influence upon the quality of water that would be discharged from the WWTP and seep from the Tailings Basin.

Consequently, PolyMet proposes to use the WWTP to treat the pond water during reclamation, and as necessary during closure, to improve the pond's water quality. The presence of the pond in closure would provide benefits as it would create a saturated layer that would permanently reduce oxygen diffusion and associated solute release in the underlying tailings.

Engineering Controls

The LTVSMC Tailings Basin is not lined. Several tailings and water management options were considered in the development of the NorthMet Project Proposed Action (Chapter 3 alternatives section). The NorthMet Project Proposed Action does not include a liner for the Tailings Basin. In lieu of a liner, PolyMet proposes the following engineering controls to reduce the release and transport of solutes from the Tailings Basin:

- Collection of Tailings Basin's seepage by surface and groundwater seepage containment systems;
- Bentonite amendment of the existing tailings dam to reduce infiltration;
- Installation of bentonite amendment of the Tailings Basin's beaches to reduce infiltration and oxygen diffusion into Tailings;
- Bentonite amendment of pond bottom to reduce leakage into tailings; and
- Mechanical treatment of the collected tailings seepage and pond water by the WWTP.

Tailings Basin Containment System

The containment system would be installed prior to plant operations and would consist of a surface water and groundwater collection system along the outside perimeter of the Tailings Basin where seepage has the potential to enter the surficial aquifer and adjacent surface waters (see Figure 3.2-28). The design includes a hydraulic barrier (cutoff wall) that would be keyed into bedrock, and a collection trench and drain pipe installed on the upgradient side (see Figures 5.2.2-14 and 5.2.2-15). Above the hydraulic barrier would be a berm to stop surface seepage from leaving the site. The trench and piping would convey the collected seepage to several pumping stations, which would pump the seepage to either the Tailings Basin pond for re-use, or to the WWTP for treatment prior to discharge. The containment system would continue to operate during reclamation, and closure and long-term maintenance, although in those phases, the seepage could not be re-used as process water, but would be treated at the WWTP and used to accelerate filling of the West Pit (during reclamation) and for streamflow augmentation (during reclamation and closure). Figure 5.2.2-14 illustrates the functioning of the proposed containment systems along the north-, northwest-, and west toes, while Figure 5.2.2-15 shows the functioning of the systems at the east toe. Considered together, the containment systems are designed to capture all of the Tailings Basin groundwater and surface water seepage; however, for purposes of impact evaluation they are assumed to capture:

- 100 percent of the Tailings Basin's surface seepage;
- 100 percent of the groundwater approaching the containment system from the Tailings Basin's east and south toes; and
- 90 percent of the groundwater approaching the containment systems from the Tailings Basin's north, northwest and west toes (PolyMet 2015d).

During operations, the maximum flows collected by the containment system would be 3,680 gpm originating as surface seepage and 180 gpm as groundwater seepage. During closure, the collection rates would be 1,420 gpm of surface seepage and 180 gpm of groundwater seepage.

Wastewater Treatment Plant

PolyMet proposes a WWTP to treat the Tailings Basin pond's water and tailings seepage collected by the surface and groundwater seepage containment systems. The WWTP would treat water throughout the entire mine life (operations, reclamation, and closure and long-term maintenance). The WWTP would treat all Tailings Basin seepage except the small quantity (approximately 20 gpm on average) that would bypass the containment systems. The WWTP would discharge treated effluent to augment streamflow during operations. During reclamation, some WWTP effluent would be pumped to the West Pit to accelerate its flooding. The level of water treatment at the WWTP would be sufficient to meet surface water evaluation criteria.

Bentonite-amended Tailings Cover

For the NorthMet Project Proposed Action during operations, PolyMet would cover the tailings dam embankments with a 12-inch-thick bentonite-amended soil layer, as allowed by construction activities. On top of the bentonite-amended layer would be an 18-inch-thick vegetated soil cover. After operations cease in year 20, PolyMet would place a similar two-layer cover on top of the dry tailings beaches. The objective of the cover system would be to: 1) reduce infiltration of meteoric water, and 2) maintain the bentonite layer at a high saturation to limit oxygen diffusion into the tailings.

Bentonite-amended Pond Bottom

PolyMet would also place a bentonite layer at the bottom of the tailings pond to reduce downward leakage of pond water into the tailings. The thickness and effective hydraulic conductivity of the bentonite layer would be designed to achieve a pond seepage flux of 6.5 in/yr or less.

Groundwater Transport and Evaluation Locations

Groundwater flow and solute transport away from the Tailings Basin towards the Embarrass River is tracked in three groundwater surficial flowpaths: north, northwest, and west (see Figure 5.2.2-9). Within each flowpath there is a groundwater evaluation location, coincident with the property boundary, along which predicted solute concentrations are compared to the groundwater evaluation criteria to assess potential effects. Because solute effects on surface water are of interest, the solute concentrations at locations where groundwater releases to surface water (generally at or close to the Embarrass River) are also tracked in the model because it is required to interpret the surface water chemistry in the Embarrass River and its tributary streams.

For the North, Northwest, and West Surficial flowpaths, the time at which contaminants leached from the Tailings Basin would begin to affect water quality at their respective evaluation locations depends on the following variables:

- The amount of affected water that would seep past the Tailings Basin containment system. GoldSim conservatively assumes that 10 percent of the approaching groundwater would bypass the system and this would begin at time zero. Note that the analysis assumes that all tailings surface seepage is captured. The rate at which contaminants would move in groundwater would be the same as the groundwater seepage velocity downgradient of the containment system for all but four constituents (arsenic, antimony, copper, and nickel). Because no attenuation values are used for the constituents other than arsenic, antimony, copper, and nickel–the modeled rate of groundwater transport would be faster than the actual rate of transport in the ground. Note that this velocity would increase in the downgradient direction due to meteoric aquifer recharge that would add flow to the groundwater system. Transport of the four attenuated constituents would be 10 to 100 times slower than the groundwater flow because of sorption.
- The distance between the location of solute release (Tailings Basin containment system) and the flowpath evaluation location.
- The effects of hydrodynamic dispersion, which tends to spread out the leading edge of the solute plume.

To ensure that the water quality modeling would identify the potential effects on groundwater and surface water, a 500-year GoldSim probabilistic (Monte Carlo) simulation was performed. Lead was used to illustrate groundwater transport at the Plant Site because it is not attenuated and would enter the surficial flowpaths at concentrations higher than baseline groundwater. As a consequence, the movement of solute fronts associated with this constituent is readily discernible on concentration-versus-time and concentration-versus-distance plots for the modeled flowpaths. Transport of other non-attenuated solutes should be similar to lead, but the change in concentrations is not always as visually noticeable as it is for lead. Based on the GoldSim results, P90 lead concentrations at the evaluation locations and at locations where groundwater would release to surface water are shown on Figures 5.2.2-44 and 5.2.2-45, respectively.

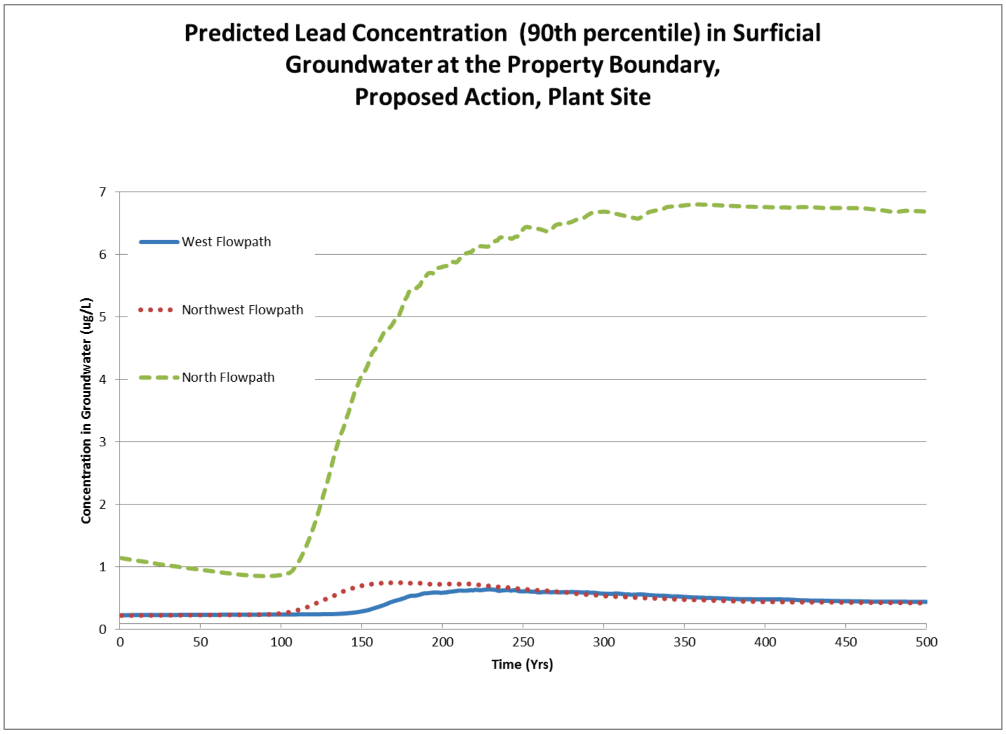

Figure 5.2.2-44 Predicted P90 Lead Concentrations at the Evaluation Locations Based on the GoldSim Probabilistic Simulation for the Plant Site

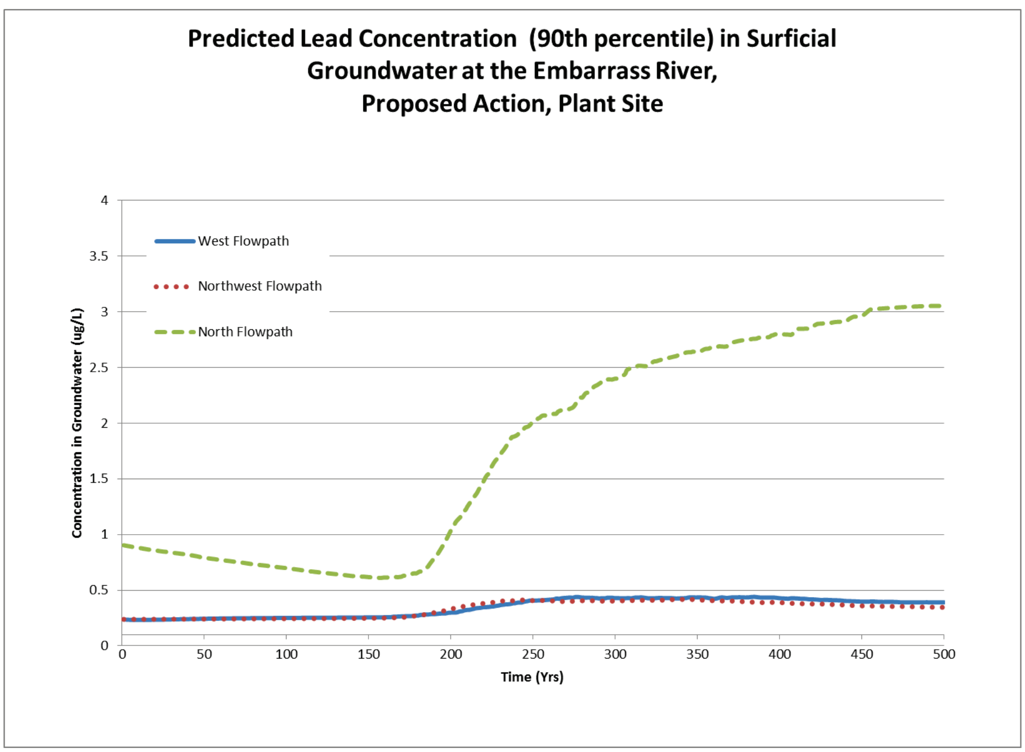

Figure 5.2.2-45 Predicted P90 Lead Concentrations at the Locations of Groundwater Release to Surface Water Based on the GoldSim Probabilistic Simulation for the Plant Site

Surficial Groundwater Quality at the Evaluation Locations

Results of a 500-year GoldSim water quality modeling simulation were reviewed for all 29 solutes at all three surficial flowpath evaluation locations. A screening process was used to identify any constituents and locations that warranted a more robust examination because of potential exceedances of water quality evaluation criteria. That process involved comparing the maximum P90 water quality prediction from among the 5,988 months covered by the simulation (i.e., 12 months times 499 years, with the first year of simulation excluded for screening review due to potential numerical artifacts in the model results) for each constituent at each of the three evaluation locations. These NorthMet Project Proposed Action modeled values were compared with both CEC scenario modeled values and the evaluation criteria (discussed previously). Each contaminant that was identified as exceeding the numerical evaluation criteria was then evaluated in more detail to understand the details and context of the potential exceedance.

Table 5.2.2-38 presents the maximum P90 values for the NorthMet Project Proposed Action Scenario and the CEC scenario in comparison with the groundwater evaluation criteria. Figure 5.2.2-46 illustrates the range of model predictions for each solute (minimum P10 to maximum P90 values) over the 500-year simulation. Figure 5.2.2-47 illustrates the relative difference between the NorthMet Project Proposed Action and CEC scenarios. If the values were the same, the relative change ratio would be 1; values greater than 1 indicate that the NorthMet Project Proposed Action would result in higher solute concentrations compared to the CEC scenario. Conversely, values less than 1 indicate that the NorthMet Project Proposed Action would result in lower solute concentrations than the CEC scenario.

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Table 5.2.2-38 Maximum P90 Groundwater Concentrations over a 500-year Model Simulation Period at All Evaluation Locations along Modeled Flowpaths in the Plant Site Surficial Aquifer

Parameter	Groundwater Evaluation Criteria[1]	Units	North Flowpath at Property Boundary		North Flowpath before MLC-2		Northwest Flowpath at Property Boundary		Northwest Flowpath before PM-19		West Flowpath at Property Boundary		West Flowpath before Embarrass River	
General			**PA**	**CEC Scenario**	**PA**	**CEC Scenario**	**PA**	**CEC Scenario**	**PA**	**CEC Scenario**	**PA**	**CEC Scenario**	**PA**	**CEC Scenario**
Alkalinity	NA	mg/L	241	243	199	200	205	220	172	179	190	201	171	175
Calcium	NA	mg/L	45.3	39.5	35.5	36.3	81.6	87.3	66.6	69.2	73.8	78.3	65.0	67.8
Chloride	250	mg/L	17.9	18.1	13.5	13.6	17.1	17.6	12.9	13.1	15.2	15.3	12.7	12.9
Fluoride	2.0	mg/L	3.4	3.4	2.5	2.5	0.1	0.1	0.16	0.13	0.18	0.18	0.18	0.18
Hardness	NA	mg/L	345	353	282	287	750	813	573	603	658	700	556	583
Magnesium	NA	mg/L	60.5	62.5	47.2	48.5	132.8	147	99.1	104.5	115.4	124.1	95.9	100.4
Potassium	NA	mg/L	8.3	8.4	6.6	6.6	8.3	9.3	6.5	6.8	7.4	8.1	6.4	6.7
Sodium	NA	mg/L	58.1	58.8	43.6	43.8	45.0	50.3	33.8	36.7	40.1	43.5	33.5	35.6
Sulfate[3]	250	mg/L	188	191	139	139	252	286	185	202	243	277	200	219
TDS[3]	500	mg/L	517	520	407	407	659	690	507	517	609	633	515	527
Metals														
Aluminum	NA	µg/L	68.0	41.2	73.6	55.1	69.4	47.9	74.9	58.1	72.7	52.9	69.4	55.9
Antimony	6.0	µg/L	0.41	0.40	0.42	0.41	0.39	0.45	0.41	0.40	0.41	0.43	0.41	0.41
Arsenic	10	µg/L	3.8	3.8	2.9	2.9	1.0	1.0	0.9	0.9	1.1	1.1	.99	.99
Barium	2,000	µg/L	177.7	179.1	148.2	148.8	70.3	46.5	75.7	58.6	73.6	53.7	70.1	59.8
Beryllium[2]	0.54	µg/L	0.26	0.28	0.22	0.25	0.31	0.65	0.24	0.49	0.27	0.59	0.24	0.49
Boron	1,000	µg/L	246.4	250	188	190	381.5	408	284	300	338	345	281	283
Cadmium	4.0	µg/L	0.38	0.16	0.22	0.14	0.15	0.21	0.14	0.18	0.15	0.21	0.14	0.18
Chromium III	100	µg/L	1.53	0.78	1.26	0.91	1.07	0.85	1.11	0.95	1.10	0.90	1.07	0.94
Cobalt	NA	µg/L	4.0	1.6	1.6	1.0	1.8	3.1	1.3	2.0	1.7	2.9	1.4	2.3
Copper	NA	µg/L	2.2	2.2	2.3	2.3	2.4	2.4	2.4	2.4	2.5	2.5	2.5	2.5
Iron	NA	µg/L	1,770	1,907	1,307	1,320	3,884	4,441	2,833	3,119	3,668	4,242	3,003	3,350
Lead	NA	µg/L	6.80	1.15	3.1	0.90	0.75	0.27	0.42	0.26	0.64	0.30	0.44	0.27
Manganese[2, 3]	704	µg/L	434	311	376	319	971	1,110	778	844	865	958	754	808
Nickel	100	µg/L	4.0	3.9	4.4	4.4	5.0	5.0	5.0	5.0	5.2	5.2	5.1	5.1
Selenium	30	µg/L	1.11	0.79	0.95	0.80	0.86	0.86	0.88	0.84	0.87	0.89	0.87	0.83
Silver	30	µg/L	0.14	0.14	0.11	0.12	0.11	0.18	0.10	0.14	0.11	0.18	0.10	0.15
Thallium	0.6	µg/L	0.20	0.19	0.20	0.19	0.19	0.16	0.20	0.17	0.19	0.18	0.18	0.16
Vanadium	50	µg/L	6.2	5.1	5.9	5.3	5.1	3.1	5.5	4.2	5.3	3.7	5.4	4.2
Zinc	2,000	µg/L	32.6	13.7	21.4	14.5	14.8	8.9	15.4	11.6	15.4	10.5	14.7	11.7

Source: PolyMet 2015o.

Notes:
CEC = Continuation of Existing Conditions
PA = NorthMet Project Proposed Action
1 References for the groundwater evaluation criteria are summarized in Table 5.2.2-2.
2 The evaluation criterion differs by location based on background water quality (see Table 5.2.2-1).
3 Not carried forward to secondary screening because NorthMet Project Proposed Action concentrations are below CEC scenario concentrations; however, additional discussion is provided.

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Several constituents in the initial screening table (Table 5.2.2-38) have NorthMet Project Proposed Action maximum P90 concentrations (over 500 years) that exceed evaluation criteria at evaluation locations in the Plant Site surficial groundwater flowpaths:

- Fluoride in North Flowpath at property boundary;
- Sulfate in Northwest Flowpath at property boundary;
- TDS in North Flowpath at property boundary;
- TDS in Northwest Flowpath at property boundary;
- TDS in West Flowpath at property boundary;
- Manganese in Northwest Flowpath at property boundary; and
- Manganese in West Flowpath at property boundary.

However, because the NorthMet Project Proposed Action Concentrations are equal to or lower than the CEC concentrations in all cases, they have not been identified for further evaluation beyond what is offered below.

Four constituents and associated evaluation locations are listed in Table 5.2.2-39. In this table, maximum P50 and P90 concentrations for the NorthMet Project Proposed Action are compared with analogous values associated with the CEC for three phases of the GoldSim 500-year simulation (operations, reclamation, and post-closure maintenance). In all cases the NorthMet Project Proposed Action maximum P90 concentration of a project phase is equal to or lower than the comparable maximum P90 concentration for CEC.

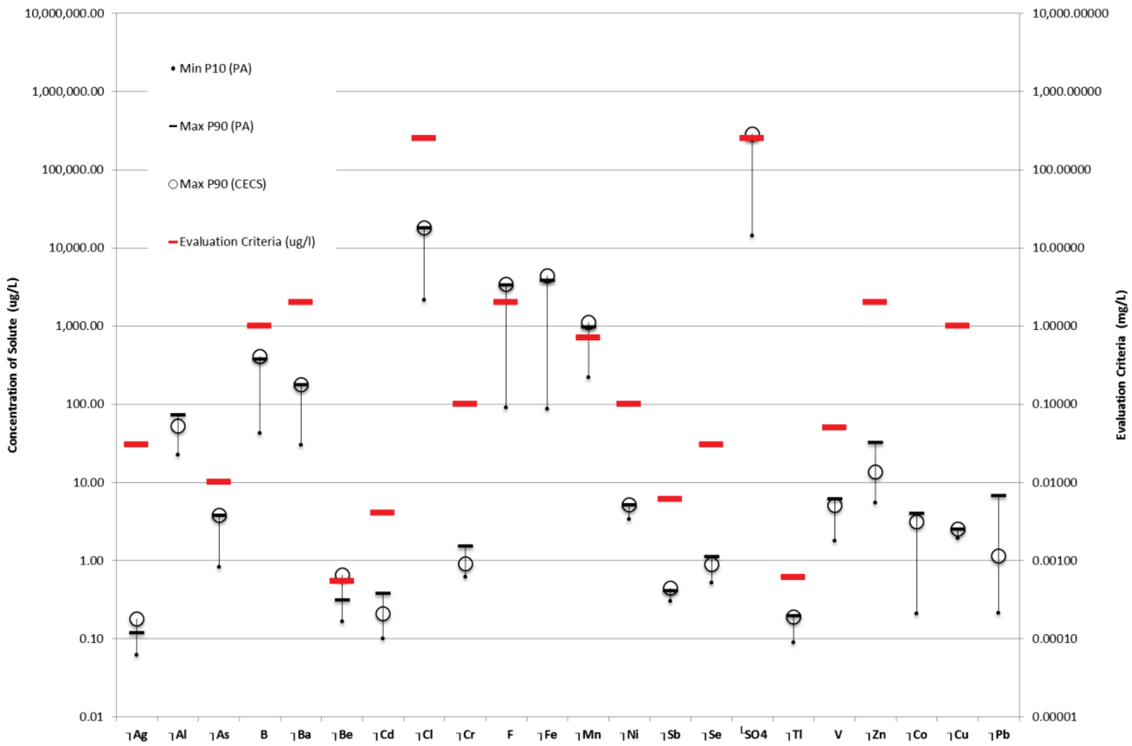
A further evaluation was performed by conducting a timestep-by-timestep analysis of the GoldSim results. The analysis indicated that over the 500-year simulation, there were no (monthly) timesteps for which the NorthMet Project Proposed Action P90 contaminant concentration was higher than the evaluation criterion ***and*** higher than the P90 concentration for CEC. The same result occurred when the comparison was made with P50 concentrations.

This assessment of the GoldSim results provides strong evidence that the NorthMet Project Propose Action would not cause impacts to Plant Site groundwater quality above and beyond what would occur without the NorthMet Project Proposed Action.

Table 5.2.2-39 GoldSim-Predicted Maximum P50 and Maximum P90 of Groundwater Concentrations at the Plant Site for Selected Constituents for Different Project Phases

Constituent	Units	Surficial Groundwater Flowpath	Evaluation Location	Evaluation Criterion	Operations (years 0–20)		Reclamation (years 20–56)		Post-Closure Maintenance (years 56–500)	
					PA	CEC	PA	CEC	PA	CEC
a. Maximum P50 of Annual Concentrations from GoldSim Output[1]										
Fluoride	mg/L	North	Property Boundary	2	2.84	2.84	2.49	2.84	2.03	2.86
Sulfate	mg/L	Northwest	Property Boundary	250	212	212	186	212	150	210
TDS	mg/L	North	Property Boundary	500	451	451	407	451	344	444
TDS	mg/L	Northwest	Property Boundary	500	570	570	510	570	422	567
TDS	mg/L	West	Property Boundary	500	501	501	459	501	391	501
Manganese	µg/L	Northwest	Property Boundary	704	860	860	785	860	681	854
Manganese	µg/L	West	Property Boundary	704	744	744	692	744	616	743
b. Maximum P90 of Annual Concentrations from GoldSim Output[2]										
Fluoride	mg/L	North	Property Boundary	2	3.38	3.38	3.04	3.38	2.62	3.41
Sulfate	mg/L	Northwest	Property Boundary	250	253	253	227	255	192	286
TDS	mg/L	North	Property Boundary	500	520	520	478	519	418	517
TDS	mg/L	Northwest	Property Boundary	500	662	662	601	662	519	690
TDS	mg/L	West	Property Boundary	500	610	610	565	611	497	633
Manganese	µg/L	Northwest	Property Boundary	704	974	974	902	989	803	1,110
Manganese	µg/L	West	Property Boundary	704	866	866	813	869	738	958

Notes:
CEC = Continuation of Existing Conditions
PA = NorthMet Project Proposed Action
[1] No timesteps for which PA > Criteria and PA > CEC for P50 concentrations.
[2] No timesteps for which PA > Criteria and PA > CEC for P90 concentrations.



Note:
CECS = Continuation of Existing Conditions Scenario
PA = NorthMet Project Proposed Action
µg/L = microgram(s) per liter

Figure 5.2.2-46 Predicted Groundwater Concentration Ranges (Minimum 10th to Maximum 90th Percentile) at All Plant Site Surficial Groundwater Evaluation Locations Based on the GoldSim Probabilistic Model

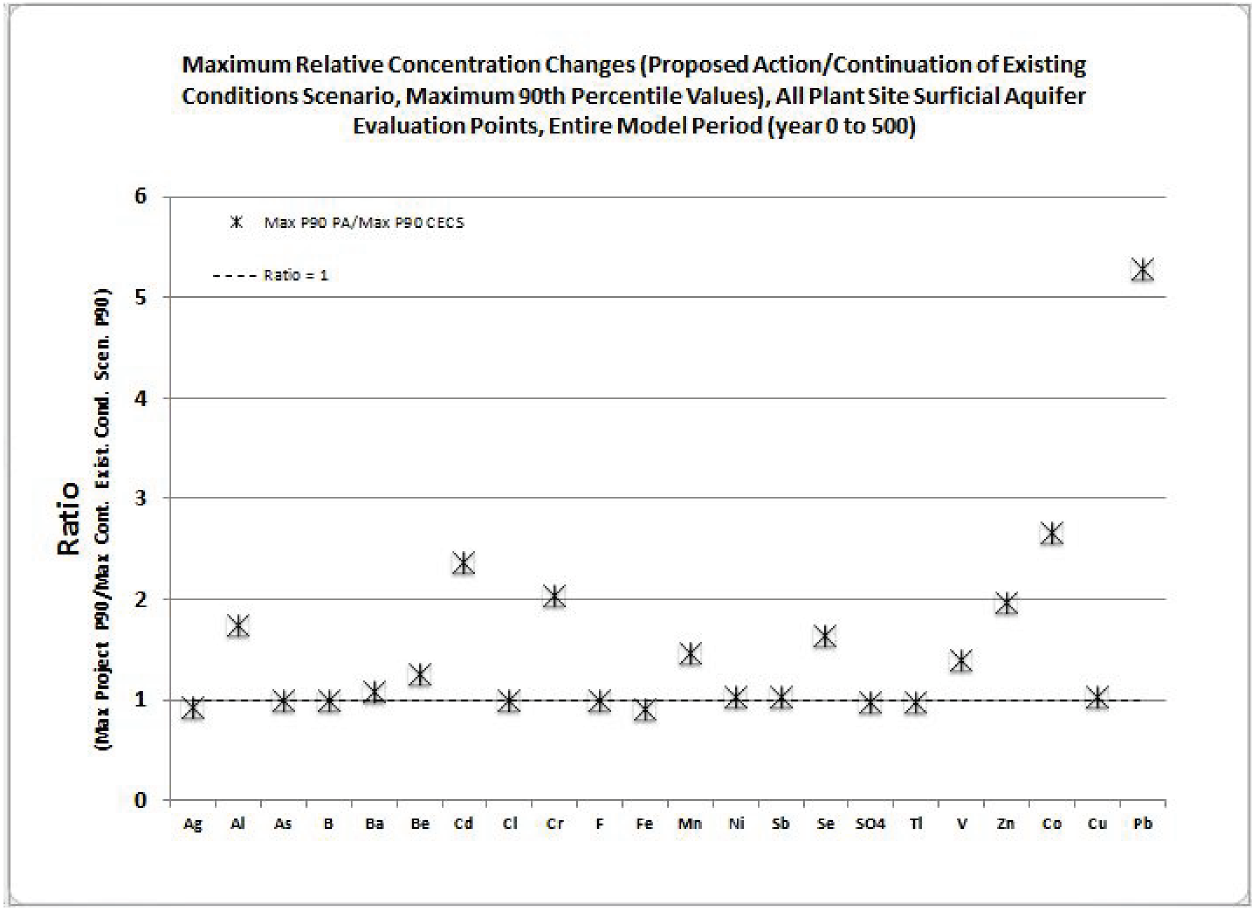


Figure 5.2.2-47 Maximum Relative Concentration Changes (NorthMet Project Proposed Action/CEC Scenario) at Surficial Aquifer Evaluation Locations, Entire Model Period

Effects on Surface Water Hydrology in the Embarrass River Watershed

This section describes the effects of the NorthMet Project Proposed Action on the surface water hydrology of the Embarrass River and its tributaries. The effects of the NorthMet Project Proposed Action on surface water hydrology, especially in the three tributary streams draining the Tailings Basin (i.e., Mud Lake Creek, Trimble Creek, and Unnamed Creek) are complex, as some project features/engineering controls would tend to increase flows while others would decrease flows and change over time. For example, during mine operations, the NorthMet Project Proposed Action would increase seepage from the Tailings Basin toe as a result of tailings deposition, but nearly all of this seepage would be captured by the containment system; this reduction in flow would, in turn, be mitigated by the proposed streamflow augmentation with treated water or the construction of a swale. The NorthMet Project Proposed Action would also slightly modify some watershed areas within the Embarrass River, which would affect streamflows. These NorthMet Project Proposed Action effects on surface water hydrology are described in more detail below.

The State of Minnesota aims to maintain existing flows to which streams and aquatic habitat have adapted. This may or may not be a pre-mining flow regime. In the case of the NorthMet Project Proposed Action where the existing LTVSMC tailings basin seeps water, containing the seeps creates a need to discharge clean water within a range of existing flows to maintain existing hydrology, geomorphology, aquatic communities, connectivity, water quality, and biology (Chisholm 2006).

Mud Lake Creek Watershed Alteration

The Tailings Basin has a contributing watershed immediately to the east of Cell 1E that provides groundwater and surface water flow into the Tailings Basin. The East Dam would be constructed to enable tailings deposition into Cell 1E. The watershed that currently drains into Cell 1E would be rerouted via a constructed drainage swale to drain to the headwaters of Mud Lake Creek. In addition, a containment facility with a cut-off wall would be constructed adjacent to the east embankment, and this would divert groundwater east of the Tailings Basin into the swale as well (see Figure 5.2.2-48). There would be no need for augmentation to Mud Lake Creek because of the additional runoff water diverted to the stream (PolyMet 2015j). Figure 5.2.2-48 shows the approximate location of the drainage swale. Construction of the swale diversion would increase the Mud Lake Creek Watershed area at MLC-3 from 1.34 mi^2 to 2.24 mi^2 (PolyMet 2015j, Appendix B).

Effects on Embarrass River Tributary Streamflow

The NorthMet Project Proposed Action includes construction of surface water and groundwater seepage containment systems along the sides of the Tailing Basin. The containment system on the north, northwest and west sides would capture all surface seepage and nearly all groundwater Tailings Basin seepage that would flow away from the Tailings Basin. In addition, a containment system would be constructed along the east embankment to prevent westward flowing groundwater and surface water fed by Spring Mine Lake from draining into the Tailings Basin. A containment trench would collect 100 percent of surface and groundwater tailings seepage that would occur at the east embankment as the Tailings Basin is raised. Seepage and local runoff captured by these systems would be pumped back into the Tailings Basin pond or to the WWTP. As indicated in Table 5.2.2-37, the containment systems would capture nearly all seepage entering the tributary streams. WWTP-treated effluent would be used to restore streamflows in the affected tributaries. This is referred to as augmentation.

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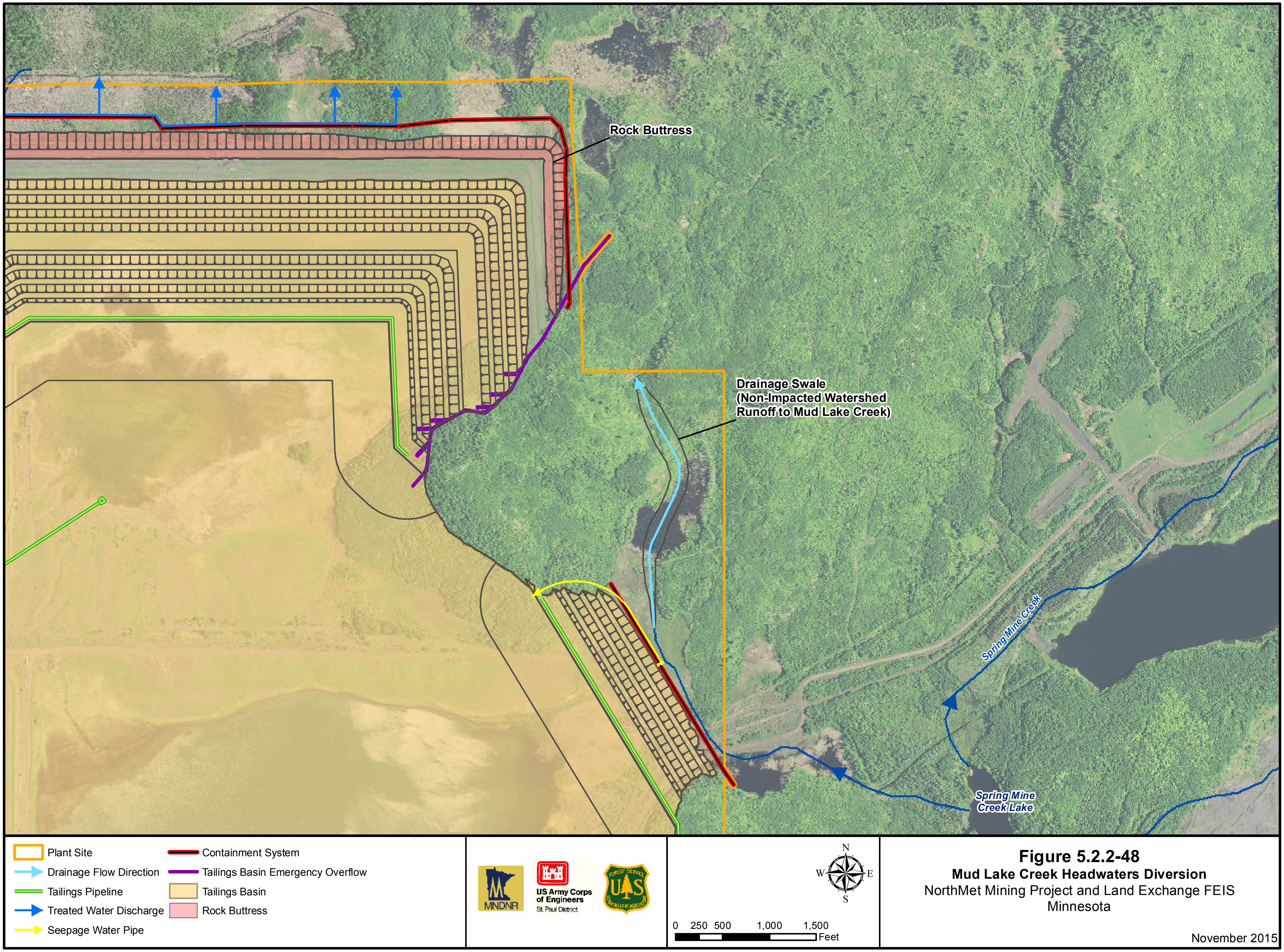

Figure 5.2.2-48

Mud Lake Creek Headwaters Diversion

NorthMet Mining Project and Land Exchange FEIS

Minnesota

November 2015

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PolyMet has proposed to augment flow by distributing treated effluent from the WWTP among Unnamed Creek and Trimble Creek to maintain average annual flow to within ±20 percent of existing conditions to maintain hydrology and existing aquatic ecology. To ensure there would be enough treated effluent from the WWTP to augment the tributary streamflow, water from Colby Lake and if required, the optional Hydrometallurgical Residue Facility Wick Drain System (if installed), would be sent to the WWTP to be treated to increase the treated effluent available. Volumes for withdrawal are shown in Table 5.2.2-40.

Table 5.2.2-40 Plant Site Water Appropriation During Operations

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

Source: PolyMet 2015i.

Note:
[1] The Hydrometallurgical Residue Facility wick drain system is an optional feature of the Hydrometallurgical Residue Facility and, if required, would tie into the FTB Containment System for collection. Appropriation quantities for the wick drain system would be determined in permitting, if required.

The total flow required from the WWTP effluent to augment Trimble Creek, Unnamed Creek and Second Creek after construction of the Mud Lake Creek drainage swale would range from 1,698 to 3,442 gpm (Table 5.2.2-41) (PolyMet 2015j). Table 5.2.2-41 shows the minimum required and maximum allowable (plus or minus 20 percent of existing average annual tributary streamflow) augmentation that would be discharged on an average annual basis to each of the three tributaries for operations, reclamation and long-term maintenance. The discharge locations would be downstream of the surface and groundwater seepage containment system. Depending on site conditions, the augmentation water would be piped directly to the stream channels or released from a distribution pipe that parallels the North and Northwest containment system, whereas West of the Tailings Basin, augmentation flow to Unnamed Creek would be via a single discharge near the current SD-006 discharge.

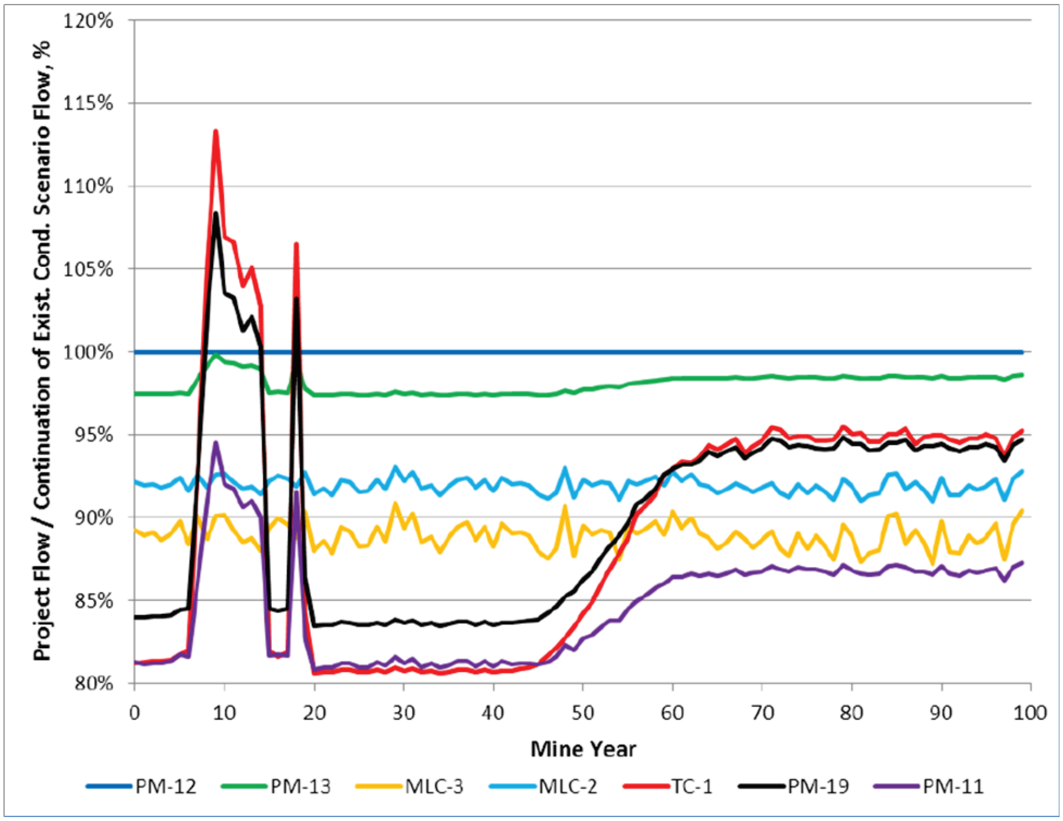
Table 5.2.2-41 WWTP Flow Requirements for Stream Augmentation

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)	1,190 – 1,890	340 – 540	185 – 295[1]
Expected Flows from WWTP (Reclamation)	1,180	336	184
Expected Flows from WWTP (Closure and Long-Term Maintenance)	1,485	423	232

Source: PolyMet 2015i, Table 2-3.

Note:
[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 SD-026. However, the high flow rate (295 gpm) is within the observed flows at SD-026 from July 1999 through September 2014 (range is from less than 10 gpm to nearly 2,500 gpm).

Figure 5.2.2-49 shows the predicted effectiveness of the proposed flow augmentation in maintaining annual average Embarrass River tributary streamflow within 20 percent of the CEC scenario. The graph only shows up to year 100 because the results are steady beyond year 70.



Source: PolyMet 2015j, Figure 6-82.

Figure 5.2.2-49 Average Annual Embarrass River and Tributary Flows in the NorthMet Project Proposed Action Model (Percent of CEC Scenario)

Hydrologic fluctuations throughout operations and reclamation would be due to changes in the available amount of WWTP effluent. At no time, however, would tributary flow change by more than the 20 percent from existing flows. Upstream of the NorthMet Project Proposed Action, at PM-12, the projected flow remains unchanged. Results for Mud Lake Creek show that starting in mine year 0 – upon construction of the drainage swale that would direct additional runoff into Mud Lake Creek the minimum required flow – 80 percent of existing conditions, is met at MLC-3 and MLC-2. Figure 5.2.2-49 shows that flow at MLC-3 and MLC-2 are relatively constant, indicating that the drainage swale is effective in preventing hydrologic impacts to Mud Lake Creek (PolyMet 2015j). Trimble Creek and Unnamed Creek show the effects of varying quantities of WWTP discharge, but at all times the NorthMet Project Proposed Action augmented stream flows are within 20 percent of the annual average CEC scenario. The effect of the NorthMet Project Proposed Action would decrease with distance downstream, as can be seen at PM-13, where the maximum change in flow would be approximately 3 percent in the annual average flow during operations, with a closure and long-term maintenance decrease of less than 2 percent (PolyMet 2015j).

Effects on Surface Water Quality

As shown on Figure 5.2.2-49, Embarrass River tributaries that would be affected by mine facilities include Unnamed Creek, Trimble Creek, and Mud Lake Creek. These tributaries currently receive Tailings Basin seepage with its associated water quality. Because the tributaries discharge into the Embarrass River, their flow rates and water quality affect Embarrass River concentrations.

Results of the GoldSim water quality modeling were reviewed for all 29 solutes at five tributary streams (i.e., MLC-2, MLC-3, TC-1, PM-19, and PM-11) (see Table 5.2.2-42) and three Embarrass River (i.e., PM-12, PM-12.2, and PM-13) evaluation locations (see Table 5.2.2-43). Model results for the NorthMet Project Proposed Action and CEC scenario are essentially identical at stations PM-12 and PM-12.2, the two stations that are upstream of the NorthMet Project area and thus would not be affected by the NorthMet Project Proposed Action. The differences in water quality between these two stations can be attributed to a significant chemical load (notably sulfate) that enters the Embarrass River just upstream of PM-12.2 via a tributary stream originating at the 5NW Pit.

An initial screening process was used to identify any constituents and locations that warranted a more robust examination because of potential exceedances of water quality evaluation criteria (see Table 5.2.2-42 for the Embarrass River tributary streams evaluation locations and Table 5.2.2-43 for the Embarrass River mainstem evaluation locations). The initial screening process compared the single-highest monthly P90 water quality prediction from among the 5,988 months covered by the simulation (i.e., 12 months times 499 years, with the first year of simulation excluded for screening review due to potential numerical artifacts in the model results) for each constituent for each of the eight evaluation locations (see Table 5.2.2-42). If the maximum P90 concentration exceeded the evaluation criteria and the NorthMet Project Proposed Action P90 concentration was greater than the CEC scenario concentration, the screening process identified it for secondary screening and further analysis. The secondary screening shown in Table 5.2.2-44 evaluated not only those constituents that did not pass initial screening, but also metals with hardness-based evaluation criteria. For these metals, it was not possible to develop a single evaluation criterion to which the GoldSim-predicted solute concentrations could be compared. For the secondary screening method, a constituent was retained for further evaluation if there was a 10 percent probability that either event (A or B described previously) would occur more than 10 percent of the time and there was a 10 percent probability that the event magnitude was more than 5 percent of the applicable NorthMet Project Proposed Action evaluation criteria (see section 5.2.2.2.3 for a more detailed explanation).

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Table 5.2.2-42 Plant Site Tributary Surface Water – Maximum P90 Solute Concentration Over Entire 500-Year Simulation Period Based on GoldSim Probabilistic Model

Parameter	**Stream Standard**	**Units**	**MLC-2**		**MLC-3**		**TC-1**		**PM-19**		**PM-11**	
General			**PA**	**CEC Scenario**	**PA**	**CEC Scenario**	**PA**	**CEC Scenario**	**PA**	**CEC Scenario**	**PA**	**CEC Scenario**
Alkalinity	NA	mg/L	132	266	103	284	101	286	104	278	102	260
Calcium	NA	mg/L	29.7	41.4	26.0	43.8	35.1	61.8	36.6	61.6	35.1	105
Chloride	230	mg/L	10.2	20.7	10.2	22.3	6.2	22.9	7.5	22.2	8.8	22.1
Fluoride	NA	mg/L	1.1	3.9	0.22	4.2	0.13	3.3	0.15	3.1	0.18	0.21
Hardness	500	mg/L	176	396	108	439	100	622	128	613	100	1,054
Magnesium	NA	mg/L	25.9	71.7	12.4	80.5	7.75	115	10.0	114	10.3	196
Potassium	NA	mg/L	3.78	9.36	2.45	10.21	1.45	10.96	1.82	10.7	2.08	11.7
Sodium	NA	mg/L	21.0	66.8	5.46	73.3	3.81	73.3	4.67	70.6	4.76	64.5
Sulfate	NA	mg/L	63.0	224	14.6	261	12.2	301	19.5	289	13.5	427
TDS	700	mg/L	234	597	133	666	127	760	143	738	136	983
Metals Total												
Aluminum	125	µg/L	**187**	**158**	**189**	**139**	112	111	**135**	**129**	**159**	**151**
Antimony	31	µg/L	0.40	0.44	0.39	0.46	20.3	0.50	19.0	0.49	19.6	0.68
Arsenic	53	µg/L	4.44	4.41	4.51	4.79	10.0	4.21	9.82	3.97	10.0	3.61
Barium	NA	µg/L	93.9	194	61.9	208	5.00	167	10.7	160	5.00	29.4
Beryllium	NA	µg/L	0.19	0.30	0.17	0.32	0.66	0.47	0.62	0.47	0.64	0.83
Boron	500	µg/L	94.5	282	28.0	311	368	379	349	370	356	517
Cadmium	NA[1]	µg/L	0.16	0.17	0.12	0.18	2.00	0.19	1.95	0.19	2.00	0.26
Chromium III	NA[1]	µg/L	1.78	1.57	1.87	1.43	7.60	1.14	7.39	1.33	7.53	1.49
Cobalt	5	µg/L	2.73	2.48	2.78	2.35	5.00	2.86	4.93	2.74	5.00	4.73
Copper	NA[1]	µg/L	2.23	2.73	2.23	2.94	9.00	3.42	8.87	3.30	9.00	5.25
Iron	NA	µg/L	12,396	10,460	12,587	9,236	6,979	7,426	8,331	8,673	10,490	10,625
Lead	NA[1]	µg/L	1.43	1.26	0.50	1.38	3.00	1.13	2.95	1.07	3.00	0.42
Manganese	NA	µg/L	1,302	1,113	1,353	979	712	867	886	982	1,085	1,379
Nickel	NA[1]	µg/L	4.08	4.55	4.02	4.83	50.0	5.89	49.1	5.77	50.0	9.84
Selenium	5	µg/L	0.87	0.76	0.82	0.76	5.00	0.79	4.87	0.77	4.99	0.93
Silver	1	µg/L	0.13	0.15	0.13	0.17	0.33	0.19	0.32	0.18	0.32	0.25
Thallium	0.56	µg/L	0.17	0.19	0.16	0.20	0.24	0.18	0.23	0.18	0.23	0.16
Vanadium	NA	µg/L	5.16	4.79	4.70	4.66	9.57	3.74	9.34	3.72	9.52	1.00
Zinc	NA[1]	µg/L	19.2	18.1	19.2	16.8	100	13.9	98.2	15.3	99.9	15.8

Source: PolyMet 2014w.

Notes:
For each constituent at each location, the maximum solute concentration over the entire 500-year simulation period is recorded for each of 500 realizations of the Monte Carlo run. At the end of the Monte Carlo run, there is a list of 500 maximum concentration values for each constituent at each location. Each list is converted to a cumulative frequency distribution. Each value in this table is the 90th percentile concentration from the associated distribution.
Bold value indicates the non-hardness based constituent was retained for secondary screening.
CEC = Continuation of Existing Conditions
PA = NorthMet Project Proposed Action
[1] Parameter has a hardness-based evaluation criterion and is screened using the secondary screening procedure (see Table 5.2.2-44)

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Table 5.2.2-43 Plant Site Embarrass River Surface Water – Maximum P90 Solute Concentration

Parameter	Stream Standard	Units	PM-12		PM-12.2		PM-13	
General			**PA**	**CEC Scenario**	**PA**	**CEC Scenario**	**PA**	**CEC Scenario**
Alkalinity	NA	mg/L	100	100	100	100	101	179
Calcium	NA	mg/L	23.4	23.4	41.5	41.5	33.9	49.3
Chloride	230	mg/L	10.1	10.1	9.9	9.9	9.7	13.1
Fluoride	NA	mg/L	0.21	0.21	0.21	0.21	0.21	1.4
Hardness	500	mg/L	96.7	96.7	463	463	208	453
Magnesium	NA	mg/L	12.3	12.3	88.3	88.3	31.6	81.3
Potassium	NA	mg/L	2.44	2.44	18.6	18.6	6.19	9.13
Sodium	NA	mg/L	5.41	5.41	32.9	32.9	12.5	42.1
Sulfate(2)	NA	mg/L	14.3	14.3	375	375	114	217
TDS	700	mg/L	128	128	626	626	269	521
Metals Total								
Aluminum	125	µg/L	188	188	180	180	**180**	**179**
Antimony	31	µg/L	0.36	0.36	0.33	0.33	9.17	0.40
Arsenic	53	µg/L	4.36	4.36	4.15	4.15	5.81	4.21
Barium	NA	µg/L	49.8	49.8	39.3	39.3	35.4	93.7
Beryllium	NA	µg/L	0.15	0.15	0.14	0.14	0.31	0.33
Boron	500	µg/L	26.5	26.5	70.1	70.1	151	225
Cadmium	NA[1]	µg/L	0.11	0.11	0.11	0.11	1.01	0.15
Chromium III	NA[1]	µg/L	1.80	1.80	1.71	1.71	4.13	1.70
Cobalt	5	µg/L	2.72	2.72	2.63	2.63	2.96	2.63
Copper	NA[1]	µg/L	2.06	2.06	2.07	2.07	5.67	2.55
Iron	NA	µg/L	12,476	12,476	11,927	11,927	11,808	11,687
Lead	NA[1]	µg/L	0.50	0.50	0.48	0.48	1.73	0.59
Manganese	NA	µg/L	1,305	1,305	1,279	1,279	1,239	1,247
Nickel	NA[1]	µg/L	3.23	3.23	3.39	3.39	28.42	4.54
Selenium	5	µg/L	0.78	0.78	0.78	0.78	2.74	0.76
Silver	1	µg/L	0.13	0.13	0.13	0.13	0.18	0.14
Thallium	0.56	µg/L	0.13	0.13	0.13	0.13	0.17	0.15
Vanadium	NA	µg/L	3.68	3.68	4.23	4.23	6.53	3.73
Zinc	NA[1]	µg/L	19.0	19.0	18.3	18.3	57.0	18.5

Source: PolyMet 2014w.

Notes:
Bold value indicates the non-hardness based constituent was retained for secondary screening.
CEC = Continuation of Existing Conditions
PA = NorthMet Project Proposed Action
1 Parameter has a hardness-based evaluation criterion and is screened using the secondary screening procedure (see Table 5.2.2-44).
2 Sulfate 10 mg/L wild rice evaluation criterion applies at PM-13.

Table 5.2.2-44 Secondary Screening for Embarrass River Watershed

Evaluation Location	Constituent	Events A or B[1,2] - Data Used for Secondary Screening												Mine Years
		Occurrence (%)[3]				Magnitude of Concentration Increase (%)[4]				Magnitude of Concentration Increase (µg/L)[5]				
		1-55		56-200		1-55		56-200		1-55		56-500		Mine Years
		50%	90%	50%	90%	50%	90%	50%	90%	50%	90%	50%	90%	Percentile
MLC-2	Cd	0	0	0	0	NA	NA	NA	NA	NA	NA	NA	NA	**Constituents with Hardness-Based Evaluation Criteria**
	Cr III	0	0	0	0	NA	NA	NA	NA	NA	NA	NA	NA	
	Cu	0.5	0.8	0.5	0.7	19.5	85.6	22.8	92	0.7	2.7	0.7	2.9	
	Ni	0	0	0	0	NA	NA	NA	NA	NA	NA	NA	NA	
	Pb	0.8	1.2	1.1	1.3	23.6	90.6	23.9	91.8	0.1	0.3	0.1	0.3	
	Zn	0.3	0.6	0.4	0.5	22.1	94.7	24.7	105.2	10.8	43.5	11.5	46.7	
MLC-3	Cd	0	0	0	0	NA	NA	NA	NA	NA	NA	NA	NA	
	Cr III	0	0	0	0	NA	NA	NA	NA	NA	NA	NA	NA	
	Cu	0.8	1.4	0.8	1	28.2	115.9	28.4	116.1	0.8	3.3	0.8	3.3	
	Ni	0	0	0	0	NA	NA	NA	NA	NA	NA	NA	NA	
	Pb	1.7	2.3	1.6	1.9	27.4	109.5	27.5	109.8	0.1	0.3	0.1	0.3	
	Zn	0.6	0.9	0.5	0.7	31.6	139.1	32.8	138.8	13.3	53.2	13.4	56.5	
PM-11	Cd	0	0	0	0	NA	NA	NA	NA	NA	NA	NA	NA	
	Cr III	0	0	0	0	NA	NA	NA	NA	NA	NA	NA	NA	
	Cu	0.9	1.4	0.9	1.1	11.7	59.8	10.2	52.9	0.5	2.3	0.5	2.3	
	Ni	0	0	0	0	NA	NA	NA	NA	NA	NA	NA	NA	
	Pb	5.8	7	6.3	6.7	7.2	34.3	6.5	30.3	0.1	0.2	0.1	0.2	
	Zn	0.2	0.5	0.1	0.2	22.2	91	25.8	98.6	11.9	47.7	13.5	53.4	
PM-12.2	Cd	0	0	0	0	NA	NA	NA	NA	NA	NA	NA	NA	
	Cr III	0	0	0	0	NA	NA	NA	NA	NA	NA	NA	NA	
	Cu	0	0	0	0	NA	NA	NA	NA	NA	NA	NA	NA	
	Ni	0	0	0	0	NA	NA	NA	NA	NA	NA	NA	NA	

Evaluation Location	Constituent	Events A or B[1,2] - Data Used for Secondary Screening												
		Occurrence (%)[3]				Magnitude of Concentration Increase (%)[4]				Magnitude of Concentration Increase (µg/L)[5]				
		1-55		56-200		1-55		56-200		1-55		56-500		Mine Years
		50%	90%	50%	90%	50%	90%	50%	90%	50%	90%	50%	90%	Percentile
	Pb	0	0	0	0	NA	NA	NA	NA	NA	NA	NA	NA	
	Zn	0	0	0	0	NA	NA	NA	NA	NA	NA	NA	NA	
PM-12.3	Cd	0	0	0	0	NA	NA	NA	NA	NA	NA	NA	NA	
	Cr III	0	0	0	0	NA	NA	NA	NA	NA	NA	NA	NA	
	Cu	0.2	0.3	0.1	0.2	2.4	15	3.3	19.8	0.2	1	0.3	1.2	
	Ni	0	0	0	0	NA	NA	NA	NA	NA	NA	NA	NA	
	Pb	0	0.2	0	0.1	2.3	11.5	3.2	18.1	<0.05	0.1	0	0.2	
	Zn	0	0.3	0.1	0.1	2	15.6	1.3	17.3	2.1	13.4	1.5	13.4	
PM-12.4	Cd	0	0	0	0	NA	NA	NA	NA	NA	NA	NA	NA	
	Cr III	0	0	0	0	NA	NA	NA	NA	NA	NA	NA	NA	
	Cu	0.2	0.3	0.1	0.2	2.3	13.6	3	18	0.2	0.9	0.2	1	
	Ni	0	0	0	0	NA	NA	NA	NA	NA	NA	NA	NA	
	Pb	0	0.2	0	0.1	2.2	13.7	3.5	18.7	<0.05	0.1	0	0.2	
	Zn	0	0.3	0.1	0.2	1.9	16.1	1.2	16.2	2.1	11.7	1.3	12.9	
PM-13	Cd	0	0	0	0	NA	NA	NA	NA	NA	NA	NA	NA	
	Cr III	0	0	0	0	NA	NA	NA	NA	NA	NA	NA	NA	
	Cu	0.2	0.3	0.1	0.2	3	20.7	4	24.9	0.2	1.2	0.3	1.4	
	Ni	0	0	0	0	NA	NA	NA	NA	NA	NA	NA	NA	
	Pb	0	0.2	0.1	0.1	3.2	19.9	5.7	25	<0.05	0.1	0	0.2	
	Zn	0.2	0.3	0.1	0.2	2.6	21	1.8	23.1	3	17.7	2	16.8	
PM-19	Cd	0	0	0	0	NA	NA	NA	NA	NA	NA	NA	NA	
	Cr III	0	0	0	0	NA	NA	NA	NA	NA	NA	NA	NA	
	Cu	0.2	0.5	0.3	0.4	13.7	62	10.1	44	0.7	3.3	0.6	2.3	
	Ni	0	0	0	0	NA	NA	NA	NA	NA	NA	NA	NA	

Evaluation Location	Constituent	Events A or B[1,2] - Data Used for Secondary Screening												
		Occurrence (%)[3]				Magnitude of Concentration Increase (%)[4]				Magnitude of Concentration Increase (µg/L)[5]				
		1-55		56-200		1-55		56-200		1-55		56-500		Mine Years
		50%	90%	50%	90%	50%	90%	50%	90%	50%	90%	50%	90%	Percentile
	Pb	0.5	0.9	1.3	1.6	9.1	36.8	6.6	26.2	0.1	0.3	0.1	0.2	
	Zn	0	0.2	0	0.1	20.4	81.9	21.9	75.2	12.7	56	14.2	51	
TC-1	Cd	0	0	0	0	NA	NA	NA	NA	NA	NA	NA	NA	
TC-1	Cr III	0	0	0	0	NA	NA	NA	NA	NA	NA	NA	NA	
TC-1	Cu	0.5	0.8	0.4	0.5	6	35.3	5.3	27.3	0.4	2.1	0.4	1.7	
TC-1	Ni	0	0	0	0	NA	NA	NA	NA	NA	NA	NA	NA	
TC-1	Pb	3	3.9	2.9	3.2	4.2	18.3	3.8	15.1	0.1	0.2	0.1	0.2	
TC-1	Zn	0	0.2	0	0	16.5	83.3	22.3	84.9	11.7	54.1	16	64.8	
MLC-2	Al	15.6	17.7	16.2	17.9	12.7	38.6	12.8	38.9	17.5	53.1	17.6	53.2	Constituents with *Non*-Hardness-Based Evaluation Criteria
MLC-3	Al	19.4	21.7	19.4	20.9	17.9	54.4	17.8	54.3	23.3	71.4	23.2	71.2	
PM-11	Al	5.9	7	4.9	5.4	6	15.9	3.5	11.3	8.8	23.4	5.1	16.7	
PM-12.3	Al	11.2	12.9	10.1	10.9	1.8	5.4	1.1	4.2	2.8	8.2	1.7	6.4	
PM-12.4	Al	11.7	13.3	10.6	11.5	1.7	5.1	1	4	2.6	7.7	1.6	6	
PM-13	Al	11.5	13.3	11.1	11.8	1.9	5.9	1.2	4.5	3	8.9	1.8	6.7	
PM-19	Al	2.2	2.9	0.8	1	4.8	9.6	3	10.2	7	14.7	4.2	14.9	

Notes:

- (yellow) 90th percentile of the percent of time is greater than 10%
- (blue) 90th percentile of the magnitude of events is greater than 5% of NorthMet Project Proposed Action evaluation criterion
- (red) Constituent/Evaluation Location characterized by both of the above for the same time period

CEC = Continuation of Existing Conditions
PA = NorthMet Project Proposed Action

1 Event A is when PA>Evaluation Criterion and CEC<Evaluation Criterion; Event B is when PA>CEC and CEC>Evaluation Criterion
2 For Event A, the magnitude of exceedance (in µg/L) equals the PA concentration minus the PA water quality evaluation criterion. For Event B, the magnitude of exceedance (in µg/L) equals the PA concentration minus the CEC concentration.
3 As a percent of time
4 As a percent of PA evaluation criterion
5 Unless otherwise noted

Tables 5.2.2-42 and 5.2.2-43 show that the maximum P90 concentrations for the NorthMet Project Proposed Action would not exceed the applicable evaluation criteria with the following exceptions:

- The aluminum criterion would be exceeded at all locations except TC-1 (on Trimble Creek) for both the CEC scenario and the NorthMet Project Proposed Action;
- The 10 mg/L wild rice sulfate criterion would be exceeded at PM-13 for both the CEC scenario and the NorthMet Project Proposed Action, however sulfate concentrations are far less under the NorthMet Project Proposed Action.

As shown, in Table 5.2.2-44, aluminum did not pass secondary screening. It was retained for further analysis below along with sulfate and lead because they are constituents of interest. Some constituents indicated a relatively high magnitude percent increase in concentration. However, with the exception of aluminum, the percent of time a modeled impact occurred for these constituents was very small. Table 5.2.2-45 below compares the P50 and P90 modeled concentrations for the NorthMet Project Proposed Action and the CEC scenario for selected key constituents during mine operations, reclamation, and closure and post-closure maintenance at PM-13, which is the most downstream evaluation location that would reflect all NorthMet Project Proposed Action-related contaminant loadings. As these data show, the sulfate concentrations would decrease for the NorthMet Project Proposed Action relative to the CEC scenario across all three probability values and all three mine phases.

Current Tailings Basin seepage with high sulfate concentrations reaches the Embarrass River, affecting sulfate concentrations at PM-13. Under the NorthMet Project Proposed Action, nearly all of this seepage would be collected and prevented from reaching the river, and the flow is replaced by treated WWTP effluent with a low sulfate load. As a result, the sulfate load to the Embarrass River is reduced, as reflected by lower sulfate concentrations at PM-13 under the NorthMet Project Proposed Action compared with the CEC scenario. However, this reduction is not sufficient to meet the 10 mg/L wild rice sulfate evaluation criterion that applies at PM-13.

Comparison of GoldSim-predicted CEC scenario and NorthMet Project Proposed Action conditions at PM-13 for arsenic, copper, lead, nickel, and zinc indicates that NorthMet Project Proposed Action concentrations of these metals would all be higher than CEC scenario concentrations during all phases. The reason for increased PM-13 concentrations for these metals is that concentrations of these metals in the WWTP effluent, which is used for stream augmentation, would be higher than the concentrations in the existing LTVSMC Tailings Basin seepage (assumed for CEC scenario). As a consequence, there would be an increase in solute loading to the Embarrass River during operations and closure and post-closure maintenance when compared to the CEC scenario.

Table 5.2.2-45 Comparison of the Maximum P50 and P90 Values for NorthMet Project Proposed Action and CEC Scenario Concentrations at PM-13 for Selected Key Constituents, by Phase

Parameter	Units	Maximum P50 Operations (Years 2-20)		Maximum P50 Reclamation (Years 21-55)		Maximum P50 Closure & Post-Closure Maintenance (Years 56-500)		Maximum P90 Operations (Years 2-20)		Maximum P90 Reclamation (Years 21-55)		Maximum P90 Closure & Long-Closure Maintenance (Years 56-500)	
		PA	**CEC**	**PA**	**CEC**	**PA**	**CEC**	**PA**	**CEC**	**PA**	**CEC**	**PA**	**CEC**
Sulfate	mg/L	88.8	187.2	89.0	185.4	89.0	184.8	111.7	209.1	112.5	217.4	113.6	215.1
Aluminum	µg/L	100.5	100.2	104.5	103.0	102.1	100.9	168.3	165.1	173.3	169.8	179.9	178.7
Arsenic	µg/L	5.0	1.9	3.8	1.9	3.7	1.9	5.8	3.9	4.4	3.9	4.9	4.2
Copper	µg/L	4.9	1.9	3.9	1.8	3.8	1.7	5.7	2.3	4.5	2.6	4.5	2.5
Lead	µg/L	1.5	0.5	1.1	0.5	1.1	0.5	1.7	0.6	1.3	0.6	1.3	0.6
Nickel	µg/L	23.7	3.3	17.2	3.1	16.7	3.1	28.4	4.0	20.8	4.5	20.4	4.5
Zinc	µg/L	48.0	9.4	33.3	9.3	15.0	9.3	57.0	18.0	42.6	18.3	21.3	18.5

Source: PolyMet 2014w.

Notes:
CEC = Continuation of Existing Conditions
PA = NorthMet Project Proposed Action

Aluminum in Surface Waters of the Embarrass River Watershed

As shown in screening Tables 5.2.2-43 and 5.2.2-44, the maximum P90 values for aluminum would exceed the 125 µg/L water quality evaluation criterion at nearly all surface water evaluation locations for both the NorthMet Project Proposed Action and CEC scenarios. The exceedances are shown for Embarrass River stations PM-12, PM12.2, and PM-13, and for tributary stations MLC-2 and MLC-3 on Mud Lake Creek, PM-19 on Trimble Creek, and PM-11 on Unnamed Creek (locations are shown on Figure 5.2.2-9). These initial screening results indicate the need for secondary screening. Secondary screening in Table 5.2.2-44 shows further discussion is required because aluminum did not pass this screening at MLC-2, MLC-3, PM-12.3, PM-12.4, and PM-13.

Based on GoldSim results, Table 5.2.2-46 was developed to provide further analysis of aluminum at surface water evaluation locations. For three different phases of the project, maximum P90 values of annual maximum aluminum concentrations are listed for both the NorthMet Project Proposed Action and CEC scenarios. The three NorthMet Project Proposed Action phases considered are operations (mine years 1 to 20), reclamation (years 21 to 56), and post-closure maintenance (years 56 to 200). Inspection of GoldSim outputs indicated that predicted surface water concentrations were generally stable or decreasing after 200 years due to depletion of the chemical sources at the Tailings Basin, so mine years 201-500 were not included in the evaluation. Highlighted in the table are conditions where: 1) the CEC value is *lower* than the evaluation criterion (yellow), and 2) where the NorthMet Project Proposed Action concentration exceeds the criterion while the comparable CEC concentration does not (blue). Based on Table 5.2.2-46, the following observations are made:

- All maximum P50 values of annual aluminum for the three operating phases are below the 125 µg/L aluminum evaluation criterion. Most maximum P90 values of annual aluminum for the three operating phases are above the aluminum evaluation criterion. The maximum P90 values of annual aluminum are on average 66 µg/L higher than corresponding P50 values.
- For the P90 values, the maximum difference between NorthMet Project Proposed Action concentrations and comparable CEC concentrations is most significant for Mud Lake Creek (46 µg/L), but relatively small for the other tributary streams (5 µg/L for Trimble Creek and 9 µg/L for Unnamed Creek). The difference for the Embarrass River is very small (2 µg/L).
- There is only one case where the NorthMet Project Proposed Action concentration exceeds the evaluation criterion while the analogous CEC concentration is below the criterion. This occurs at PM-19 (Trimble Creek) for the maximum P90 of annual aluminum during the operations phase. However, closer inspection of the table shows that the NorthMet Project Proposed Action concentration of 129 µg/L is just above the criterion (125 µg/L) and is only 5 µg/L higher than the corresponding CEC concentration of 124 µg/L, which is just below the criterion.

Table 5.2.2-46 Maximum P50 and Maximum P90 of Annual Aluminum Concentrations for Different Project Phases

Stream	Evaluation Location	Evaluation Criterion	Operations (years 2-20)		Reclamation (years 21-55)		Post-Closure Maintenance (years 56-200)	
			PA	CEC	PA	CEC	PA	CEC
a. Maximum P50 of Annual Values from GoldSim Output								
Mud Lake Creek	MLC-3	125	105	74	109	77	107	76
	MLC-2	125	104	89	107	90	106	89
Trimble Creek	TC-1	125	57	55	60	56	56	55
	PM-19	125	70	67	74	70	68	69
Unnamed Creek	PM-11	125	89	83	91	84	87	83
Embarrass River	PM-12	125	105	105	109	109	107	107
	PM-12.2	125	101	101	104	104	103	103
	PM-13	125	100	100	105	103	102	101
b. Maximum P90 of Annual Values from GoldSim Output								
Mud Lake Creek	MLC-3	125	180	138	185	136	185	139
	MLC-2	125	178	155	180	155	180	158
Trimble Creek	TC-1	125	110	107	111	104	110	110
	PM-19	125	129	124	130	125	130	126
Unnamed Creek	PM-11	125	156	147	158	148	158	151
Embarrass River	PM-12	125	178	178	181	181	182	182
	PM-12.2	125	171	171	175	175	175	175
	PM-13	125	172	170	174	170	176	174

Notes:
CEC = Continuation of Existing Conditions
PA = NorthMet Project Proposed Action
Highlighted in the table are conditions where: 1) the CEC value is *lower* than the evaluation criterion (yellow), and 2) where the NorthMet Project Proposed Action concentration exceeds the criterion while the comparable CEC concentration does not (blue).
All concentrations are in mg/L.

Based on an evaluations of aluminum, it is generally concluded that the NorthMet Project Proposed Action is not the cause for the exceedances of the aluminum evaluation criterion at the P90 level in surface water at the Plant Site. Evaluation of the GoldSim outputs shows that predicted aluminum concentrations in surface water are dominated by mass loading from surface runoff, and the loading from other sources (including all project-related chemical sources) is minor. As such, there is no real link between the NorthMet Project Proposed Action and predicted P90 aluminum concentrations in surface water, which are commonly above the aluminum evaluation criterion.

Unlike the other Embarrass River tributaries, aluminum concentrations in Mud Lake Creek are predicted to be significantly higher for the NorthMet Project Proposed Action compared to the CEC scenario. What makes Mud Lake Creek different from the other tributaries is that under the NorthMet Project Proposed Action its drainage area above MLC-3 (2.24 mi^2) would be larger than for CEC (1.36 mi^2). This is because for the CEC, surface water and groundwater flowing toward the east toe of the Tailings Basin are assumed to continue to migrate through the Tailings Basin footprint and not provide any surface flow or groundwater to Mud Lake Creek. Under the NorthMet Project Proposed Action, a seepage containment system with barrier wall would be constructed along the East Toe, which would capture 100 percent of Tailings Basin seepage and divert surface flow and upwelling groundwater to the Mud Lake Creek via the constructed swale. Since aluminum in surface water tends to be dominated by surface runoff, there would be a greater aluminum load to Mud Lake Creek under the NorthMet Project Proposed Action compared to the CEC. The larger Mud Lake Creek watershed area under the NorthMet Project Proposed Action is responsible for the higher associated modeled aluminum concentrations. The higher aluminum concentrations in Mud Lake Creek are related to natural surface runoff and not to chemical sources associated with chemical sources from the NorthMet Project Proposed Action.

Constituents of Interest

Lead in Surface Water at PM-11

Examination of GoldSim outputs show that when lead concentrations at PM-11 are predicted to be elevated, the flow at PM-11 is dominated by WWTP discharges. In GoldSim, the WWTP effluent lead concentration is assumed to be 3 μg/L, which is the water quality standard for lead at the hardness of the discharge. Pilot testing of the proposed WWTP processes (Barr 2013f) has indicated that the WWTP is capable of discharging lead at lower concentrations, so the 3 μg/L concentration used in GoldSim is likely a higher value than what would actually be achieved. In addition, if necessary engineering modifications to the proposed WWTP could be made to ensure that WWTP effluent would have lead concentrations less than or equal to 2 μg/L. See Section 5.2.2.3.5 for a brief description of what adaptive mitigation measures could be made to achieve a lead effluent concentration of 2 μg/L.

To investigate the effect on WWTP effluent lead concentration on surface water concentrations at PM-11, a subsidiary GoldSim simulation (PolyMet 2015s) was performed for which the only change to the inputs was lowering the assumed WWTP effluent lead concentration from 3 to 2 μg/L. In making this change, the predicted frequency of lead exceedance at PM-11 (when the CEC scenario does not exceed) was reduced to 1.3 percent, which is substantially less than the 5 percent screening threshold. Given that pilot testing shows that 2 μg/L lead concentration is achievable in the WWTP effluent, it is likely that actual lead concentrations at PM-11 would have acceptably low frequencies of exceedance. If however, the proposed WWTP generates effluent with higher lead concentrations than expected, adaptive engineering measures could be invoked at the WWTP to lower the frequency of lead exceedances (see Section 5.2.2.3.5).

Sulfate in Surface Water in the Embarrass River

For the Embarrass River, the only surface water evaluation location that has a sulfate evaluation criterion is PM-13, because it has been previously identified as a draft MPCA staff-recommended wild rice production water. Therefore, a sulfate evaluation criterion of 10 mg/L was established for this FEIS. As shown in screening Table 5.2.2-43, the GoldSim maximum P90 concentration at PM-13 for the CEC scenario is 179 μg/L, which is well above 10 mg/L. Given that existing sulfate at PM-13 is above the evaluation criterion, the MPCA developed a set of specific water quality performance criteria for sulfate at the Plant Site. These are each evaluated at the end of this section.

As with the previous sections, Table 5.2.2-47 shows predicted maximum P50 and P90 annual sulfate concentrations at PM-13, and PM-12 and PM-12.2 for comparison. The table provides the following observations:

- At PM-12 and PM-12.2, there is virtually no change in sulfate between CEC scenario and NorthMet Project Proposed Action conditions.
- In progressing downstream from PM-12 to PM-12.2, there is generally a large increase in sulfate concentrations.
- The GoldSim-predicted PM-13 sulfate concentrations for both the NorthMet Project Proposed Action and the CEC scenario are significantly higher than historically measured sulfate at PM-13.
- At PM-13, the concentration for the NorthMet Project Proposed Action is generally about 100 mg/L less than the associated CEC scenario.
- At PM-13, there are no cases (both the NorthMet Project Proposed Action and CEC) where sulfate is below the 10 mg/L wild rice evaluation criterion.

Table 5.2.2-47 Maximum P50 and Maximum P90 of Annual Sulfate Concentrations for Different Project Phases

Evaluation Location	Evaluation Criterion	Operations (years 2-20)		Reclamation (years 21-55)		Post-Closure Maintenance (years 56-200)	
		PA	CEC	PA	CEC	PA	CEC
a. Maximum P50 of Annual Concentrations from GoldSim Output							
PM-12	NA	5.6	5.6	5.7	5.7	5.7	5.7
PM-12.2	NA	294	294	294	294	294	294
PM-13	10	89	188	89	185	90	185
b. Maximum P90 of Annual Concentrations from GoldSim Output							
PM-12	NA	12.6	12.6	14.0	14.0	14.3	14.3
PM-12.2	NA	367	367	368	368	371	371
PM-13	10	113	209	114	217	114	217

Notes:
CEC = Continuation of Existing Conditions
PA = NorthMet Project Proposed Action
Highlighting indicates where PA is above the evaluation criterion; however, in all these cases, PA is less than the corresponding CEC concentration.
All concentrations are in mg/L.

The similarity of CEC scenario and the NorthMet Project Proposed Action is reasonable for PM-12 and PM-12.2 because these evaluation locations are upstream of all mine facilities and would not be expected to exhibit any effects from the NorthMet Project Proposed Action. Also, the increase in sulfate at PM-12.2 is explained by surface discharge from Pit 5NW, which enters the Embarrass River just upstream of PM-12.2 and has sulfate concentrations of about 1,000 mg/L. The chemical sulfate load from Pit 5NW largely controls the magnitude of sulfate in downstream portions of the Embarrass River including PM-13.

As discussed in Section 4.2.2.3.2, the current increase in the Embarrass River chloride load in going from PM-12.2 (upstream of Plant Site) to PM-13 (downstream of Plant Site) provides reasonable evidence that nearly all surface seepage from the northern, northwestern, and western sides of the LTVSMC Tailings Basin is reaching the Embarrass River. It is estimated that this surface seepage is about 2,400 gpm and has an average sulfate concentration of about 230 mg/L, so that the associated sulfate load leaving the Tailings Basin is about 3,000 kg/day. However the plot of sulfate load in the Embarrass River (see Figure 4.2.2-51) indicates that between PM-12.2 and PM-13, the sulfate load increases by only about 200 kg/day. In Section 4.2.2.3.2, it is hypothesized that there is a natural process that sequesters sulfate in wetlands between the Tailings Basin and the Embarrass River and this explains the reduced sulfate load from the Tailings Basin to the Embarrass River. For conservativeness, the GoldSim model was programmed to *not* consider any loss of chemical load in surface flow between the Tailings Basin and the Embarrass River. As consequence, the model would be expected to overestimate sulfate concentrations at PM-13, with the difference being greater for CEC scenario for which there is no capture of the Tailings Basin surface seepage. This effect is illustrated on Figure 5.2.2-50, which uses cumulative probability to compare GoldSim predicted sulfate with measured sulfate at PM-13. The figure shows that GoldSim-predicted sulfate concentrations for both the NorthMet Project Proposed Action and the CEC scenario are greater than measured sulfate at PM-13. In recognition of GoldSim's tendency to overestimate sulfate concentrations at PM-13, evaluation of the NorthMet Project Proposed Action is oriented toward comparing the *difference* between the NorthMet Project Proposed Action and CEC scenario values, rather than focusing on the magnitude of predicted concentrations.

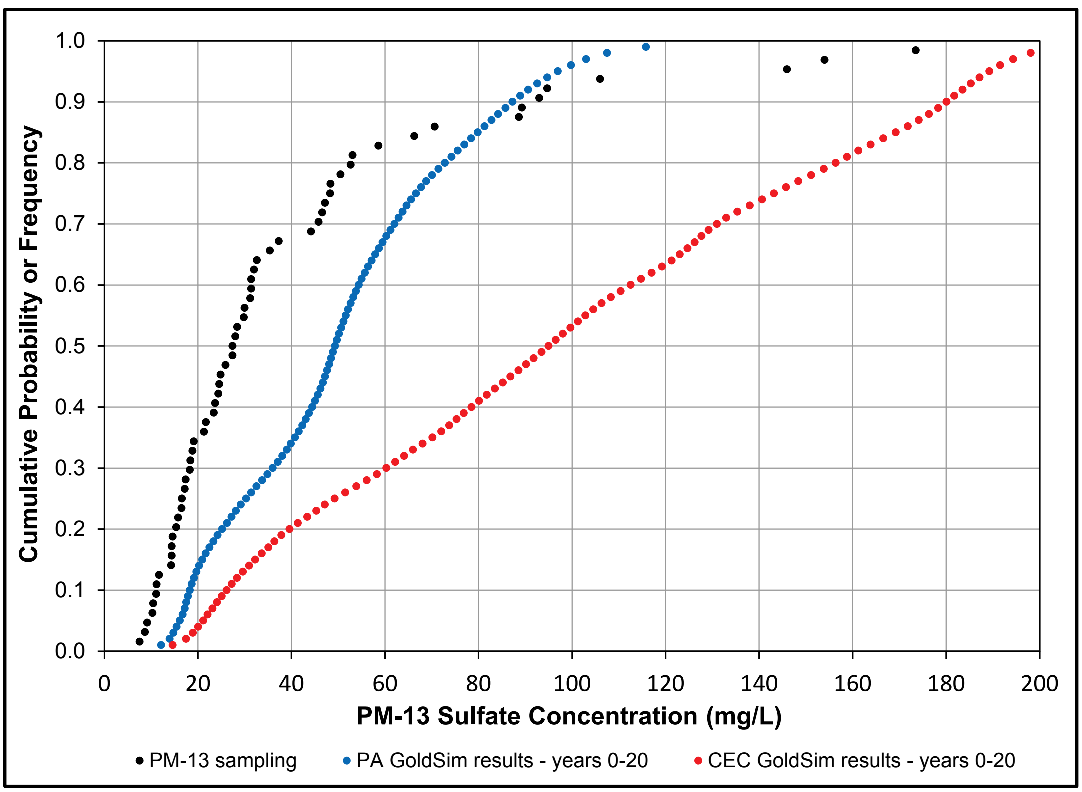


Figure 5.2.2-50 Comparison of Measured and Modeled Sulfate Concentrations at PM-13

Figure 5.2.2-51 shows GoldSim-predicted sulfate concentrations at PM-13. For sampling, NorthMet Project Proposed Action and CEC scenario plots, the model predicts that sulfate at PM-13 would be substantially reduced under the NorthMet Project Proposed Action compared to the CEC scenario. Although the model may overestimate the magnitude of sulfate concentrations, the relative reduction in concentrations at PM-13 is apparent. This result is explained by the engineering controls associated with the NorthMet Project Proposed Action. Currently there is about 2,400 gpm of surface seepage leaving the northern, northwestern, and western sides of the Tailings Basin that contains sulfate concentrations of about 230 mg/L. Under the CEC scenario, all Tailings Basin seepage reaches the Embarrass River and contributing its sulfate load to the Embarrass River. Under the NorthMet Project Proposed Action, nearly all of the surface seepage would be collected by the seepage containment system and sent to the WWTP. To augment the flow loss, at least 80 percent of the captured flow rate would be discharged to the tributaries after treatment has reduced the sulfate concentration to 9 mg/L. The result is that a substantial reduction in sulfate load to the Embarrass River would occur under the NorthMet Project Proposed Action and this explains the lower sulfate concentrations at PM-13 when compared to the CEC scenario.

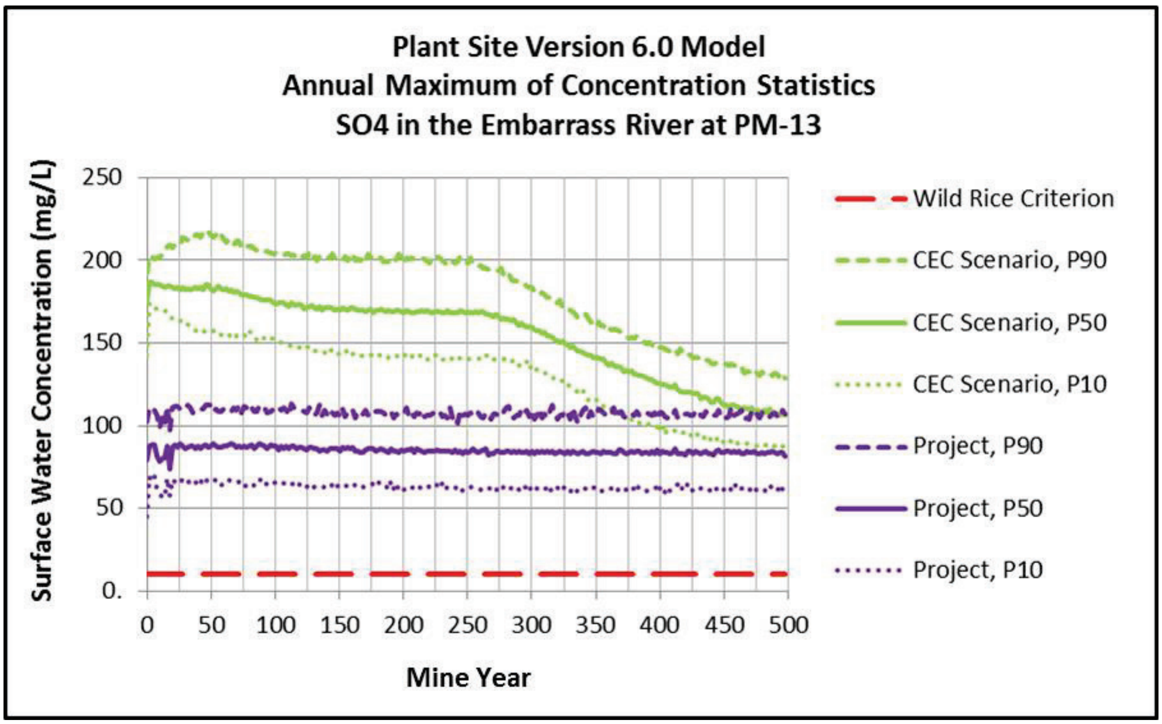


Figure 5.2.2-51 Maximum Annual Sulfate Concentrations at PM-13

The effect of the NorthMet Project Proposed Action on sulfate concentrations in the Embarrass River Watershed is of concern because MPCA has previously recommended waters within and downstream from Embarrass Lake, the northernmost tip of Wynne Lake, and the segment of the Embarrass River from Sabin Lake to the Highway 135 bridge, as waters used for production of wild rice (see Figure 5.2.2-1). Given that current sulfate concentrations at PM-13 are almost always higher than the 10 mg/L wild rice sulfate evaluation criterion, the MPCA has developed three supplemental water quality performance criteria for sulfate at the Plant Site (MPCA 2011d), which are each discussed below.

Performance Criterion 1

No increase in sulfate-loading from existing conditions would occur at PM-11 (Unnamed Creek), PM-19 (Trimble Creek), and MLC-2 (Mud Lake Creek).

Figures 5.2.2-52, 5.2.2-53, and 5.2.2-54 show GoldSim-predicted sulfate loading at PM-11, PM-19, and MLC-2, respectively, based on annual maximum values. As shown, the sulfate-loading at these three locations would be reduced under the NorthMet Project Proposed Action compared to the CEC scenario. The decrease is predicted to occur for P10, P50, and P90 concentrations. The model therefore predicts that this criterion would be met under the NorthMet Project Proposed Action.

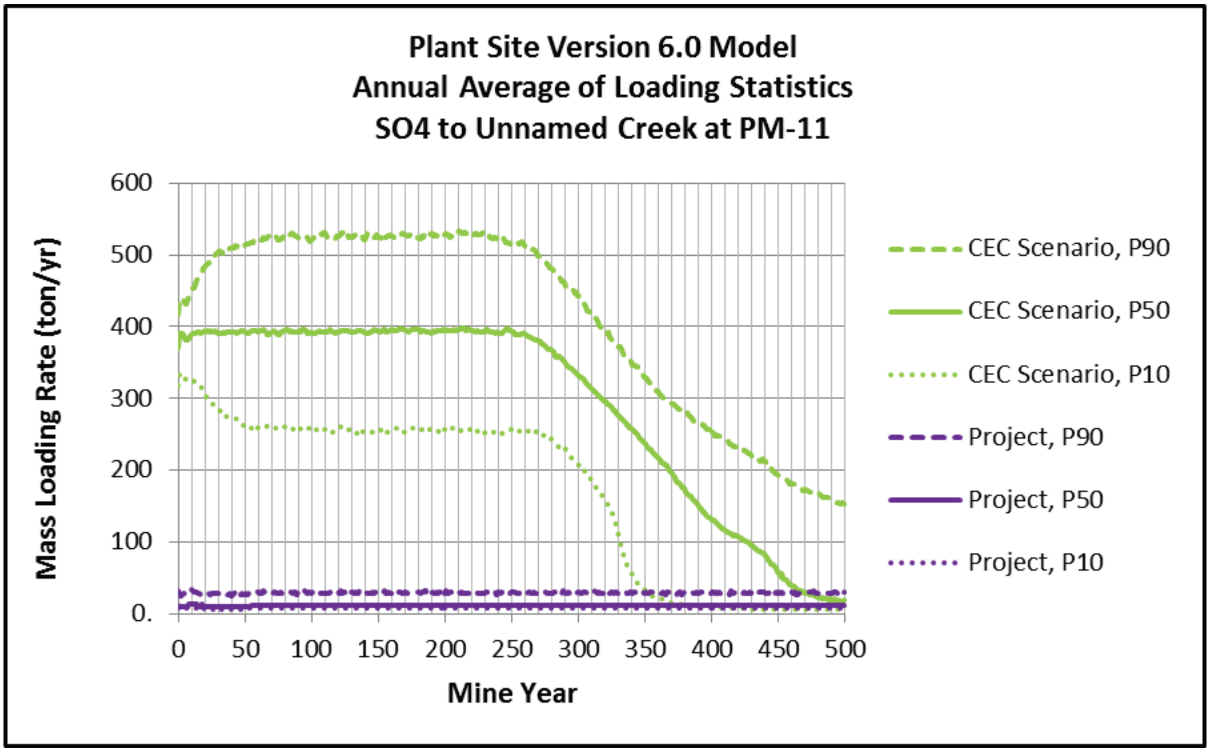


Figure 5.2.2-52 Maximum Annual Sulfate Loading at PM-11

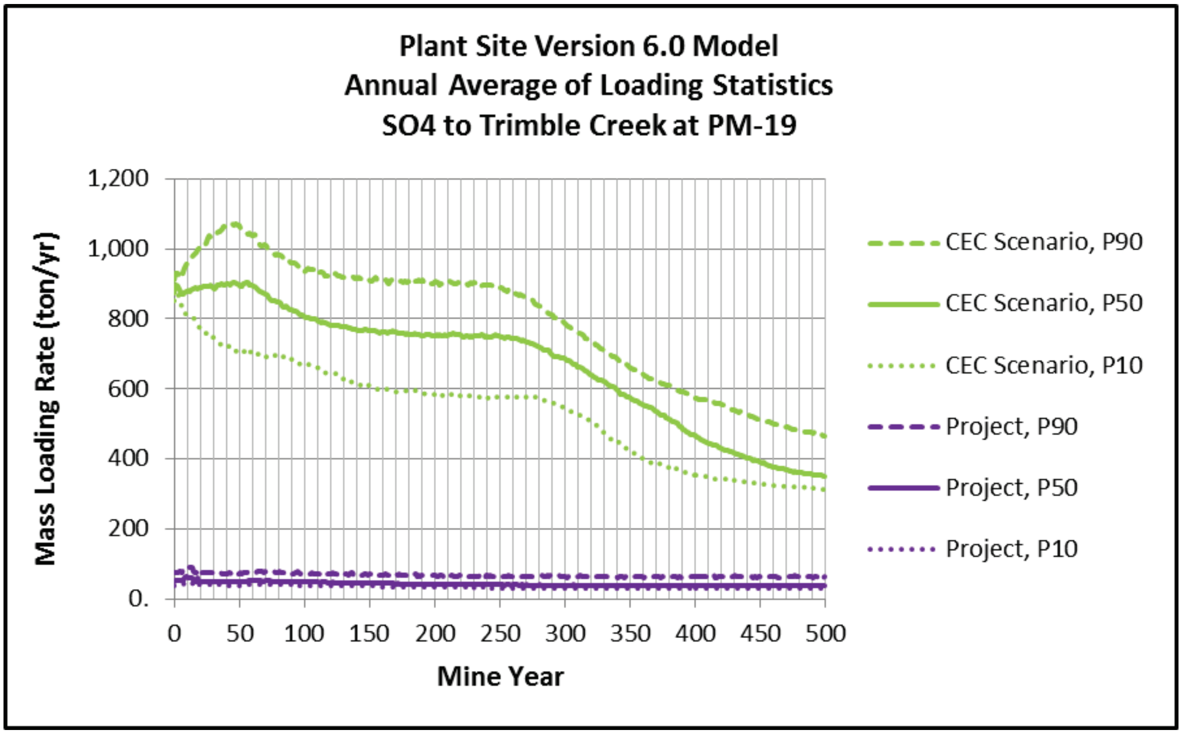


Figure 5.2.2-53 Maximum Annual Sulfate Loading at PM-19

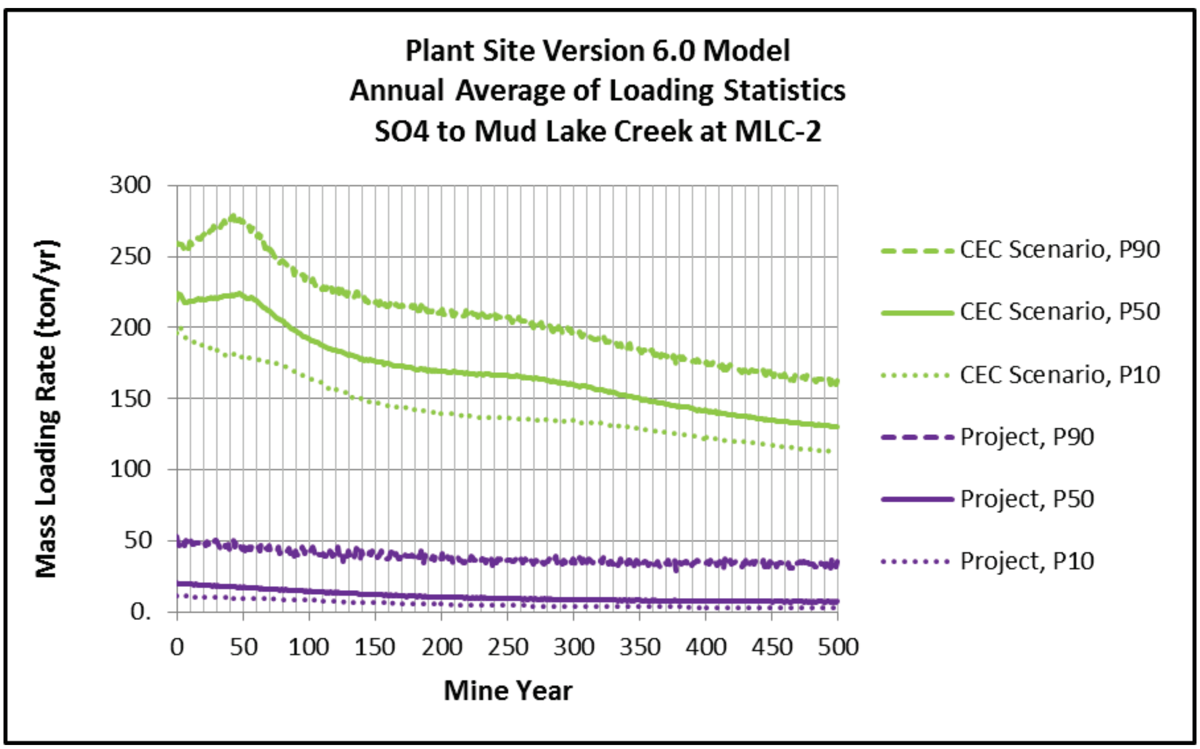


Figure 5.2.2-54 Maximum Annual Sulfate Loading at MLC-2

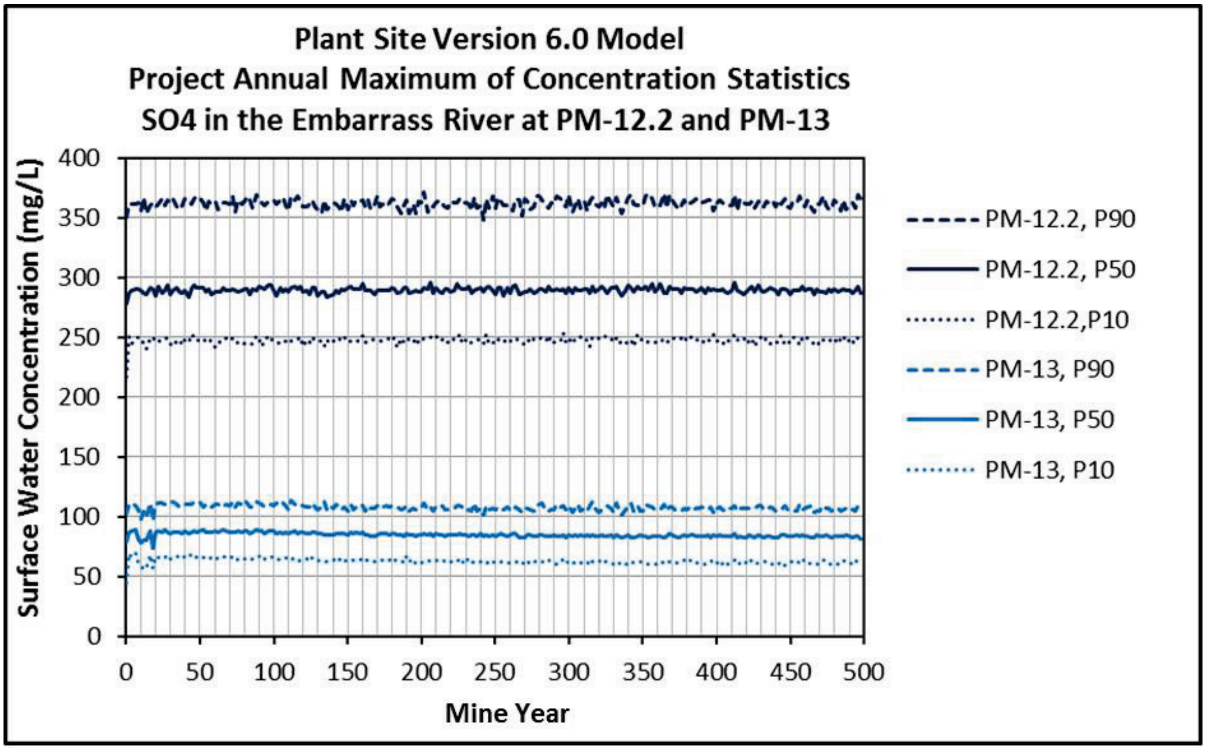


Figure 5.2.2-55 Maximum Annual Sulfate Concentrations at PM-12.2 and PM-13

Performance Criterion 2

The concentration of sulfate in the Embarrass River at PM-13 would decrease from existing condition.

Figure 5.2.2-51 shows GoldSim-predicted sulfate at PM-13 for the NorthMet Project Proposed Action and the CEC scenario. For P90, P50, and P10 values, the sulfate concentrations at PM-13 would be reduced under the NorthMet Project Proposed Action. As discussed previously, this concentration reduction under the NorthMet Project Proposed Action would result from the capture of tailings seepage with high sulfate by the seepage containment system and the discharge of most of this water to the Embarrass River with much lower sulfate due to treatment by the WWTP. The model therefore predicts that this criterion would be met under the NorthMet Project Proposed Action.

Performance Criterion 3

No statistically significant increase in sulfate would occur in the Embarrass River from upstream of the facility (e.g., PM-12.2) to downstream of the facility (e.g., PM-13).

Figure 5.2.2-55 compares GoldSim-predicted annual maximum sulfate concentrations at PM-12.2 with concentrations at PM-13. There are no NorthMet Project Proposed Action activities that would affect concentrations at PM-12.2, so this figure serves as a basis for determining downstream sulfate changes for Proposed Action conditions. Figure 5.2.2-55 shows that under the NorthMet Project Proposed Action, sulfate concentrations would substantially decrease in progressing downstream from PM-12.2 to PM-13, so this criterion would be met under the NorthMet Project Proposed Action.

<u>Plant Site Model Sensitivity Analyses</u>

The sensitivity of the GoldSim Model was evaluated for changes to groundwater recharge rates and climate change. The following sections summarize the sensitivity analysis findings for the Plant Site.

Recharge to Groundwater Sensitivity Analysis

A sensitivity analysis was performed to assess to what extend the model predictive simulation results depend on the definition of recharge (to groundwater) used to set up the NorthMet Plant Site water quality model. This analysis showed that changing the distribution used for aquifer recharge from triangular to lognormal and correlating recharge to precipitation in GoldSim model simulations does result in minor changes to 10th percentile, 50th percentile, and 90th percentile of the model calculated groundwater and surface water concentrations. However, the changes are minimal. Further, the potential to exceed an applicable groundwater and surface water standards is not sensitive to these model input changes (Barr 2015d).

Climate Change Sensitivity Analysis – Plant Site

The potential effects of a climate change upon the predictions of both the GoldSim probabilistic models developed for the Plant Site, the Plant Site NorthMet Project Proposed Action Model and No Action Plant Site NorthMet Project Proposed Action Model, were evaluated by running the "climate change sensitivity analysis." The ranges of precipitation and temperature input parameters were varied following the guidance provided by the Co-lead Agencies (Kellogg 2011). The sensitivity of the model predictions to changes in values of those parameters was quantitatively assessed at the toes of the Tailings Basin and qualitatively assessed at other locations within the model domain. In summary, the Climate Change Sensitivity Analysis Model was set by increasing: 1) the mean annual temperature by 2.0 to 5.2 degrees Celsius, 2) the mean annual precipitation from 28.1 to 29.8 in/yr, and 3) the mean annual open water evaporation by 6.5 percent. The parameter values were linearly increased from mine year 1 to mine year 60 and, then, were kept constant. Such modified model was used to run 200-year predictive simulations, similar to the NorthMet Project Proposed Action Models.

The impacts of the modeled changes upon contaminant concentrations in seepage water at the toes were analyzed for lead, sulfate, copper, and iron. Lead concentrations would change most at the west and northwest toes, up to 13 percent. Similarly, the largest increase in sulfate concentrations, up to 15 percent, would occur at the west and northwest toes. The largest increase in copper concentrations, up to 12 percent, would occur, again, at the west and northwest toes. Finally, the largest increase in iron concentrations, up to 15 percent, would also occur at the west and northwest toes.

Seepage at the toes is expected to increase slightly due to the increased infiltration through the Tailings Basin. Climate change is not expected to cause significant changes in groundwater quality. Likewise, surface water quality in the Embarrass River and its tributaries is expected to be minimally affected by the NorthMet Project Proposed Action under climate change conditions. All water leaving the Tailings Basin's footprint would be treated by the WWTP, except for approximately 21 gpm of seepage that is conservatively expected to escape the Containment System. Runoff from the exterior of the East Dam is relatively inert.

It is likely that the amount of water that would need treatment at the WWTP would increase under climate change conditions. This is because the increase in precipitation would be slightly greater than the amount of water lost to increased evaporation (Barr 2015d).

5.2.2.3.4 Mercury

Mercury can be released to surface water or groundwater through mobilization of mercury stored in rock, soil, peat, and vegetation, and can also be deposited to surface water through atmospheric dry deposition and precipitation. Methylmercury, which is an organic form of mercury, accumulates in fish and is toxic to humans and wildlife at concentrations above a toxicity threshold. Current scientific understanding of the factors and mechanisms affecting mercury methylation and bioaccumulation is limited. Mercury concentrations in fish sampled from downstream lakes presently trigger advice to limit fish consumption. An increase in mercury in fish tissue would be counter to statewide efforts to reduce mercury concentrations in fish.

Mercury was not included in the GoldSim model for either the Mine Site or the Plant Site, as insufficient data and unique modeling requirements for mercury dynamics prevented modeling mercury like the other solutes. Regardless, the NorthMet Project Proposed Action would still need to demonstrate that the mercury evaluation criteria would be protected (see Section 5.2.2.1). Details of overburden management, which includes peat, is included in Section 5.2.2.3.2. Adaptive management has also been identified within the FEIS process that could reduce mercury concentrations if necessary (see Section 5.2.2.3.5). Therefore, a simple mass balance model estimation method was used. This simple estimation method was preferred over a detailed mechanistic model because it incorporated the important input and removal processes for mercury, was very transparent with regard to data inputs, and allowed for easy assessment of the effects of changing parameter values on mercury concentrations. For the Mine Site, this method, in combination with analog data from existing natural and mine pit lakes in the region, was used to assess future mercury concentrations in the West Pit lake and in the overflow water (PolyMet 2015m). A similar mass balance approach was used for the Plant Site to estimate future mercury concentrations released from the Tailings Basin.

The NorthMet Project Proposed Action and project area watershed information used to assess the potential effects on average annual mercury loading and concentrations at the Plant Site and Mine Site (Upper Embarrass River and Upper Partridge River, respectively) were also used in assessing the potential effects from the NorthMet Project Proposed Action on mercury loading in the St. Louis River (Barr 2015f).

This section discusses mercury from only a water-concentration perspective; the potential effects of the NorthMet Project Proposed Action on the bioaccumulation of methylmercury in fish are discussed in Section 5.2.6. Cumulative effects are discussed in Section 6.2.3.3.4 and 6.2.3.5.4.

Direct Release of Mercury to the Partridge River Watershed

The NorthMet waste rock and ore contain trace amounts of mercury. Laboratory analysis of humidity cell leachates from waste rock samples found average total mercury concentrations between 5 and 7 ng/L, with concentrations unrelated to rock type or sulfur content (SRK 2007b).

Separate 36-day batch tests using local rainfall (12 ng/L total mercury) found that contact with Duluth Complex rock actually decreased total mercury concentrations to between 1.9 and 3.2 ng/L as a result of adsorption (SRK 2007b). Therefore, the data suggest that most of the mercury present in rainfall or released by sulfide oxidation is typically adsorbed by other minerals present in the mine waste rock. The primary NorthMet Project Proposed Action-related source of mercury to the Partridge River would be the WWTF discharge.

As discussed previously, there would be no surface water discharges to the Partridge River or its tributaries from the Mine Site until approximately year 52, when the West Pit would be flooded and the overflow would be directed to the WWTF for treatment and discharge. The WWTF discharge would be subject to the GLI standard for mercury (1.3 ng/L). Mercury concentrations in the West Pit were estimated two ways: using analog data from other natural lakes and mine pit lakes in northeastern Minnesota, and using a mass balance approach.

The West Pit, like seepage/headwater lakes (e.g., lakes with no significant inflowing streams), would receive most of its water from precipitation and direct runoff from the surrounding watershed. Water balance modeling estimates that 70 percent of the West Pit inflow after reclamation would be from precipitation. Therefore, natural seepage/headwater lakes and existing mine pits in the vicinity of the NorthMet Project Proposed Action area can provide an analog for mercury concentrations that would occur in the West Pit at the time of overflow. Of particular significance are the Dunka Pit Lakes. Because the Dunka Pit intersects the Duluth Complex, the mercury concentration data from the Dunka Pit Lakes are considered an important indicator of potential total mercury concentrations for the West Pit at closure. Data from 16 mine pit lakes and five natural headwater/seepage lakes in northeastern Minnesota were evaluated. As Table 5.2.2-48 shows, despite the fact that the primary source of inflow to these lakes/pits was precipitation, which averages about 13 ng/L based on the annual average mercury concentration from the National Atmospheric Deposition Program for the Fernberg Road Monitoring Site (2010-2011) (PolyMet 2015m), only two of the lakes/pits had average total mercury concentrations above the GLI standard of 1.3 ng/L (Pit 2W at 1.61 ng/L and Pit 9S at 1.87 ng/L).

Table 5.2.2-48 Total Mercury Concentration Data from Natural Lakes and Mine Pits in Northeastern Minnesota

Lake/Pit Type	Number of Lakes/Pits	Minimum Mercury Concentration[1] (ng/L)	Average Mercury Concentration (ng/L)	Maximum Mercury Concentration[1] (ng/L)	Number with Avg Concentration >1.3 ng/L
Natural Lakes	5	0.34	0.66	1.73	0
Pit Lakes	16	0.5	0.97	2.55	2

Source: PolyMet 2015m.

Note:
[1] Data represent lowest and highest individual samples from lakes.

A mass balance approach was also used to evaluate potential mercury concentrations in the West Pit. For this evaluation, unless otherwise specified, ‘mercury’ refers to total mercury. Elemental mercury was not a part of the evaluation process, as no elemental mercury releases are anticipated from mining or processing operations. Mass balance models range from simple spreadsheet-based formats to more complex such as the GoldSim model. An important consideration in the selection of a water quality model is the complexity of the chemical being assessed and the available data, and the consideration that a complex situation may not require a complex water quality model (Loucks et al. 2005). The MPCA's spreadsheet-based model allows reviewers to focus on key inputs and their impact on model behavior and results. Furthermore, the use of a separate spreadsheet model for mercury enabled the specification of assumptions that were specifically conservative for mercury but that were not necessarily conservative for other contaminants, for example the depth of the mixing zone (Barr 2015f).

The mass balance took into consideration average inflows and estimated potential mercury inputs from precipitation, atmospheric dry deposition, groundwater inflow, Category 1 Stockpile drainage, other stormwater runoff within the Mine Site, supplemental water from the Plant Site WWTP, collected seepage from the Tailings Basin, and inflows from the East Pit (see Table 5.2.2-49). The mass balance also took into consideration the loss of mercury via burial (i.e., loss due to settling), evasion/volatilization, and outflow (i.e., pumping to the WWTF for treatment and discharge). Category 1 Stockpile drainage was assumed to be unaltered by the waste rock in the stockpile (i.e., no adsorption of mercury to the waste rock), which is a conservative assumption as there is evidence that waste rock likely adsorbs mercury from precipitation. The mass balance model conservatively assumed that mixing only occurred in the upper 30 ft of the water column, as this would limit the volume of water available to dilute the mercury-loading.

Table 5.2.2-49 Initial and Final Parameter Values for the Mercury Mass Balance

Parameter	Flow in Mine Year 60	Total Mercury Concentration or Flux
Wet and Dry Deposition Precipitation (based on monitoring data) (1) Atmospheric dry deposition Total wet and dry deposition	697 acre-ft/yr(1) NA NA	13 ng/L; 9,407 ng/m²/yr(1) 3,093 ng/m²/yr(1) 12,500 ng/m²/yr(1)
Contained/Uncontained Category 1 Stockpile drainage	0.3 ac-ft/yr(2)	13 ng/L
Watershed runoff (stormwater runoff from undisturbed or reclaimed/revegetated areas; includes the runoff from the Category 1 Stockpile)	30 ac-ft/yr(2)	4 ng/L(3)
Groundwater Inflow (shallow aquifer)	45 ac-ft/yr(2)	3 ng/L(3)
East Pit flow (from wetland)	248 ac-ft/yr(2)	4 ng/L
Backfilled East Pit flow (groundwater) (“lower pore water seepage”)	0 (2) (Intermittent contribution; 0.02 to 0.15 ac-ft/yr during pit flooding)	4 ng/L
Treated Water: Mine Site WWTF	0(2) (Up to 588 acre-ft/yr during pit flooding)	8 ng/L
Plant Site Water: Treated water from the WWTP and collected seepage water (untreated) from the Tailings Basin seepage containment systems (supplemental water for pit flooding)	0(2) (Up to 3,500 acre-ft/yr during pit flooding)	1.3 ng/L
West Pit Mercury Losses		
Burial	NA	92% of total load; 12,700 ng/m²/yr(4)
Evasion/Volatilization (~5% of atmospheric inputs)	NA	5% of atmospheric inputs(5)
Outflows	490 acre-ft/yr(2)	Varies with concentration of West Pit water column

Source: PolyMet 2015m, Table 6-15.

Notes:
1 Precipitation volume from monitoring stations within 30 miles of the NorthMet Project Proposed Action area based on mean annual precipitation (1981-2010 climate normal); annual average mercury concentration from the National Atmospheric Deposition Program for the Fernberg Road Site (MN18) (2010-2011). Total atmospheric deposition is assumed to equal 12,500 nanograms per square meter per year (ng/m²/yr) (Swain et al. 1992). Dry deposition is set equal to the difference between total and wet deposition and represents about 25% of total deposition.
2 Flow estimate from GoldSim Modeling results.
3 Estimate of mercury concentration based on NorthMet Project Proposed Action data.
4 Burial rate for mercury is lower (more conservative) than initial estimate according to the burial regression equation discussed in PolyMet 2015m.
5 Volatilization rate is estimated based on the low end of the range of values discussed PolyMet 2015m.

Based on the input values from Table 5.2.2-49 above, the estimated average mercury concentration of the West Pit during flooding (years 20 to 52) would initially be approximately 0.3 ng/L, and after flooding (after year 52) would stabilize at approximately 0.9 ng/L.

It should be noted that the West Pit overflow would be treated by the WWTF using RO or equivalent technology known to remove mercury and would meet water quality targets prior to discharge. Therefore, the actual mercury concentrations in the WWTF effluent discharge are expected to be less than the concentrations predicted for the West Pit lake (i.e., less than 0.9 ng/L), although an effluent mercury concentration of 1.3 ng/L was assumed for purposes of estimating mercury concentrations in the WWTF discharge. Table 5.2.2-50 provides a summary of the initial mass balance results, with the largest input of mercury to the West Pit coming from atmospheric deposition (about 66 percent of total estimated inputs), and the largest loss of mercury attributed to burial (about 92 percent of total mercury inputs).

The Overburden Storage and Laydown Area would not be lined, but would have a compacted soil bottom. Unsaturated overburden and peat would be temporarily stored at the Overburden Storage and Laydown Area until it is utilized for reclamation purposes. Some of the temporarily stored organic material would decompose on site, which would release mercury into solution. Any dissolved mercury would be transported in solution with precipitation that falls on the Overburden Storage and Laydown Area (PolyMet 2015r). Any mercury released from the peat decomposition process is thought to be transported with precipitation that falls on the Overburden Storage and Laydown Area. Because the Overburden Storage and Laydown Area would be unlined, there would be some potential for seepage to enter the groundwater system from peat that has decomposed and releases as a pulse of mercury. However, construction of the Overburden Storage and Laydown Area would result in a compacted bed that would limit downward seepage and facilitate routing of water to storage ponds.

Stormwater runoff from the Overburden Storage and Laydown Area would be considered process water which would be routed to the process water pond and eventually collected and routed to the Tailings Basin for years 1 to 11, where much of the mercury would be sequestered in the tailings through sorption. In years 12 to 20, the Overburden Storage and Laydown Area stormwater runoff would be collected and routed to help flood the East Pit, where most of the remaining mercury would be sequestered with waste rock at depth (e.g., through settling and other chemical processes within the pit). Because peat removal from the areas to be mined would be completed between years 5 to 11, any potential release of mercury from stored peat materials would have occurred or would be ending by the time water is routed from the Overburden Storage and Laydown Area pond to the East Pit beginning in year 12. After year 20, the Overburden Storage and Laydown Area would be closed, reclaimed, and material removed, and therefore would no longer serve as a potential source of mercury.

The potential for mercury release from peat decomposition in the Overburden Storage and Laydown Area is included in the mass balance as part of the Process Water input. The mercury load from the Mine Site would slightly decrease during closure and long-term maintenance, because a portion of the flow that is currently watershed yield (total mercury concentration of 3.6 ng/L) would be captured in the West Pit lake and discharged via the WWTF at a conservatively assumed total mercury concentration of 1.3 ng/L. Flows from the Mine Site in closure and long-term maintenance are not expected to change from existing conditions; therefore, the change in total mercury concentration from 3.6 ng/L to 1.3 ng/L for a portion of the flow from the Mine Site results in reduced loading to the Partridge River (Barr 2015g). Therefore, the NorthMet Project Proposed Action is predicted to result in a net decrease in mercury-loading to the Partridge River from 24.2 to 23.0 grams per year, primarily due to a decrease in natural runoff and a proportional increase in water discharged from the West Pit via the WWTF (with a total mercury concentration of 1.3 ng/L).

Table 5.2.2-50 Summary of Estimated Mercury-Loading (Inputs)[1] and Losses (Outputs) for the West Pit Lake (Mine Year 20 to about Mine Year 52)

Parameters	Annual Average Load of Mercury (nanograms)	Percent of Summed Inputs	Comments
Inputs			
Atmospheric (wet + dry)	1.26E+10	66%	Dry deposition ~30% wet deposition
East Pit wetland overflow	9.03E+08	5%	Includes runoff from the East Pit and watershed to the East Pit
Process water (other than from the East Pit)	1.65E+09	9%	Includes runoff from the Category 1 Stockpile
Groundwater	2.74E+08	1%	Includes groundwater flow from undisturbed portions of the Mine Site + groundwater inflow from the East Pit + contained/ uncontained Category 1 Stockpile drainage
WWTF	1.61E+09	8%	
Pumping from the Plant Site: WWTP and collected seepage from the Tailings Basin	2.12E+09	11%	
SUM	1.91E+10		
Outputs (Losses)			
Evasion/Volatilization	6.30E+08	3%	Loss from the water column
Burial	1.76E+10	92%	
Groundwater	NE		
Overflow	2.58E+07	0.1%	
Removal by RO WWTF	NE		
SUM	1.82E+10		
NET (retention)			
Inputs – Outputs	8.73E+08		Net retention of mercury

Source: PolyMet 2015m, Table 6-16.

Notes:
NE = Not estimated for this analysis.
[1] Reasonably conservative estimates of mercury concentrations and average annual flow estimates from GoldSim modeling were used to estimate mercury-loading.

Direct Release of Mercury to the Embarrass River Watershed from the Tailings Basin

The Plant Site would receive inputs of mercury from two primary sources: residual trace concentrations in the tailings and process consumables, with some minor contributions from Mine Site process water, which would be pumped to the Tailing Basin pond through year 11 (and possibly through year 20, but is dependent on the NorthMet Project Proposed Action's water balance). As discussed in Section 5.2.2.3.1, all process make up water used for stream augmentation would be treated at the WWTP prior to discharge. Mercury would be released from the Tailings Basin via seepage, discharge from the WWTP, and volatilization from the Tailings Basin pond (this mechanism is discussed in Section 5.2.7, Air Quality). As with the Mine Site, mercury was not included in the GoldSim model, but a mass balance approach was used to estimate future mercury concentrations.

Several studies have been conducted by state agencies regarding the release of mercury from taconite ore processing and tailings facilities. Berndt (2003) concluded that wet and dry deposition of mercury was the major source of dissolved mercury in taconite tailings pond water, deposition of mercury was the major source of dissolved mercury in taconite tailings pond water, rather than the actual tailings themselves. Further, Berndt found that taconite tailings appear to be a sink for mercury in full-scale actual tailings basins in northern Minnesota, at least similar to other media like soils, as evidenced by lower mercury concentrations in waters seeping from tailings basins (specifically at U.S. Steel's Minntac Mine and Northshore Mining's Northshore Mine) than in either precipitation input or pond water in the tailings basin. The loss of mercury through adsorption to solids in the tailings basin and subsequent burial in the sediments results in an overall permanent retention of mercury within the basin and decreases the mercury load released to receiving waters. Berndt (2003) demonstrates that mercury released to surface waters during taconite processing is insignificant with respect to mercury concentrations found in local precipitation and existing background surface waters. This finding is supported by surface water monitoring around the existing LTVSMC Tailings Basin, which found mercury concentrations in surface water seepage to be consistent with baseline levels (see Table 4.2.2-4), generally averaging less than 2.0 ng/L. The overall average total mercury concentration at two discharge locations at the Tailings Basin (SD-026 and SD-004) over a 9-year period was 1.0 ng/L, indicating relatively low mercury concentrations in the existing LTVSMC Tailings Basin seepage. All monitoring results were well below average concentrations in precipitation, so most mercury appears to be sequestered in the LTVSMC tailings through adsorption (see Table 4.2.2-4).

A mass balance model was developed to aid in estimating potential release of mercury from the Plant Site. All major inputs of mercury were included in the mass balance model. The major outputs of mercury include the hydrometallurgical residue, air emissions from the hydrometallurgical process, the tailings, and the ore concentrate. The vast majority of the mercury is predicted to remain in the concentrate, with only about 8 percent predicted to be sent to the Tailings Basin via the tailings and process water. Process and tailings water samples from a pilot study conducted with NorthMet ore were found to have mercury concentrations of 11.2 and 0.7 ng/L, respectively. Mercury loadings to the Tailings Basin are estimated to be 16.2 pounds per year (lbs/yr), with about 15.8 lbs/yr from solids and about 0.4 lbs/yr from process water. For comparison, this is significantly less than the 610 lbs/yr estimated average mercury-loading to the existing LTVSMC tailings basin during LTVSMC operations.

In 2006, Northeast Technical Services, Inc. (NTS) conducted a bench study using NorthMet tailings to determine the rate of mercury adsorption by the tailings. The study utilized large-volume shake flask tests to evaluate mercury adsorption of tailings over time (PolyMet 2015j). The concentration of dissolved mercury in a treatment flask containing process water and NorthMet tailings decreased from 3.3 ng/L (at time 0) to 0.9 ng/L (at 480 minutes). Although the exact mechanisms behind the adsorption process are not yet clearly understood, the ability of NorthMet tailings to adsorb mercury, in combination with the proven ability of the underlying taconite tailings to adsorb mercury, is expected to result in an overall increase in the adsorption of mercury and subsequent lower concentrations of mercury at the Tailings Basin with the addition of the NorthMet tailings. Although adsorption was not explicitly included in the mass balance model, its effects are observed in the mercury concentrations in runoff from the existing LTVSMC tailings, and are therefore assumed in the modeled future concentrations in Tailings Basin seepage.

In summary, the Tailings Basin is predicted to receive less loading of mercury (about 2 to 3 percent) and less flow than the existing LTVSMC Tailings Basin historically received, while retaining the adsorption benefits of the LTVSMC tailings, as well as the demonstrated mercury adsorption capability of the NorthMet tailings. For these reasons, it is reasonable to conclude that the seepage from the NorthMet tailings should have similar or lower mercury concentrations as the LTVSMC tailings seepage, which has averaged about 1.0 ng/L. Therefore, the total mercury concentration in seepage from the Tailings Basin is expected to be less than the GLI standard of 1.3 ng/L.

During long-term maintenance, the Tailings Basin seepage would be captured and pumped to the WWTP for treatment. The WWTP would also receive water from the Tailings Basin pond, as well as stormwater runoff from the basin. The discharge from the WWTP, like the discharge from the WWTF, would be subject to the GLI standard of 1.3 ng/L. The estimated mercury concentration and flow rate for each of these influent streams is shown in Table 5.2.2-51. As this table shows, the combined influent streams are estimated to have a mercury concentration of 1.3 ng/L prior to treatment.

Table 5.2.2-51 Estimated Mercury Concentration of the Combined Inflows to the Plant Site WWTP

Stream	Flow Rate (gpm)	Mercury Concentration (ng/L)	Total Mercury Flow (ng/yr)
Seepage water	1,635	1.0	3.3E+09
Runoff (interacting with tailings)	290	1.0	5.8E+08
Runoff (not interacting with tailings)	75	3.5	5.3E+08
Tailings Basin pond dewatering	425	2.0	1.7E+09
Combined stream	**2,425**	**1.3**	**6.0E+09**

Source: Table 6-8, PolyMet 2015j.

The WWTP would use a greensand filtration process followed by RO unit or equivalently performing technology that would meet water quality targets. RO treatment or equivalently performing technology that would meet water quality targets are known to remove mercury, particularly when the influent is pre-treated, and this potential additional removal of mercury is not accounted for in mass balance calculations, which adds a level of overestimation to the mass balance results. Any reduction in mercury by the WWTP would reduce discharge concentration; therefore, the total mercury concentration in the WWTP discharge is expected to meet the evaluation criteria of 1.3 ng/L.

The NorthMet Project Proposed Action is predicted to result in a net increase in mercury loadings to the Embarrass River of up to 0.2 grams per year (from 22.3 to 22.5 grams per year), which is about a 1 percent increase. This increase is primarily attributable to:

- The redirection of surface runoff diverted via the drainage swale constructed east of the Tailings Basin East Dam directly to Mud Lake Creek (at an assumed mercury concentration of 3.5 ng/L, versus a seepage concentration of 1.0 ng/L); and
- The Tailings Basin containment systems, which would collect seepage from the Tailings Basin, with an estimated mercury concentration of 1.0 ng/L, and route it to the WWTP, which would discharge with an assumed mercury concentration of 1.3 ng/L, which is considered conservative in that the WWTP and the greensand filter are expected to remove some mercury from the effluent.

Enhanced Mercury Methylation

Virtually all dispersal of mercury in the environment (especially atmospheric dispersal) occurs in inorganic form (Fitzgerald and Clarkson 1991), but nearly all of the mercury accumulated in fish tissue (more than 95 percent) is organic methylmercury (Bloom 1992). Thus, methylation is a key step in bioaccumulation and the uptake of mercury by aquatic biota. Methylmercury can be a product of the methylation of inorganic mercury by sulfate-reducing bacteria, a process that can be stimulated by increased sulfate concentrations in aquatic systems where sulfate is limiting (Gilmour et al. 1992; Krabbenhoft et al. 1998), although recent research has shown that numerous other types of bacteria can methylate mercury (Gilmour et al. 2013). Although, as described above, the NorthMet Project Proposed Action is expected to result in a negligible release of inorganic mercury to groundwater or surface waters and is predicted to meet the 1.3 ng/L discharge evaluation criteria, the potential effects of the NorthMet Project Proposed Action on mercury methylation must be evaluated. Bacteria that cause mercury methylation require an anoxic environment, and consequently methylation occurs in sediments or in anoxic waters rather than in the turbulent well-oxygenated water of a river. Therefore, methylation is unlikely to occur in the Partridge River or Embarrass River water column; however, it may occur in sediments or possibly in anoxic environments downstream.

There are several factors that influence mercury methylation, including total available mercury, organic carbon, temperature, micronutrients required by sulfate-reducing bacteria, sulfate loadings (over the range for which sulfate may be a limiting factor for sulfate-reducing bacteria), lack of oxygen, and certain hydrologic conditions. The NorthMet Project Proposed Action is expected to have little or no effect on most of these factors, but the effects on sulfate concentrations and hydrologic conditions warrants further discussion and are discussed below.

Sulfate Loadings

Research indicates that sulfate-reducing bacteria are the primary mercury methylators in aquatic systems, especially in wetlands (Compeau and Bartha 1985). Biologically available sulfate is believed to be one of several limiting factors for the methylating bacteria (Jeremiason et al. 2006; Watras et al. 2006). Adding sulfate to aquatic systems where sulfate is limiting can therefore stimulate sulfate-reducing bacteria activity, leading to increased mercury methylation as the sulfate is consumed (Gilmour et al. 1992; Harmon et al. 2004; Branfireun et al. 1999; Branfireun et al. 2001). Recent research in northern Minnesota suggests that increased atmospheric sulfate-loading to a peatland can result in increased mercury methylation and export (Jeremiason et al. 2006), but other research suggests that this effect is not linear and diminishes at higher loads where sulfate may no longer be limiting (Mitchell et al. 2008). Heyes et al. (2000) reported a significant positive correlation between methylmercury and sulfate in a poor fen ($R2 = 0.765$, $p = 0.005$) and in a bog ($R2 = 0.865$, $p = 0.022$).

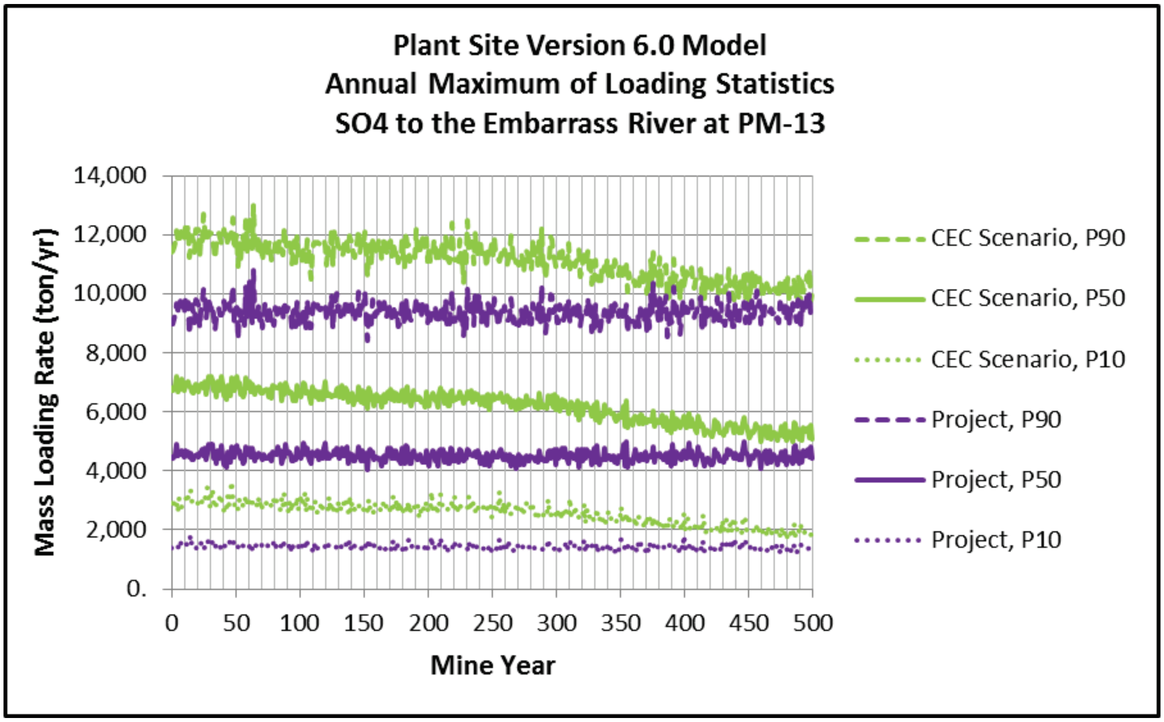
Many studies have shown that wetlands can be sinks for mercury and sources of methylmercury to surrounding watersheds (St. Louis et al. 1996). Galloway and Branfireun (2004) found that wetlands were an important site of sulfate reduction and methylmercury production. Balogh et al. (2004) and Balogh et al. (2006) concluded that increases in methylmercury in several Minnesota rivers during high-flow events was likely the result of methylmercury transport from surrounding wetlands to the main river channel. A recent study by the MDNR found little, if any, correlation between total mercury or methylmercury and sulfate concentrations in northeastern Minnesota streams (Berndt and Bavin 2012a; Berndt and Bavin 2012b; Berndt et al. 2014). Instead, the study found strong correlations between mercury and dissolved organic carbon concentrations and total wetland area. Overall, these studies suggest that most mercury methylation, at least in the St. Louis River Basin, primarily occurs within wetlands rather than in stream channels and the methylmercury is flushed to rivers from wetlands during storm events.

The MPCA and MDNR recognize the important role of sulfate in methylmercury production, as well as the uncertainties regarding site-specific relationships between sulfate discharges and water body impairment. The MPCA has set forth a strategy (MPCA 2006a) for addressing the effects of sulfate on methylmercury production that encompasses technical, policy, and permitting issues. The strategy acknowledges that the technical basis does not exist to establish sulfate concentration limits. The strategy, however, sets forth steps the MPCA can take to improve the technical basis for controlling sulfate discharges and establishes guidance for considering potential sulfate effects during environmental review and NPDES permitting. The strategy focuses on avoiding “discharges,” which could include groundwater seepage, to “high-risk” situations. These high-risk areas include wetlands, low-sulfate water (less than 40 mg/L) where sulfate may be a limiting factor in the activity of sulfate-reducing bacteria, and waters that flow to a downstream lake that may stratify, all or most of which apply to the area downstream of the WWTP and the WWTF discharges.

In response to this policy, as well as to comply with sulfate standards that apply to waters previously recommended as supporting the production of wild rice, PolyMet has proposed several significant changes to the NorthMet Project Proposed Action design from that proposed in the DEIS. These changes would significantly reduce sulfate loadings, and include a surface and groundwater seepage containment system around the Category 1 Stockpile and a WWTF to treat the West Pit overflow at the Mine Site and a containment system around the Tailings Basin and a WWTP to treat tailings seepage at the Plant Site.

As a result of the design changes at the Mine Site, the NorthMet Project Proposed Action is predicted to increase the sulfate load by less than 2 percent in the Partridge River watershed, but maintain the same maximum P90 concentration (19.4 mg/L) as the CEC scenario. Effluent from the WWTF would be discharged at a water quality based effluent limit concentration that protects the sulfate standard for waters used for production of wild rice (10 mg/L), beginning when the West Pit is predicted to flood around year 55. Sulfate concentrations in this range coupled with the oxygenated hydrologic environment to which the effluent would be discharged would not be expected to promote mercury methylation.

As a result of the design changes at the Plant Site, the NorthMet Project Proposed Action is predicted to significantly decrease sulfate loadings to the wetlands north of the Tailings Basin and to the Embarrass River, primarily because the containment system would capture nearly all Tailings Basin seepage and ultimately route it to the WWTP, which would treat the seepage and discharge the effluent at a target concentration of 10 mg/L as part of the Embarrass River tributary streams flow augmentation. The net effect of these engineering controls would be a reduction in sulfate loadings relative to the CEC scenario model results at PM-13 (see Figure 5.2.2-56).



Source: Barr 2015j.

Figure 5.2.2-56 Range of Annual Sulfate Loading Rates to the Embarrass River at PM-13 – CEC Scenario versus NorthMet Project Proposed Action

Hydrologic Changes and Water Level Fluctuations

Methylation of environmental mercury by sulfate-reducing bacteria is also stimulated by drying and rewetting associated with hydrologic changes and water level fluctuations (Gilmour et al. 2004; Selch et al. 2007). Drying (and subsequent increase in exposure to oxygen) of substrate containing reduced sulfur species (sulfides and organic sulfur) oxidizes those species into sulfate, which is remobilized and available to sulfate-reducing bacteria upon rewetting of the substrate. This mechanism stimulates production of methylmercury in sediments exposed to wetting and drying cycles (Gilmour et al. 2004) and probably accounts for some of the elevated methylmercury concentrations observed in releases from wetlands during high-flow events (Balogh et al. 2006). Thus, hydrologic changes and water level fluctuations can potentially stimulate mercury methylation and enhance bioaccumulation. The effect of the NorthMet Project Proposed Action would decrease with distance downstream, as can be seen at PM-13, where the maximum change in flow would be approximately 3 percent in the annual average flow during operations, with a closure and long-term maintenance decrease of less than 2 percent (PolyMet 2015j).

Mercury Summary

Based on the above analysis, the NorthMet Project Proposed Action would have negligible effects on hydrologic changes or water level fluctuations in the Partridge River and Embarrass River, would maintain relatively low sulfate loadings and concentrations to the Partridge River, would significantly reduce sulfate loadings to the Embarrass River, and would meet the GLI mercury standard for discharges.

The cumulative MMREM analysis for two scenarios showed a 0.5 to1.8 percent and 0.3 to 0.5 percent potential increase in fish mercury concentration above background. This potential change is considered to be small compared to background levels and is not expected to affect fish consumption advisories or effect consumers of locally caught fish. The increase is not expected to have an appreciable effect on the loading estimates from permitted discharges to the Embarrass, Partridge, or lower St. Louis rivers. Discharges are expected to meet the 1.3 ng/L standard for mercury, with an overall net decrease in mercury loading predicted for the NorthMet Project Proposed Action.

Sulfur is inherent to the mineral matrix of the dust particles that would deposit in the Project area; it is therefore likely that less than 100 percent of the sulfur would be weathered from the particles and be available to go into solution if deposited to soils or water. This potential incremental change may warrant future monitoring, as small sulfate increases in sulfate-poor wetlands would be expected to increase the production of methylmercury in wetlands (Jeremiason et al. 2006). However, methylmercury produced in wetlands is not necessarily incorporated into food chains and concentrated to levels of concern.

Overall, mercury loadings are predicted to increase slightly in the Embarrass River (0.1 percent), and decrease in the Partridge River (1.0 percent). Overall, the changes in total mercury concentrations associated with the NorthMet Project Proposed Action in closure and long-term maintenance at the respective Mine Site and Plant Site are estimated to be too small to distinguish from natural background variability in the Partridge River and the Embarrass River using available laboratory methods (Barr 2015g).

The NorthMet Project Proposed Action and project area watershed information used to assess the potential effects on average annual mercury loading and concentrations at the Plant Site and Mine Site (Upper Embarrass River and Upper Partridge River, respectively) were also used in assessing the potential effects from the NorthMet Project Proposed Action on mercury loading in the St. Louis River. The result would be a net decrease in overall mercury loadings (1.0 grams per year) with no detectable change in mercury concentrations to the St. Louis River as a result of the NorthMet Project Proposed Action (Barr 2015g).

5.2.2.3.5 Proposed and Recommended Mitigation Measures

PolyMet has proposed or agreed to measures to avoid, minimize, or mitigate potential environmental effects. These measures are considered part of the NorthMet Project Proposed Action (see Section 3.2) and include design changes since the DEIS, including fixed engineering controls, PolyMet would be required by its permits to monitor water quality and quantity to refine modeling and to predict future conditions for consideration in permit renewals. In the event that monitoring, coupled with modeling, identifies the potential for water quality exceedances, PolyMet has proposed adaptive engineering controls and contingency mitigation that could be implemented to prevent exceedances of water quality standards. An overview of the evolution of the NorthMet Project Proposed Action with respect to alternatives analysis is provided in Section 3.2.3.3. PolyMet commits to monitoring and management through application of facility management plans that form the NorthMet Project Proposed Action; these plans are listed in Section 3.2.2.

NorthMet Project Proposed Action Design Changes

PolyMet has proposed several significant improvements to the design of the NorthMet Project Proposed Action for this FEIS from the NorthMet Project Proposed Action as described in the DEIS (October 2009) and SDEIS (December 2013), which would avoid or minimize effects on water resources. These are described in Table 3.2-16.

Fixed Engineering Controls

PolyMet has proposed several fixed engineering controls that would decrease effects on water resources from the NorthMet Project Proposed Action. These fixed engineering controls are not expected to be modified during the life of the NorthMet Project Proposed Action and would be included as part of the NorthMet Project Proposed Action's financial assurance package. The fixed engineering controls include the following:

- Ditches, perimeter and pit rim, and sedimentation basins to separate and control stormwater and process waters;
- Pipes, pumps, and lined process water ponds to separate and control stormwater and process waters;
- Geomembrane liners, underdrain systems, sumps, and overflow ponds, for temporary storage of Category 2/3 Category 4 and Ore Surge Pile rock;
- Category 1 Stockpile hydraulic barrier and drain pipe which would collect surface and groundwater seepage that would then be pumped to the WWTF, enabling the capture and treatment of nearly all Category 1 Stockpile seepage;
- Treated Water Pipeline and Central Pumping Station to allow the re-use of water at the processing plant and zero liquid discharge during operations at the Mine Site;
- Haul Roads designed for the collection and separation of stormwater from road surfaces;
- Tailings Basin for the collection and control of NorthMet tailings and re-use of process water;
- Bentonite-amended Tailings Basin beaches and bottom (during reclamation) and embankment face (during operations) to reduce both water and oxygen intrusion into the tailings during reclamation;
- Tailings Basin containment system to collect, surface and groundwater seepage on the western, northwestern northern, eastern and southern sides of the Tailings Basin and pump it back to the Tailings Basin pond or to the Plant Site WWTP;
- Hydrometallurgical Residue Facility for collection, control, and storage of hydrometallurgical residue and re-use and recycle of process water. This facility would have a double geomembrane liner with a leakage collection system that would return any leachate to the Hydrometallurgical Residue Facility pond;
- Colby Lake pump house, pipeline from Colby Lake to the Plant Site reservoir; and
- Tailings Basin tributary augmentation system to maintain flows within ± 20 percent of existing flows using WWTP effluent.

Adaptive Water Management Plan

Adaptive management is a system of management practices, based on clearly defined outcomes and monitoring requirements, that assesses whether management actions are meeting the desired outcomes, and, if not, prescribes potential actions that would ensure the defined outcomes are met. In the case of the NorthMet Project Proposed Action, PolyMet has developed an Adaptive Water Management Plan (AWMP), which includes adaptive engineering controls and contingency mitigation measures (PolyMet 2015d). Adaptive engineering controls may have their design, operation, or maintenance modified before or after their installation based on measured and modeled water quality during and after operations. Monitoring data in particular are important because not all questions about water management can be answered by GoldSim (i.e., transport time for constituent load in the Category 1 stockpile). Certain model assumptions may not be applicable to all potential project feature modifications. If water quality were better or worse than predicted, adaptive engineering controls would be adjusted accordingly, or contingency mitigation implemented with the approval of regulatory agencies.

Adaptive Engineering Controls

Adaptive engineering controls would be included as part of the permit to mine financial assurance package and would include the following:

- Mine Site WWTF – The WWTF would be upgraded to a RO process or equivalently performing technology that would meet water quality targets during closure and long-term maintenance to manage influent sulfate concentrations. The WWTF is an adaptive engineering control because its operating configuration, process unit requirements and capacity can be modified to treat varying influent streams and discharge requirements. WWTF construction plans include a phased build-out of the capacity to meet the Mine Site's P90 maximum flow requirements (year 14). Therefore, greater capacity could be achieved sooner if necessary. The WWTF processes could be adapted depending on actual water quality conditions encountered during the NorthMet Project Proposed Action phases and estimated by water quality monitoring and model updating. Treatment performance issues that could occur from changes in influent water quality could be addressed by making adjustments to operating conditions (PolyMet 2015d). Lime could also be added to the East Pit during waste rock backfilling if additional alkalinity were needed (Adaptive Water Management Plant, v7, Feb 2015).
- Adaptive management would be implemented as necessary based on monitoring for total mercury to determine whether the treated water could be discharged to surface waters, or whether some additional treatment is needed. Adaptive management strategies would include pretreatment modifications such as a chemical scavenger addition ahead of the greensand filter units to obtain additional metals, the use of tighter RO membranes for the primary RO system, treatment of some portion of the Vibratory Shear Enhanced Process (VSEP) permeate by the primary RO system to further remove some dissolved constituents, and addition of polishing treatment units for removal of trace metals (e.g., ion exchange).
- If future modeling, informed by the results of the monitoring, predicted that the NorthMet Project Proposed Action would not protect surface waters, then adaptive mitigation measures could be implemented to decrease NorthMet Project Proposed Action effects on the Partridge

River prior to an actual effect occurring (PolyMet 2015d). Possible adaptive measures that could be implemented include the following:

- Modify the WWTF design to generate cleaner effluent. For example, pilot-testing of the proposed RO unit resulted in average sulfate removal rates of 99.8 percent with average and maximum sulfate concentrations observed in the effluent of 3.7 and 6.9 mg/L, respectively, for the blended (RO and vibratory shear enhanced processing) streams, which is below the 9 mg/L value assumed for modeling purposes during closure (Barr 2013f). Given that the WWTF would have an annual average discharge of approximately 300 gpm, as compared to about 78 gpm from the three groundwater sources of sulfate, a small decrease in the actual sulfate concentration in the WWTF effluent could offset the loading from the three groundwater sources.
- Increase the WWTF discharge in closure. PolyMet could temporarily increase the volume of the WWTF (which is operating below its actual capacity) effluent discharge during low-flow conditions, which would help further dilute concentrations in the Partridge River.

- Category 1 Stockpile Cover System – PolyMet proposes to install a geomembrane cover system, in lieu of the originally proposed evapotranspiration cover, to reduce the load of the constituents that would reach the West Pit via drainage from the Category 1 Stockpile. Construction of the Category 1 Stockpile cover system would be progressive, starting in year 14 and being fully constructed by the end of year 21. Under the NorthMet Project Proposed Action, the Category 1 Stockpile would be the only permanent waste rock stockpile. Water quality modeling indicates that for many constituents, this stockpile would be the largest source of constituent load to the West Pit. The Category 1 Stockpile cover system would be the primary engineering control that limits constituent loading from the Category 1 Stockpile to the West Pit.

  The design of the Category 1 Stockpile cover system could be adapted up to the point of construction, depending on the actual water quality conditions encountered during the NorthMet Project Proposed Action phases and estimated by water quality monitoring and model updating. Design options, which would need to be approved by the MPCA and MDNR, include:

  - Increased or decreased thickness of the geomembrane material to modify the potential for defects to be created during installation and to modify the life of the geomembrane;
  - Increased or decreased soil cover thickness above the geomembrane material to modify water storage capacity;
  - Increased or decreased soil hydraulic conductivity of the granular drainage layer above the geomembrane to modify lateral drainage capacity;
  - Increased or decreased uninterrupted slope length to modify lateral drainage capacity;
  - Modified soil type and/or thickness below the geomembrane to modify leakage rate through potential geomembrane defects; and/or
  - Including a geosynthetic clay liner below the geomembrane to modify leakage rate through potential geomembrane defects.

After installation of the cover system, post-installation adjustments, such as modifying vegetation density and erosion of the cover system, could be made if approved by the MPCA and MDNR (PolyMet 2015d).

- Plant Site WWTP – The WWTP would treat process water. A RO treatment plant it proposed or equivalently performing technology that would meet water quality targets. Because the plan for construction of the WWTP envisions a phased build-out of the capacity that would be needed when the maximum flow occurs, variations in quantity can easily be addressed by either accelerating or delaying the installation of the additional equipment that is planned for the expansion of the WWTP.
- Treatment performance issues that could occur from changes in influent water quality can be addressed by making adjustments to operating conditions. At times throughout the year, it is expected that the WWTP would have excess hydraulic capacity, which can be used to improve treatment performance, for example by reducing the recovery rates for the membrane separation processes or increasing the hydraulic retention times in the chemical precipitation processes.
- Other examples of how the WWTP can be adapted during the Project to modify treatment performance include:
  - Selection of alternative membranes for either the RO or the Vibratory;
  - Shear Enhanced Processing (VSEP) process units to modify the removal efficiencies of some parameters across these systems;
  - Chemical addition to increase metals removal by the WWTP; and
  - Softening pretreatment.

  Adaptive management would be implemented as necessary based on monitoring for total mercury to determine whether the treated water could be discharged to surface waters, or whether some additional treatment is needed. Adaptive management strategies would include pretreatment modifications such as chemical scavenger addition to obtain additional metals; the use of tighter RO membranes for the primary RO system; treatment of some portion of the VSEP permeate by the primary RO system to further remove some dissolved constituents; and addition of polishing treatment units for removal of trace metals (e.g., ion exchange).
- Tailings Basin Pond Bottom Cover – During reclamation, PolyMet proposes to deposit granular or pelletized bentonite into the Tailings Basin pond, which would then settle and form a cover. This cover would reduce the diffusion of oxygen and water percolation into the tailings, thereby reducing oxidation and the resultant production of contaminants. In addition, the seepage through the tailings would be reduced, resulting in less flow being collected in the Tailings Basin surface and groundwater seepage containment system, and then treated.

  The Tailings Basin pond bottom cover thickness or the percent of bentonite in the pellets or grains or both can be changed if monitored water quantity or quality suggested that modifications were needed to meet water resource objectives. This modification can occur before or after installation to modify performance.

In addition, the bentonite amended layer could be excavated from portions of the pond bottom to modify performance. Any design modifications would need to be approved by the MPCA and MDNR (PolyMet 2015d).

Contingency Mitigation

Contingency mitigation measures are technically feasible options that could be undertaken should engineering controls (fixed or adaptive) be unable to ensure compliance with applicable water quality standards. These contingency measures were not included in GoldSim modeling, as current model results at the P90 confidence level did not show these measures were needed to meet or not cause or add to an exceedance of the evaluation criteria. If monitoring or refined modeling were to indicate that contingency mitigation would be needed, these measures would be employed as appropriate and approved by the MPCA and MDNR. The contingency mitigation measures would not be initially included in the financial assurance package, but, if required in the future, these measures would be added to the financial assurance package. These contingency mitigation measures would address the following situations (PolyMet 2015r; 2015i):

- A pattern of overflows of the process water sumps or ponds developed – In all the process water sumps and ponds, there would be excess capacity designed as a safety factor ranging from approximately 30 to 270 percent of required capacity. Additional capacity could be developed by expanding the pond areas.
- Streams along the railroad corridor between the Mine Site and Plant Site showed degradation in water quality as a result of material spilled from the rail cars – Catchment areas could be developed adjacent to the tracks at stream crossings to minimize the amount of material that reaches the streams.
- Groundwater downgradient of lined infrastructure had compliance issues – Interception wells could collect groundwater flows affected by a leak from one of the liner systems or by the OSLA. Interception wells would only be needed while groundwater was affected by the temporary mine features.
- West Pit water quality was not as expected – This could be addressed by reducing the contaminant load from the West Pit walls or the East Pit using methods such as low-permeability soil barriers or a PRB to treat discharge, adding water with lower concentrations of contaminates to the West Pit by routing additional stormwater to the West Pit, or treating the West Pit either by pumping West Pit water to the WWTF for treatment or treating the West Pit Lake in situ with iron salts, fertilizer, or other methods tailored to the contaminant.
- If East Pit or West Pit groundwater inflows are greater than expected due to faults, use of a grout curtain to control groundwater flow into pits and eventually out of pits when they are filled with water or water and rock would be evaluated (PolyMet 2014l).
- New surface seepage locations emerged as the Tailings Basin was developed – The surface and groundwater seepage containment system or the Tailings Basin south surface seepage management system could be expanded to collect seepage from any new seepage locations.
- Tailings Basin pond water quality was worse than expected – This could be addressed by several methods, including: reducing solute load delivered to the Tailings Basin pond by incorporating additional treatment at the Mine Site WWTF; sending all or a portion of the water from the surface and groundwater seepage containment system and Tailings Basin

south surface seepage management systems to the WWTP for treatment before being returned to the Tailings Basin pond; sending pond water to the WWTP for treatment before being returned to the Tailings Basin pond; or treating the Tailings Basin pond in situ with iron salts, fertilizer, or other methods tailored to the constituent of concern.

- Groundwater or surface water downgradient of the Tailings Basin has compliance issues – This could be addressed by several methods, including inspecting the containment system around the Tailings Basin for breaches and repaired or using interception wells to collect groundwater flows affected by a breach, or improving Tailings Basin pond water quality (see above).
- Bedrock Northward Flowpath Strategies – The purpose of mitigation in this instance is to prevent a northward flow of pit water from the proposed NorthMet pits to the Northshore pits. By the time mitigation may be needed, much more would be known about the intervening hydrogeology given the data obtained and analysis completed during the early operational period. It is expected that monitoring data would be available continuously from mine year 1 as well as quantitative analysis to inform mitigation options before engineered solutions would be needed and constructed. Options and associated designs would continue to be refined throughout this data collection period so that an effective engineering design is available (if needed) to prevent any adverse impact. (MDNR et al. 2015c). See section 6.2.2.3.1 for the discussion of potential cumulative impacts.

  There are a number of mitigation measures that could be implemented, either individually or in combination with one another, which would prevent any potential cumulative adverse impact. The exact type, location, scale, and timing of mitigation measures are not known at this time. The measures discussed below are considered feasible in this region and have been shown to be effective in mitigating impacts in similar conditions. They are discussed conceptually in this FEIS because more site data would be necessary to complete detailed designs. Other methods to prevent northward bedrock groundwater flow from the proposed NorthMet pits to the Northshore pits may also become feasible as the hydrogeology is better understood during mine operations.

  The description of each measure includes a brief qualitative assessment of potential environmental effects. This is based upon the theoretical application of these mitigation measures and the water management dynamics understood through the evaluation of the NorthMet Project Proposed Action. If mitigation is necessary, the action would need to meet all applicable environmental review and permitting requirements.

  - ***Grouting:*** Industrial mining grout (commonly a mixture of bentonite, cement, and water) injection can be used to reduce the hydraulic conductivity of the fractures/faults network, which then controls bedrock groundwater flow to and from mine pits. Particular grout curtains, which are a series of closely spaced drilled holes from which grout is injected into fractures, can be used for groundwater control in both unconsolidated deposits and fractured rock. At the NorthMet Mine Site, if monitoring and analysis indicate conditions could arise that create a northward flowpath, PolyMet would have the necessary information about site conditions to grout fractures and faults. This method is desirable because of the relative lack of maintenance and lack of effects to water resources. However, its effectiveness at the NorthMet site is uncertain and it may need to be combined with other mitigation options (Barr 2015b).

- ***Pit Lake Depression:*** The water elevation within the NorthMet pits are expected to be higher than those in the Northshore pits after Northshore closes, and may also be higher during the NorthMet and/or Northshore Mine operations. Water levels could be managed in the NorthMet East and/or West pits to be equal to or lower than the Northshore pits. The purpose would be to reduce hydraulic heads between the mines such that potential for northward bedrock flow is avoided entirely, or provides a degree of head reduction in concert with application of other measures to prevent bedrock groundwater flow northward. The exact pit water levels required to maintain a bedrock groundwater mound with south flow to the NorthMet pits would depend on the downward leakage rate and the potential implementation and effectiveness of other complementary mitigation measures.

  The benefit of lowering the West Pit and/or East Pit water elevations would be the elimination of *all* surficial deposit and bedrock flowpaths (north and south) from these sources at the NorthMet Mine Site. This is a highly feasible option from an engineering perspective and can be implemented relatively quickly because the infrastructure to do so already exists, only requiring additional pumping and water treatment capacity. If applied, the mitigation would operate entirely within the area of disturbance described in this FEIS. However, this measure would expose pit walls to additional oxygen, which could increase the chemical loading to the West Pit lake water and East Pit backfill pore water. Reduced pit water quality and increased pit pumping would require a higher capacity water treatment facility and possibly additional treatment processes entailing additional expense. If pit wall grouting were to be done, and if it proved effective, it would reduce the pit inflow and associated wastewater treatment rates.

  If the West Pit and East Pit water levels were kept depressed, additional water would need to be managed at the Mine Site and Plant Site, likely increasing the need to discharge more water at the Plant Site during NorthMet operations. Treated water would likely be discharged to the Partridge River in closure and increase its flows in comparison to the NorthMet Project Proposed Action. In addition, transition to a non-mechanical treatment system would be more difficult. With a depressed water level, construction of a wetland in the East Pit would likely be limited.

  The Co-lead Agencies note that pit lake depression is of particular interest for the NorthMet East Pit because of the presence of higher-permeability Virginia Formation in the north pit highwall. In the simplest sense, maintaining a depressed East Pit water level (relative to Northshore pit lake elevations) would ensure there is no bedrock groundwater flow to the north. Depending on the timing, implementing this mitigative strategy could have implications for mine waste management proposed for the NorthMet East Pit. This is because the proposed inundation of Category 2/3 and Category 4 waste rock is an important water quality control feature and waste rock management strategy. Although pit wall inundation is also planned for the NorthMet West Pit, depressing pit lake elevations there does not have the same bedrock groundwater flow implications as implementing this for the East Pit.

  The water level that would need to be maintained could be evaluated based upon the monitoring information collected and analysis performed during the mining process and initial phases of pit refill. Short-term application of this measure would likely have lesser consequences to pit water quality or operational requirements than long-term.

Additionally, using artificial aquifer recharge in combination with pit lake depression could further reduce effects.

- ***Groundwater Extraction Wells:*** Using extraction wells, PolyMet could pump water from bedrock to create a hydraulic depression in the bedrock groundwater system between the NorthMet and Northshore mines.

  The wells would be located between the NorthMet mine pits and the Partridge River. The number, geographic extent, and configuration of the wells would depend upon the width of the northward bedrock flowpath, the hydrologic properties of bedrock, and the addition or not of other mitigation measures such as a partial pit drawdown, grouting, or artificial aquifer recharge (described below).

  There would be relatively small disturbance (compared to the NorthMet Project Proposed Action) related to laying the water line(s), electrical lines, pads, and access. Wells would need to be drilled, water lines to transport pumped groundwater would need to be laid out, and likely electricity would need to be supplied to the sites. Roads would likely be needed to access the wells for ongoing operations and maintenance. If the condition of a northward flowpath occurs, the number, capacity, and location of wells would be considered based on monitoring information obtained during the mining process and after the contingency is adopted. The wells would be sealed and site(s) restored if and when the wells are no longer needed.

  If implemented in isolation of other mitigation measures, this system would increase flow rates to the WWTF. Potential flow rate increases to the WWTF could be reduced by using some of the extracted water to saturate the East Pit backfill. If pit wall grouting were to be done, and if it proved effective, it would lower extraction well pumping rates. Bedrock extraction wells would induce a north flow from the NorthMet Mine Site to the extraction wells, but no further. After the pits fill, water chemistry would stabilize and gradually improve as predicted under the NorthMet Project Proposed Action. Due to slower refill, the start of bedrock and surficial groundwater flow toward the Partridge River would be delayed when compared to the NorthMet Project Proposed Action.

  Long-term WWTF influent water quality would not likely differ significantly from that modeled for the NorthMet Project Proposed Action. However, WWTF influent flow rates would likely be greater as it would consist of both pit pumping and bedrock well pumping. This would increase the NorthMet Project Proposed Action discharges to the Partridge River.

  Wetlands would be directly impacted from groundwater extraction well installation and access road construction. The number of acres of ground disturbance is unknown as the location and number of wells is unknown. If the number of wells necessary resulted in unacceptable wetland impacts, other mitigation measures used in tandem with extraction wells would lower the number of required extraction wells.

- ***Artificial Recharge***: A bedrock groundwater mound can be artificially created between the NorthMet mine and the Northshore Mine by increasing aquifer recharge into bedrock via wells, an infiltration trench, or a combination of both. The recharge water would need to be free of particulates to minimize clogging. Periodic well or trench redevelopment would be required. This type of system would be located between the NorthMet mine pits and the Partridge River. The extent, water source, and configuration of the artificial recharge system would depend upon the information obtained during monitoring of conditions during mining operations. The trench may only need to operate in non-frozen conditions to supply sufficient water to create a bedrock groundwater mound (Barr 2015b).

For wells, the geographic extent, number, and configuration of the artificial recharge system would depend upon the width of the northward bedrock flowpath. The wells would need to be drilled, water supply lines from the source water to the wells would need to be laid out, and likely electricity would need to be supplied to the sites. Roads would likely be needed for access to facilitate their operation and maintenance. If the condition of a northward flowpath occurs, the number, capacity, and location of wells would be considered based on monitoring information obtained during the mining process and after the contingency is adopted. The wells would be sealed and site(s) restored after the wells are no longer needed.

For an infiltration trench, road access would be needed for the trench excavation and backfilling. Construction details would depend upon the adopted design, though it is possible a single-pass construction methodology could be employed to minimize disturbance. Water lines would likely need to be laid out for introduction into the trench.

Both treated WWTF effluent or un-impacted (i.e., non-contact) stormwater would be available indefinitely during closure, and could provide water for recharge. Bedrock well field tests would be necessary to further evaluate the design and operation of this mitigation measure. Because this option would introduce recharge water migration northward to the Northshore pits, the possibility of coupling this strategy with extraction wells would be necessary to prevent the recharge water from migrating to the Northshore pits.

Artificial recharge would induce southern bedrock groundwater flow towards the West Pit and/or East Pit. Because the recharge water would have low chemical concentrations, it is unlikely to adversely affect pit water quality. As a result, estimates of bedrock and surficial deposit groundwater water chemistry entering the Partridge River from the Mine Site are unlikely to be significantly different from what is currently modeled in this FEIS. Surficial deposit groundwater flowpaths and flow rates to the Partridge River are unlikely to change significantly from what is currently predicted in this FEIS. Furthermore, the flow rates and effluent quality of the WWTF that would be discharged to a tributary of the Partridge River are unlikely to be significantly different from what is currently modeled in this FEIS. Under the artificial recharge scenario (without the extraction wells), treated or unaffected water would flow north to the Northshore Mine.

Wetlands would be directly affected from recharge wells and/or infiltration trench and access road construction. The number of acres of ground disturbance is unknown as the final location and number of wells and/or trench is unknown. If the design of the artificial recharge system resulted in unacceptable wetland impacts, other mitigation measures used in tandem with artificial recharge would decrease the number of wells or size of the trench.

The mitigation measures discussed above, if needed, would be maintained indefinitely or until acceptable bedrock groundwater flow conditions are obtained without those measures. This may include maintaining and periodically replacing recharge or extraction wells. The performance of the adaptive mitigation measures would be determined by monitoring the direction of bedrock groundwater flow. If the artificial recharge or pit lake depression option is chosen, a south bedrock flow toward the NorthMet pits would need to be verified. If the groundwater extraction well is chosen, a south flow away from the Northshore pits would need to be verified.

Future Transition from Mechanical to Non-Mechanical Treatment Systems

The NorthMet Project Proposed Action would rely upon mechanical treatment to achieve water resource objectives as long as needed; however, the goal would be to transition to non-mechanical treatment—which would be a low-maintenance, low-energy treatment system—to ensure attainment of water resources objectives, including compliance with applicable groundwater and surface water standards, during the closure phase.

State of Minnesota Non-Ferrous Rules allow for maintenance after closure, known as "post-closure maintenance" (*Minnesota Rules*, part 6132.3200, subpart 2.E.6.). While "closure" is defined in the Rules to mean, "…the process of terminating and completing final steps in reclaiming any specific portion of a mining operation." Post-closure maintenance includes those activities required to "sustain reclamation" after closure (*Minnesota Rules*, part 6132.0100). Both of these maintenance methods can meet the goals of *Minnesota Rules*, part 6132.3200, subpart 1. It is important to recognize that the goals in the Non-Ferrous Rules are not requirements.

When mining activities cease, a permittee is required to initiate "closure" of the mine. As part of the closure process, reclamation of the mining area must be completed. If continued maintenance is needed following closure of the mine to sustain the reclamation, the permittee is responsible for "post-closure maintenance." To ensure that reclamation is completed and sustained, the Non-Ferrous Rules require the permittee to provide financial assurance in amounts sufficient to pay for both closure and post-closure maintenance. A permittee cannot be released from its responsibilities, including financial assurance requirements, until there is no longer a need for post-closure maintenance.

The permit to mine would require PolyMet to present a plan for eventual transition from mechanical water treatment to non-mechanical water treatment. PolyMet plans to test non-mechanical water treatment technologies during mine operations and following closure and then transition from mechanical to non-mechanical water treatment technologies as soon as the company can demonstrate that that these technologies would treat water to the required water quality standards.

Non-mechanical treatment systems, which are described below, would be designed and pilot-tested before being implemented to treat water from the Category 1 Stockpile surface and groundwater seepage containment system, the West Pit Overflow, the Tailings Basin seepage containment system, and the Hydrometallurgical Residue Facility.

Category 1 Stockpile Groundwater Containment Non-mechanical Treatment System

PolyMet proposes to install a Category 1 Stockpile groundwater containment non-mechanical treatment system at the Mine Site to replace the mechanical treatment of the water collected by the containment system during the closure and long-term maintenance phase of the NorthMet Project Proposed Action. The system would likely include two PRBs, which are flow-through treatment systems, for metal precipitation and solids removal. The PRBs would reduce constituent loading through physical, chemical, and/or biological treatment processes including: biochemical reduction of sulfate to sulfide using sulfate-reducing bacteria, sorption to solid-phase surfaces such as iron oxides or organic matter, chemical precipitation to convert dissolved-phase constituents to solid-phase particles, and physical filtering of solid-phase particles. The PRBs would ideally be located where they could take advantage of gravity flow. The locations would be dependent on the final hydraulic plan for discharge from the Category 1 Stockpile surface and groundwater seepage containment system into the West Pit (PolyMet 2015d).

West Pit Overflow Non-mechanical Treatment System

PolyMet proposes to install a West Pit overflow non-mechanical treatment system at the Mine Site to replace the pumping of West Pit lake water to the WWTF during the closure and long-term maintenance phase of the NorthMet Project Proposed Action. It is expected to be a multi-stage system with a constructed wetland for metal (copper, cobalt, nickel, and lead) precipitation and solids removal, a PSB for metal sorption, and an aeration pond to provide time for water exiting the PSB to re-equilibrate with the atmosphere and to increase the concentration of dissolved oxygen before the water would be discharged. The proposed design and operation of any non-mechanical system at the Mine Site would be adapted as necessary to effectively treat actual flows and to meet all applicable regulatory requirements (PolyMet 2015d).

Tailings Basin Non-mechanical Treatment System

PolyMet proposes to install a Tailings Basin non-mechanical treatment system to replace the mechanical treatment of the water draining through the Tailings Basin and collected in the Tailings Basin seepage containment system and the south seepage management system during the closure and long-term maintenance phase of the NorthMet Project Proposed Action. In closure and long-term maintenance, seepage flow to the east would be less than 1 gpm. Provisions to adaptively manage this low-volume flow from the eastern segment of the containment system would be included in the development of the Non-Mechanical Treatment System. During closure and long-term maintenance, any water collected by the Hydrometallurgical Residue Facility leakage collection system would also be routed to this treatment system. The Tailings Basin non-mechanical treatment system would consist of a constructed wetland for metals precipitation, sulfate load reduction, and solids removal and PSBs for polishing (i.e., additional removal of metals, if needed). It would be constructed by rebuilding the natural wetlands between the Tailings Basin and the containment system as a vertical, upflow constructed wetland system with PSB systems at the outer perimeter within the access road. The total flow for the Tailings Basin non-mechanical treatment system is expected to be 1,200 gpm, which would include flows at the northern, northwestern, western, and southern toes (PolyMet 2015d).

Tailings Basin Pond Overflow Post-mechanical Treatment Options

During the initial portion of the closure and long-term maintenance period, Tailings Basin pond water would be pumped to the WWTP to prevent overflow. A monitoring program would document changes in pond water levels and water quality over time. One goal of the NorthMet Project Proposed Action during closure and long-term maintenance would be to allow overflow of the tailings pond. This could only be done after demonstrating that water in the Tailings pond was stormwater and that it complied with applicable standards. The Tailings Basin closure overflow structure would be embedded into bedrock of the hillside east of Cell 2E during reclamation. This structure would likely be modified to serve as a stormwater overflow, which would allow water discharged to enter the Mud Lake Creek Watershed (PolyMet 2015d).

5.2.2.3.6 Monitoring

Monitoring would be a critical component of the NorthMet Project Proposed Action to better understand impacts and to inform facility operation and maintenance and the selection and implementation of possible adaptive or contingency mitigation measures. The NorthMet Project Proposed Action includes PolyMet's proposed water quality and quantity monitoring plan. Overviews of the water monitoring plans at the Mine Site and Plant Site, with PolyMet proposed monitoring locations and frequencies, are presented in the sections below. The specifics of monitoring—including specific locations, frequencies, and parameters—would be finalized during the permitting process after a detailed evaluation. An NPDES permit would be required for any point source water discharge that adds pollutants to waters of the United States.

Partridge River Watershed

Overview

Water monitoring within the Partridge River Watershed would be used on a continual basis to document compliance with permit conditions, annually validate and update water models, and provide input to optimize operations including any adaptive engineering controls or contingency mitigation measures. Depending on the component (i.e., water flow, water flow direction, elevation, or quality) monitoring frequency would range from continuously to quarterly (PolyMet 2015r). An overview of PolyMet's proposed water monitoring plan within the Partridge River Watershed is in Table 5.2.2-52.

Table 5.2.2-52 Overview of Monitoring Plans within the Partridge River Watershed

Monitoring Plan	Component	Purpose	Summary	General Locations
Internal Streams	Pit water	Compare water balance with expected conditions. Define future pumping requirements and evaluate trends in pit water quantity and quality.	Continuous flow monitoring and monthly water quality sampling at up to four sumps[1] as well as pit water elevation monitoring	Stations installed to monitor flows and water quality from each pit sump
	Stockpile drainage	Compare water balance with expected conditions. Define future pumping requirements, and evaluate trends in stockpile drainage water quality.	Continuous flow monitoring and monthly water quality sampling from up to 12 locations[1]	Stations installed to monitor drainage from each stockpile liner and each stockpile underlain and the two Category 1 Waste Rock Stockpile containment system sumps
	Overburden Storage and Laydown Area runoff	Compare water balance with expected conditions. Define future pumping requirements, and evaluate trends in Overburden Storage and Laydown Area water quality.	Continuous flow monitoring and monthly water quality sampling in the Overburden Storage and Laydown Area pond[1]	Stations installed to monitor flows and water quality from the Overburden Storage and Laydown Area pond
	Haul road runoff	Compare water balance with expected conditions. Define future pumping requirements, and evaluate trends in haul road water quality.	Continuous flow monitoring and monthly water quality sampling of the haul road ponds[1]	Stations installed to monitor flows and water quality from the haul road ponds
	Rail Transfer Hopper runoff	Compare water balance with expected conditions. Define future pumping requirements, and evaluate trends in Rail Transfer Hopper water quality.	Continuous flow monitoring and monthly water quality sampling of the Rail Transfer Hopper pond[1]	Stations installed to monitor flows and water quality from the Rail Transfer Hopper pond
	WWTF influents and effluents	Optimize the treatment operations and demonstrate acceptable effluent characteristics.	Continuous flow monitoring and monthly water quality sampling of the influent and effluent streams	Inlet and outlet of the WWTF
	Treated Water Pipeline flows	Compare water balance with expected conditions	Flow monitoring and water quality sampling at the inlet and outlet	Inlet and outlet of the Treated Water Pipeline
Stormwater	Stormwater	Evaluate trends in stormwater quality.	Flow monitoring and water quality sampling at pond outlets[1]	Stormwater pond outlets

Monitoring Plan	Component	Purpose	Summary	General Locations
Groundwater	Surficial aquifer	Evaluate groundwater level and water quality trends in the surficial aquifer.	33 sampling locations sampled approximately April, July, and October	Surficial aquifer monitoring wells installed downgradient of each stockpile and pit
	Bedrock	Evaluate groundwater level, bedrock flow direction north of the Mine Site, and water quality trends in the bedrock.	PolyMet proposes eight bedrock wells north of the Mine Site, and four to the south; in addition to these wells, the Co-lead Agencies recommend an additional well north of the East Pit; Sampling approximately April, July, and October	Approximate bedrock monitoring well locations are shown on Figure 5.2.2-57.
Wetlands	Wetlands	Predict and evaluate potential hydrologic and water quality effects of mining operations on wetlands and determine if potential indirect impacts from the mining operations have occurred or if additional mitigation is needed.	Number of piezometers and sampling frequency to be determined	Continuation of baseline monitoring program
Surface Water	Partridge River and tributaries	Evaluate trends in surface water quality and flow.	Monthly sampling of flow and water quality at nine sampling locations during non-frozen conditions	Partridge River, Longnose Creek, Wetlegs Creek, Wyman Creek, and West Pit Overflow Creek,
	Second Creek	Evaluate trends in surface water quality and flow.	Monthly sampling of flow and water quality	Second Creek downstream of seepage barrier
	Colby Lake and Whitewater Reservoir	Evaluate trends in water quality of Colby Lake and water levels for Colby Lake and Whitewater Reservoir.	Water quality and water level sampling at one location for each water body during non-frozen conditions	Colby Lake and Whitewater Reservoir

Source: PolyMet 2015r; MDNR et al. 2015c.

Note:
[1] Cumulative flow volume would be measured, with values recorded on a monthly basis. Water quality monitoring would occur during non-frozen conditions.

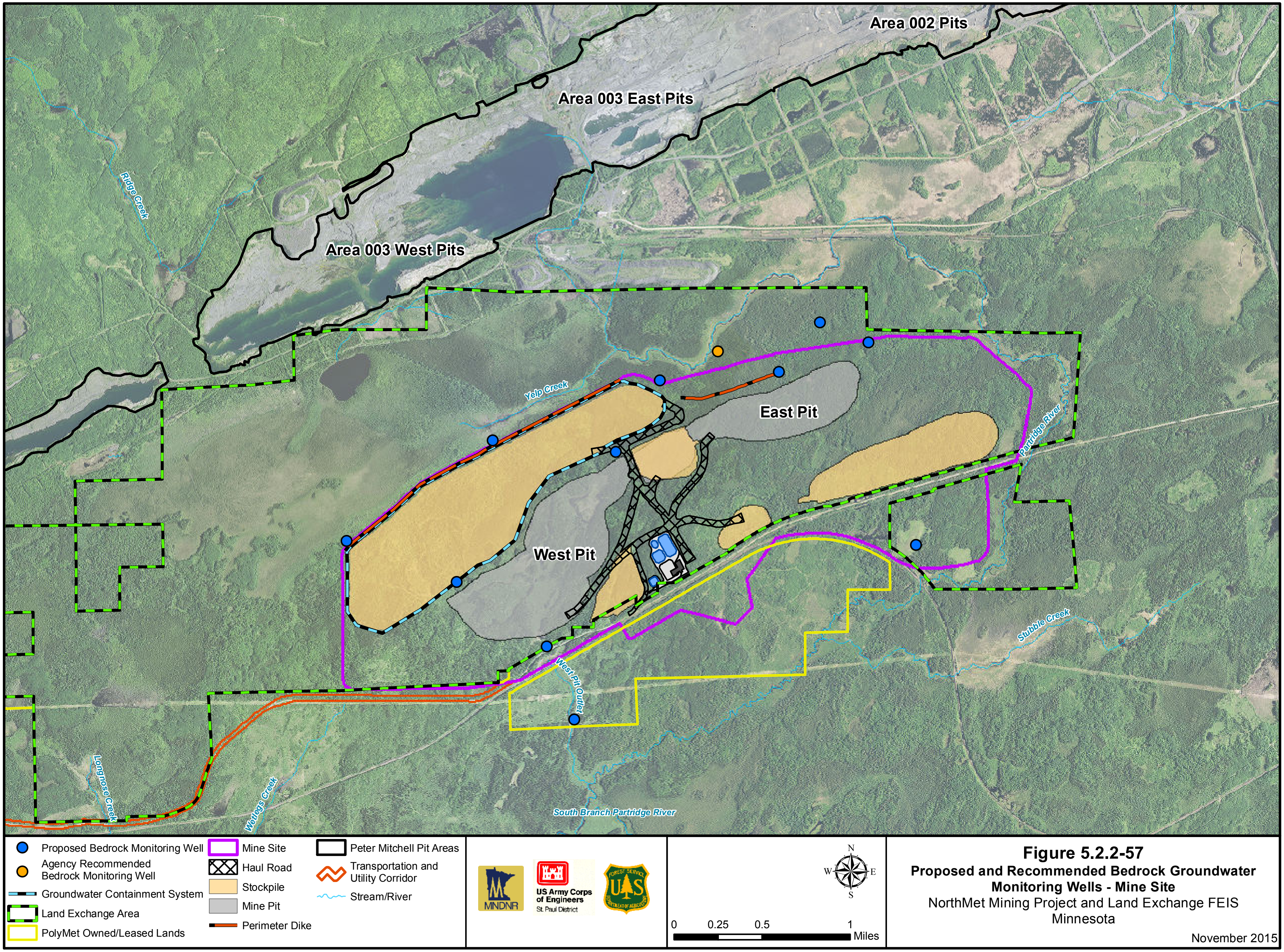


Figure 5.2.2-57

Proposed and Recommended Bedrock Groundwater Monitoring Wells - Mine Site

NorthMet Mining Project and Land Exchange FEIS

Minnesota

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Waste Rock and Overburden

Proper placement of waste rock and overburden in the appropriate stockpile and for ultimate disposal would be important to achieve the NorthMet Project Proposed Action's predicted water quality. PolyMet has developed a Rock and Overburden Management Plan for monitoring and testing of waste rock during mine operations. The USEPA, MDNR, and MPCA have agreed that they will review this Plan and include requirements for waste rock testing and monitoring to ensure it is properly categorized and managed during permitting.

Ore Spillage

The MDNR would require a Spilled Ore Plan as part of the Permit to Mine for monitoring the extent of spillage and identifying appropriate mitigation measures.

Faults/Fractures

The Co-lead Agencies recommend a robust monitoring program during all phases of mining to provide evidence of the presence or absence of hydrologically significant faults. If identified, mitigation can be employed to minimize flow through the faults.

Bedrock Groundwater North of the Mine Site

The Co-lead Agencies would require monitoring of bedrock groundwater levels north of the Mine Site to determine the potential for northward flow between the NorthMet and Northshore pits during operations, reclamation, and closure of both facilities. The results of the monitoring would be used to identify the need for installation of engineered mitigation measures to prevent any such northward flow. Monitoring would start in mine year 1 where data evaluation and quantitative analysis would be used to predict the ultimate flow direction before the NorthMet West Pit and East Pit are fully refilled.

The monitoring network would include a Co-lead Agencies' recommended minimum of 13 wells where the number and location of wells is based on a three-point, monitoring network design. The monitoring points in the network are: water level in NorthMet pits; near field water levels; and far field water levels, including Northshore pits. The final design would be defined in permitting, where additional wells could be added to the monitoring network at the direction of regulatory agencies before or during mine operations. See Figure 5.2.2-57.

The monitoring and analysis window that starts at pit development and continues through operations and pit refill would provide ample opportunity to collect necessary data, and complete applicable environmental review and/or permitting, engineering and construction prior to the development of a northward flowpath (if one were to form at all). This is because conditions potentially supporting development of a northward flowpath would not exist until water levels in the NorthMet pits are higher than at the Northshore pits. The exact requirements for the construction and operation of these wells would be determined during permitting. If installation of contingency mitigation(s) proved necessary, the monitoring wells would continue to be used to verify system performance (MDNR et al. 2015c).

Embarrass River Watershed

Overview

Water monitoring within the Embarrass River Watershed would be used on a continual basis to document compliance with permit conditions, annually validate and update water models, and provide input to optimize operations of adaptive engineering controls. Depending on the component (i.e., water flow, elevation, or quality) monitoring is proposed to occur continuously, monthly, or three times a year in the first month of non-freezing quarters (PolyMet 2015i). An overview of PolyMet's proposed water monitoring plan at the Plant Site is in Table 5.2.2-53.

Table 5.2.2-53 Overview of Monitoring Plans for the Embarrass River Watershed

Monitoring Plan Component		Purpose	Summary	General Locations
Internal Process Water Streams	Tailings Basin pond	Monitor pond WLs and trends in Tailings Basin pond water characteristics over time	Daily WL monitoring and WQ monitoring	WL monitoring location TBD; WQ monitoring at pond barge
	Tailings Basin seepage	Evaluate seepage rate and trends in WQ characteristics over time	Continuous flow monitoring and monthly WQ samples from seepage collection systems	Groundwater containment system lift stations and Tailings Basin south surface seepage management system pump station
	Hydrometallurgical Residue Facility pond	Monitor WL to prevent overtopping the Hydrometallurgical Residue Facility dam and monitor WQ trends over time	Daily WL monitoring and monthly WQ monitoring.	WL monitoring location TBD; WQ monitoring at pond barge
	Hydrometallurgical Residue Facility leachate	Evaluate leachate quantity and characteristics over time	Continuous flow monitoring and monthly monitoring of leachate quality	Underdrain
	Continued existing waste streams	Continue existing WQ monitoring requirements as appropriate	Quarterly monitoring of flow and WQ during non-frozen conditions (April, July, and October)	Seep into Cell 1E
Stormwater	Stormwater	Monitor stormwater quality and quantity	Monthly (during non-frozen conditions, April through October) flow rate and WQ monitoring	Stormwater control features

Monitoring Plan Component		Purpose	Summary	General Locations
Surface Discharges	WWTP	Demonstrate acceptable effluent characteristics	Continuous flow monitoring of WWTP effluent, and monthly WQ monitoring and monthly total flow monitoring at discharge locations	WWTP effluent
Surface Water	Embarrass River and tributaries	Evaluate trends in surface WQ and flow	Monthly sampling of flow and WQ	Embarrass River, Mud Lake Creek, Trimble Creek, and Unnamed Creek
	Colby Lake intake	Evaluate water quantity use over time for plant use	Continuous flow monitoring at intake,	Colby Lake intake
Groundwater	General	Evaluate groundwater quality and WL trends over time	Monitoring wells sampled during non-frozen conditions (April, July, and October)	Existing monitoring wells installed around the Tailings Basin
Wetlands	Wetlands	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

Source: PolyMet 2015i.

Notes:
WL = Water Level
WQ = Water Quality

In addition to the details offered in Table 5.2.2-53, the state further recommends that piezometers or other measurement devices would be installed on opposite sides of the containment system to frequently monitor head differential to verify that hydraulic gradient have been reversed which would show that the containment system is achieving complete capture. Additionally, permit(s) would require a robust monitoring program during all phases of mining to provide evidence of the presence or absence of hydrologically significant faults. If identified, mitigation would be employed to minimize flow through the faults.

5.2.2.4 NorthMet Project No Action Alternative

Under the NorthMet Project No Action Alternative, the NorthMet Project Proposed Action would not occur and, therefore, the environmental effects associated with the NorthMet Project Proposed Action, as described in Section 5.2.2, would not occur. Although under the No Action Alternative, the NorthMet Project Proposed Action, including the proposed Tailings Basin seepage collection and water treatment engineering controls, would not occur, the No Action Alternative would not be static. Under the No Action Alternative, water quality would continue to be maintained by generally effective existing natural ecosystem functions. Under the NorthMet Project Proposed Action, these functions would be provided by the WWTP or WWTF (or alternative, if developed) and this reflects a substantial shift in how water quality is maintained.

In the Partridge River Watershed, there are actions occurring as part of the Cliffs Erie Consent Decree that would be expected to result in improvements to the water quality of Second Creek and the Lower Partridge River, but there are also other proposals for mining and mineral processing, and mitigative actions under other existing water quality permits, that could also affect the water quality of these waterbodies, but which cannot be predicted at this time.

In the Embarrass River Watershed, it is anticipated that the water quality of the existing LTVSMC Tailings Basin seepage would improve over time as a result of natural attenuation and/or possible additional mitigation measures at some point in the future pursuant to new permit requirements or other state or federal remediation requirements. Other actions are underway to improve the water quality of the Area 5NW Pit overflow, which contributes a high sulfate load to the Embarrass River. At this time, the exact nature, timing, and effectiveness of these measures are unknown and, therefore, not quantifiable in this FEIS, but it is reasonable to expect that water quality within the Embarrass River could improve over time, absent other unforeseen activities that could affect water quality. In addition, climate change would be likely to affect the hydrology and, indirectly, the water quality, of the NorthMet Project Proposed Action area as the result of predicted increases in mean annual temperature and mean annual precipitation.

Therefore, there are several factors that could dynamically affect the hydrology and water quality of the Partridge and Embarrass River watersheds in the future, but in ways that cannot be quantified with any reasonable level of confidence at this time. It should be noted that PolyMet did analyze the effects of climate change on water quality and quantity estimates for the NorthMet Project Proposed Action by conducting a sensitivity analysis. As described in Section 5.2.2.3, the GoldSim model was used to evaluate the CEC scenario for comparison with the NorthMet Project Proposed Action. The CEC scenario represents future conditions without the NorthMet Project Proposed Action, including all proposed facilities, but is not synonymous with the No Action Alternative because it does not account for other foreseeable changes within the NorthMet Project area.

5.2.3 Wetlands

This section describes the potential environmental consequences of the NorthMet Proposed Action to wetland resources, including the potential direct and indirect effects. Discussions are also included on actions taken to avoid or mitigate wetland impacts, proposed wetland mitigation options, and wetland monitoring plans.

Summary

The NorthMet Project Proposed Action would result in direct impacts and indirect effects on wetland resources at the Mine Site, along the Transportation and Utility Corridor, at the Plant Site, and around the Mine Site (Area 1) and north of the Plant Site (Area 2). This section describes these effects within each of these areas and provides a summary of the effects over the operational life of the facility.

Direct wetland impacts would result from mining-related activities involving filling, excavation, a combination of filling and excavation which includes the installation of a containment system within the wetland boundary, and therefore these wetlands would be permanently lost. The NorthMet Project Proposed Action would directly impact 913.8 acres of wetlands located within the NorthMet Project area. The Mine Site would be subject to the majority of the direct wetland impacts. The direct wetland impacts within the entire NorthMet Project area would occur in the following wetland types: coniferous bog (56 percent), shrub swamp (12 percent), coniferous swamp (9 percent), shallow marsh (8 percent), deep marsh (8 percent), sedge/wet meadow (4 percent), hardwood swamp (1 percent), and open bog (1 percent). The majority of the direct impacts would occur as a result of a combination of filling and excavation (65 percent).

Wetlands directly impacted within the Mine Site would result in a combined effect area of 758.2 acres. These direct wetland impacts would be caused by fill (10 percent), excavation (12 percent), or a combination of fill and excavation (78 percent). The Transportation and Utility Corridor would directly impact 7.2 acres of wetlands, all of which would be directly filled. Approximately 148.4 acres of wetlands within the Plant Site would be directly impacted. These wetland impacts would be caused by fill (12 percent), excavation (31 percent), and excavation and fill (58 percent).

The proposed mitigation is expected to compensate for all the direct wetland impacts, as well as the indirect fragmentation impacts—a total of 940.7 acres. Compensatory mitigation is required for the 913.8 acres of wetlands that would be directly impacted. In addition, compensatory mitigation for the 26.9 acres of wetland fragmentation that would be indirectly affected would be provided up front. The overall wetland mitigation strategy for the NorthMet Project Proposed Action is to compensate for unavoidable wetland impacts in-place, in-kind where possible and in-advance of impacts when feasible in order to replace lost wetland functions. Off-site wetland mitigation projects would be implemented to fulfill the requirements for compensatory mitigation. PolyMet's current mitigation proposal, 1799.8 acres of wetland restoration and preservation and upland buffer, includes the following:

- Off-site mitigation including:
  - Aitkin Site – 808.3 acres of wetland restoration and 83.2 acres of upland buffer;

- Hinckley Site – 286.2 acres of wetland restoration and 91.2 acres of upland buffer; and
- Zim Site – 508.2 acres of wetland restoration and preservation and 22.7 acres of upland buffer.

USACE St. Paul wetland compensatory mitigation replacement ratios are based on three factors: in-place versus out-of-place, in-kind versus out-of-kind, and in-advance versus concurrent. The 2009 USACE St. Paul District's policy states a base compensation ratio of 1.5:1, and a minimum of 1:1, with a provision for a case-by-case determination of higher ratios to account for factors including difficult-to-replace, rare and/or exceptional wetlands/aquatic resources. Therefore, per the 2009 policy, the District Engineer may determine that a higher compensation ratio of 2:1 (or higher) would be required to offset losses of wetlands that would be difficult to replace and/or provide an exceptional level of functions. The USACE St. Paul District has not made a final determination of the compensation ratios that would be required for the NorthMet Project Proposed Action. The final decision on compensatory mitigation ratios would be determined at the time of the DA permit decision pursuant to Section 404 of the CWA based on current District guidance. PolyMet would ultimately need to satisfy both the federal and state mitigation requirements. The number of mitigation credits to be earned by replacement wetlands would be determined during permitting by the appropriate agencies reviewing the wetland mitigation plan. This would be based on the extent to which the sites meet the target goals established during permitting. These include, among other things, restoration of wetland appropriate hydrology and the establishment of a target plant community or type. The NorthMet Project Proposed Action is estimated to directly affect 913.8 acres. Depending on the location, type, and timing of compensatory mitigation, the minimum required amount of replacement wetlands for direct impacts could range from 913.8 acres up to 1,827.6 acres (i.e., 1:1 up to 2:1 compensation ratios). In addition, compensatory mitigation for the 26.9 acres of wetland fragmentation would also be provided up front.

The USACE has concluded that the mitigation sites selected and the wetland credits generated at the three mitigation sites would be acceptable for use in compensating for direct wetland losses. The USACE has not made a final decision on the mitigation ratios that would be required to compensate for direct wetland impacts; if fully successful, it is likely these three mitigation sites would generate sufficient credits to compensate for the 940.7 acres of wetlands directly impacted. In the event that not all of the credits generated by these sites are utilized to compensate for direct wetland impacts, any excess credits could be used to compensate for indirect losses (USACE 2015a). The current proposed mitigation presented below shows that PolyMet could have an excess of mitigation credits from the three mitigation sites if the mitigation sites are successful and meet the performance standards. However, it is understood that mitigation sites sometimes are not fully successful; contingency plans (discussed below) would be developed for the NorthMet Project Proposed Action and approved during permitting. In the event that additional wetland mitigation is required for direct impacts, it would be consistent with current USACE guidelines which include a watershed approach. The USACE encourages the development of mitigation for foreseeable indirect effects, and PolyMet is exploring mitigation options for indirect effects.

Financial assurances for the direct wetland impact mitigation would be required until success of the mitigation sites can be assured. While this wetland mitigation would be expected to be approved and constructed in advance of any authorized wetland impacts, it is unclear whether these sites would be well enough established for financial assurances to be waived. The USACE would also consider the application of financial assurances for potential indirect wetland effects and monitoring. Both the USACE and state would require consideration of financial assurances during the permitting process.

Off-site wetland compensation of 1,602.7 acres could provide 1,513.3 wetland mitigation credits. In addition, a total of 197.1 acres of upland buffer areas are proposed to be established with native vegetation around the wetland restoration areas. In accordance with USACE guidelines, credit for the upland buffer areas would be at a 4:1 ratio, resulting in an additional 49.3 credits. The total off-site mitigation could provide 1,562.5 wetland mitigation credits. Compensatory ratios determined in permitting may vary from these assumptions. The determination of final mitigation credits required to offset the impacts of the proposed NorthMet Project Proposed Action would be determined during permitting.

Finally, post-closure establishment of 101.8 acres of wetland on-site would likely occur during reclamation of the Mine Site; this establishment is not included in the mitigation credits discussed above as credit is not being requested at this time. The generation of wetland credits in these areas has the potential to be used on a contingency basis, but compensatory credit would not be considered at this time for a variety of reasons including the fact that any restoration efforts would not occur for many years.

Potential indirect wetland effects from the NorthMet Project Proposed Action would result from one or more of the following six factors: 1) wetland fragmentation; 2) changes in wetland hydrology resulting from changes in watershed area; 3) changes in wetland hydrology due to groundwater drawdown resulting from open pit mine dewatering; 4) changes in wetland hydrology from groundwater drawdown resulting from operation of the Plant Site, including groundwater seepage containment; 5) changes in stream flow near the Mine Site and Plant Site, as well as associated effects on wetlands abutting the streams; and 6) changes in wetland water quality related to atmospheric deposition of dust and rail car spillage associated with Mine Site and Plant Site operations. The change in wetland hydrology from groundwater drawdown at the Mine Site was assessed by two different methodologies; therefore, total potential indirect wetland effects were provided based on both approaches. The NorthMet Project Proposed Action could indirectly affect up to either 7,694.2 acres of wetlands located within and around the NorthMet Project area, based on the method of wetlands crossing analog impact zones, or up to 6,568.8 acres of wetlands located within and around the NorthMet Project area, based on the method of wetlands within analog impact zones (PolyMet 2015b).

Regardless of the method used, wetland mitigation for potential indirect wetland effects would be determined by the agencies during permitting. If the NorthMet Project Proposed Action were to be permitted, wetland monitoring for hydrology and vegetation would be conducted to identify if future indirect effects to wetlands would occur. Wetland hydrology and vegetation would be monitored, and additional monitoring locations may be considered during permitting. A component of the monitoring plan would be based on those wetlands that would have a high likelihood of indirect effects as a result of groundwater drawdown. If the monitoring were to determine that indirect wetland effects had occurred, additional compensation could be required if determined necessary by the permitting agencies. In the event that the required wetland monitoring identified additional indirect effects, permit conditions would likely include a plan for adaptive management practices to be implemented, such as expanded monitoring and hydrologic controls. Additionally, compensatory mitigation may be required if additional impacts are identified during annual reporting. Permit conditions would likely include an adaptive management plan to account for any additional impacts that may be identified in the annual monitoring and reporting.

5.2.3.1 Methodology and Evaluation Criteria

Wetland effects for the NorthMet Project Proposed Action include direct, indirect, and cumulative effects. As previously mentioned, a Wetland IAP Workgroup was formed, and based on this workgroup, effects were assessed using agency-prescribed methods as presented in the Wetland Analysis Work Plan (PolyMet 2011b) and using the wetland types and acreages identified in the report *NorthMet Project Wetland Data Package* Version 7 (PolyMet 2015b). Methods used to evaluate direct impacts and indirect effects are described below; cumulative effects are described in Chapter 6.

5.2.3.1.1 Direct Wetland Impacts Methodology and Evaluation Criteria

Direct wetland impacts for the NorthMet Project Proposed Action were determined through a GIS analysis of the areas that would be directly disturbed by mining features and operations, such as mine pits, stockpiles, and access roads. The area of analysis for the direct impacts included the Mine Site, Transportation and Utility Corridor, and Plant Site.

Direct impacts would result from mining-related activities such as filling or excavation of wetlands, and therefore, these wetlands would be permanently lost. Wetlands within the NorthMet Project area were identified using the Eggers and Reed (1997, 2014) community classification system, as described in Section 4.2.3. The analysis for the direct wetland impacts included identification of wetland type, total wetland acreage, total acres of direct effect, type of direct effect (i.e., fill, excavation, etc.), and the quality of each wetland to be impacted by the NorthMet Project Proposed Action.

5.2.3.1.2 Potential Indirect Wetland Effects Methodology and Evaluation Criteria

Wetlands that are not filled or excavated, but have a reduced function or value, would be considered indirectly affected. The most likely types of indirect effect on the functions and values of remaining wetlands at the Mine Site include wetland fragmentation from NorthMet Project area elements such as open pits, stockpiles, and haul roads; and indirect hydrological effects that may result in a conversion of one wetland type to another or the conversion of a wetland to an upland. Other indirect effects could result from changes in wetland watershed areas (during operation and post-closure); groundwater drawdown resulting from open pit mine dewatering; groundwater drawdown resulting from operation of the Tailings Basin, including groundwater seepage containment system; changes in streamflow near the Mine Site and Tailings Basin and associated effects on wetlands abutting the streams (during operation and post-closure); and changes in wetland water quality related to atmospheric deposition of dust and rail car spillage associated with the Mine Site and the Tailings Basin operations.

Potential indirect wetland effects from drawdown were estimated using the analog method. Various models, some of which were associated with impact analysis of other environmental resources such as air, groundwater, and surface water that affect wetland resources, were also used to analyze and estimate potential indirect wetland effects. Each analysis was completed using the same set of non-directly impacted wetlands. The analyses were completed separately; therefore, the wetlands have the potential for indirect effects resulting from more than one assessed source. The potential indirect wetland affects for each wetland cannot be summed across the analysis as this would likely result in double-counting of wetland acres. The results of the analyses and assessments identify areas to be monitored for wetland effects.

Wetland acreage by wetland type was calculated using GIS analysis with 500-ft radius increments beginning at the mine pits and continuing out to a total radius of 10,000 ft (for a total of 20 increments); and 500-ft radius increments beginning at the Plant Site and continuing out to the Embarrass River. The area of analysis for the indirect effects extended beyond the NorthMet Project area component boundaries and included Area 1 and Area 2, as identified in Section 4.2.3. The analysis did not include wetlands identified as directly impacted. Additionally, wetlands in the Northshore Mine and areas directly north of the Northshore Mine have been excluded from the evaluation (PolyMet 2011b).

Noise and dust effects on wildlife that utilize the wetland habitat are discussed in Section 5.2.5 (Wildlife Section).

Additional description of the specific methods used to assess individual indirect effects is provided below.

The indirect effects analyses performed for the EIS were not performed to characterize impacts but were done to inform where monitoring should take place for those areas that were identified as having a potential for indirect wetland effects. The Co-lead Agencies agree that multiple factors can affect whether a wetland would experience indirect effects due to a project. This FEIS quantitatively assessed all potential indirect wetland effects from the NorthMet Project Proposed Action that may result from one of the following six factors: 1) wetland fragmentation; 2) changes in wetland hydrology from changes in watershed area; 3) changes in wetland hydrology from groundwater drawdown resulting from open pit mine dewatering; 4) changes in wetland hydrology from groundwater drawdown resulting from operation of the Plant Site, including groundwater seepage containment; 5) changes in stream flow near the Mine Site and Plant Site, as well as associated effects on wetlands abutting the streams; and 6) change in wetland water quality related to atmospheric deposition of dust and rail car spillage associated with Mine Site and Plant Site operations. The methodology and evaluation criteria used for assessing potential indirect wetland effects are described in detail below. The monitoring and mitigation for potential indirect effects would be determined during permitting. Section 5.2.3.3 of this FEIS includes a detailed discussion on the monitoring and mitigation plan for the indirect wetland effects. The proposed wetland impact, avoidance, minimization, mitigation and monitoring plan presented in this FEIS would be reviewed, modified as required, and approved during permitting; therefore, this information could change during permitting.

While the Co-lead Agencies believe that the analog method used in the SDEIS to assess potential indirect effects from mine dewatering is adequate, this FEIS has been updated with a more conservative approach to address concerns raised by the Bands. Section 5.2.3.2.2 of this FEIS has been updated to make a more conservative assumption of the potential indirect effects for all bog communities within the zero to 1,000-ft analog zone such that all bogs are reclassified from the “no effect” category to “low likelihood” category of wetland hydrology effects. The complex mixes of bedrock, surficial deposits, and wetland soils at the Mine Site impede the ability to reasonably model and accurately assess the potential effect of pit dewatering on wetlands. In light of this modeling limitation, wetlands were divided into zones based on distance from the open pit. The closer a wetland was to the pit during dewatering, the greater the assumed water table drawdown would be and the greater potential there would be for hydrologic effects on overlying wetlands. These impact assessment methodologies are presented below and in Section 5.2.2.3.2.

The Co-lead Agencies are not relying solely on the potential impact zones determined in the analog method for this FEIS, but would be monitoring wetlands for potential indirect effects as part of an adaptive management plan. Permit conditions would include a plan for additional compensatory mitigation if indirect wetland impacts were identified, and appropriate changes to the adaptive management plan would be made as required.

When an agency is evaluating reasonably foreseeable significant adverse effects on the human environment in an EIS and there is incomplete or unavailable information because the overall costs of obtaining it are exorbitant or the means to obtain it are not known, NEPA directs the agency to: 1) make it clear that such information is lacking, 2) discuss the relevance of the lacking information, and 3) discuss any information relevant to evaluation the future impacts. In these cases, NEPA also directs the agency to evaluate these impacts based upon theoretical approaches or research methods generally accepted in the scientific community provided that the analysis of the impacts is supported by credible scientific evidence, is not based on pure conjecture, and is within the rule of reason.

The Co-lead Agencies believe this is the case for evaluating indirect wetland effects. The Co-lead Agencies have thoroughly considered throughout the development of the EIS and through the Wetland IAP Working Group how to assess potential indirect wetland effects. As a result, strengths and weaknesses of the approach used, as well as other suggested approaches, have been carefully considered. The Co-lead Agencies ultimately decided that the use of the analog method and the 20 percent change in watershed area metric described in this section as factors considered in identifying potential indirect effects to wetlands is a credible and reasonable approach consistent with the requirements of NEPA.

Potential Indirect Wetland Effects Resulting from Wetland Fragmentation

For each wetland that would not be directly impacted at the Mine Site, along the Transportation and Utility Corridor, or at the Plant Site, an estimate of indirect wetland effects (wetland acres by wetland type, and type of effect) from wetland fragmentation by NorthMet Project area features (e.g., open pits, stockpiles, haul roads) was determined based on an analysis of the various factors that may contribute to fragmentation. A wetland may be fragmented as the result of direct impacts that may split a wetland resource area into multiple parts. These fragmented parts could potentially be isolated from other wetlands and would no longer have any adjacent upland watershed area, which could result in the loss of functions in the wetland fragments. While a wetland may be fragmented by direct impacts, this does not necessarily mean the remaining fragmented part of the wetland resource area would be affected. These fragmented parts therefore required further evaluation to determine if these areas would remain viable and/or would retain their functions (PolyMet 2015b; PolyMet 2015j).

The evaluation (PolyMet 2015b; PolyMet 2015j) to determine if a wetland resources area would remain viable included the following criteria: change in the size of remaining wetland, wetland type, source of hydrology, direction of flow in the area, location in the current watershed, location in the future watershed, and connectivity to other wetlands. The evaluation criteria used are described below:

- **Size of Remaining Wetland:** Wetland fragments that were identified using GIS as being less than about 0.5 acre in size were determined to be too small to retain their functions. These wetlands were determined for the analysis to be considered fragmented.
- **Wetland Type:** The wetland types for the wetland fragments that were greater than 0.5 acre in size were reviewed to determine if they were bogs. Ombrotrophic bogs that would become fragmented were not identified as indirectly impacted by fragmentation; they would maintain their functions because their sole source of hydrology is precipitation (see below). Minerotrophic bogs and small non-bog wetlands that were fragmented were further evaluated to determine their hydrologic sustainability.
- **Source of Hydrology:** Wetlands were further subclassified as ombrotrophic (solely precipitation-fed) or somewhat minerotrophic (receives surface and/or groundwater inputs). The hydrology of ombrotrophic bogs is solely supported by precipitation; therefore, these wetlands are not dependent on the watershed size to maintain their functions and were not identified as indirectly impacted by fragmentation. The hydrology of minerotrophic bogs and non-bog wetlands is primarily supported by shallow groundwater systems that are connected within different scales: wetland watershed, local (e.g., Mine Site) watershed, or regional watershed. Therefore, these minerotrophic bogs and non-bog wetlands were further evaluated because they are considered to be dependent on their watershed size to maintain their functions, and their watersheds would be altered due to construction of project infrastructure.
- **Direction of Flow in the Area:** The Mine Site is located in the Upper Partridge River watershed, and water on the Mine Site eventually drains to the Partridge River. PolyMet evaluated the locations of the minerotrophic bogs and non-bog wetlands relative to the sub-watersheds on each side of the Mine Site groundwater divide, which is generally located from southwest to northeast near the northern boundary of the Mine Site. Under existing conditions, surface water and surficial groundwater in the northernmost area of the Mine Site generally drains (flows) north and surface water and surficial groundwater in the southern area of the Mine Site generally drains (flows) south. There are several sub-watersheds on each side of the divide. Based on the location of predicted wetland fragments on the Mine Site, their locations within the sub-watersheds in relation to direct impacts within that same sub-watershed and the direction of flow were noted. A wetland is more likely to retain its function if the fragment that remains is located in the upper portion of its sub-watershed than in the lower portion. Ultimately, if the area of the wetland's watershed is modified, it could result in a change to the equivalent flow (expressed as ac-ft/yr per acre of wetland), a measure of hydrologic support.
- **Determination of the Wetland's Current Watershed:** The current (existing) conditions include the wetlands and watersheds, which represent the existing and relatively undisturbed conditions in the Mine Site area. The current watersheds for ombrotrophic bog wetlands were not analyzed because they are not dependent on watershed area for their hydrology as they are precipitation-fed. The watersheds for the minerotrophic bogs and non-bog wetlands are the land areas that contribute surface water to the wetlands (upland areas and wetland areas). For each minerotrophic bog and non-bog wetland in the analysis, GIS was used to determine the acreage of its watershed area. The location of each minerotrophic bog and non-bog wetland in its current (existing) watershed was compared with its location in the future watershed.

- **Location of the Minerotrophic Bog and Non-bog Wetland Fragment in the Wetland's Future Watershed:** During operations, some watershed areas would be directly impacted by the NorthMet Project Proposed Action and would no longer be considered as tributary areas to the minerotrophic bogs and non-bog wetlands. Using the same methodology as in the previous evaluation criteria, for each minerotrophic bog and non-bog wetland in the analysis, GIS was used to determine the acreage of upland area and wetland area within its watershed area. As a result, the amount of water potentially contributed by the watershed to support the hydrology of the remaining wetland may also change (increase or decrease). If the wetland fragments had a change in equivalent yield of plus or minus 20 percent, the minerotrophic bogs and non-bog wetlands were further determined to have a potential for indirect impacts. Depending on the results of the other evaluation criteria, the minerotrophic bog and non-bog wetland fragments were either considered to be indirectly affected or included as a monitoring location in the wetland hydrology monitoring plan.
- **Connectivity to Other Wetlands:** Each wetland fragment was evaluated based on its location, adjacency to upland, and adjacent infrastructure characteristics to determine if it would be expected to maintain its functions. Some of the wetland fragments being divided by Mine Site infrastructure would become isolated from other wetlands; therefore, no longer located within or adjacent to an intact, relatively undisturbed upland. These wetland fragments were not expected to maintain their functions. However, other wetland fragments would still be hydrologically connected to wetlands and would be located within or adjacent to an intact, relatively undisturbed upland. For example, these fragmented wetlands would be located in the vicinity of the haul roads on the Mine Site. Construction of the haul roads would require excavation and fill with blasted rock that would allow groundwater connectivity for wetlands on either side of the haul road.

Potential Indirect Wetland Effects Resulting from a Change in Watershed Area

For each wetland that would not be directly impacted, but would have NorthMet Project area elements affect its watershed, an estimate of the change in watershed area (acreage and percent gain or loss) was calculated for the following conditions: pre-NorthMet Project Proposed Action, during operation when the maximum amount of watershed has been removed, and at closure and long-term maintenance. For those non-directly affected wetlands that would have changed watershed areas (during operation and post-closure), an estimate of indirect wetland effects (wetland acres by wetland type and type of indirect effect) was calculated.

Potential Indirect Wetland Effects Resulting from Changes in Hydrology Due to Drawdown at the Mine Site

An estimate of indirect wetland effects (wetland acres by wetland type, and type of indirect effect) due to groundwater drawdown from open pit mine dewatering was determined using an analog model in which the degree of effect was correlated to the distance from the open pit mine (PolyMet 2011b). The analog approach was based on mines in similar settings (e.g., within the glacial till in the region). It consisted of well data from the Canisteo Pit, the only mine pit within the Mesabi Iron Range that has well data and an associated water balance study that could be used to assess potential drawdown effects. In addition, two wells near Kinney were also used for the evaluation. Please refer to Section 5.2.2.3.2 for more information on the analog approach. The closer a wetland was to the pit where dewatering would occur, the greater the assumed water table drawdown would be and the greater the potential for hydrologic effects on overlying wetlands. Wetlands were divided into zones based on distance from the open pit. The use of the impact zones may overestimate indirect effects on wetlands. The analog distances, referenced to the pit edge, were as follows:

1. 0 to 1,000 ft;
2. greater than 1,000 to 2,000 ft;
3. greater than 2,000 to 3,500 ft; and
4. greater than 3,500 to 10,000 ft (within Area 1).

The following is a discussion of the justification for the use of the analog data based upon comparisons of the existing regional and site-specific geologic data (e.g., bedrock faults, bedrock joint systems, bedrock topography, surficial deposits hydraulic conductivities), site-specific engineering controls (e.g., Category 1 Stockpile surface and groundwater seepage containment system), and the geologic settings of the analog information sites and the Mine Site (PolyMet 2011b; PolyMet 2015b). Analog data were used instead of a model such as MODFLOW. MODFLOW could not practicably be used to estimate potential indirect wetland effects of pit dewatering on wetlands due to complex mixes of bedrock, surficial deposits, and wetland soils at the Mine Site; therefore, MODFLOW could not be used to accurately assess the potential effect of pit dewatering on wetlands (PolyMet 2015b).

The Mine Site contains localized heterogeneous vertical and horizontal hydraulic conductivities within each soil unit. It is challenging to accurately represent this complex hydrogeology through modeling. Hydraulic conductivities between the different deposits range from 0.00026 to 31 ft/day (PolyMet 2015b). Because there is such a wide range in hydraulic conductivity within the natural geologic formations at the Mine Site, each model layer would contain widely variable hydraulic conductivities. Thus, it was not feasible to model the expected effects of mine dewatering on wetlands in a meaningful way. Prior to conducting the analysis to identify indirect wetland effects resulting from changes in hydrology, bog wetlands within and surrounding the Mine Site were reclassified as either ombrotrophic or somewhat minerotrophic. This distinction is important because ombrotrophic bogs would be less likely to be affected by groundwater drawdowns associated with proposed mining operations, whereas more minerotrophic bogs would have a higher likelihood of being affected (Eggers 2011a, 2015).

A discussion of potential indirect wetland hydrology drawdown effects at the Mine Site, including conversion to other wetland community types, a change in vegetation without a change in community type, conversion to uplands, or other effects is provided below in Section 5.2.3.2.2. These effects were categorized by applying the Eggers and Reed (1997, 2014) wetland classification system to each wetland type based on wetland sensitivity class tables for falling groundwater tables that were developed for a previously proposed mine project in Wisconsin (PolyMet 2015b).

<u>Potential Indirect Wetland Effects Resulting from Changes in Hydrology at the Plant Site</u>

Potential indirect wetland effects from hydrological changes were evaluated based on estimates of groundwater upwelling and resulting surface water flow in wetlands and/or groundwater drawdown near the water containment system that would surround the Plant Site. An estimate of potential indirect wetland effects (wetland acres by wetland type, and type of effect) from hydrologic changes resulting from the containment system was determined as follows:

1. The amount of Plant Site groundwater seepage water that would bypass the containment system and emerge in surface water features, including wetlands, downgradient of the Tailings Basin was quantified. The quantity of seepage evading the containment system was confirmed using MODFLOW and incorporated into the GoldSim model as a deterministic value.
2. All wetlands (type, acreage) within the surficial aquifer groundwater flowpaths downgradient of the Plant Site were identified within the boundaries used in the water quality modeling (as shown in the Groundwater IAP Summary document [MDNR et al. 2011]).
3. Using the wetlands identified in step 2, wetlands were categorized into minerotrophic (groundwater-fed) and ombrotrophic (precipitation-fed) wetlands using guidance in the Corps Memorandum (CEMVP-OP-R) *Distinguishing Between Bogs That Are Entirely Precipitation Driven Versus Those with Some Degree of Mineral Inputs from Groundwater and/or Surface Water Runoff* (Eggers 2011b) and evaluating the potential for indirect effects resulting from construction of the water containment system.

A discussion regarding potential indirect wetland hydrology effects at the Plant Site, including conversion to other wetland community types, a change in vegetation without a change in community type, conversion to uplands, or other effects is provided below in Section 5.2.3.2.4. These effects were categorized by applying the Eggers and Reed (1997, 2014) wetland classification system to each wetland type based on the wetland sensitivity class tables for rising groundwater tables that were developed for a previously proposed mine project in Wisconsin (PolyMet 2015b).

<u>Potential Indirect Effects on Wetlands Abutting the Partridge River and Four Creeks</u>

An estimate of potential indirect wetland effects (wetland acres by wetland type and type of effect) was determined for wetlands abutting the following:

- the Partridge River, as a result of changes in river flow resulting from the NorthMet Project Proposed Action (during operation and post-closure); and
- the three creeks north and west of the Plant Site (Trimble Creek, Mud Lake Creek, and Unnamed Creek) and Second Creek south of the Plant Site, as a result of changes in streamflow resulting from operation of the Plant Site and containment system.

Changes in river and creek flow were estimated using mass balance techniques.

<u>Potential Indirect Wetland Effects Resulting from Water Quality Changes</u>

A screening analysis for depositional effects was conducted using air dispersion/ deposition modeling (AERMOD) to estimate the potential annual deposition of dust, metals, and sulfur to wetlands within and adjacent to the Mine Site and Plant Site. Emission rates and particle size distributions were based on total particulate matter. The estimated deposition from fugitive dust emissions was used to identify wetlands that have the potential for water quality changes related to sulfide dust deposition. The estimated deposition from fugitive dust emissions was used to identify a threshold for a negative effect on vegetation. The estimated inputs of the dust, metals, and sulfur to wetlands were evaluated for significance to potential changes in water quality. The receptors of interest were the wetlands that were not identified as directly impacted.

Leakage from stockpiles at the Mine Site was evaluated to determine if wetlands would be impacted. The amount of stockpile leakage water that would potentially discharge to surface waters and wetlands downgradient of the stockpiles was based on the water quality modeling (see Section 5.2.2). Wetlands within the surficial aquifer groundwater flowpaths from mine features were identified and then further characterized into minerotrophic and ombrotrophic wetlands per Eggers 2011a. Wetlands were then evaluated to determine the potential for indirect effects based on potential water quality changes from the mine features.

Tailings Basin groundwater seepage at the Plant Site was evaluated to determine if wetlands would be impacted. The chemistry from the Tailings Basin groundwater seepage based on the water quality modeling (see Section 5.2.2) was determined. Wetlands within the downgradient zone were identified and then further characterized into minerotrophic and ombrotrophic wetlands (Eggers 2011a). Wetlands were then evaluated to determine the potential for indirect effects based on potential water quality changes from the Tailings Basin.

Wetlands within and adjacent to the Transportation and Utility Corridor were assessed to determine if indirect wetland effects would occur as a result of water quality changes. The assessment evaluated the potential release of dust from: railcars transporting ore from the Mine Site to the Plant Site, use of Dunka Road, and product shipping at the Plant Site.

5.2.3.2 NorthMet Project Proposed Action

The NorthMet Project Proposed Action would result in both direct and indirect effects. This section describes effects within the NorthMet Project area and provides a summary of wetland effects. Estimates of both direct and indirect wetland effects have changed during the EIS process as the result of refined analysis and changes in project design. The effects identified in this FEIS are based on the most current information available and may differ from those identified in prior reports. Avoidance, minimization, mitigation, and monitoring measures for the NorthMet Project Proposed Action are discussed in Section 5.2.3.3.

5.2.3.2.1 Mine Site and Transportation and Utility Corridor Direct Wetland Impacts

Direct wetland impacts would result from the following Mite Site and Transportation and Utility Corridor components: construction and/or installation of the mine pits, Category 1 Stockpile, Category 2/3 Stockpile, Category 4 Stockpile, Overburden Storage and Laydown Area, haul roads, rail transfer loadout, WWTF, perimeter dike, culverts, groundwater discharge pipe, surface and groundwater seepage containment system, stormwater collection ditches and ponds, CPS, process water pipes and ponds, Treated Water Pipeline, transmission lines, and Dunka Road upgrades. The Mine Site features would result in 758.2 acres of directly impacted wetlands (see Figure 5.2.3-1). Table 5.2.3-1 summarizes the directly impacted wetlands within the Mine Site by community type while Table 5.2.3-2 identifies the activity that causes the impacts expected at the Mine Site. Three wetland types comprise 89 percent of the expected wetland impacts in the Mine Site, including 508.3 acres of coniferous bog (67 percent), 97.8 acres of shrub swamp (13 percent), and 70.3 acres of coniferous swamp (9 percent). Direct impacts would be caused by fill (10 percent), excavation (12 percent), or a combination of fill and excavation (78 percent). The majority of the wetlands (99 percent) that would be directly impacted are rated high quality, while 1 percent are rated as moderate quality (PolyMet 2015b).

Table 5.2.3-1 Total Projected Direct Wetland Impacts at the Mine Site and the Transportation and Utility Corridor

	Directly Impacted Wetlands at Mine Site			Directly Impacted Wetlands at Transportation and Utility Corridor		
Eggers and Reed Class[1]	**Acres**	**%**	**No.**	**Acres**	**%**	**No.**
Coniferous bog	508.3	67	22	0.9	12	2
Coniferous swamp	70.3	9	7	1.6	22	7
Deep marsh	0.1	<1	1	0.0	0	0
Hardwood swamp	12.5	2	2	0.0	0	0
Open bog	7.6	1	4	0.0	0	0
Open Water (includes shallow, open water, and lakes)	0.0	0	0	0.0	0	0
Sedge/wet meadow	38.2	5	5	0.0	0	0
Shallow marsh	23.4	3	6	0.6	8	3
Shrub swamp (includes alder thicket and shrub-carr)	97.8	13	12	4.1	57	13
Total Direct Impacts	758.2	100	59	7.2	100	25

Source: PolyMet 2015b.

Note:
1 Eggers and Reed 1997, 2014.

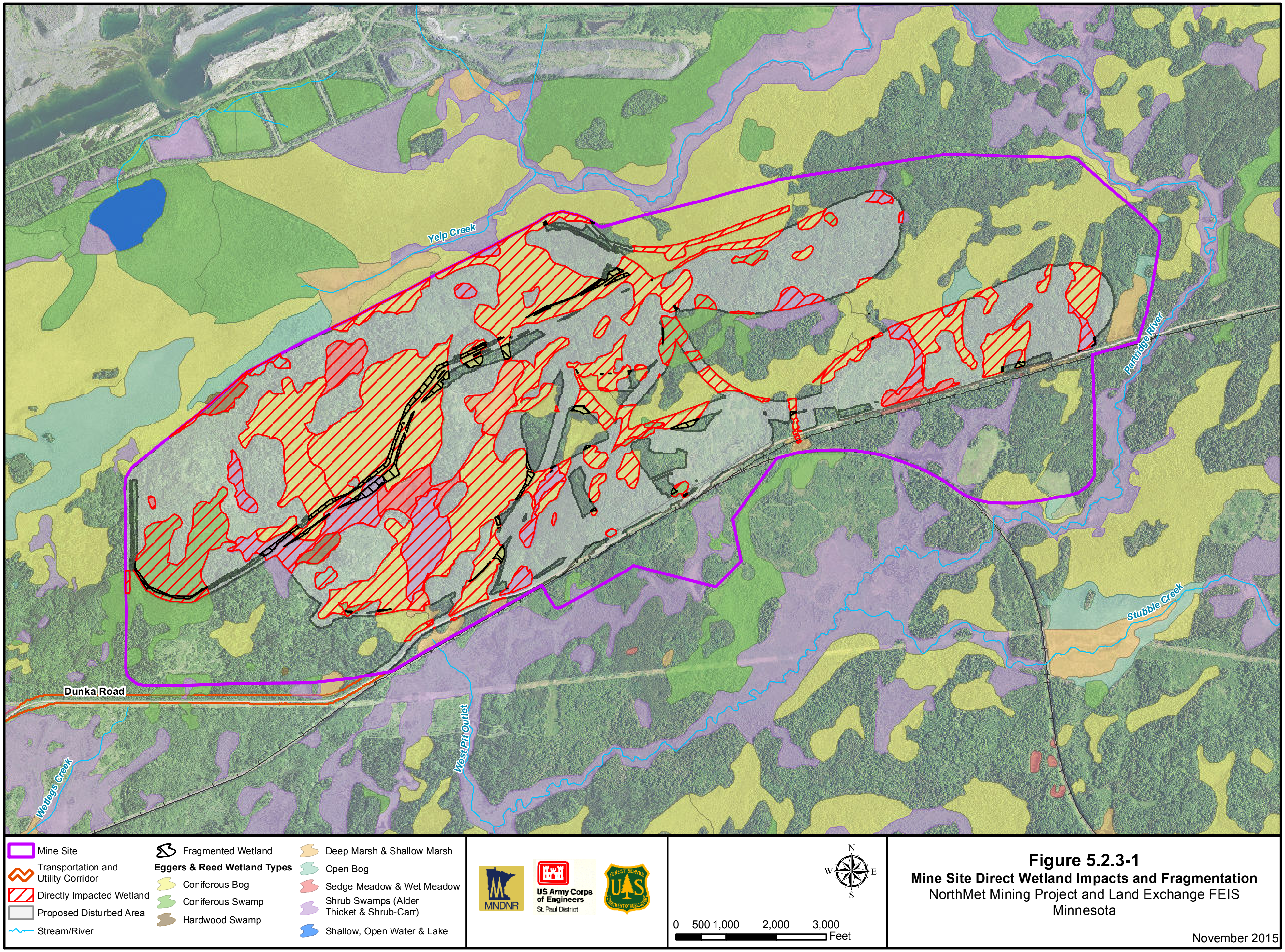

Figure 5.2.3-1

Mine Site Direct Wetland Impacts and Fragmentation

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Table 5.2.3-2 Type of Projected Direct Wetland Impacts at the Mine Site and the Transportation and Utility Corridor

Type of Effect	Directly Impacted Wetlands at Mine Site			Directly Impacted Wetlands at Transportation and Utility Corridor		
	Acres	**%**	**No.**	**Acres**	**%**	**No.**
Fill	77.3	10	23	7.2	100	25
Excavation	87.9	12	14	0.0	0	0
Fill and Excavation	593.0	78	22	0.0	0	0
Total Direct Impacts	758.2	100	59	7.2	100	25

Source: PolyMet 2015b.

PolyMet proposes to minimize wetland impacts by placing waste rock back into the East Pit and Central Pit after year 11, thereby reducing the need for additional surface stockpile areas that would otherwise affect wetlands. In addition, PolyMet proposes to combine the saturated overburden and temporary stockpiles, and leave only unsaturated overburden and peat in the Overburden Storage and Laydown Area. By doing so, the footprint of these stockpiles would be reduced, resulting in fewer direct wetland impacts.

In approximately year 52, flooding to the West Pit would be complete. Discharge from the West Pit would be pumped to the WWTF for treatment. The WWTF would then be upgraded to include RO or equivalently performing technologies treatment to achieve a 9 mg/L sulfate effluent, which would then be discharged into a wetland and finally through the West Pit Outlet Creek to the Partridge River. The direct impacts on this wetland have been included within the wetland effect direct totals in Table 5.2.3-1.

Construction activities within the Transportation and Utility Corridor would affect 7.2 acres of wetlands, all of which would be filled. Table 5.2.3-1 summarizes the directly impacted wetlands within the Transportation and Utility Corridor by community type while Table 5.2.3-2 identifies the activity that causes the impacts expected within the Transportation and Utility Corridor. The wetland types that would be directly impacted include shrub swamps (57 percent), coniferous swamps (22 percent), coniferous bogs (12 percent), and shallow marshes (8 percent) (see Figure 5.2.3-2). All of the wetlands to be directly impacted are rated as high quality. The rail spur was designed to use an existing rail alignment in order to avoid wetlands to the extent possible within the requirements for rail construction.

5.2.3.2.2 Mine Site and Transportation and Utility Corridor Indirect Wetland Effects

The potential indirect wetland effects were assessed by identifying wetlands in Area 1 within 500-ft increments beginning at the edge of the mine pits and extending to a maximum distance of 10,000 ft (see Figure 5.2.3-3) (PolyMet 2015b). The area of evaluation for the Mine Site potential indirect wetlands effects included only wetlands within Area 1 where wetland type information had been developed and does not include the directly impacted wetlands.

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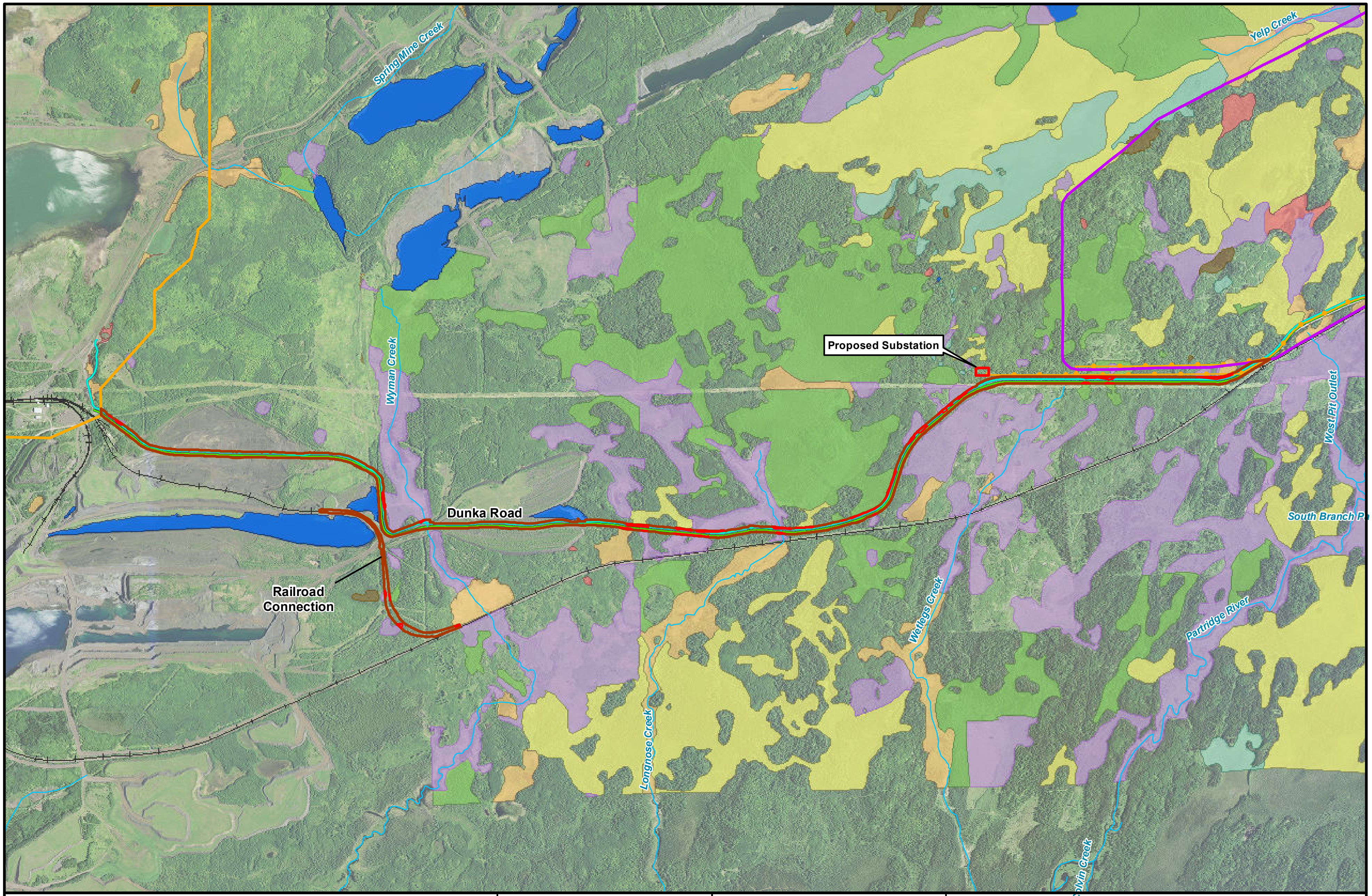

Transportation and Utility Corridor
Directly Affected Wetland
Proposed Transmission Line
Treated Water Pipeline
Dunka Road
Mine Site
Plant Site
Existing Railroad
Stream/River

Eggers & Reed Wetland Types

Coniferous Bog
Coniferous Swamp
Deep Marsh & Shallow Marsh
Hardwood Swamp
Open Bog
Sedge Meadow & Wet Meadow
Shrub Swamps (Alder Thicket & Shrub-Carr)
Shallow, Open Water & Lake

MNDNR
US Army Corps of Engineers
St. Paul District

N
W E
S

0 1,000 2,000 4,000
Feet

Figure 5.2.3-2
Transportation and Utility Corridor
Wetlands and Direct Wetland Impacts
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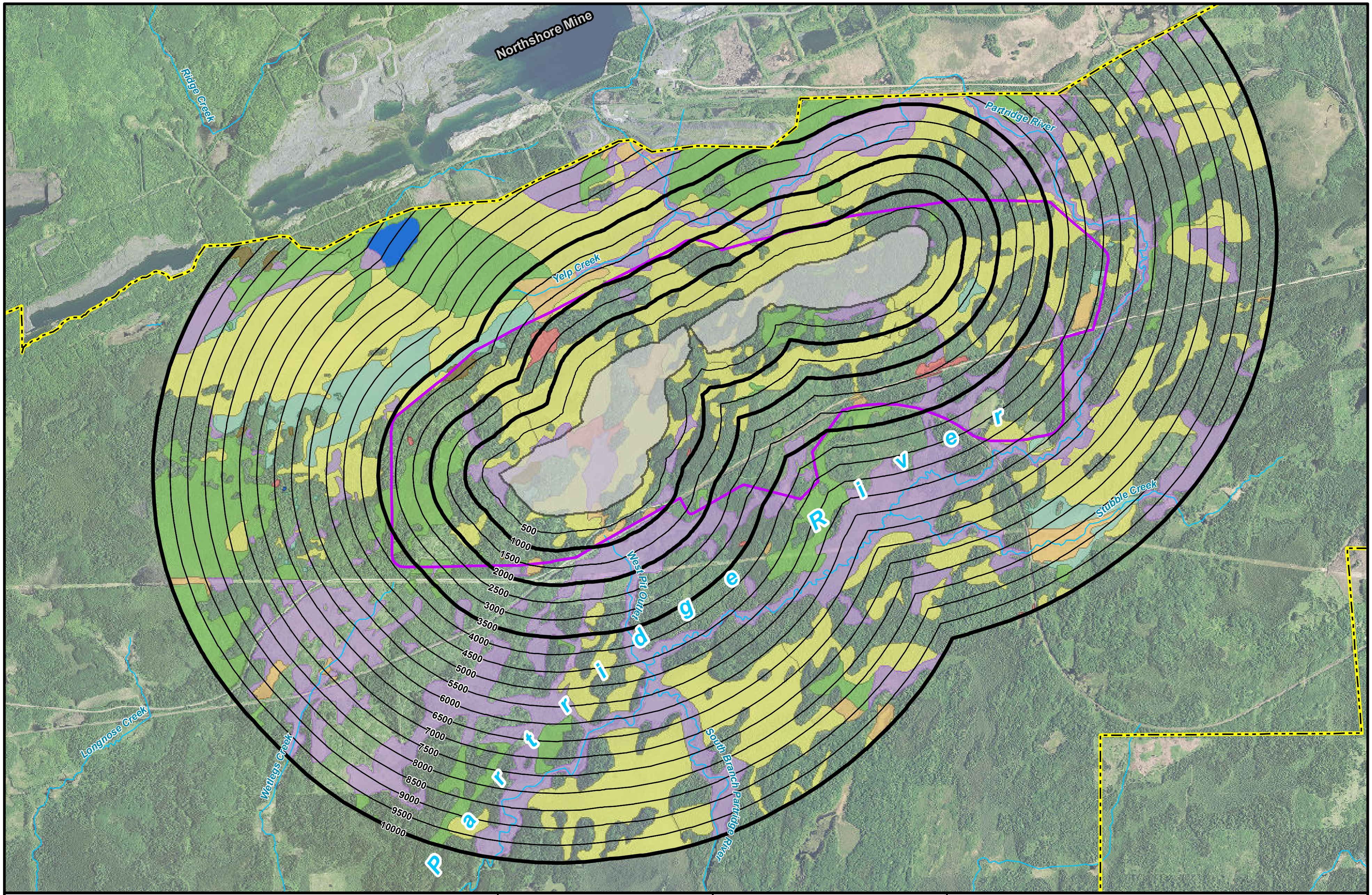

Figure 5.2.3-3
Wetlands within 500 ft Increments at the Mine Site
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Wetland Fragmentation

Construction of the Mine Site features (e.g., open pits, stockpiles, haul roads, etc.) would result in 26.4 acres of wetland fragments (see Figure 5.2.3-1). Wetlands were determined to be fragmented and their associated remaining acreage included as a potential indirect wetland effect if they were small remnants of a directly impacted wetland located between Mine Site features (e.g., in the area between the Category 1 Stockpile and the West Pit or along Dunka Road or the Railroad Connection Corridor) and their functions were lost. The majority of the wetland fragments in the Mine Site would consist of coniferous bog (79 percent), alder thickets (14 percent), coniferous swamp (7 percent), and sedge/wet meadow (less than 1 percent). In addition, a 0.01 acre alder thicket would become fragmented just outside of the Transportation and Utility Corridor near Dunka Road but within Area 1 (PolyMet 2015b). No wetlands would become fragmented along the Railroad Corridor. The wetland fragments that are expected to maintain their functions would be included in the wetland hydrology and vegetation monitoring plan that would be approved during permitting and implemented for the NorthMet Project Proposed Action.

Changes in Hydrology Due to Change in Watershed Area

The potential for indirect effects to wetland acreage due to change in watershed area was assessed by evaluating the change in watershed area per acre of wetland (PolyMet 2015b). Watersheds were defined for each wetland within the Mine Site boundary, as well as wetlands outside the Mine Site with a watershed area that may be affected by NorthMet Project area features. Wetland and watershed areas were determined for the following conditions: existing conditions, during operations when the maximum amount of watershed has been removed (i.e., maximum NorthMet Project Proposed Action extent), and at closure and long-term maintenance.

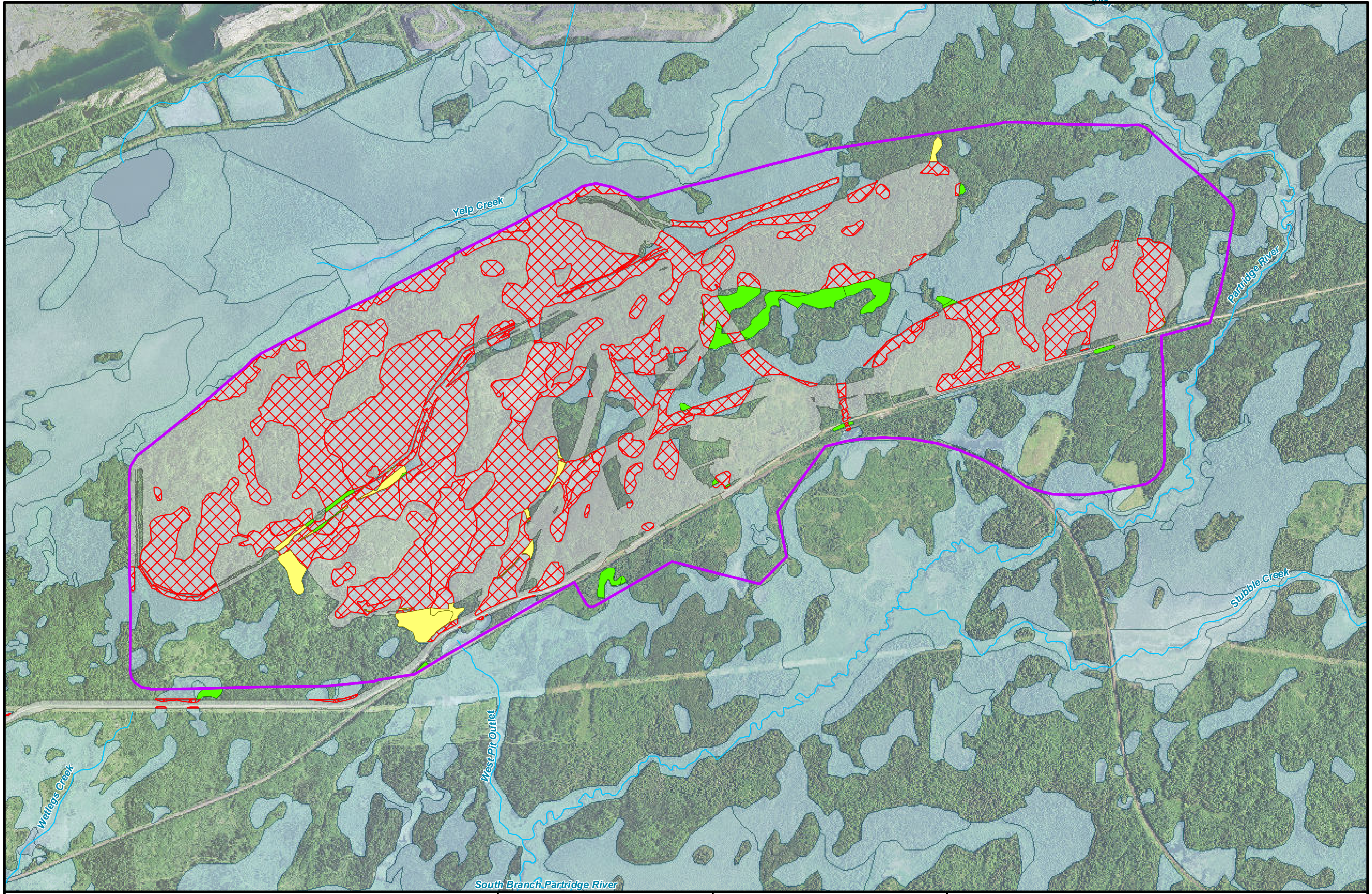
The analysis was completed by first defining the watershed area (i.e., the sum of upland area and wetland area). For each wetland in the Mine Site, GIS was used to determine the upland area (acres) and wetland area (acres) within each watershed area (acres). Using these acreages, the percentage of a wetland within its watershed was calculated. In addition, the tributary acres per wetland acre were determined as a proportion of the watershed area to wetland area; the equivalent watershed yield (acre-feet per year) was determined for the existing, maximum operational extent, and closure and long-term maintenance conditions (the average net precipitation rate is 11.77 inches per year); and the change in the equivalent yield (inches per year) estimated over the life of the NorthMet Project Proposed Action was evaluated relative to existing conditions equivalent yield to calculate the maximum percent change in yield (PolyMet 2011b; PolyMet 2015b).

The existing conditions include wetlands that represent the existing and relatively undisturbed conditions at the Mine Site. The analysis included wetlands and associated watersheds that are partially or completely within the Mine Site boundary. There are a total of 3,325 acres of wetlands within 6,287 acres of watershed, which results in approximately 53 percent of the analysis area covered by wetlands (PolyMet 2015b).

During operations, some wetlands and watershed areas would be directly impacted by the NorthMet Project Proposed Action and would no longer be considered as a tributary area to the wetland. Consequently, the amount of water potentially contributed by the watershed to support the hydrology of the remaining wetlands would also change.

There would be 20 wetlands, potentially indirectly affected, displaying an increase or decrease of greater than 20 percent equivalent yield. Ombrotrophic coniferous bogs and open bogs were not included in the total wetland acreage because their hydrology is solely supported by precipitation and may contain groundwater flowpaths. The hydrology of the ombrotrophic bogs is not dependent on the size of the watershed. There would be 35 acres (11 wetlands) that would have the potential to experience an increase in yield per wetland acre of greater than 20 percent, and 15 acres (9 wetlands) that would likely experience a decrease in yield per wetland acre in excess of 20 percent (see Figure 5.2.3-4). The 49.4 acres of potentially indirectly affected wetland types include alder thickets (52 percent), coniferous swamp (34 percent), minerotrophic coniferous bog (8 percent), shallow marsh (6 percent), and sedge/wet meadow (less than 1 percent) (PolyMet 2015b).

During reclamation, a portion of the wetlands and wetland watersheds within the Mine Site would be restored to the existing condition.



Mine Site
Disturbed Area
Directly Affected Wetland
Stream/River
Wetlands

Potential Indirect Wetland Effects

Decrease in Yield per Wetland Acre of Greater Than 20%

Increase in Yield per Wetland Acre of Greater Than 20%

0 500 1,000 2,000 3,000 Feet

Figure 5.2.3-4

Wetlands Potentially Indirectly Affected by Change in Watershed Area

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Changes in Wetland Hydrology Due to Surficial Aquifer Drawdown

The geologic and hydrogeologic settings of the Mine Site and the analog sites are fairly similar with a thin veneer of heterogeneous surficial deposits underlain by fractured bedrock. The hydraulic conductivities of the surficial deposits and bedrock are lower at the Mine Site than at the analog sites, and so it is expected that the wetland impact zones would likely overestimate the extent of potential wetland effects. Because of the thin, discontinuous nature of the surficial deposits at the Mine Site, drawdown effects are expected to be more localized at the Mine Site than at the analog sites. Additionally, the numerous bedrock outcrops present at the Mine Site are expected to act as barriers to flow in the unconsolidated aquifer, thereby limiting the area of influence of the mine pits. The analog sites have fewer or no bedrock outcrops compared to the Mine Site. Last, the presence of the Partridge River approximately 4,000 to 6,000 ft south (downstream) of the mine pits is likely to act as a natural barrier to the expansion of the cone of depression within the surficial aquifer from 3,500 to 10,000 ft from the pit (PolyMet 2015b).

Open and coniferous bog wetlands within and surrounding the Mine Site were subcategorized as either ombrotrophic (hydrology and mineral inputs solely from direct precipitation) or minerotrophic (some degree of mineral inputs from groundwater and/or surface water runoff) to determine if the bogs would be affected by groundwater drawdown. Due to the potential connection to groundwater flowpaths, ombrotrophic bogs would have a low likelihood of being affected by groundwater drawdowns associated with proposed mining operations. Similarly, more minerotrophic bogs would have also had a low likelihood of being affected (Eggers 2015a). Using a conservative approach for the analysis (i.e., one that errs on the side of estimating greater wetland impacts), all bog communities within 0-1,000 ft from the edge of the mine pits were categorized as Low Likelihood of wetland hydrology impact (PolyMet 2015b).

The potential indirect wetland effect from surficial aquifer drawdown was based on the analog impact zone with the greater potential drawdown (zone closer to the open pit mine) for wetlands that lie on both sides of the analog distance boundary. Wetlands were identified within four analog impact zones (0-1,000 ft, >1,000-2,000 ft, >2,000-3,500 ft, and >3,500-10,000 ft) from the edge of the mine pits within Area 1 (see Figure 5.2.3-5).

The change in wetland hydrology from groundwater drawdown at the Mine Site was assessed by two different methodologies; therefore, total potential indirect wetland effects were provided based on both approaches. The two approaches are as follows:

- **Wetlands Crossing Analog Zones**: Wetlands that were located within multiple analog impact zones were included in the analog impact zone closest to the edge of the mine pits. The likelihood of wetland hydrology impact was categorized as High, Medium, Low, and No Impact for each analog impact zone.
- **Wetlands within Analog Zones**: Wetlands that were located within multiple analog impact zones were split along zone edges and acreages were calculated by zone. As a result, the acreage for wetlands crossing zone edges was split among multiple zones, rather than included in the analog impact zone that was closest to the edge of the mine pits. The likelihood of wetland hydrology impact was categorized as High, Medium, Low, and No Impact for each analog impact zone.

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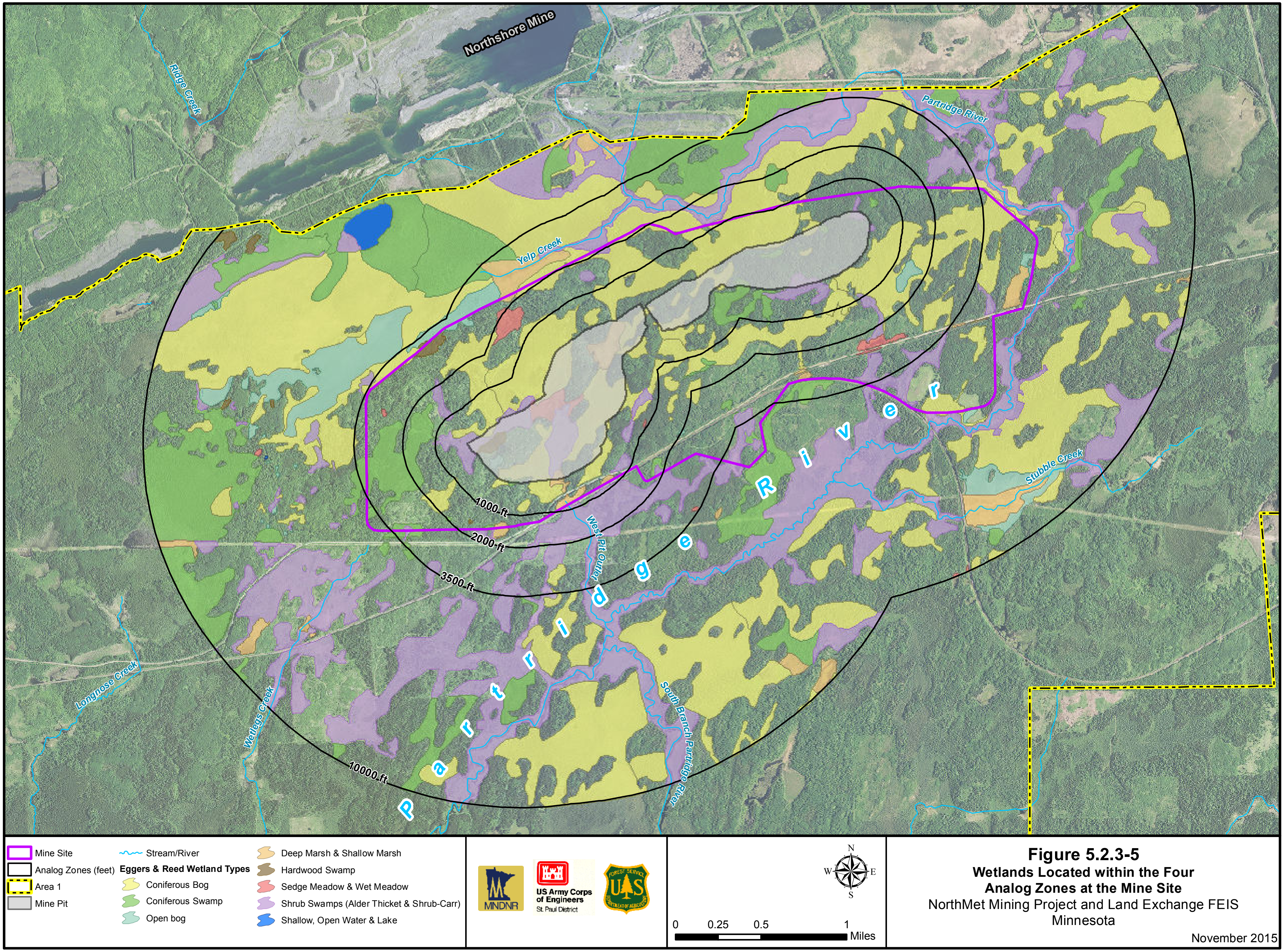

Figure 5.2.3-5
Wetlands Located within the Four Analog Zones at the Mine Site
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Minnesota

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Based on the wetlands crossing analog zones analysis approach, there would be 1,328.0 acres of wetlands in the 0-1,000 ft zone, 618.6 acres in the >1,000-2,000 ft zone, 1,162.0 acres of wetlands in the >2,000-3,500 ft zone, and 2,718.3 acres of wetlands in the >3,500-10,000 ft zone beyond the edge of the pits (see Table 5.2.3-3; Figures 5.2.3-6 through 5.2.3-10) (PolyMet 2015b).

Table 5.2.3-3 Wetlands Crossing Analog Impact Zones Resulting from Potential Changes in Hydrology

Likelihood of Wetland Hydrology Effect Based on Wetland Type for Each Analog Distance	Wetland Area (acres) within each Analog Increement: 0-1,000 ft	1,000-2,000 ft	2,000-3,500 ft	3,500-10,000 ft	Eggers and Reed Wetland Community
0 – 1,000 ft					
High Likelihood	866.9	-	-	-	Coniferous swamp, sedge meadow, and alder thicket
Moderate Likelihood	8.3	-	-	-	Deep marsh and shallow marsh
Low Likelihood	452.8	-	-	-	Minerotrophic and ombrotrophic coniferous bog
No Effect	-	-	-	-	No wetland types
1,000 – 2,000 ft					
Moderate Likelihood	-	522.4	-	-	Coniferous swamp, hardwood swamp, shrub-carr, and alder thicket
Low Likelihood	-	4.1	-	-	Shallow marsh
No Effect	-	92.1	-	-	Minerotrophic and ombrotrophic coniferous bog and open bog
2,000 – 3,500 ft					
Low Likelihood	-	-	293.1	-	Coniferous swamp, hardwood swamp, sedge/wet meadow, shrub-carr, and alder thicket
No Effect	-	-	868.9	-	Minerotrophic and ombrotrophic coniferous bog and open bog and shallow marsh
3,500 – 10,000 ft					
No Effect	-	-	-	2,718.3	All wetland types
Total Acres of Wetland	**1,328.0**	**618.6**	**1,162.0**	**2,718.3**	

Source: PolyMet 2015b

Under this methodology, the likelihood of wetland hydrology effects would be as follows: no effect on 3,679.3 acres of wetlands (63 percent); low likelihood to 750.0 acres of wetlands (13 percent); moderate likelihood to 530.7 acres of wetlands (9 percent); and high likelihood to 866.9 acres of wetlands (15 percent) (see Table 5.2.3-3). Within 0-10,000 ft from the edge of the mine pits, wetland types with a high likelihood of wetland hydrology effects include shrub swamps (847.8 acres), coniferous swamp (18.9 acres), and sedge/wet meadow (less than 1 acre); with a moderate likelihood include shrub swamp (327.2 acres), coniferous swamp (194.9 acres), deep marsh (4.9 acres), shallow marsh (3.4 acres), and hardwood swamp (less than 1 acre); and with a low likelihood include coniferous bog (452.8 acres) coniferous swamp (222.7 acres), shrub swamps (67.8 acres), shallow marsh (4.1 acres), sedge/wet meadow (1.7 acres), and hardwood swamp (less than 1 acre) (PolyMet 2015b).

The wetlands categorized as high likelihood are dominated by one alder thicket (823.7 acres) that has approximately 4 acres (less than 1 percent) within the 0-1,000 ft analog impact zone. The remainder of this wetland (more than 99 percent) is located more than 1,000 ft away from the edge of the mine pits and extends out to the edge of Area 1 (see Figure 5.2.3-6).

Based on the analog data, hydrologic effects to peat wetlands would only be observed to occur within 1,000 ft from the edge of the mine pits. Therefore, wetlands were categorized within the analog impact zones using an alternate method to determine the likelihood of wetland hydrology effects as described below.

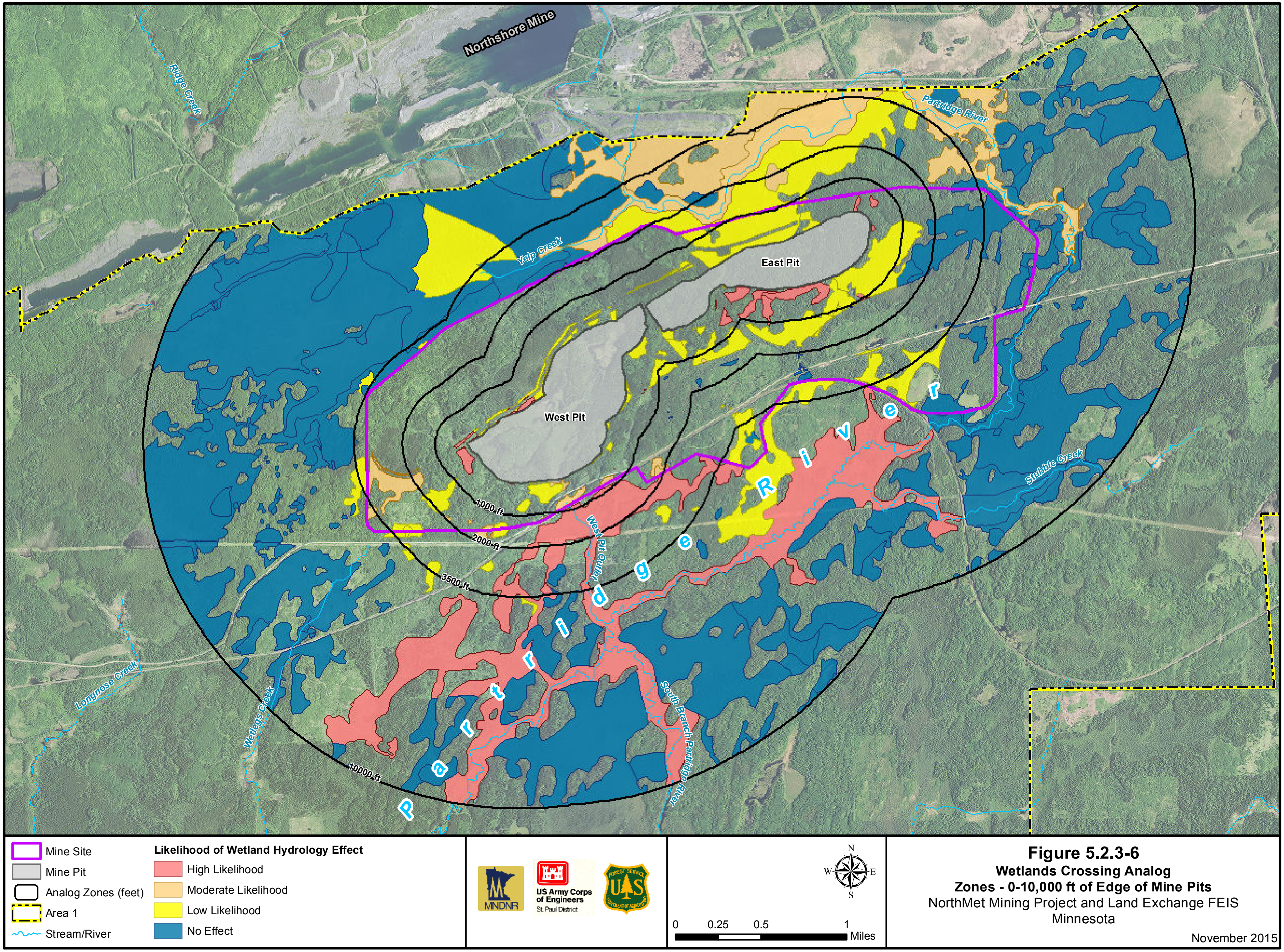

Figure 5.2.3-6

Wetlands Crossing Analog

Zones - 0-10,000 ft of Edge of Mine Pits

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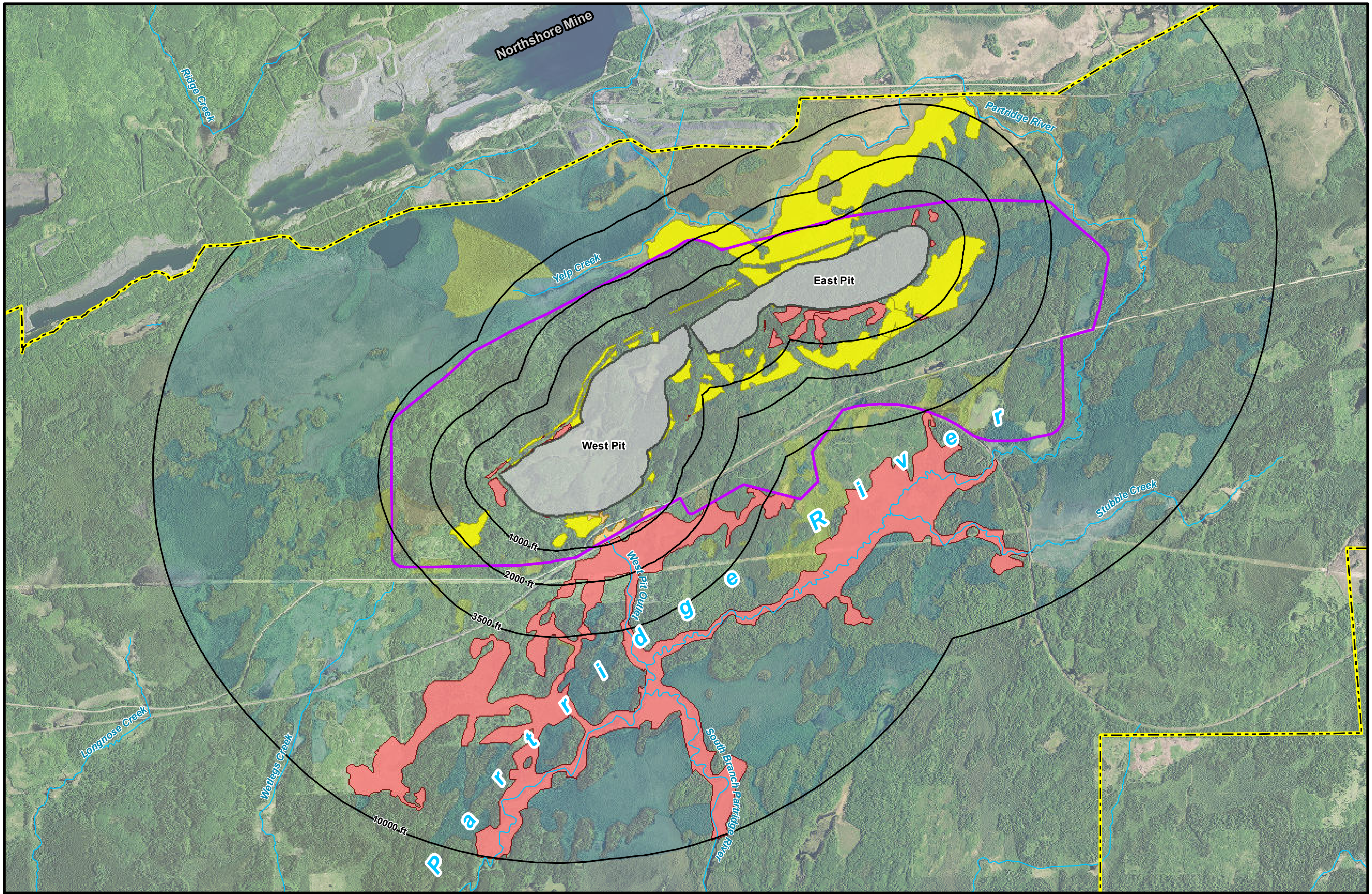

Mine Site
Mine Pit
Analog Zones (feet)
Area 1
Stream/River

Likelihood of Wetland Hydrology Effect
High Likelihood
Moderate Likelihood
Low Likelihood
No Effect

MNDNR
US Army Corps of Engineers St. Paul District

N W E S

0 0.25 0.5 1 Miles

Figure 5.2.3-7
Wetlands Crossing Analog Zones -
0-1,000 ft of Edge of Mine Pits
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Minnesota

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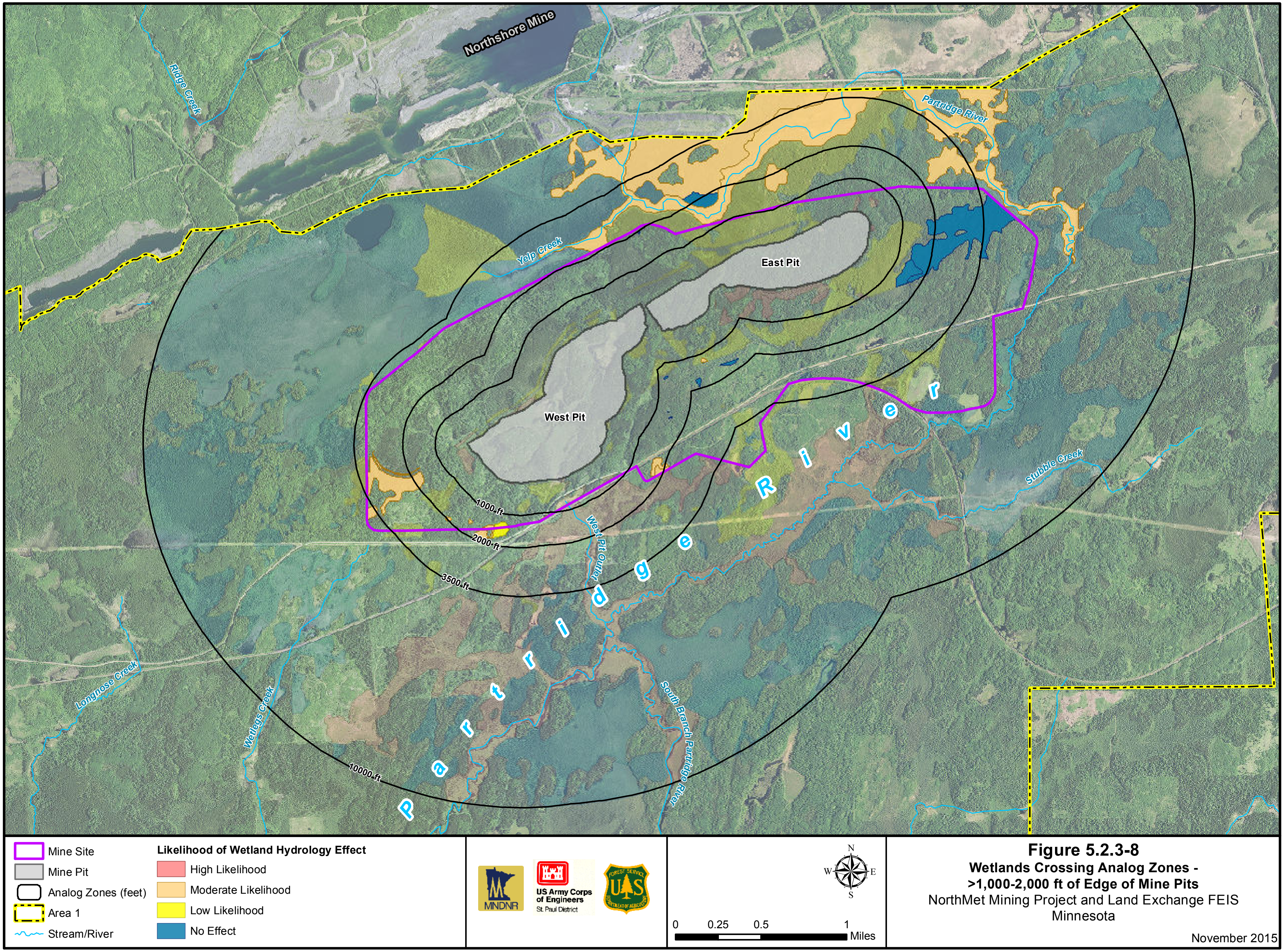

Figure 5.2.3-8
Wetlands Crossing Analog Zones - >1,000-2,000 ft of Edge of Mine Pits
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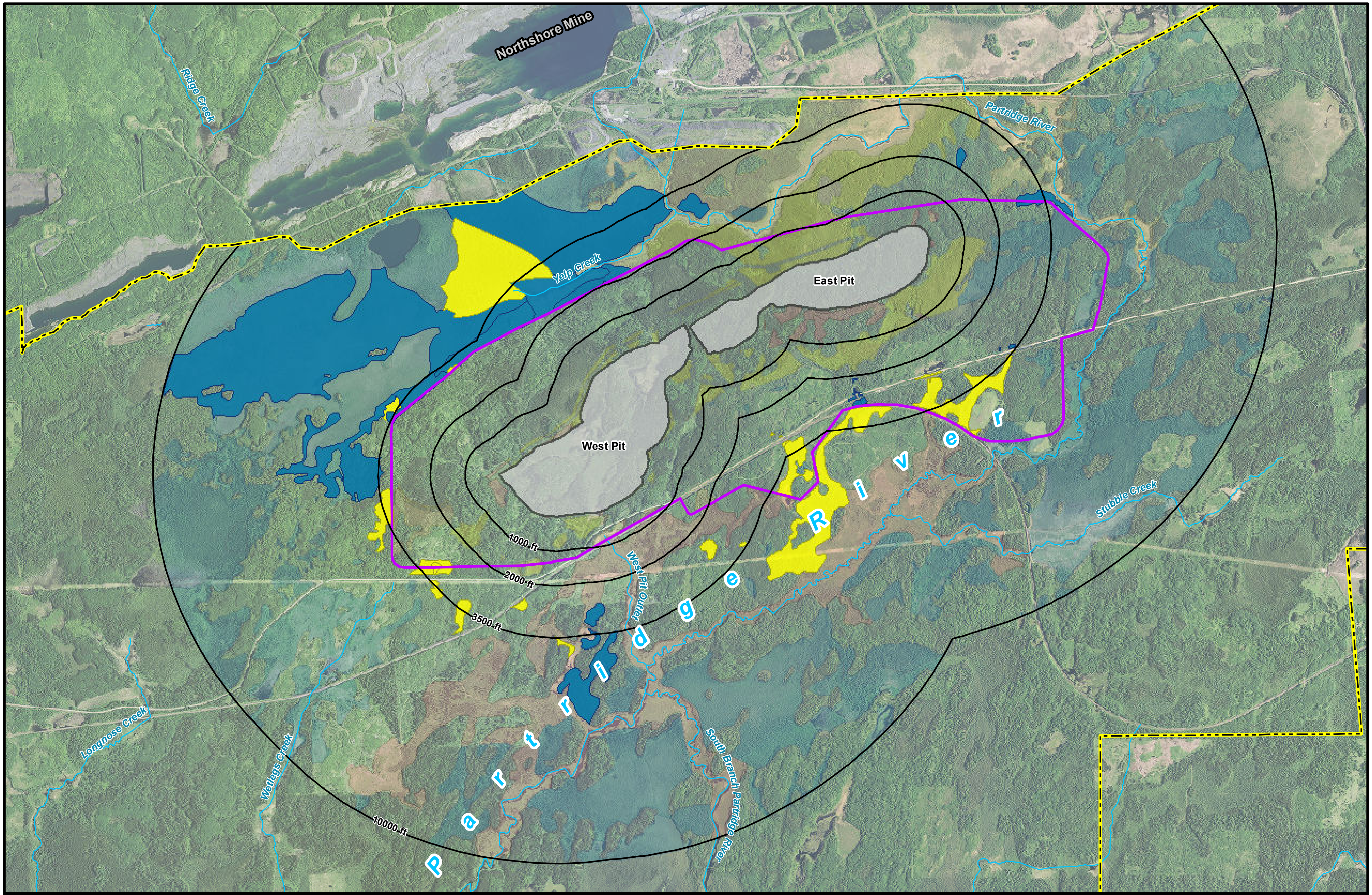

Mine Site
Mine Pit
Analog Zones (feet)
Area 1
Stream/River

Likelihood of Wetland Hydrology Effect
High Likelihood
Moderate Likelihood
Low Likelihood
No Effect

MNDNR
US Army Corps of Engineers St. Paul District

N W E S

0 0.25 0.5 1 Miles

Figure 5.2.3-9
Wetlands Crossing Analog Zones - >2,000-3,500 ft of Edge of Mine Pits
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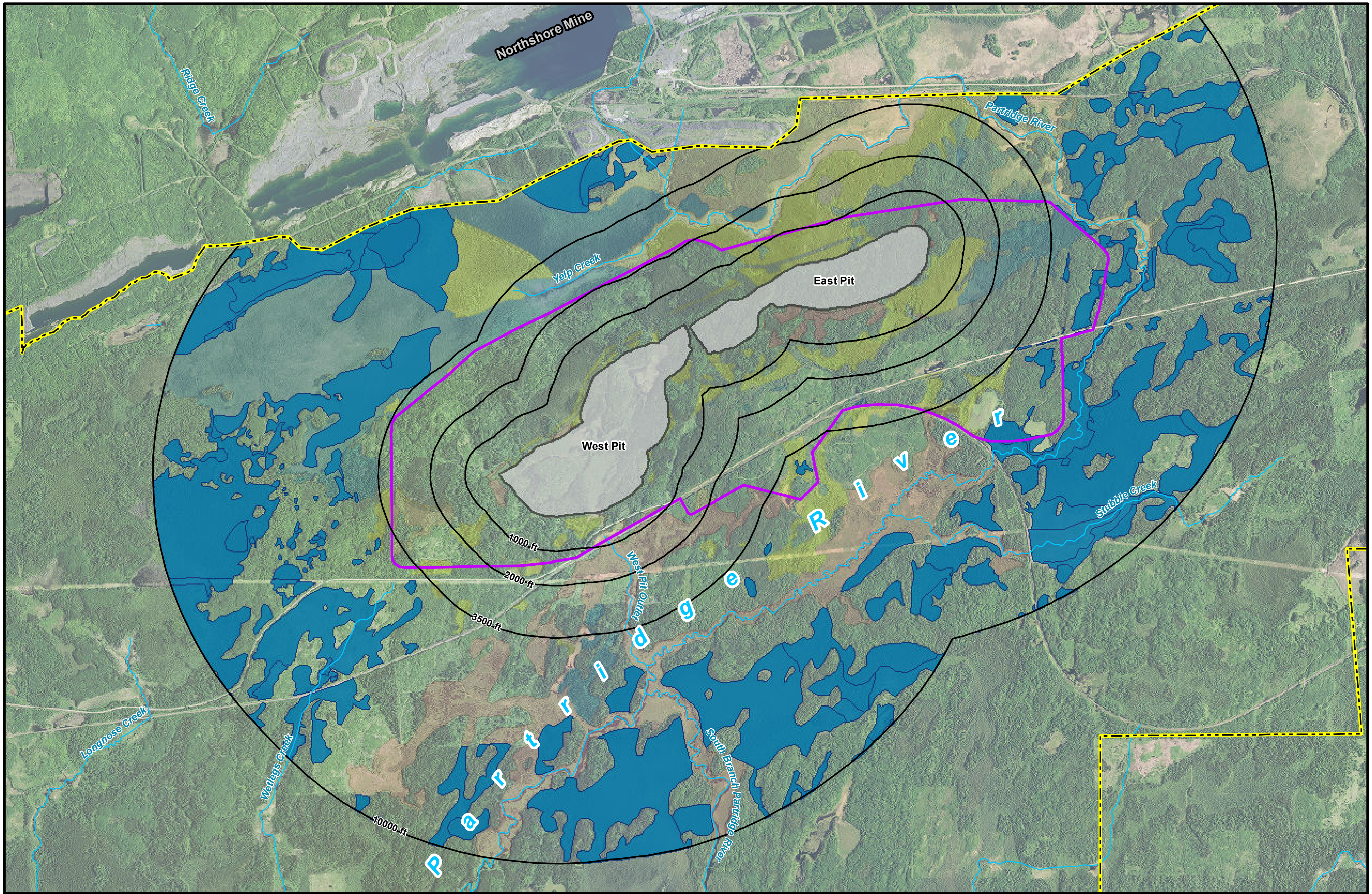

Mine Site
Mine Pit
Analog Zones (feet)
Area 1
Stream/River

Likelihood of Wetland Hydrology Effect
High Likelihood
Moderate Likelihood
Low Likelihood
No Effect

MNDNR
US Army Corps of Engineers St. Paul District

N W E S

0 0.25 0.5 1 Miles

Figure 5.2.3-10
Wetlands Crossing Analog Zones - >3,500-10,000 ft of Edge of Mine Pits
NorthMet Mining Project and Land Exchange FEIS
Minnesota

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For the wetlands within analog zones, those wetlands that were located within multiple analog impact zones were split along zone edges, and acreages were calculated by zone. The acreage of each wetland type located within these impact zones is summarized in Table 5.2.3-4 and locations are shown in Figures 5.2.3-11 through 5.2.3-15. Using this analysis approach, there would be 233.5 acres of wetlands in the 0-1,000 ft zone, 311.0 acres in the >1,000-2,000 ft zone, 718.0 acres of wetlands in the >2,000-3,500 ft zone, and 4,564.4 acres of wetlands in the >3,500-10,000 ft zone (PolyMet 2015b).

Table 5.2.3-4 Wetlands Within Analog Impact Zones Resulting from Potential Changes in Hydrology

Likelihood of Wetland Hydrology Effect Based on Wetland Type for Each Analog Distance	Wetland Area (acres) within each Analog Increment				Eggers and Reed Wetland Community
	0-1,000 ft	1,000-2,000 ft	2,000-3,500 ft	3,500-10,000 ft	
0 – 1,000 ft					
High Likelihood	46.4	-	-	-	Coniferous swamp, sedge meadow, and alder thicket
Moderate Likelihood	8.3	-	-	-	Deep marsh and shallow marsh
Low Likelihood	178.8	-	-	-	Minerotrophic and ombrotrophic coniferous bog
No Effect	-	-	-	-	No wetland types
1,000 – 2,000 ft					
Moderate Likelihood	-	110.8	-	-	Coniferous swamp, hardwood swamp, shrub-carr, and alder thicket
Low Likelihood	-	4.1	-	-	Shallow marsh
No Effect	-	196.1	-	-	Minerotrophic and ombrotrophic coniferous bog and open bog
2,000 – 3,500 ft					
Low Likelihood	-	-	385.0	-	Coniferous swamp, hardwood swamp, sedge/wet meadow, shrub-carr, and alder thicket
No Effect	-	-	333.0	-	Shallow marsh and minerotrophic and ombrotrophic coniferous bog and open bog
3,500 – 10,000 ft					
No Effect	-	-	-	4,564.4	All wetland types
Total Acres of Wetland	**233.5**	**311.0**	**718.0**	**4,564.4**	

Source: PolyMet 2015b.

Under this methodology, the likelihood of wetland hydrology effects would be as follows: no effect on 5,093.5 acres of wetlands (87 percent); low likelihood to 567.9 acres of wetlands (10 percent); moderate likelihood to 119.1 acres of wetlands (2 percent); and high likelihood to 46.4 acres of wetlands (less than 1 percent) (see Table 5.2.3-4). Within 0-10,000 ft from the edge of the mine pits, wetland types with a high likelihood of wetland hydrology effects include shrub swamps (27.5 acres), coniferous swamp (18.8 acres), and sedge/wet meadows (less than 1 acre); those with a moderate likelihood include shrub swamp (96.0 acres), coniferous swamp (14.4 acres), deep marsh (4.9 acres), shallow marsh (3.4 acres), and hardwood swamp (less than 1 acre); and those with low likelihood include shrub swamp (247.1 acres), coniferous swamp (135.3 acres), coniferous bog (178.8 acres), shallow marsh (4.1 acres), sedge/wet meadow (1.7 acres), and hardwood swamp (less than 1 acre) (PolyMet 2015b).

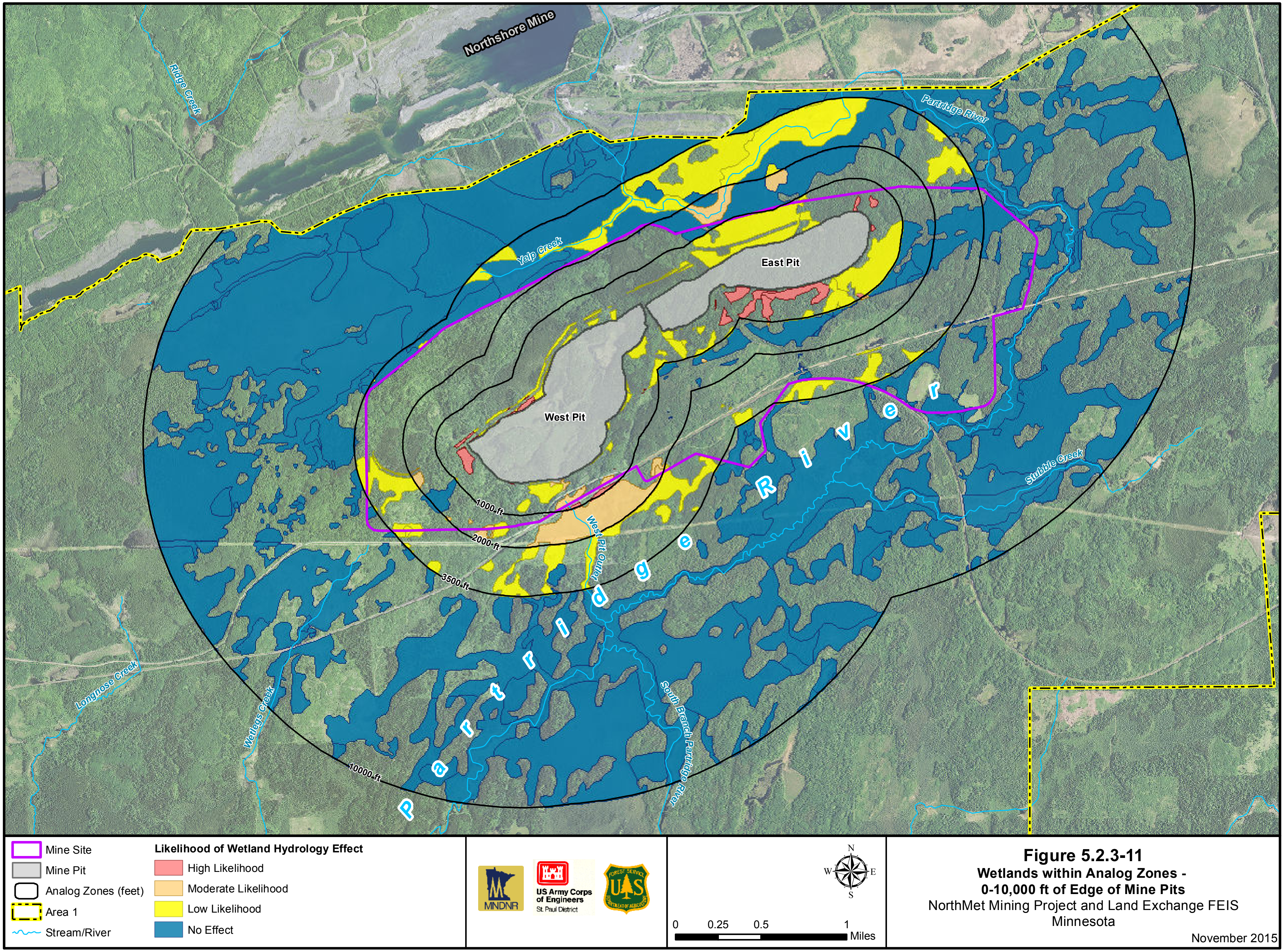

Figure 5.2.3-11
Wetlands within Analog Zones -
0-10,000 ft of Edge of Mine Pits
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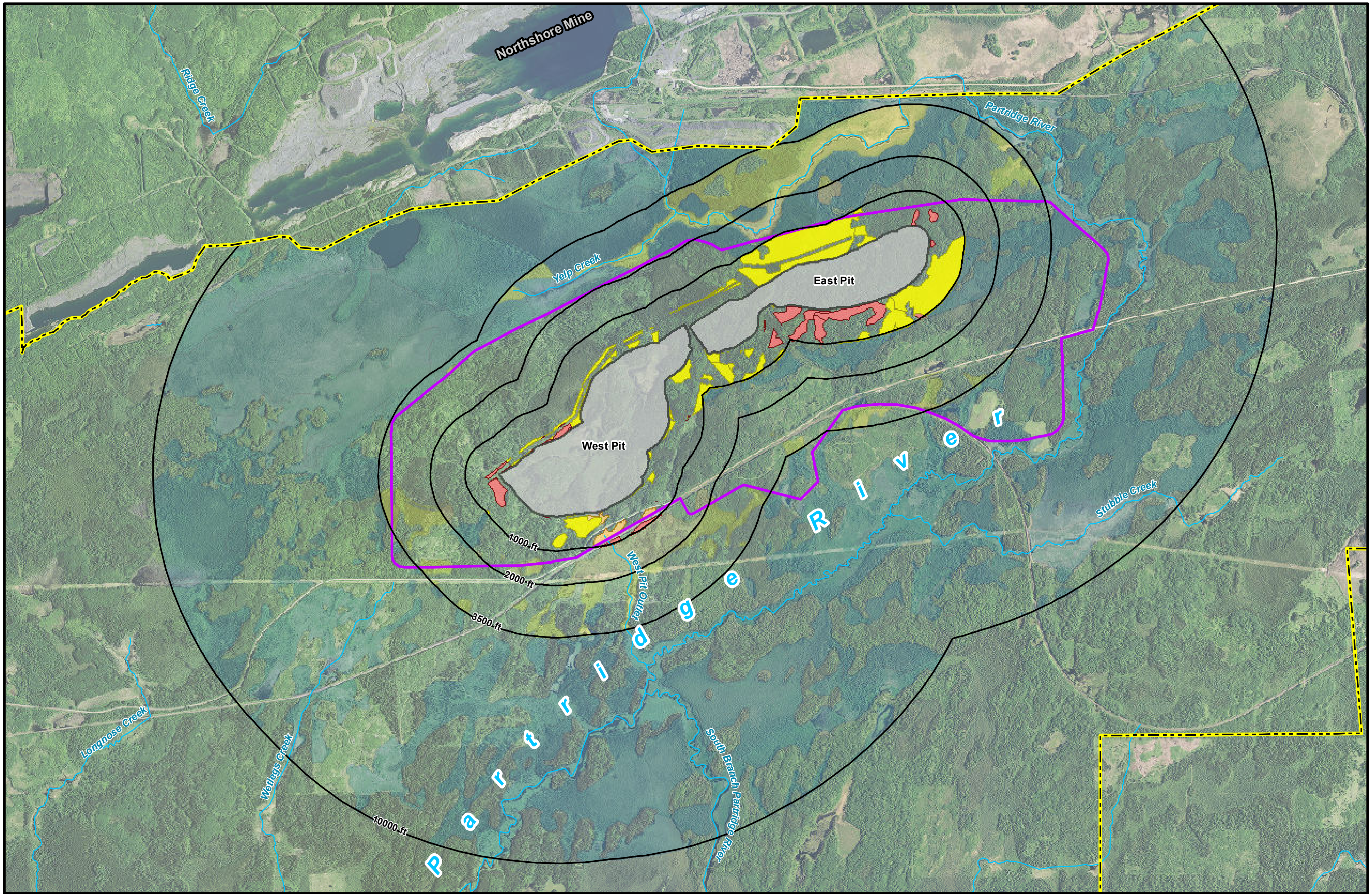

Mine Site
Mine Pit
Analog Zones (feet)
Area 1
Stream/River

Likelihood of Wetland Hydrology Effect

High Likelihood
Moderate Likelihood
Low Likelihood
No Effect

MNDNR
US Army Corps of Engineers
St. Paul District

0 0.25 0.5 1 Miles

Figure 5.2.3-12
Wetlands within Analog Zones -
0-1,000 ft of Edge of Mine Pits
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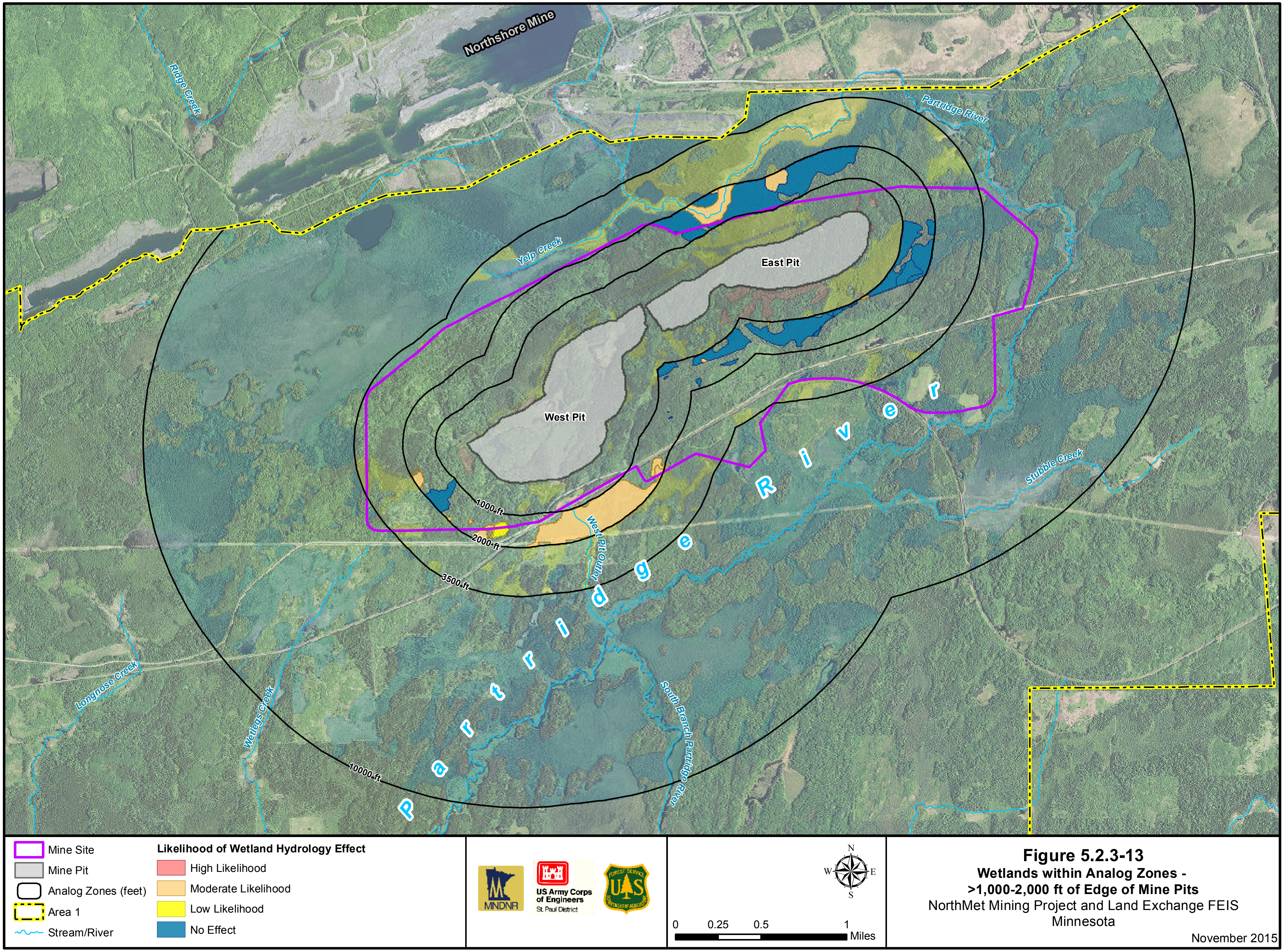

Figure 5.2.3-13

Wetlands within Analog Zones - >1,000-2,000 ft of Edge of Mine Pits

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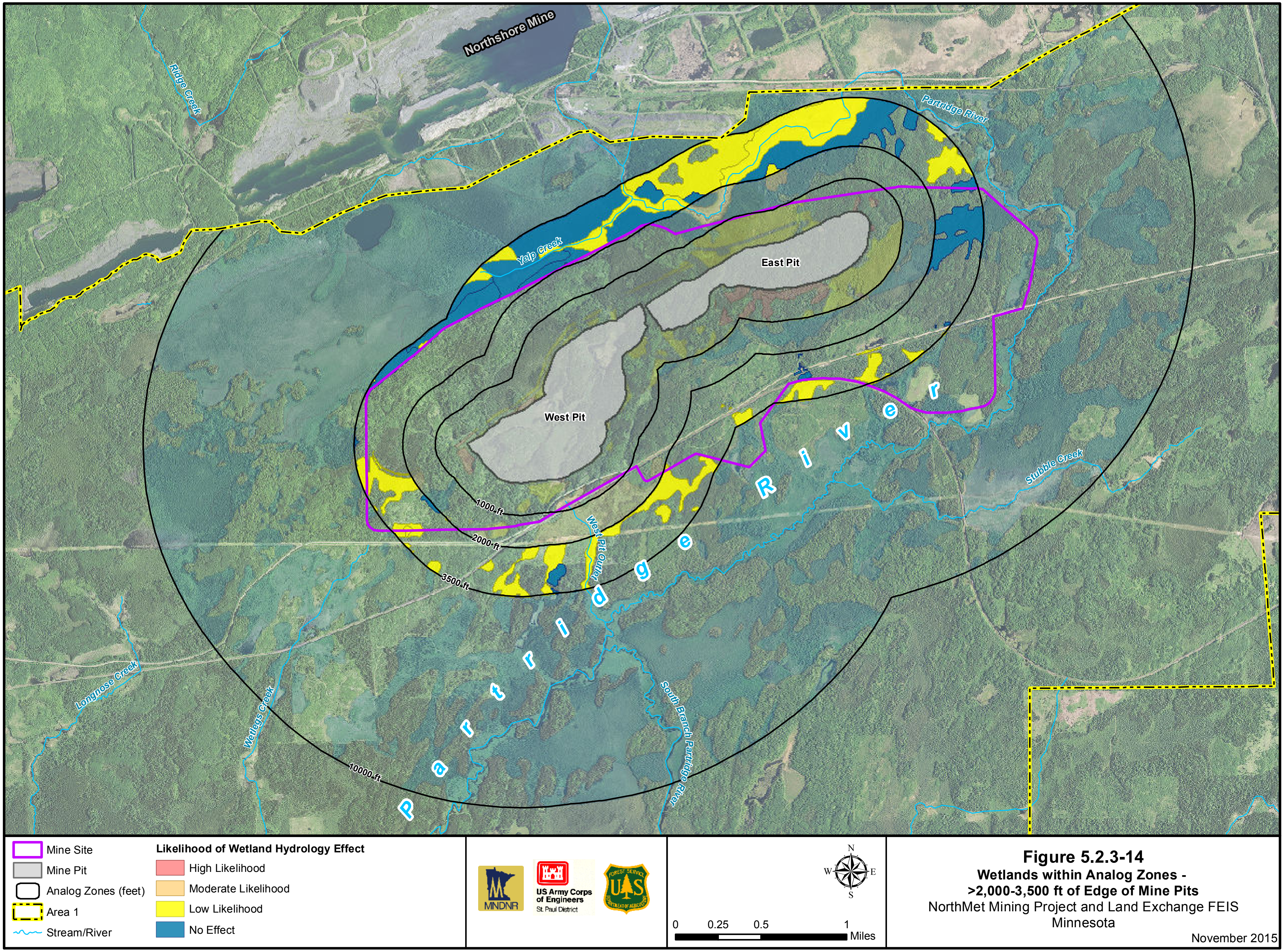

Figure 5.2.3-14
Wetlands within Analog Zones - >2,000-3,500 ft of Edge of Mine Pits
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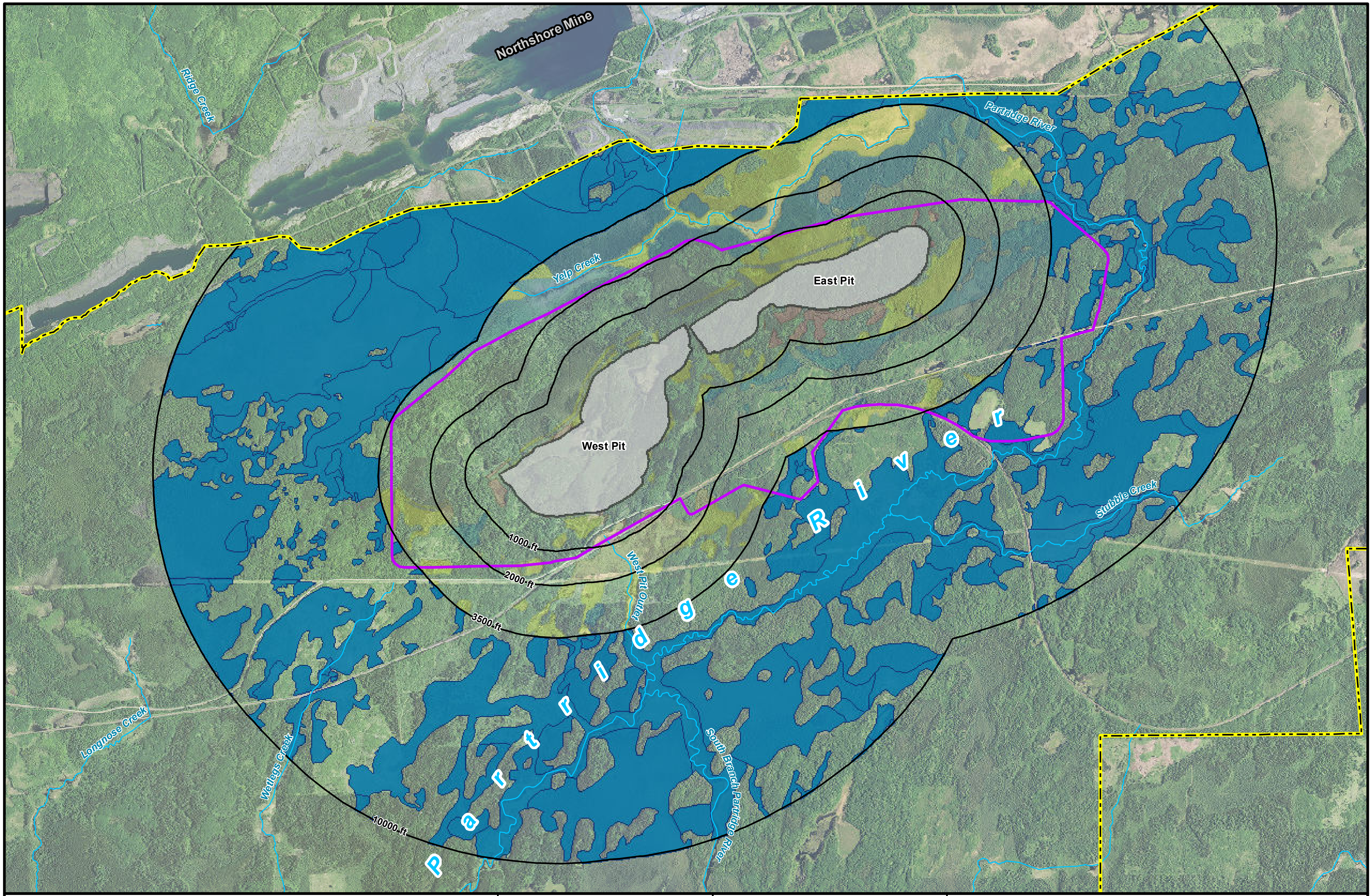

Mine Site
Mine Pit
Analog Zones (feet)
Area 1
Stream/River

Likelihood of Wetland Hydrology Effect
High Likelihood
Moderate Likelihood
Low Likelihood
No Effect

MNDNR
US Army Corps of Engineers St. Paul District

N
W E
S

0 0.25 0.5 1 Miles

Figure 5.2.3-15
Wetlands within Analog Zones -
>3,500-10,000 ft of Edge of Mine Pits
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The potential indirect wetland hydrology drawdown effects on each wetland type were assessed based on the wetland sensitivity class tables for falling groundwater tables found in the Crandon mine project document titled *Wetland Impact Assessment Technical Memorandum – Appendix B*. The following provides a general discussion regarding potential indirect wetland effects that could occur based on hypothetical hydrologic drawdown levels using the hydrologic wetland sensitivity method. The potential indirect wetland effects that could occur include: conversion to other wetland community types, a change in vegetation without a change in community type, conversion to uplands, or other effects.

Three categories of hydrologic wetland sensitivity, each with associated groundwater drawdown levels for each wetland community type, were created for the hypothetical hydrologic drawdown wetland sensitivity assessment (PolyMet 2015b).

- None-to-Slight: Water level changes in which effect on the community would be slight to none with the potential for slight changes in abundance of various species but no change in species present. Monitoring or mitigation not anticipated.
- Moderate: Water level changes that may have a moderate effect on the wetland community with the potential for the loss and addition of some species. Monitoring recommended with mitigation based on monitoring results.
- Severe: Water level changes expected to result in severe effects on the community with the potential for considerable loss of characteristic plant species and invasion by other species, conversion of wetland type or conversion to upland. Monitoring should be conducted and mitigation may be required. According to the hydrologic wetland sensitivity method, wetlands in which groundwater is not the principal source of water and in which mitigation of surface water is planned (e.g., streamflow augmentation) should be excluded from this category.

The hydrologic wetland sensitivity method estimated how wetland communities would respond to groundwater drawdown by assuming that they would change to drier native plant communities or variants of the original community. No data or research was utilized from actual wetlands responding to groundwater drawdown; therefore, this analysis and related data can only be used as an initial estimate of what changes could be expected should groundwater levels actually fall as a result of the NorthMet Project Proposed Action. Monitoring of hydrology and vegetation within potentially affected wetlands represents the best method for documenting actual community changes resulting from hydrology changes, understanding complex hydrologic conditions, and identifying potential future indirect effects related from mine features.

The preliminary information developed for the hydrologic wetland sensitivity method was utilized to estimate what type of wetland effects might occur at the Mine Site assuming various, theoretical groundwater drawdown levels. Table 5.2.3-5 provides a summary of the estimated wetland community changes using the groundwater drawdown thresholds for each wetland type based on the hydrologic wetland sensitivity method.

Table 5.2.3-5 Potential Wetland Community Changes Due to Drawdown

Impact Sensitivity Category	**None**		**Moderate**		**Severe**	
Community Type	**Water Level Drawdown (ft)**	**Potential Effect**	**Water Level Drawdown (ft)**	**Potential Effect**	**Water Level Drawdown (ft)**	**Potential Effect**
Ombrotrophic Coniferous and Open bog	<0.75	None	0.75-2	Minor changes in vegetation; Increased tree growth	>2	Possible conversion of wetland type
Minerotrophic Coniferous and Open bog	<0.5	None	0.5-2	Change in vegetation; Increased tree growth	>2	Possible conversion of wetland type
Shallow marsh[1]	<1	None	1-3	Conversion of type	>3	Conversion of wetland type
Deep marsh[1]	<2	None	2-4	Conversion of type	>4	Conversion of wetland type
Shallow, open water[1]	<2	None	2-4	Conversion of type	>4	Conversion of wetland type
Conifer swamp	<1	None	1-2	Minor changes in vegetation; Increased tree growth	>2	Change in vegetation
Hardwood swamp	<2	None	2-4	Change in vegetation; Increased tree growth	>4	Conversion of wetland type; possible conversion to upland
Alder thicket	<1	None	1-4	Change in vegetation; Increased shrub growth	>4	Conversion of wetland type; increased shrub growth
Shrub-carr	<0.5	None	0.5-3	Change in vegetation; Increased shrub growth	>3	Conversion of wetland type
Sedge/wet meadow	<0.5	None	0.5-3	Change in vegetation; Conversion of type	>3	Conversion to upland

Source: PolyMet 2015b.

Note:
[1] Shallow marsh, deep marsh, and shallow open water communities were not evaluated in the hydrologic wetland sensitivity method as described in the Wetland Work Plan, but were estimated based on best professional judgment (PolyMet 2015b).

For minor groundwater drawdown (ranging from 0.5 to 2 ft), no substantial wetland community changes were identified. For the moderate sensitivity category (water level changes ranging from 0.5 to 4 ft), some changes to vegetation would be possible in all wetland communities with marshes, open water, and meadows, potentially resulting in conversion of wetland type, and there could be increased shrub or tree growth in shrub or forested wetlands. For the severe sensitivity category, nearly all wetland community types would be estimated to convert to other wetland types with a few wetlands estimated to convert to upland, including sedge/wet meadows and possibly hardwood swamps (PolyMet 2015b). Monitoring to document effects to wetlands would be recommended for all potential effects in the moderate and severe categories.

Groundwater modeling cannot reasonably estimate potential indirect wetland effects; therefore, analog impact zones can provide a reasonable estimate of the extent of potential indirect wetland effects resulting from hydrologic effects. In addition, the evaluation of theoretical groundwater drawdown levels can help estimate what types of potential indirect wetland effects might occur. However, wetland hydrology is a complex mix of precipitation, surface runoff, and in some cases, groundwater. The response of complex natural systems to human disturbances can only be estimated. Therefore, monitoring of wetland hydrology and vegetation communities would occur to document the extent and magnitude of wetland responses (potential indirect effects) to human disturbances. The monitoring plan, developed as part of the federal and state permitting process, would be based on those wetlands that have a high likelihood of indirect effects as a result of groundwater drawdown. The requirements of the monitoring plan would be determined during the permitting process. Permit conditions would likely include an adaptive management plan to account for any additional effects that may be identified in the annual monitoring and reporting.

Wetlands Abutting the Partridge River

There are 1,478.5 acres of wetlands abutting the Partridge River within Area 1 (see Figure 4.2.3-2); they are presented in Table 5.2.3-6.

Table 5.2.3-6 Wetlands Abutting the Partridge River

Eggers and Reed Class[1]	Wetland Size (acres)	Wetland Size (percent)
Coniferous bog	193.0	13
Shallow marsh	12.1	1
Shrub swamp (including alder thicket or shrub-carr)	1,273.5	86
Total Acres of Wetlands	1,478.5	100

Source: PolyMet 2015b.

Note:
[1] Eggers and Reed 1997.

The XP-SWMM model identified that the changes in average annual flow (and therefore stage) of the Partridge River would be within the naturally occurring annual variation for the Partridge River. Thus, no potential indirect wetland effects were identified for the wetlands abutting the Partridge River (PolyMet 2015b).

Water Quality Changes

The screening analysis for depositional effects was conducted using air dispersion/ deposition modeling (AERMOD) to estimate the potential annual deposition of dust, metals, and sulfur to wetlands within and adjacent to the Mine Site. The estimated deposition from fugitive dust emissions was used to identify wetlands that have the potential for water quality changes. The estimated deposition from fugitive dust emissions was used to identify a threshold for a negative effect on vegetation. Below is a summary of the assessment from the *NorthMet Project Wetlands Data Package* (PolyMet 2015b).

Receptors

The receptors of interest for this analysis were the wetlands that were not directly affected. The respective initial receptor grids for the Mine Site were set up with near-field receptor spacing of 250 meters (within the ambient air boundary and out to 1,000 meters beyond the ambient air boundary) and far-field receptor spacing of 1,000 meters (from 1 km out to 5 km from the ambient air boundary).

Dust Deposition and Speciation to Individual Metals and Sulfur

For the dust emission sources identified for assessing potential metals and sulfur deposition at the Mine Site, the highest estimated dust deposition rate for each receptor node was then speciated to the respective metal and sulfur deposition rates based on the contribution of the sources to a receptor node and the metal and sulfur composition identified for each contributing source (e.g., ore and waste rock at the Mine Site). The estimated metal or sulfur deposition for each contributing dust source at a receptor node was then summed to provide a "total" deposition rate for each respective metal and for sulfur at that receptor location. Dust deposition rates were speciated for arsenic, cadmium, chromium, lead, manganese, nickel, and selenium. Copper and vanadium were also included. For each receptor node, the post-processing of the dust deposition rate by source contribution was then summed to provide a "total" metal deposition rate and a "total" sulfur deposition rate.

Sulfur associated with fugitive dust is part of the mineral matrix of the rock particles (sulfide). Therefore, weathering of the particles must occur before any of the sulfur would be released to soil, soil water, or surface water. Mercury was not considered as part of the evaluation of dust deposition at the Mine Site because the concentration of mercury in the rock to be mined is very low and would not be considered environmentally significant in this medium (PolyMet 2015b). Potential mercury air emissions from ore processing (i.e., potential emissions from the autoclave) were evaluated for potential local deposition impacts (see Section 5.2.7).

Estimates of Rural Background Deposition

For dust, an annual effects-level deposition rate of 365 grams per square meter per year ($g/m^2/yr$) was compared to modeled annual dust deposition rates. This deposition rate is a potential effects threshold for photosynthesis (i.e., potential for reduced photosynthesis due to "dusting" of the plant surface). However, for this analysis, the vegetative surface area of the wetlands was not calculated or included in the analysis. The modeled dust deposition rate was assumed to be applied to the land surface area which is a smaller area than the vegetative surface area. Vegetative surface area can be up to 13 times greater than the land surface area. By only assessing dust deposition to the land surface area instead of the vegetative surface area, it is likely the ratio of modeled deposition rate to the effects level was being overestimated. In other words, the modeled deposition rate is not being spread over the larger surface area of the vegetation, which would reduce the effective deposition rate. Because this application did not include the deposition of dust to the vegetative surface area, it is likely that the areas identified to exceed the effects threshold of 365 $g/m^2/yr$ have been overestimated.

For metals, background deposition is based on the data from *Atmospheric Deposition of Trace Metals at Three sites near the Great Lakes* (Sweet et al. 1997), which indicated that precipitation was under-collected by 45 to 70 percent when sample volumes were compared to corresponding rain gage amounts. Because wet deposition was considered to be underestimated, the wet deposition component was adjusted upward by a factor of 1.6.

Total background sulfur deposition included both wet and dry deposition, which was calculated to be 0.16 $g/m^2/yr$. The estimated background deposition used in the analysis for metals and sulfur was from data collected at sites characterized as open areas in rural settings that were reasonably distant from industrial sources and population centers. For forested areas, dry deposition may be underestimated. Vegetation can effectively scavenge fine particles and aerosols from the atmosphere and this interception can result in dry deposition being 50 percent or more of the total deposition. At a monitoring site in Ely (Fernberg Road), dry deposition was assumed to be 22 percent of total deposition. Therefore, it is likely that the background sulfur deposition estimated for this analysis may be low due to an underestimation of dry deposition; however, no adjustments were made to the background sulfur deposition estimated for this analysis.

Significance Levels for Estimating the Potential Effects for Identifying Future Monitoring

For dust, metals, and sulfur, the following general categories were used for assessing the significance of a modeled deposition rate at a receptor node:

- Less than 100 percent of background: no potential for effects expected.
- Greater than 100 percent of the background value: potential for effects, include in future wetland monitoring.

These are general categories of potential for effects. Since this was a screening analysis to identify wetlands for potential inclusion in the monitoring program, there was some flexibility in identifying a potential level of deposition that suggested a potential for effect and would then trigger a requirement for monitoring. Another consideration for selecting a deposition rate that was a high percent of the background rates was the likely overestimation of modeled deposition and the underestimation of background deposition.

Adding to the conservatism in the modeling of particulate metals, this screening analysis used a maximum dust deposition from a range of possible modeled values and a high-end metal or sulfur concentration for each source contributing to that receptor node to derive a maximum potential metal or sulfur deposition for a receptor node.

Using a maximum concentration for each contributing emission source to speciate a metal or sulfur deposition from a maximum modeled dust deposition rate for each receptor node overestimates individual metal or sulfur deposition. Also adding to the conservatism of this analysis is the underestimation of background deposition because the ratio of the NorthMet Project Proposed Action-related deposition is compared to the background deposition. If background deposition is underestimated, that would indicate that estimated NorthMet Project Proposed Action-related deposition at more receptor nodes would be higher than background and further increase the area for potential future monitoring. The underestimation of background metal deposition (i.e., wet deposition due to under-collection of precipitation) was identified by Sweet et al. (1997). In addition to the underestimation of background metal deposition, background wet sulfate deposition may be underestimated, as well, because the National Atmospheric Deposition Program data for the Fernberg Road monitoring site indicated rainfall in the last 3 years was about 22 percent below the annual average. If sulfate deposition from 2007 and 2008 was used (both years approximately normal for precipitation amount), a background sulfur deposition rate of 0.23 $g/m^2/yr$ was calculated—about 44 percent higher than the background deposition used in the screening analysis. If the higher estimate of background sulfur deposition was used in the screening analysis, a smaller number of receptor nodes would have been identified to have modeled sulfur deposition that was more than 100 percent of background deposition and the area for potential monitoring would be smaller than that identified. Also, it was found that for forested areas, dry deposition may be systematically underestimated due to sample collection and analysis methodology. It is possible that the background sulfur deposition estimated for this analysis may be low due to an underestimate of dry deposition.

Given the potential for overestimation of modeled deposition and underestimation of background deposition, and balancing the conservatism when their respective results are combined in this analysis, it seems reasonable to select the wetlands estimated to receive greater than 100 percent of background deposition (a potential doubling of the background deposition) for consideration in potential future monitoring (PolyMet 2015b).

Fugitive Dust/Metals and Sulfide Dust Emissions

At the Mine Site, dust deposition was concentrated relatively close to the ore loading area near the southern portion of the ambient air boundary. All receptors have model-estimated dust deposition of 25 percent or less of the effects-level background of 365 $g/m^2/yr$) (see Figure 5.2.3-16). The model-estimated dust deposition is largely constrained to within the ambient air boundary at the Mine Site, and the model-estimated dust deposition would be 50 percent or less of the effects-level background dust deposition.

The highest model-estimated metal and sulfur depositions at the Mine Site were in two defined areas, which include the ore loading area and at the east end of the Category 2/3 Stockpile (see Figure 5.2.3-17). All of the receptor nodes with the highest model-estimated deposition rates (deposition rates greater than 100 percent background) were located within the ambient air boundary.

Of the 19,914 acres of wetlands identified within the Mine Site receptor grid, deposition modeling results indicated that 234 acres of wetlands could be potentially indirectly affected (modeled metal deposition rates greater than 100 percent of background). Of the 234 acres of wetlands, 228 acres (97 percent) would be located within the Mine Site ambient air boundary (PolyMet 2015b). The 234 acres of wetlands would be included in any future monitoring to be conducted for the NorthMet Project Proposed Action.

The deposition modeling results for dust, metals, and sulfur indicate there would likely not be an adverse effect on wetlands; however, the modeling only indicated those areas that had deposition rates greater than 100 percent of background deposition. These specific wetlands areas would be identified for consideration in any future monitoring to be conducted for the NorthMet Project Proposed Action.

The initial assessment provided a discussion on conservatism, including a discussion that the estimated sulfur deposition was as particle-bound sulfur, with the sulfur being inherent to the mineral matrix of the dust and not readily available for dissolution in soils or surface waters. A supplemental assessment has been conducted to provide for a worst-case scenario where all of the sulfur in fugitive dust converts to sulfate and would mix with surface water in a wetland

(Barr 2015f). A summary of the supplemental assessment evaluation of sulfur from stack emissions is included in Section 5.2.7.2.6, while the fugitive dust evaluation is presented here.

Based on a conservative, not model-based, assumption that all sulfur in fugitive dust converts to sulfate and mixes with surface water in wetlands, a potential incremental increase in sulfate was calculated as 4.2 mg/L. When the potential incremental sulfate concentration is mixed with annual precipitation, the sulfate value was calculated as 1.7 mg/L.

Because the sulfur is inherent to the mineral matrix of the dust particles, it is likely that less than 100 percent of the sulfur would be weathered from the particles and be available to go into solution if deposited to soils or water. This potential incremental change may warrant future monitoring, as small sulfate increases in sulfate-poor wetlands may increase methylmercury production in wetlands (Jeremiason et al. 2006). However, methylmercury produced in wetlands is not necessarily incorporated into food chains and concentrated to levels of concern.

Although the actual potential for deposition of fugitive dust to wetlands, and the potential release of sulfur in that dust, is uncertain, any adverse effects on wetlands are unlikely. The fugitive dust control plan for both the Mine Site and the Plant Site (including the Tailings Basin) would minimize such deposition, and the sulfur from any rock dust particles that would be deposited may not be released or only released slowly through weathering. Using a conservative assumption that all sulfur in the deposited dust is both released and transformed to sulfate, no significant increase in methylmercury concentrations would be expected (Barr 2015f). Additional information relating to mercury methylation is provided in Section 5.2.2.3.4. A discussion of mercury deposition and bioaccumulation in fish and the assessment of the cumulative effects is provided in Section 6.2.6.3.3.

Mine to Plant Site Railroad Corridor – Ore Spillage

The potential release of dust from railcars transporting ore from the Mine Site to the Plant Site was addressed in the May 6, 2011, Air IAP Summary Memo (MDNR et al. 2011):

> The air IAP group concluded that there would be minimal air impacts from any dust generated from ore hauled in the railcars due to the coarse nature of the ore.

Based on this conclusion, air modeling of potential release of dust from railcars was not performed because the potential wetland effects would not be significant.

The air IAP group concluded that any dust generated from ore hauled in railcars would be coarse in nature (i.e., relatively large particles). These larger particles would tend to deposit near the railcar and not be dispersed to any great extent. An estimate of the spillage of ore fines along the rail corridor is provided in Section 8.4.3 of the Waste Characterization Data Package (PolyMet 2015q). Assuming that all spillage of the coarse material would occur in a 2-meter-wide strip on both sides of the centerline of the railway (total width equals 4 meters) over the entire haul distance after loading (approximately 8 miles or 13,000 meters), results in approximately 0.11 kilograms per square meter (kg/m^2) of ore fines annually or 2.14 kg/m^2 for the 20-year NorthMet Project Proposed Action. This equates to 0.002 inch of depth annually or 0.05 inches for the 20-year NorthMet Project Proposed Action. However, as described in Section 3.2.2.2.4, PolyMet has committed to refurbish the rail cars to minimize the gaps along hinges and joint areas to reduce potential ore spillage. Based upon the rail car modification evaluation performed by

PolyMet (2014a), the ore spillage may be reduced by up to 97 percent which would proportionally reduce the dilution needed to meet surface water standards (PolyMet 2015b).

For most contaminant constituents, the contact water leaving the spillage strip has been estimated to have a greater than 90 percent likelihood of complying with surface water standards at all times. Constituents that have the potential to exceed surface water standards at the edge of the 2-meter spillage strip include aluminum, cobalt, copper, and nickel. Aluminum concentrations are often above the surface water standard in the background runoff, and it is not possible to achieve a less than 10 percent likelihood of exceeding the standard in the mixed water (PolyMet 2015b). For cobalt, copper, and nickel the estimated area (square meters per meter of railroad track on each side) necessary to provide sufficient dilution for 90 percent probability of compliance is 2.5, 675, and 30 square meters per meter of railroad track on each side, respectively. Therefore, the limiting area required to provide sufficient dilution water for all constituents has been estimated at 675 square meters per meter of track (one-sided). Please refer to 5.2.2.3.2 for more information on ore spillage. Approximately 542.7 acres of wetlands along the railroad corridor could be potentially indirectly affected by the NorthMet Project Proposed Action.

Wetlands that have contributing watersheds that include no segments of the railway (e.g., many of the wetlands uphill to the north of the rail corridor) were identified as having no potential indirect effects from rail spillage. Wetlands immediately abutting the railway and whose watersheds included the rail centerline were identified as potentially being affected, although the effects may not extend to the full area of the wetland. Wetlands that have contributing watersheds, which include natural areas that are larger than 675 square meters per meter of track (one-sided) in the contributing watershed, were identified as having no potential indirect effects.

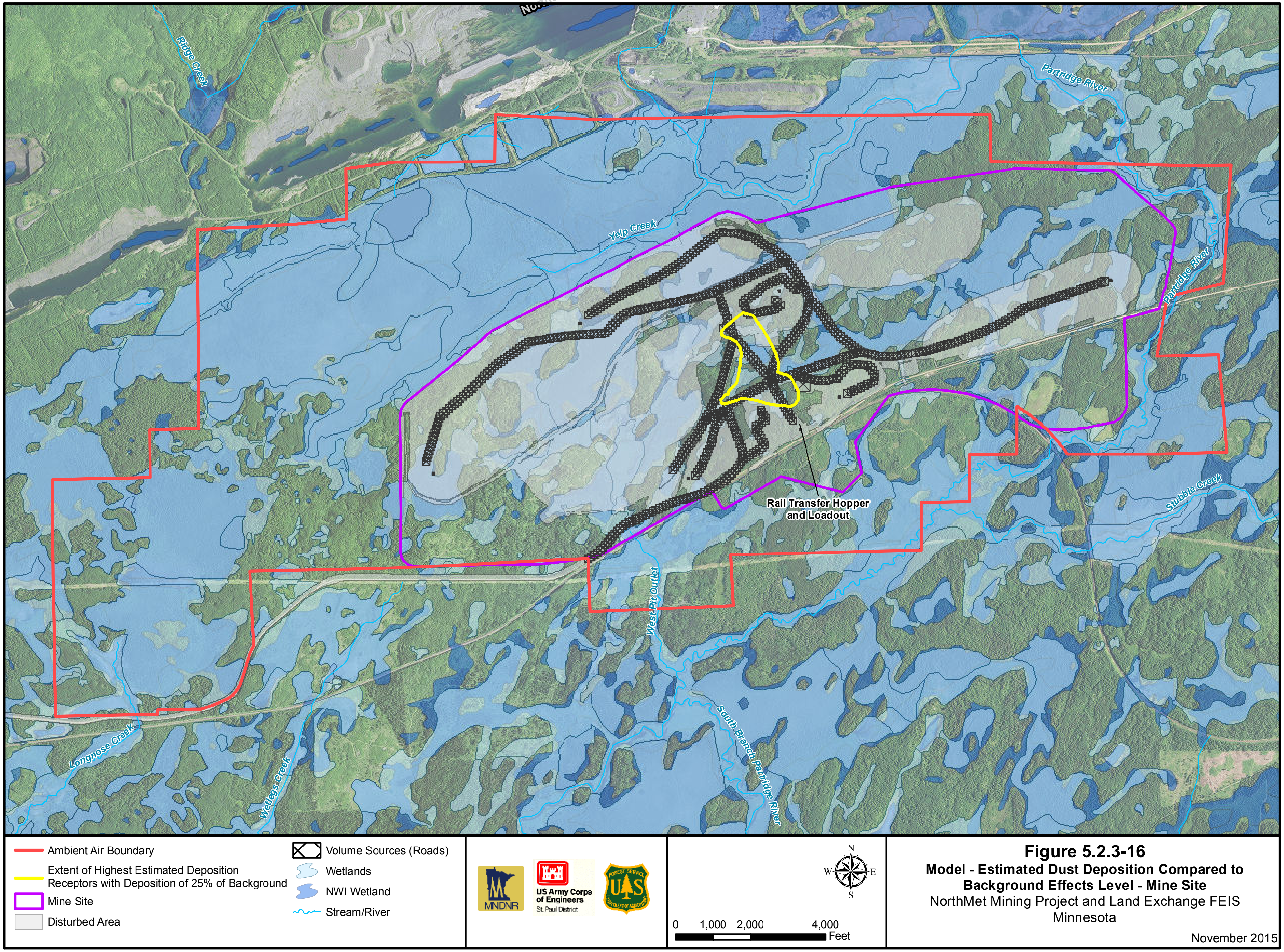

Figure 5.2.3-16

Model - Estimated Dust Deposition Compared to Background Effects Level - Mine Site

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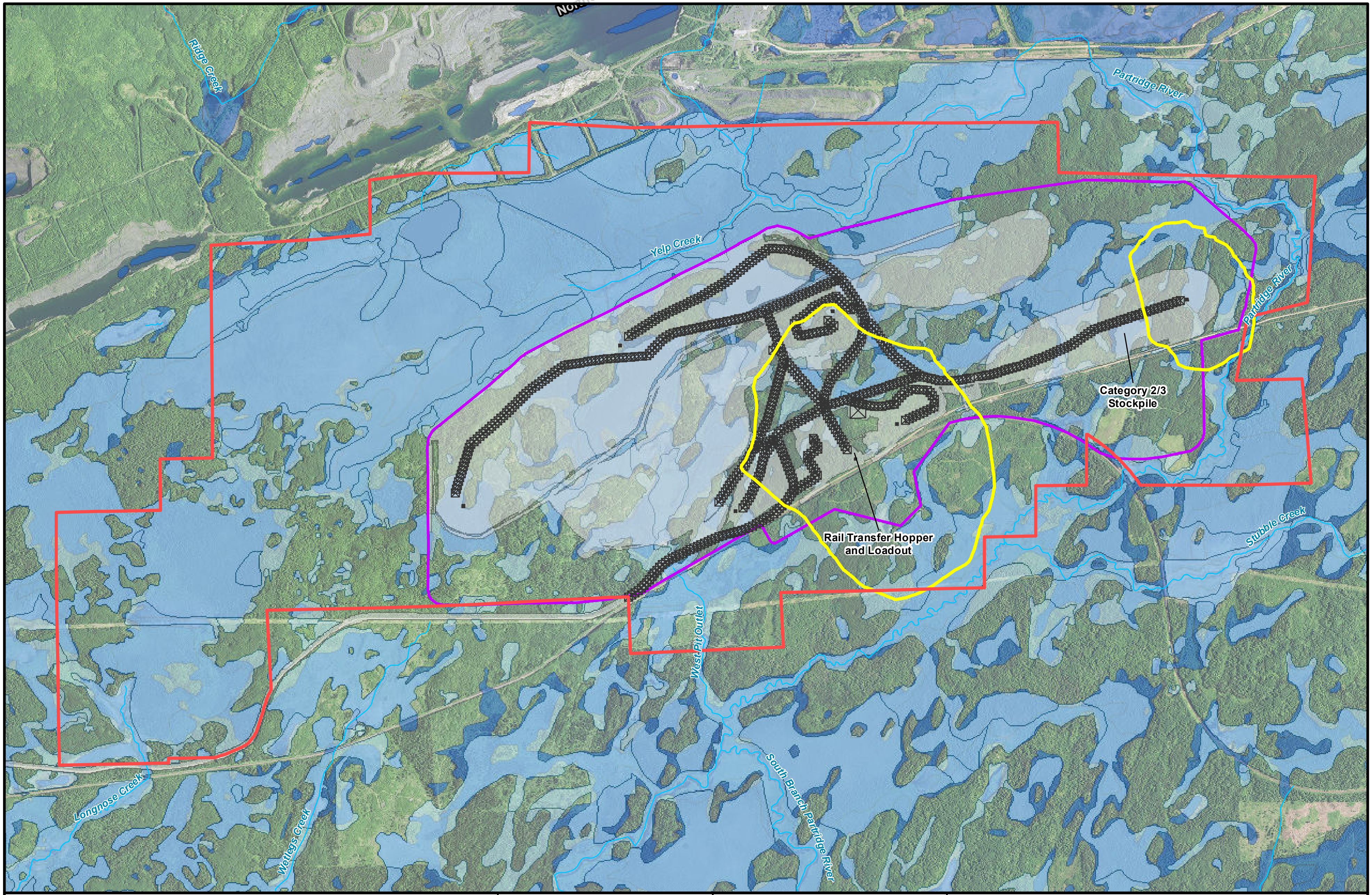

Ambient Air Boundary
Extent of Highest Estimated Deposition Receptors with Deposition of 100% of Background
Mine Site
Disturbed Area
Volume Sources (Roads)
Wetlands
NWI Wetland
Stream/River

MNDNR
US Army Corps of Engineers St. Paul District

0 1,000 2,000 4,000 Feet

Figure 5.2.3-17
Model - Estimated Metal Deposition Compared to Background Effects Level - Mine Site
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Leakage from Stockpiles/Mine Features and Seepage from Mine Pits

The stockpiles, mine pits, and other mine features (e.g., WWTF) are located within the Partridge River Watershed. Water containing constituents generated in the waste rock stockpiles and mine pits has the potential to enter the shallow groundwater system via potential leakage through the liners (e.g., stockpiles and WWTF equalization basins) or seepage from the pits. The leakage or seepage that enters groundwater would then be transported toward the Partridge River along groundwater flowpaths. There are five groundwater flowpaths connecting the mine features to the Partridge River, which include: East Pit – Category 2/3 flowpath, Ore Surge Pile flowpath, WWTF flowpath, Overburden Storage and Laydown Area flowpath, and West Pit flowpath. Because the water quality within these flowpaths has the potential to change as a result of the NorthMet Project Proposed Action, these same flowpaths were considered in the assessment of potential indirect wetland effects associated with leakage or seepage from mine features (PolyMet 2015b).

Wetlands were identified within the groundwater flowpaths, and the bog wetlands within and surrounding the Mine Site were subcategorized as either ombrotrophic or minerotrophic consistent with the November 2011, USACE Memorandum (Eggers 2011a). There are 515.8 acres of wetland resources within the groundwater flowpaths. Other wetlands were classified as dominated by groundwater, although all wetlands receive precipitation and virtually all water movement in peat wetlands occurs horizontally in the upper layers of peat. Approximately 66 percent of the wetlands within the flowpaths are classified as dominantly minerotrophic (groundwater-fed) while 34 percent of the wetlands are supported only by precipitation (ombrotrophic) (see Table 5.2.3-7).

Water quality modeling results indicate groundwater quality along each flowpath would likely change from existing conditions. It was conservatively assumed that these changes may cause potential indirect effects to the character, function, and quality of minerotrophic wetlands; therefore, it was also assumed that all downgradient minerotrophic wetlands located within the five Mine Site surficial aquifer flowpaths may have potential indirect wetland effects related to water quality changes as a result off leakage/seepage from mine features (PolyMet 2015b). This analysis indicates areas that can be conservatively assumed to have potential indirect effects due to changes in groundwater quality. These specific wetland areas are identified for consideration in the proposed wetland monitoring plan.

Table 5.2.3-7 Wetlands within the Mine Site Groundwater Flowpaths

Eggers and Reed Class[1]	Hydrology	West Pit Acres	Overburden Storage and Laydown Area Acres	WWTF Acres	Ore Surge Pile Acres	East Pit - Category 2/3 Acres
Coniferous bog (Minerotrophic)	Precipitation/ Groundwater	0.04	0.0	0.0	0.0	6.3
Coniferous bog (Ombrotrophic)	Precipitation	16.5	0.0	0.0	0.0	148.2
Coniferous swamp	Groundwater	0	2.9	20.1	10.2	0.04
Deep marsh	Groundwater	4.9	0.0	0.0	0.0	0.0
Open bog	Precipitation	0.0	0.0	0.0	0.0	8.9
Sedge/wet meadow	Groundwater	0.0	0.0	0.0	0.0	1.2
Shallow marsh	Groundwater	3.4	0.1	0.0	0.0	5.5
Shrub swamps (including alder thicket and shrub-carr)	Groundwater	90.5	47.7	18.8	27.6	103.1
Total Acres of Wetland		115.3	50.7	38.9	37.8	273.2

Source: PolyMet 2015b.

Note:
[1] Eggers and Reed 1997, 2014.

The Partridge River currently represents the primary discharge location for shallow groundwater at the Mine Site. During operations, reclamation, and closure and long-term maintenance, groundwater in areas south of the mine pits would continue to discharge to the Partridge River while groundwater in areas north of the mine pits would discharge to the mine pits. The amount of groundwater emerge in surface water and wetlands between the mine features and the Partridge River would be expected to be minimal relative to the amount of groundwater emerge in the Partridge River itself. Significant quantities of groundwater are not expected to discharge to the wetlands because of the very low hydraulic conductivities of the underlying peat layers (PolyMet 2015b). The water quality model assumed that the leakage/seepage from mine features releases directly to the Partridge River; therefore, it is assumed that groundwater would not emerge in surface water or wetlands along intermediate portions of the flowpaths (PolyMet 2015m). The water quality model cannot be used to quantify the amount of leakage/seepage from mine features that discharge directly to individual wetlands. However, the water quality model was used to provide a conservative estimate of the potential indirect wetlands effects caused by water quality changes due to leakage/seepage from mine features (PolyMet 2015b).

The leakage/seepage analysis could not indicate or suggest that an effect or adverse effect would occur on wetlands; however, the analysis only indicated those areas that could be conservatively assumed to have a potential indirect effect due to changes in groundwater (PolyMet 2015b).

Dunka Road Effects

Loaded mine haul trucks would not travel on the Dunka Road. Empty mine haul trucks would only travel on Dunka Road when they are in need of maintenance at the Area 1 Shop. The total one-way trips per year has been estimated to be 44 trips. Given the low traffic volumes of haul trucks (less than one trip per week) and that the ore trucks would likely be empty, no potential indirect wetland effects were identified for wetlands abutting Dunka Road (PolyMet 2015b). The additional light vehicles (e.g., pickups and SUVs), field service trucks, and fuel trucks that would travel on Dunka Road more regularly would not contribute to wetland effects.

5.2.3.2.3 Plant Site Direct Wetland Impacts

PolyMet proposes to reuse the former LTVSMC processing plant and Tailings Basin. The processing plant is located on uplands with no wetland resources present. The existing constructed plant reservoir located east of the concentrator is not anticipated to be regulated as a wetland but will be determined during permitting. Therefore, no direct wetland impacts are anticipated in this portion of the Plant Site.

Direct wetland impacts would result from the following Plant Site components: construction of the Tailings Basin, pump station, treated water discharge pipelines, flotation tailings pipeline, Tailings Basin containment system to manage Tailings Basin seepage, rock buttress for stability along the north and east sides of Cell 2E, drainage swale and overflow channel located northeast of Cell 2E, and the Hydrometallurgical Residue Facility.

Direct wetland impacts within the Plant Site would total 148.4 acres. These wetlands impacts would be caused by fill (12 percent), excavation (31 percent), and excavation and fill ((58 percent), and therefore, these wetlands would be permanently lost. Table 5.2.3-8 summarizes the directly impacted wetlands within the Plant Site by community type while Table 5.2.3-9 identifies the activity that causes the impacts expected within the Plant Site. The majority of the wetlands (94 percent) that would be impacted are rated as low quality and 6 percent are rated as moderate quality wetlands.

The rock buttress described in Section 3.2.3 and Section 4.2.13 would abut the existing toe of the Tailings Basin. The water containment system would extend approximately 300 ft around the northern and western sides, and portions of the eastern sides of the Tailings Basin, encapsulating the Tailings Basin, the rock buttresses and wetlands between it and the rock buttresses. Construction of the Tailings Basin for the NorthMet Project Proposed Action would also result in expansion of the existing eastern footprint onto natural highland. The majority of the impacted wetlands are rated as low quality, primarily because the hydrology supporting these wetlands has been modified by seepage from the Tailings Basin and other drainage modifications made in the area (PolyMet 2015b). These hydrologic modifications have resulted in inundation and changes in wetland cover types from forested and scrub shrub wetlands (as evidenced in aerial photographs from the 1940s prior to LTVSMC operations) to deep marsh (Barr 2008b).

Wetlands located outside of the Cliffs Erie Permit to Mine Ultimate Tailings Basin boundary (this boundary is shown on Figure 5.2.3-18 and Figure 5.2.3-19) but within the Hydrometallurgical Residue Facility are included in the direct wetland impact analysis. As previously noted, approximately 28.6 acres of wetlands in the Hydrometallurgical Residue Facility are not anticipated to be subject to state or federal regulations as they are located within an actively permitted waste storage facility. Actual jurisdiction by state and federal agencies will be determined during permitting. Two wetlands located in the Hydrometallurgical Residue Facility are subject to state or federal regulation covering 7.5 acres and would be directly impacted by fill. Both wetlands are shallow marsh wetlands (see Figure 5.2.3-19).

There would be no direct wetland impacts along the Colby Lake Water Pipeline Corridor or in the Second Creek area as there would be no construction within these two areas.

Table 5.2.3-8 Total Projected Direct Wetland Impacts for the Plant Site

	Directly Impacted Wetlands at the Plant Site		
Eggers and Reed Class[1]	**Acres**	**%**	**No.[2]**
Coniferous bog	0.0	0	0
Coniferous swamp	10.7	7	3
Deep marsh	74.0	50	14
Hardwood swamp	0.7	<1	1
Open bog	0.0	0	0
Open water (includes shallow, open water, and lakes)	0.0	0	0
Sedge/wet meadow	1.5	1	6
Shallow marsh	52.7	36	13
Shrub swamp (includes alder thicket and shrub-carr)	8.9	6	6
Total Direct Impacts	148.4	100	44

Source: PolyMet 2015b.

Notes:
[1] Eggers and Reed 1997, 2014.
[2] There are 44 unique wetlands directly impacted at the Plant Site, which includes the Tailings Basin and Hydrometallurgical Residue Facility footprint. One wetland (ID 1155) has been split between the Tailings Basin and Hydrometallurgical Residue Facility footprint in the Wetland Data Package for a total of 45 wetlands directly impacted in Wetland Data Package report.

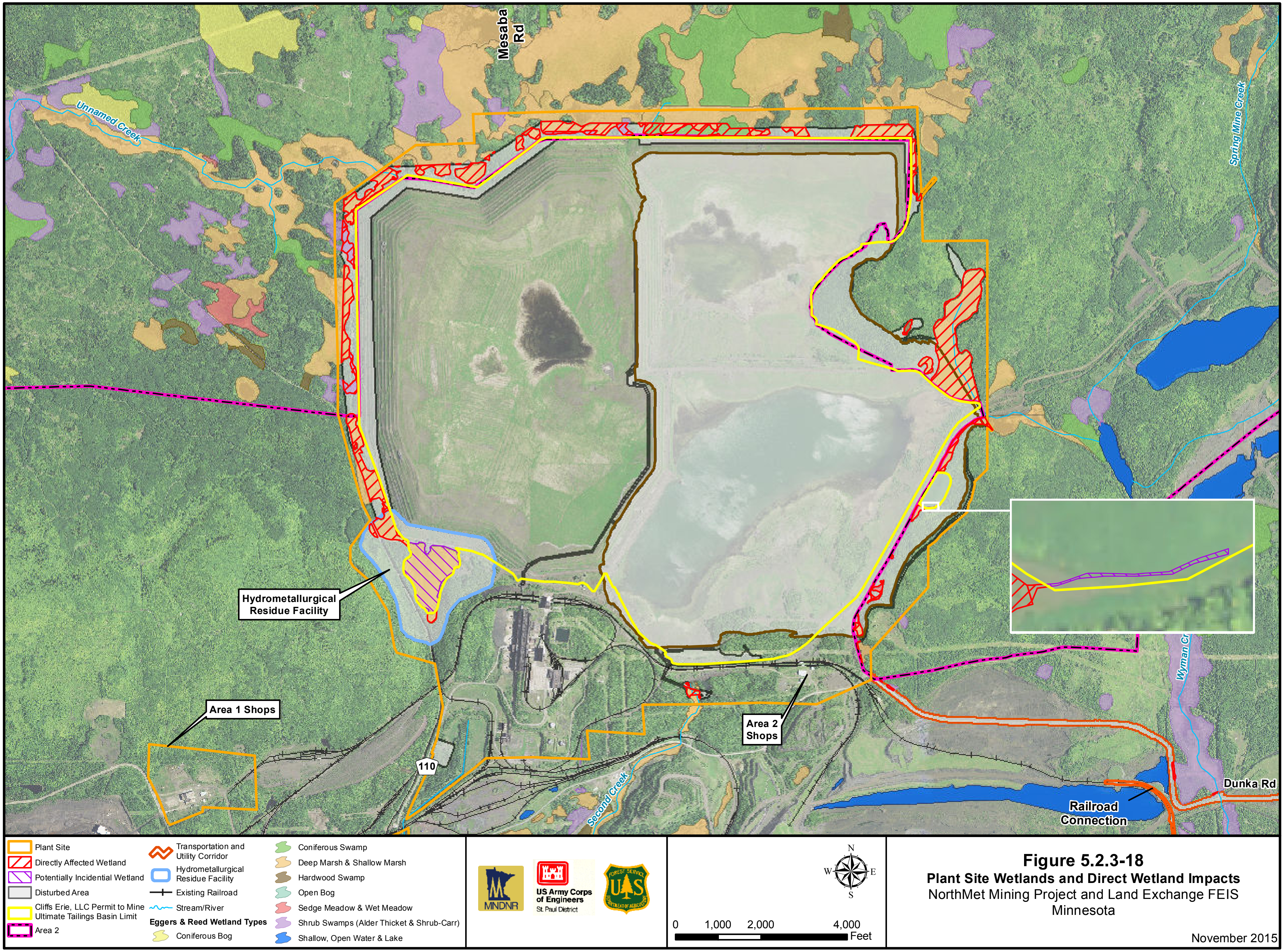

Figure 5.2.3-18
Plant Site Wetlands and Direct Wetland Impacts
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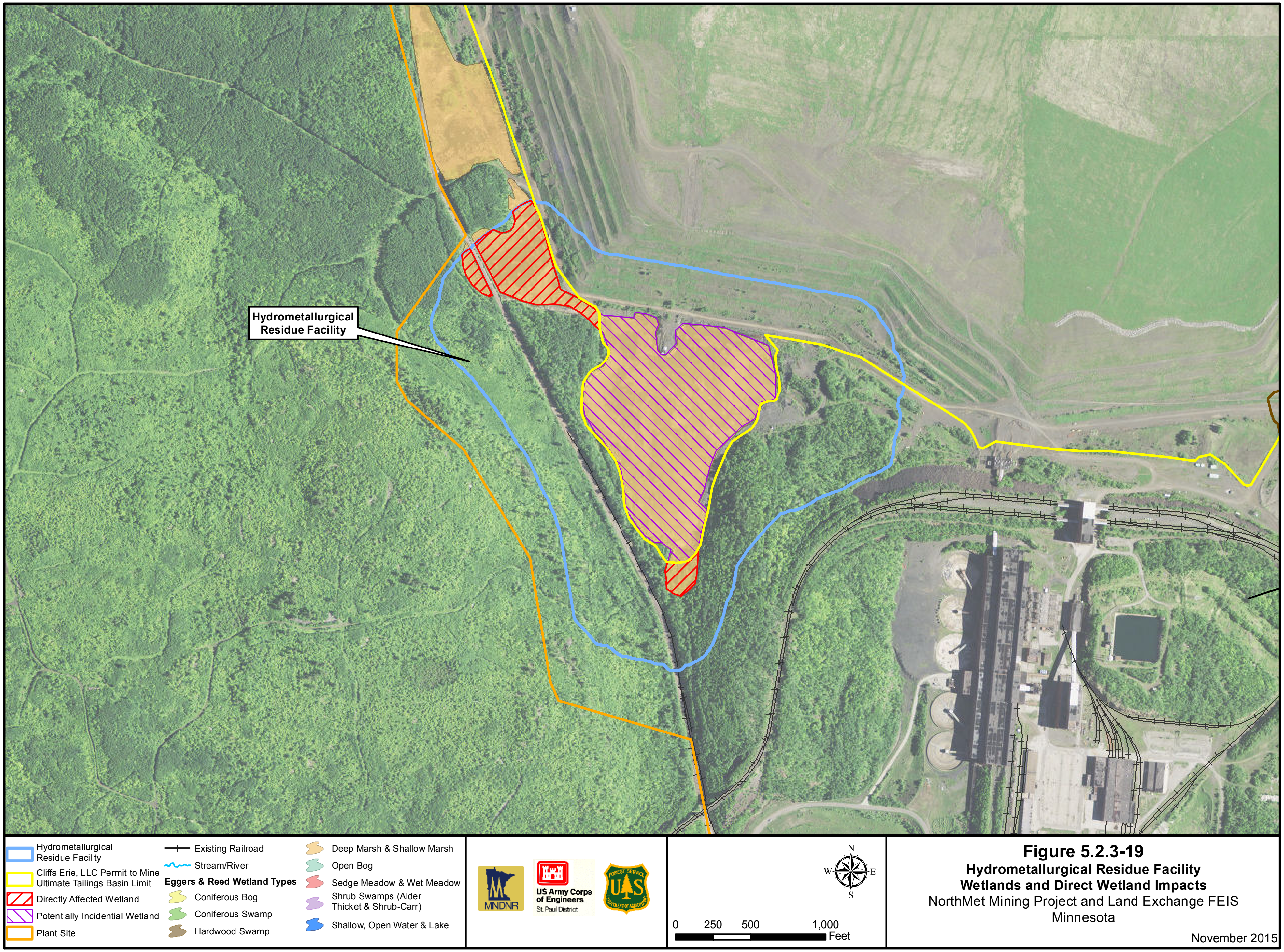

Figure 5.2.3-19
Hydrometallurgical Residue Facility
Wetlands and Direct Wetland Impacts
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Table 5.2.3-9 Type of Projected Direct Wetland Impacts at the Plant Site

Type of Impact	Directly Impacted Wetlands at the Plant Site		
	Acres	%	No.[1]
Fill	17.6	12	19
Excavation	45.2	31	1
Fill and Excavation	85.6	58	25
Total Direct Impacts	148.4	100	45

Source: PolyMet 2015b.

Note:
[1] There are 44 unique wetlands directly impacted at the Plant Site, which includes the Tailings Basin and Hydrometallurgical Residue Facility footprint. One wetland (ID 1155) has been split between the Tailings Basin and Hydrometallurgical Residue Facility footprint in the Wetland Data Package for a total of 45 wetlands directly impacted in Wetland Data Package report. This would result in impacts on wetlands as a result of filling at the Hydrometallurgical Residue Facility and placement of the containment system at the Tailings Basin.

5.2.3.2.4 Plant Site Indirect Wetland Effects

The indirect wetland effects were assessed by identifying wetlands in Area 2 within 500-ft increments beginning at the Plant Site and continuing out to a total of 30,000 ft (see Figure 5.2.3-20). The area of evaluation for the Plant Site indirect wetlands effects included wetlands within Area 2 where wetland type information had been developed and wetlands within and near Second Creek, and does not include the directly impacted wetlands. No wetlands are located within the former LTVSMC processing plant; therefore, no indirect wetland effects would occur from its reuse. Furthermore, no indirect wetland effects would occur at the Hydrometallurgical Residue Facility as all wetlands would be directly impacted.

The potential indirect wetland effects to the Second Creek area of analysis were assessed based on changes to hydrology due to groundwater flow or seepage, drawdown or surface water quantity, or changes in surface water quality or metals deposition. There are no predicted potential indirect wetland effects due to wetland fragmentation, changes in watershed area, or dust deposition in the Second Creek area of analysis (PolyMet 2015b).

Wetland Fragmentation

Construction of the Plant Site features (e.g., containment system) would result in 0.5 acre of wetland fragments losing their functions. Wetland fragments would consist of the following wetland types: shallow marsh (61 percent), deep marsh (35 percent), coniferous swamp (4 percent), and shrub swamps (less than 1 percent). Furthermore, no wetland fragmentation would result from activities to wetlands in Second Creek area of analysis (PolyMet 2015b). The wetland fragments that are expected to maintain their functions would be included in the wetland hydrology and vegetation monitoring plan that would be approved during permitting and implemented for the NorthMet Project Proposed Action.

Changes in Hydrology due to Surficial Groundwater Flowpaths or Seepage from Plant Site

There are three surficial aquifer groundwater flowpaths from the Plant Site (see Figure 5.2.3-21), which include: Unnamed Creek (west flowpath), Trimble Creek (northwest flowpath), and Mud Lake Creek (north flowpath). Wetland types within the flowpaths that would have potential indirect wetland effects resulting from changes in hydrology are presented in Table 5.2.3-10.

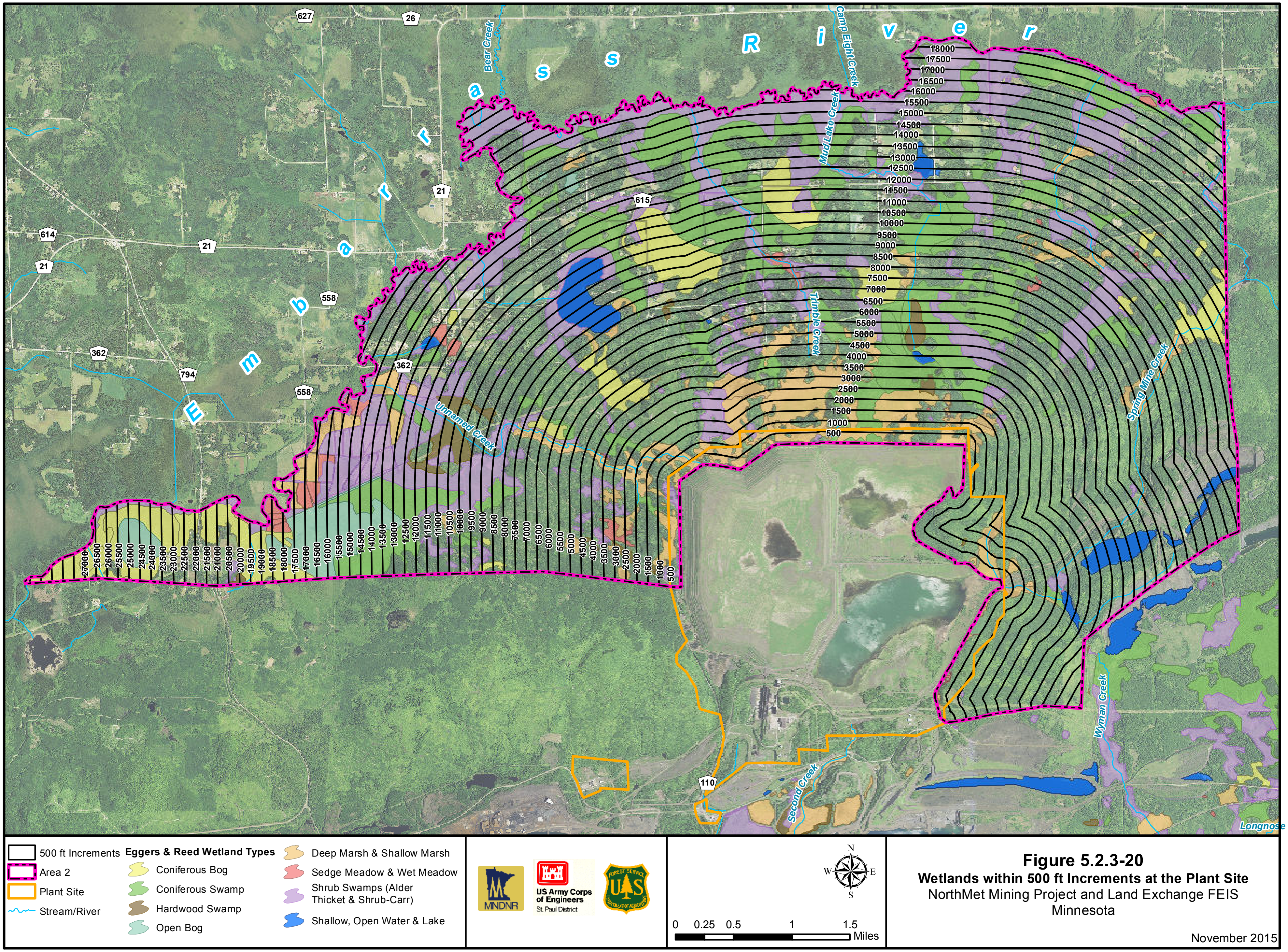

Figure 5.2.3-20
Wetlands within 500 ft Increments at the Plant Site
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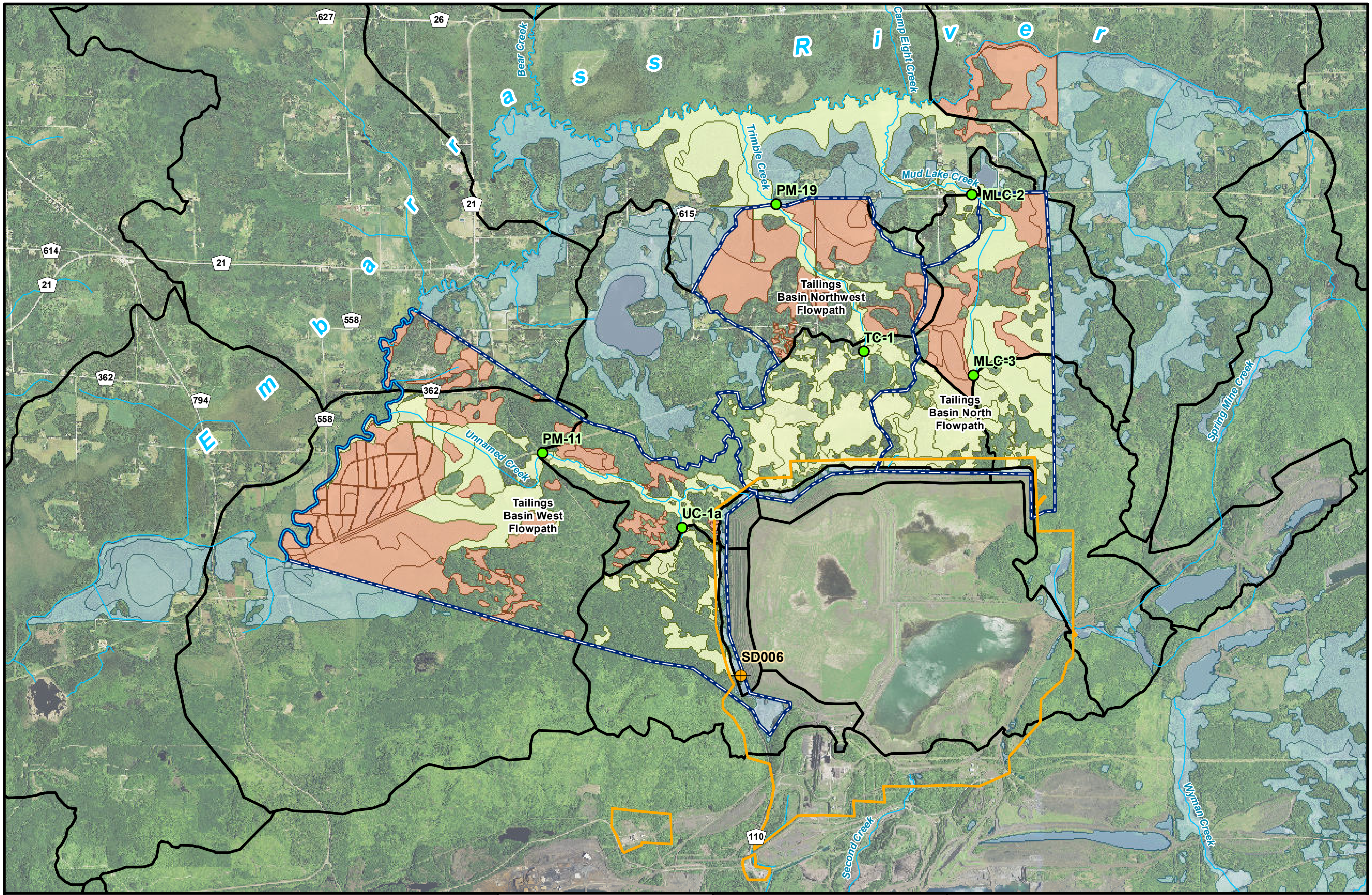

Plant Site

Surface Water Monitoring Location

Approximate Location of NorthMet Project Surface Water Discharge

Groundwater Flowpath

Embarrass River Subwatershed

Wetlands

Wetlands with Potential for Indirect Effects

Surface Water and Groundwater

Groundwater Only

Stream/River

MNDNR

US Army Corps of Engineers St. Paul District

0 0.25 0.5 1 1.5 Miles

Figure 5.2.3-21

Wetlands within Groundwater Flowpaths at the Plant Site

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Table 5.2.3-10 Wetlands within the Plant Site Flowpaths

Eggers and Reed Class[1]	Hydrology	Unnamed Creek (west flowpath) Acres	Trimble Creek (northwest flowpath) Acres	Mud Lake Creek (north flowpath) Acres
Coniferous bog (Ombrotrophic)	Precipitation	37.6	196.6	58.1
Coniferous swamp	Groundwater	375.5	308.4	630.6
Deep marsh	Groundwater	130.9	97.6	125.8
Hardwood swamp	Groundwater	126.1	0.0	40.9
Open bog	Precipitation	157.5	0.0	0.0
Open water	Groundwater	8.3	0.0	7.4
Sedge/wet meadow	Groundwater	99.3	17.7	0.4
Shallow marsh	Groundwater	196.5	225.8	124.1
Shrub swamps (including alder thicket and shrub-carr)	Groundwater	721.5	236.9	144.9
Total acres of wetland		1,853.0	1,083.0	1,132.3

Source: PolyMet 2015b.

Note:
1 Eggers and Reed 1997, 2014.

The Tailings Basin containment system, located along the northern and western sides, and portions of the eastern side of the Tailings Basin, is modeled to collect at least 90 percent of the Tailings Basin groundwater seepage and 100 percent of the surface water seepage. The uncaptured groundwater seepage would travel within the northern, northwestern, and western groundwater flowpaths (see Section 5.2.2). The Tailings Basin containment system located along a portion of the eastern side of the Tailings Basin would collect 100 percent of groundwater and surface water seepage.

All of the surface flow that currently upwells near the west, northwest, and north toes of the Tailings Basin would be captured and treated by the WWTP and then discharged to the tributaries to prevent significant hydrologic effects due to reduction in flow. To the west, the discharge(s) would be directed to a location near the existing surface discharge SD-006 (see Figure 5.2.3-21). To the northwest and north, the discharge(s) would be spigotted at multiple locations along the downstream side of the Tailings Basin containment system to add flow to the adjacent wetlands (PolyMet 2015b). Flow to Mud Creek would be augmented entirely with off-site runoff diverted toward Mud Lake Creek by a drainage swale constructed northeast of Cell 2E. Augmentation would not be necessary at the eastern segment of the Tailings Basin containment system as this area is currently flowing into the Tailings Basin; therefore, the collection of seepage would not have a hydrologic effect to the watershed (PolyMet 2015b). For a detailed discussion of seepage from the Plant Site, refer to Section 5.2.2.

Seepage from the south side of the Plant Site is generally restricted by bedrock outcrops and does not contribute to the groundwater flow south of the Plant Site. All of the seepage from the south side of the Plant Site is surface water, thereby forming the headwaters of Second Creek. There would be no potential indirect effects on wetlands in or abutting Second Creek as a result of changes in groundwater flow (PolyMet 2015b).

Change in Hydrology due to Drawdown

The augmentation described above has been designed such that the existing flows within the tributaries at the Plant Site are maintained within plus or minus 20 percent, which is within the range of annual variability in precipitation as well as streamflow, within the Embarrass River Watershed. Therefore, changes to downstream hydrology, including adjacent wetlands, would be expected to be within the range of that typically observed due to natural variability (PolyMet 2015b).

Potential indirect effects on Mud Lake Creek, Trimble Creek, and Unnamed Creek due to reduced or increased seepage at the toe of the Tailings Basin are greatest immediately downstream of the toe, where seepage and augmentation account for nearly all the water yield. Downstream of the toe, the indirect effects on these three creeks would be reduced as the watershed area tributary to that location increases, and the portion of total water yield derived from runoff increases. Therefore, hydrologic effects diminish as distance from the Tailings Basin increases. Wetlands further from the Tailings Basin would likely experience less potential for indirect effects due to hydrologic changes (PolyMet 2015b).

Flow augmentation at the southern toe of the Tailings Basin has been designed such that flows to Second Creek would be within ±20 percent of the pre-Consent Decree condition, which is within the range of annual variability in precipitation as well as streamflow, within the Partridge River and Embarrass River watersheds. No potential indirect wetland effects would be anticipated for the wetlands abutting Second Creek (PolyMet 2015b).

Wetland hydrology is a complex mix of precipitation, surface runoff, and, in some cases, groundwater. Despite the use of augmentation to mitigate effects, the response of complex natural systems to human disturbances could only be estimated. Therefore, monitoring of wetland hydrology and vegetation communities would be the most appropriate way to document the extent and magnitude of wetland responses to the NorthMet Project Proposed Action.

Please refer to Section 5.2.3.2.2, Changes in Hydrology Due to Drawdown subsection, for the hydrologic wetland sensitivity assessment that was performed to estimate how wetland communities would respond to groundwater drawdown by assuming that they would change to drier native plant communities or variants of the original community.

Wetlands Abutting Unnamed Creek, Trimble Creek, Mud Lake Creek, and Second Creek

There are 2,754.8 acres of wetlands abutting Unnamed Creek, Trimble Creek, and Mud Lake Creek within Area 2, and Second Creek, which include shrub swamps, coniferous swamp, hardwood swamp, shallow marsh, deep marsh, and sedge/wet meadow (see Figure 4.2.3-5); these are presented in Table 5.2.3-11.

Table 5.2.3-11 Wetlands Abutting Unnamed Creek, Trimble Creek, Mud Lake Creek, and Second Creek

	Unnamed Creek		**Trimble Creek**		**Mud Lake Creek**		**Second Creek**		**Total Wetlands Abutting Creeks**	
Eggers and Reed Class[1]	**Acres**	**%**	**Acres**	**%**	**Acres**	**%**	**Acres**	**%**	**Acres**	**%**
Coniferous swamp	16.3	3	130.3	15	474.3	41	0.0	0	620.9	23
Deep marsh	53.8	10	5.9	1	0	0	14.3	8	74.0	3
Hardwood swamp	98.1	19	0	0	31.0	3	0.0	0	129.1	5
Sedge/wet meadow	0	0	17.7	2	0	0	0.0	0	17.7	1
Shallow marsh	85.8	16	36.7	4	0	0	45.8	26	168.3	6
Shrub swamp (including alder thicket or shrub-carr)	273.0	52	695.8	78	657.1	57	118.8	66	1744.7	63
Total Acres of Wetlands	527.1	100	886.4	100	1,162.4	100	178.9	100	2,754.8	100

Sources: PolyMet 2015b

Note:
[1] Eggers and Reed 1997, 2014.

Water management at the Plant Site would consist of flow augmentation immediately downstream of the Tailings Basin containment system to minimize hydrologic effects on downstream watercourses (PolyMet 2015b). The hydrologic analysis (see Section 5.2.2) estimated that the changes in average annual flow of Unnamed Creek, Trimble Creek, Mud Lake Creek, and Second Creek would be within the annual variability that naturally occurs within the Partridge River and Embarrass River watersheds. Therefore, no potential indirect wetland effects were identified for the wetlands abutting Unnamed Creek, Trimble Creek, Mud Lake Creek, and Second Creek (PolyMet 2015b).

Water Quality Changes

The screening analysis for depositional effects was conducted using air dispersion/ deposition modeling (AERMOD) to estimate the potential annual deposition of dust, metals, and sulfur to wetlands within and adjacent to the Plant Site. The estimated deposition from fugitive dust emissions was used to identify wetlands that have the potential for water quality changes. The estimated deposition from fugitive dust emissions was used to identify a threshold for a negative effect on vegetation.

Below is a summary of the assessment from the *NorthMet Project Wetlands Data Package* (PolyMet 2015b).

Receptors

The receptors of interest for this analysis were the wetlands that were not directly impacted. The respective initial receptor grids for the Plant Site were set up with near-field receptor spacing of 250 meters within the ambient air boundary and the far-field receptor spacing was 1,000 meters from the ambient air boundary out to 5 km.

Dust Deposition and Speciation to Individual Metals and Sulfur

For the dust emission sources identified for assessing potential metals and sulfur deposition at the Plant Site, the highest estimated dust deposition rate for each receptor node was then speciated to the respective metal and sulfur deposition rates based on the contribution of the sources to a receptor node and the metal and sulfur composition identified for each contributing source (e.g., tailings at the Plant Site). The estimated metal or sulfur deposition for each contributing dust source at a receptor node was then summed to provide a "total" deposition rate for each respective metal and for sulfur at that receptor location. Dust deposition rates were speciated for arsenic, cadmium, chromium, lead, manganese, nickel, and selenium. Copper and vanadium were also included. For each receptor node, the post-processing of the dust deposition rate by source contribution was then summed to provide a "total" metal deposition rate and a "total" sulfur deposition rate.

Sulfur associated with fugitive dust is part of the mineral matrix of the rock particles (sulfide). Therefore, weathering of the particle must occur before any of the sulfur would be released to soil, soil water, or surface water. Because the NorthMet ore is low in mercury, the tailings would also be low in mercury, and the pilot study indicated that the mercury preferentially goes to the flotation concentrate. The mercury is also expected to be strongly bound within the mineral matrix. This would also be true for the LTVSMC tailings that would be used to construct the Tailings Basin dams and that may be present on some road surfaces. Therefore, any mercury present in dust from the Tailings Basin would not be biologically available (PolyMet 2015b). Potential mercury air emissions from ore processing (i.e., potential emissions from the autoclave) were evaluated for potential local deposition impacts (see Section 5.2.7).

Estimates of Rural Background Deposition

For dust, an annual effects-level deposition rate of 365 $g/m^2/yr$ was compared to modeled annual dust deposition rates. This deposition rate is a potential effects threshold for photosynthesis (i.e., potential for reduced photosynthesis due to "dusting" of the plant surface). However, for this analysis, the vegetative surface area of the wetlands was not calculated or included in the analysis. The modeled dust deposition rate was assumed to be applied to the land surface area, which is a smaller area than the vegetative surface area. Vegetative surface area can be up to 13 times greater than the land surface area. By only assessing dust deposition to the land surface area instead of the vegetative surface area, it is likely the ratio of modeled deposition rate to the effects level was being overestimated. In other words, the modeled deposition rate is not being spread over the larger surface area of the vegetation which would reduce the effective deposition rate. Because this application did not include the deposition of dust to the vegetative surface area, it is likely that the areas identified to exceed the effects threshold of 365 $g/m^2/yr$ have been overestimated.

For metals, background deposition is based on the data from *Atmospheric Deposition of Trace Metals at Three sites near the Great Lakes* (Sweet et al. 1997), which indicated that precipitation was under-collected by 45 to 70 percent when sample volumes were compared to corresponding rain gage amounts. Because wet deposition was considered to be underestimated, the wet deposition component was adjusted upward by a factor of 1.6.

Total background sulfur deposition included both wet and dry deposition, which was calculated to be 0.16 $g/m^2/yr$. The estimated background deposition used in the analysis for metals and sulfur was from data collected at sites characterized as open areas in rural settings that are reasonably distant from industrial sources and population centers. For forested areas, dry deposition may be underestimated. Vegetation can effectively scavenge fine particles and aerosols from the atmosphere and this interception can result in dry deposition being 50 percent or more of the total deposition. At a monitoring site in Ely (Fernberg Road), dry deposition was assumed to be 22 percent of total deposition. Therefore, it is likely that the background sulfur deposition estimated for this analysis may be low due to an underestimation of dry deposition; however, no adjustments were made to the background sulfur deposition estimated for this analysis.

Significance Levels for Estimating the Potential Effects for Identifying Future Monitoring

For dust, metals, and sulfur, the following general categories were used for assessing the significance of a modeled deposition rate at a receptor node:

- Less than 100 percent of background: no potential for effects expected.
- Greater than 100 percent of the background value: potential for effects, include in future wetland monitoring.

These are general categories of potential for effects. Since this was a screening analysis to identify wetlands for potential inclusion in the monitoring program, there was some flexibility in identifying a potential level of deposition that suggested a potential for effect and would then trigger a requirement for monitoring. Another consideration for selecting a deposition rate that was a high percent of the background rates was the likely overestimation of modeled deposition and the underestimation of background deposition.

Adding to the conservatism in the modeling of particulate metals, this screening analysis used a maximum dust deposition from a range of possible modeled values and a high-end metal or sulfur concentration for each source contributing to that receptor node to derive a maximum potential metal or sulfur deposition for a receptor node.

Using a maximum concentration for each contributing emission source to speciate a metal or sulfur deposition from a maximum modeled dust deposition rate for each receptor node overestimates individual metal or sulfur deposition. Also adding to the conservatism of this analysis is the underestimation of background deposition because the ratio of the NorthMet Project Proposed Action-related deposition is compared to the background deposition. If background deposition is underestimated, that would indicate that estimated NorthMet Project Proposed Action-related deposition at more receptor nodes are higher than background and further increases the area for potential future monitoring. The underestimation of background metal deposition (i.e., wet deposition due to under-collection of precipitation) was identified by Sweet et al. (1997). In addition to the underestimation of background metal deposition, background wet sulfate deposition may be underestimated, as well, because the National Atmospheric Deposition Program data for the Fernberg Road monitoring site indicated rainfall in the last three years was about 22 percent below the annual average. If sulfate deposition from 2007 and 2008 was used (both years approximately normal for precipitation amount), a background sulfur deposition rate of 0.23 $g/m^2/yr$ was calculated—about 44 percent higher than the background deposition used in the screening analysis. If the higher estimate of background sulfur deposition was used in the screening analysis, a smaller number of receptor nodes would have been identified to have modeled sulfur deposition that was more than 100 percent of background deposition and the area for potential monitoring would be smaller than that identified. Also, it was found that for forested areas, dry deposition may be systematically underestimated due to sample collection and analysis methodology. It is possible that the background sulfur deposition estimated for this analysis may be low due to an underestimate of dry deposition.

Given the potential for overestimation of modeled deposition and underestimation of background deposition, and balancing the conservatism when their respective results are combined in this analysis, it seems reasonable to select the wetlands estimated to receive greater than 100 percent of background deposition (a potential doubling of the background deposition) for consideration in potential future monitoring (PolyMet 2015b).

Fugitive Dust/Metals and Sulfide Dust Emissions

At the Plant Site, dust deposition was highest in three locations: southwest corner, near Area 2; southeast corner; and the northeast corner, towards Area 5. All receptors have model-estimated dust deposition of 50 percent or less of the effects-level background of 365 $g/m^2/yr$ (see Figure 5.2.3-22). The model-estimated dust deposition is largely constrained to within the ambient air boundary at the Plant Site, and the model-estimated dust deposition is 50 percent or less of the effects-level background dust deposition. There would be no potential indirect wetland effects due to dust deposition in the Second Creek area of analysis (PolyMet 2015b).

At the Plant Site, there would be two locations showing model-estimated metal and sulfur deposition rates greater than 100 percent of background deposition: 1) approximately the southern and western two-thirds of the basin, and 2) a small area on the northern and eastern portion of the ambient air boundary (see Figure 5.2.3-23). Approximately 90 percent of the receptor nodes with the highest model-estimated metal and sulfur deposition rates (rates greater than 100 percent of background deposition) were located within the ambient air boundary. The remaining 10 percent of the receptor nodes with the highest modeled-estimated metal and sulfur deposition are located to the south and east of the Plant Site outside of the ambient air boundary (PolyMet 2015b).

Of the 25,846 acres of wetlands identified within the Plant Site receptor grid, deposition modeling results indicate that 193.9 acres of wetland could be potentially indirectly affected (modeled metal deposition rates greater than 100 percent of background). Of the 193.9 acres, 58.8 acres would be located within the Plant Site ambient air boundary (PolyMet 2015b). The 193.9 acres of wetlands should be included in any future monitoring to be conducted for the NorthMet Project Proposed Action.

The deposition modeling results identified approximately 44 acres in the Second Creek area of analysis that could potentially indirectly affected (modeled metal deposition greater than 100 percent background). Of the 44 acres, 1 acre is located within the Plant Site ambient air boundary. These wetlands are accounted for in the 193.9 acres noted above and would already be included in any future monitoring.

The deposition modeling results for dust, metals, and sulfur indicate there would likely not be an adverse effect on wetlands; however, the modeling only indicated those areas that had deposition rates greater than 100 percent of background deposition (PolyMet 2015b). These specific wetlands areas would be identified for consideration in any future monitoring to be conducted for the NorthMet Project Proposed Action.

The initial assessment provided a discussion on conservatism, including a discussion that the estimated sulfur deposition was as particle-bound sulfur, with the sulfur being inherent to the mineral matrix of the dust and not readily available for dissolution in soils or surface waters. A supplemental assessment has been conducted to provide for a worst-case scenario where all of the sulfur in fugitive dust converts to sulfate and would mix with surface water in a wetland

(Barr 2015f). A summary of the supplemental assessment evaluation of sulfur from stack emissions is included in Section 5.2.7.2.6, while the fugitive dust evaluation is presented herein.

Based on a conservative, not model-based, assumption that all sulfur in fugitive dust converts to sulfate and mixes with surface water in wetlands, a potential incremental increase in sulfate was calculated as 4.2 mg/L. When the potential incremental sulfate concentration is mixed with annual precipitation, the sulfate value was calculated as 1.7 mg/L. Because the sulfur is inherent to the mineral matrix of the dust particles, it is likely that less than 100 percent of the sulfur would be weathered from the particles and be available to go into solution if deposited to soils or water. This potential incremental change may warrant future monitoring, as small sulfate increases in sulfate-poor wetlands may increase methylmercury production in wetlands (Jeremiason et al. 2006). However, methylmercury produced in wetlands is not necessarily incorporated into food chains and concentrated to levels of concern.

Although the actual potential for deposition of fugitive dust to wetlands, and the potential release of sulfur in that dust, is uncertain, any adverse effects on wetlands are unlikely. The fugitive dust control plan for both the Mine Site and the Plant Site (including the Tailings Basin) would minimize such deposition, and the sulfur from any rock dust particles that would be deposited may not be released or only released slowly through weathering. Using a conservative assumption that all sulfur in the deposited dust is both released and transformed to sulfate, no significant increase in methylmercury concentrations would be expected (Barr 2015f). Additional information in regards to mercury methylation is provided in Section 5.2.2.3.4. A discussion of mercury deposition and bioaccumulation in fish and the assessment of the cumulative effects is provided in Section 6.2.6.3.3.

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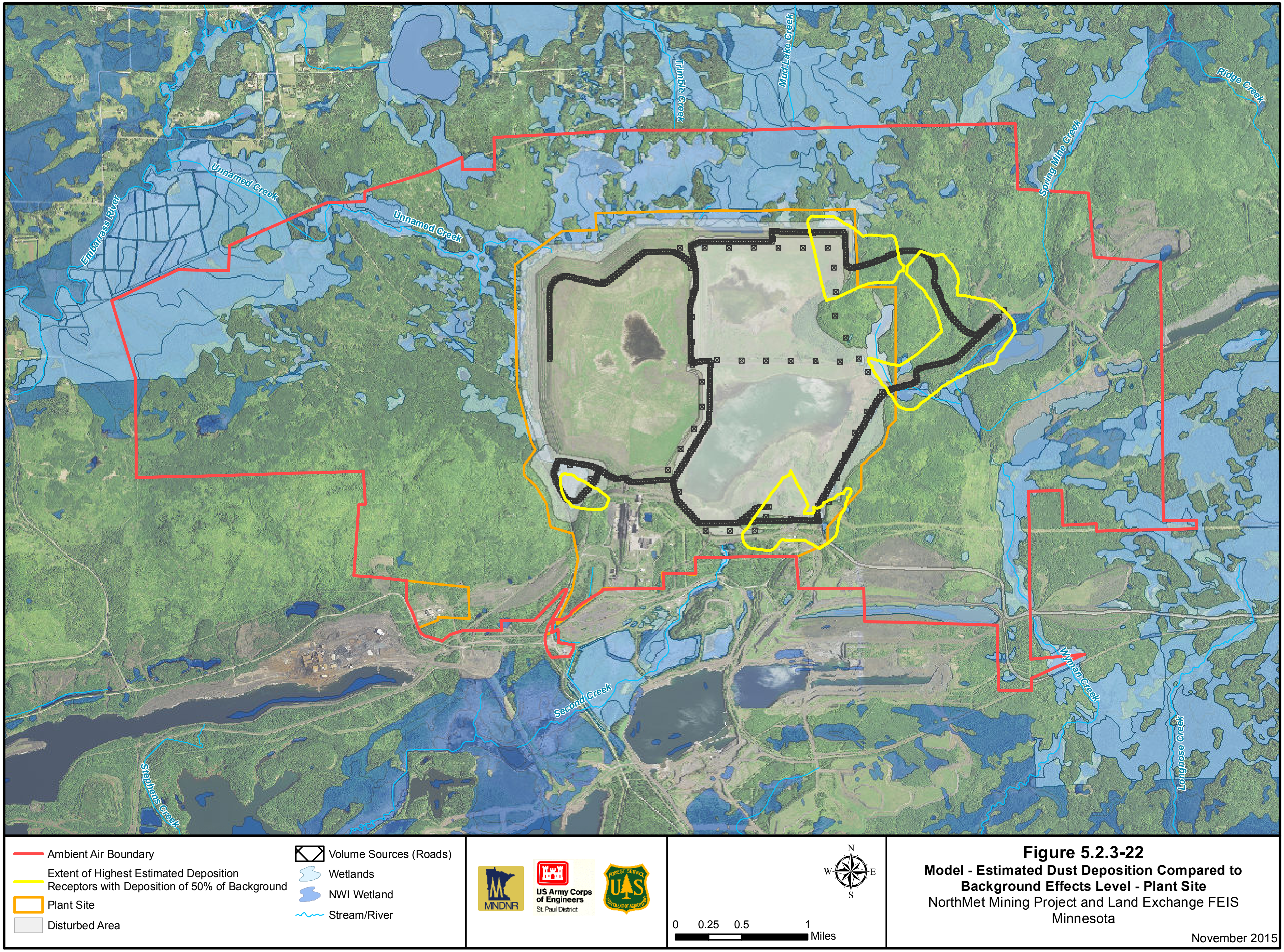

Figure 5.2.3-22

Model - Estimated Dust Deposition Compared to Background Effects Level - Plant Site

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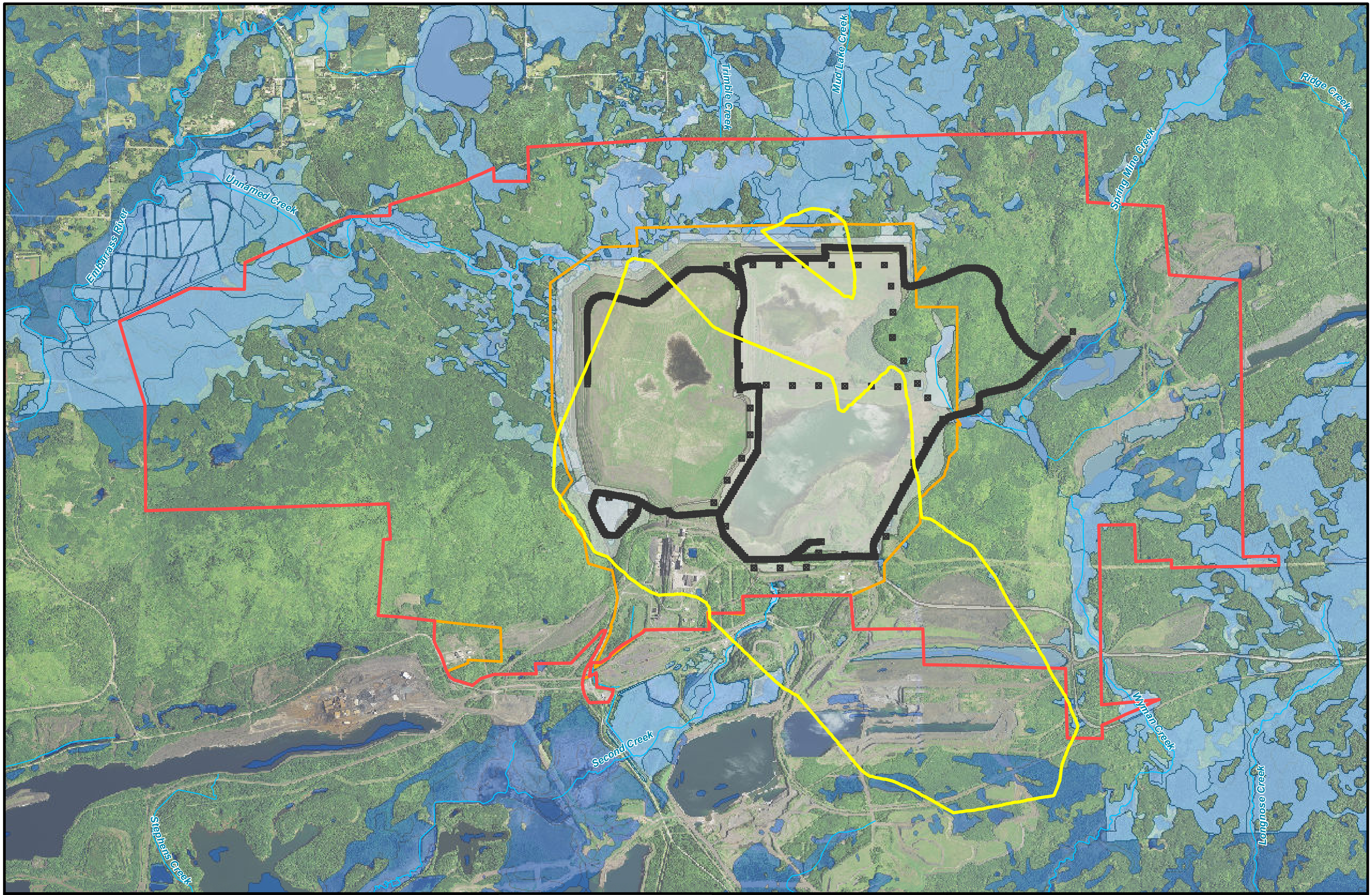

Ambient Air Boundary

Extent of Highest Estimated Deposition Receptors with Deposition of 100% of Background

Plant Site

Disturbed Area

Volume Sources (Roads)

Wetlands

NWI Wetland

Stream/River

MNDNR

US Army Corps of Engineers St. Paul District

0 0.25 0.5 1 Miles

Figure 5.2.3-23

Model - Estimated Metal Deposition Compared to Background Effects Level - Plant Site

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Water Quality Changes

The NorthMet Project Proposed Action could affect wetland water quality downstream of the Tailings Basin and in the Second Creek area by altering the chemistry and volume of seepage and surface water discharges leaving the Tailings Basin and going to the headwaters of Second Creek (PolyMet 2015b; PolyMet 2015j). The NorthMet Project Proposed Action is predicted to meet all water quality evaluation criteria, or not worsen conditions where contamination already exceeds the criteria. The collection of existing seepage by the containment system and augmentation with WWTP effluent water would generally improve downstream water quality relative to current conditions. Effects that would occur on surface water and groundwater quality are discussed in Section 5.2.2. Even if water quality improves, there would be a potential for indirect effects to wetlands due to changes in water quality. Potential indirect wetland effects due to water quality changes that would likely occur at the Plant Site would be a result of changes in groundwater quality, in surface water quality, or in both groundwater and surface water quality and would be limited to the wetlands abutting Second Creek (PolyMet 2015b).

Wetland areas that would be potentially affected by water quality changes are shown in Figure 5.2.3-21 and listed in Table 5.2.3-12. Note that within this section, the term groundwater and surface water refer to the path by which NorthMet Project Proposed Action water leaves the Tailings Basin (e.g., potential effects from Tailings Basin groundwater seepage that discharges to surface water at a downstream location are classified as a potential effect due to changes in groundwater quality). Potential indirect effects due to changes in surface water quality are expected to diminish as the distance from the Tailings Basin increases. Upstream of County Road 666, there are approximately 179 acres of wetlands abutting Second Creek that could be potentially indirectly affected by the change in water quality due to stream flow augmentation of Second Creek.

Table 5.2.3-12 Wetland Areas Potentially Indirectly Affected by Changes in Water Quality

Wetland Area Potentially Affected by Changes in Water Quality	Mud Lake Creek (North)	Trimble Creek (Northwest)	Unnamed Creek (West)	Downstream of Groundwater Flowpaths[3]	Total
	Acres	Acres	Acres	Acres	Acres
Groundwater Quality[1]	296.5	514.0	1,162.1	--	1,972.7
Surface Water and Groundwater Quality[2]	835.8	568.9	690.9	570.2	2,665.7
Total	1,132.3	1,082.9	1,853.0	570.2	4,638.4

Source: PolyMet 2015b.

Notes:

1 Groundwater refers to water leaving the Tailings Basin within the surficial aquifer. Effects resulting from the discharge of that seepage to surface water have been considered an effect due to groundwater in the analysis.

2 All areas potentially affected by changes in surface water quality have also been potentially affected by changes in groundwater quality.

3 Potentially affected wetlands are located along Trimble Creek and Mud Lake Creek, but outside of groundwater flowpaths (see also Note (1)).

Potential for indirect effects from changes in groundwater quality may occur anywhere along the modeled groundwater flowpaths previously mentioned. Wetlands abutting the three creeks that may be indirectly affected (4,068.2 acres) by changes in groundwater quality are shown on Figure 5.2.3-21. The effects on groundwater quality diminish as distance from the Tailings Basin increases, as the relative portion of total groundwater that originates from the Tailings Basin decreases (see Section 5.2.2). It has been determined that the amount of Tailings Basin seepage remaining in the surficial aquifer would be small; therefore, the potential for indirect effects as a result of changes in groundwater quality are anticipated to be small.

Potential effects from changes in groundwater quality may also occur in wetlands abutting tributary streams (all reaches of Unnamed Creek, Trimble Creek, and Mud Lake Creek) into which affected groundwater would discharge (see Figure 5.2.3-21). Wetlands abutting these streams and outside of the modeled groundwater flowpaths resulted in an additional 570.2 acres of potential indirect effects due to changes in groundwater quality (PolyMet 2015b).

Potential indirect effects from changes in surface water quality would also likely occur in wetlands within the surface watersheds immediately downstream of the Tailings Basin, which includes watersheds upstream of modeling locations UC-1a, TC-1, and MLC-3 (see Figure 5.2.3-21). The potential indirect effects from changes in surface water quality include 1,158 acres of wetlands (all of which would also likely be potentially indirectly affected by changes in groundwater quality). Downstream of these locations, potential indirect effects due to changes in surface water quality are limited to wetlands abutting the tributary streams. These areas include an additional 1,505 acres of wetlands (all of which may also be potentially indirectly affected by changes in groundwater quality) (PolyMet 2015b).

As with effects from changes in groundwater quality, potential effects as a result of changes in surface water quality would be expected to diminish as distance from the Tailings Basin increases and flows originating from the NorthMet Project Proposed Action are diluted by natural runoff.

The wetland hydrology downstream of the Tailings Basin is too complex to be accurately incorporated into the Plant Site probabilistic model detailed in Section 5.2.2. The response of such complex natural systems to water quality changes originating at the Tailings Basin can only be estimated (PolyMet 2015b). Therefore, monitoring of wetland hydrology and vegetation communities would be the best way to document the extent and magnitude of wetland responses (potential indirect wetland effects) to the NorthMet Project Proposed Action.

5.2.3.2.5 Summary of NorthMet Project Proposed Action Direct Impacts and Indirect Wetland Effects

<u>Direct Impacts</u>

Direct wetland impacts for the NorthMet Project Proposed Action are summarized in Table 5.2.3-13. Of the 166 wetlands within the NorthMet Project area, 128 wetlands would be directly impacted, totaling 913.8 acres of direct wetland impact. The Mine Site would contain the majority of the direct wetland impacts. The majority of the direct impacts would occur as a result of a combination of filling and excavation (74 percent) (see Table 5.2.3-14).

Table 5.2.3-13 Total Projected Direct Wetland Impacts for the NorthMet Project Proposed Action

Eggers and Reed Class[1]	Directly Impacted Wetlands		
	Acres	%	No.
Coniferous bog	509.1	56	24
Coniferous swamp	82.6	9	17
Deep marsh	74.1	8	16
Hardwood swamp	13.2	1	3
Open bog	7.6	1	4
Open water (includes shallow, deep, open water, and lakes)	0.0	0	0
Sedge/wet meadow	39.6	4	11
Shallow marsh	76.7	8	23
Shrub swamp (includes alder thicket and shrub-carr)	110.8	12	31
Total Direct Impacts	913.8	100[2]	129

Source: PolyMet 2015b.

Notes:
[1] Eggers and Reed 1997, 2014.
[2] Percent totals are less than 100 percent due to rounding.

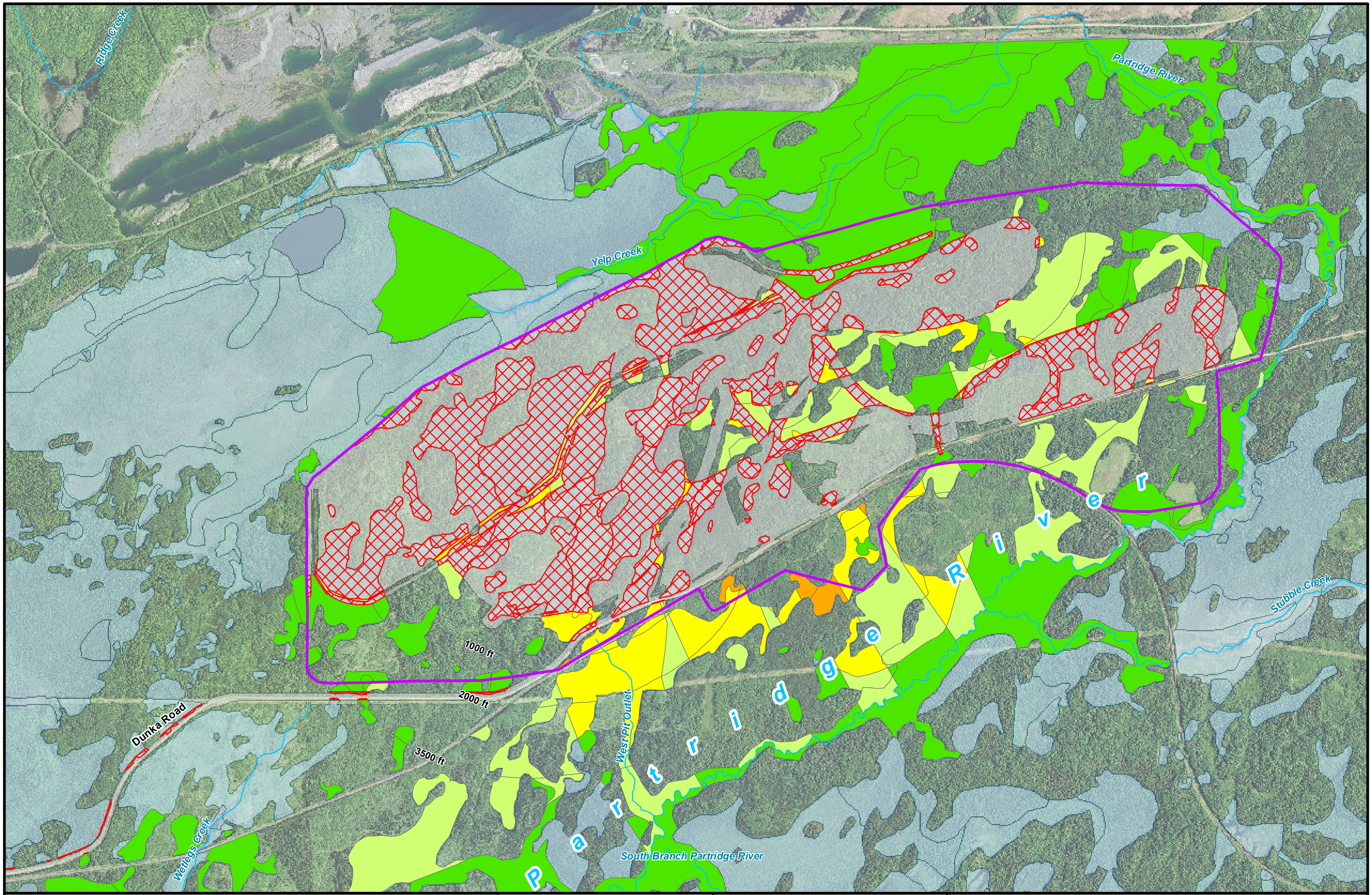
Table 5.2.3-14 Type of Projected Direct Wetland Impacts for the NorthMet Project Proposed Action

Type of Effect	Directly Impacted Wetlands		
	Acres	%	No.
Fill	102.8	11	67
Excavation	133.1	15	15
Fill and Excavation	677.9	74	47
Total Direct Impacts	913.8	100	129

Source: PolyMet 2015b.

Potential Indirect Effects

Potential indirect wetland effects from the NorthMet Project Proposed Action would result from one or more of the following six factors: 1) wetland fragmentation; 2) change in wetland hydrology resulting from changes in watershed area; 3) changes in wetland hydrology due to groundwater drawdown resulting from open pit mine dewatering; 4) changes in wetland hydrology from groundwater drawdown resulting from operation of the Plant Site, including groundwater seepage containment; 5) changes in stream flow near the Mine Site and Plant Site, as well as associated effects on wetlands abutting the streams; and 6) changes in wetland water quality related to atmospheric deposition of dust and rail car spillage associated with Mine Site and Plant Site operations. A rating system (scaled from 0 to 6) was developed for the wetlands based on the number of factors that may potentially affect it. Wetlands that were not determined to be potentially indirectly affected would be rated as zero and wetlands that were determined to be potentially indirectly affected by all six factors would be rated as a six; however, no wetlands were rated as a six (see Figures 5.2.3-24 and 5.2.3-29) (PolyMet 2015b). The NorthMet Project Proposed Action could indirectly affect up to either 7,694.2 acres of wetlands located within and around the NorthMet Project area, based on the method of wetlands crossing analog impact zones, or up to 6,568.8 acres of wetlands located within and around the NorthMet Project area, based on the method of wetlands within analog impact zones (PolyMet 2015b). The indirect effects analyses performed for the EIS were not performed to characterize impacts but were done to inform where monitoring should take place for those areas that were identified as having a potential for indirect wetland effects. Potential indirect wetland effects are presented in Table 5.2.3-15.



Mine Site
Direct Wetland Impacts
Disturbed Area
Stream/River

Potential Wetland Indirect Impact Factor Rating
5
4
3
2
1
No Impact

MNDNR
US Army Corps of Engineers
St. Paul District

0 1,000 2,000 4,000 Feet

Figure 5.2.3-24
Mine Site Wetlands and Potential Indirect Wetland Effects
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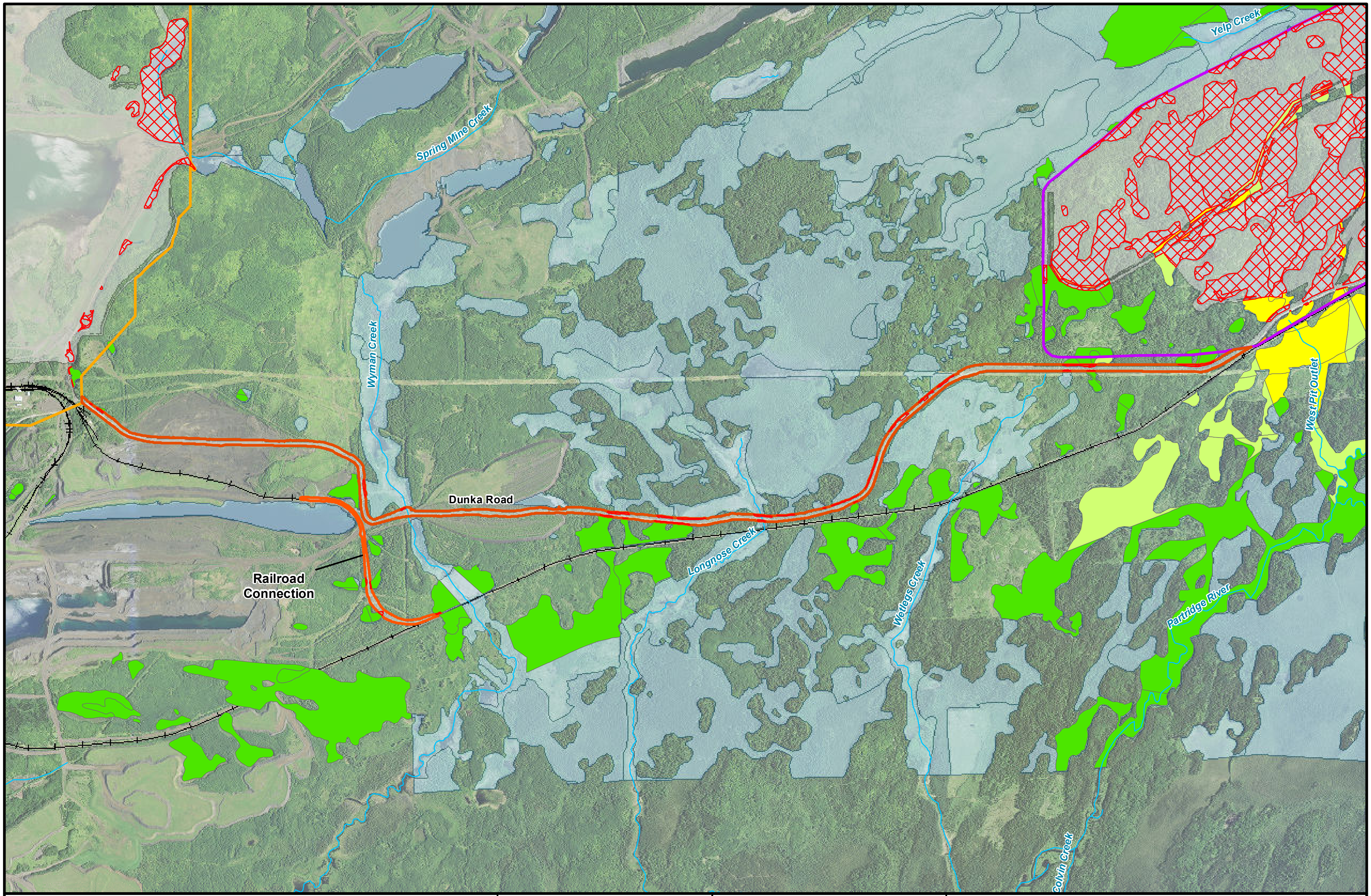

Transportation and Utility Corridor
Mine Site
Plant Site
Direct Wetland Impacts
Disturbed Area
Stream/River
Existing Railroad

Potential Wetland Indirect Impact Factor Rating
4
3
2
1
No Impact

MNDNR
US Army Corps of Engineers St. Paul District

N
W E
S

0 1,000 2,000 4,000 Feet

Figure 5.2.3-25
Transportation and Utility Corridor Wetlands and Potential Indirect Wetland Effects
NorthMet Mining Project and Land Exchange FEIS
Minnesota

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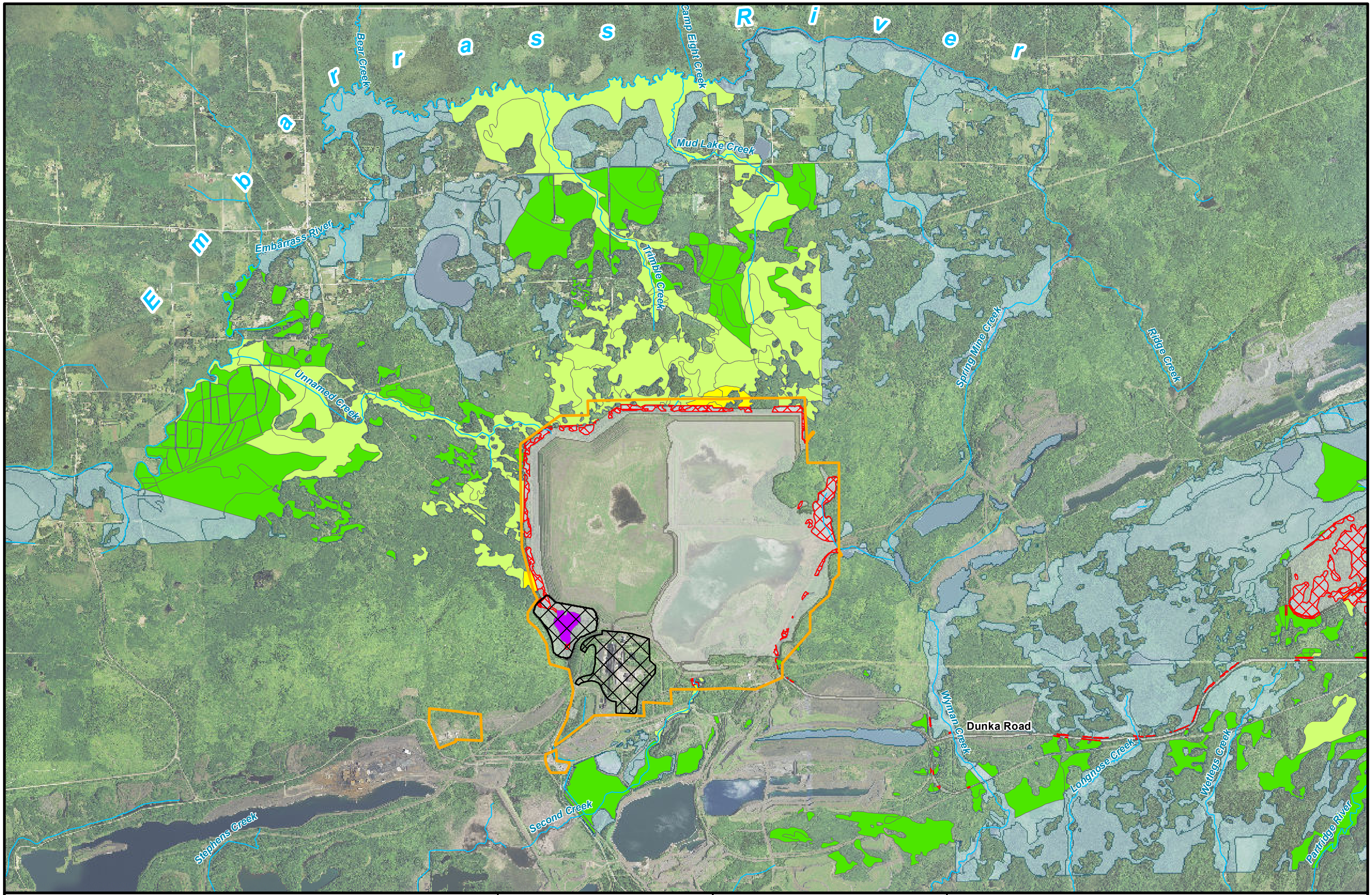

Plant Site
Direct Wetland Impacts
Areas Excluded from Plant Site Boundary
Disturbed Area
Stream/River
No Impact

Potential Wetland Indirect Impact Factor Rating

Potentially Incidental
5
4
3
2
1

MNDNR
US Army Corps of Engineers St. Paul District

0 0.25 0.5 1 Miles

Figure 5.2.3-26
Plant Site Wetlands and Potential Indirect Wetland Effects
NorthMet Mining Project and Land Exchange FEIS
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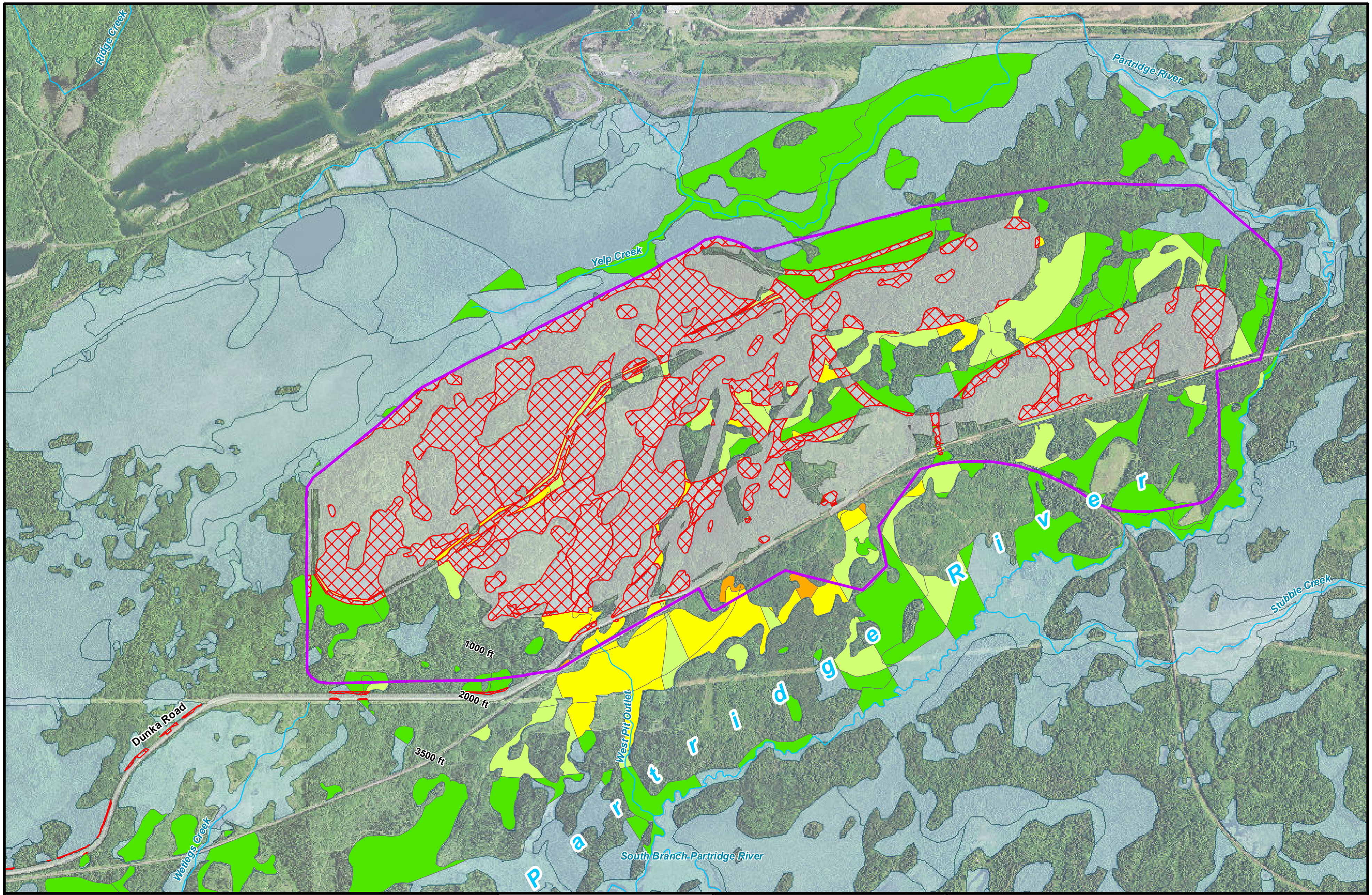

Mine Site
Direct Wetland Impacts
Disturbed Area
Stream/River

Potential Wetland Indirect Impact Factor Rating

5
4
3
2
1
No Impact

MNDNR
US Army Corps of Engineers St. Paul District
Forest Service U.S. Department of Agriculture

0 1,000 2,000 4,000 Feet

Figure 5.2.3-27
Mine Site Wetlands and Potential Indirect Wetland Effects - Alternate Method
NorthMet Mining Project and Land Exchange FEIS
Minnesota

November 2015

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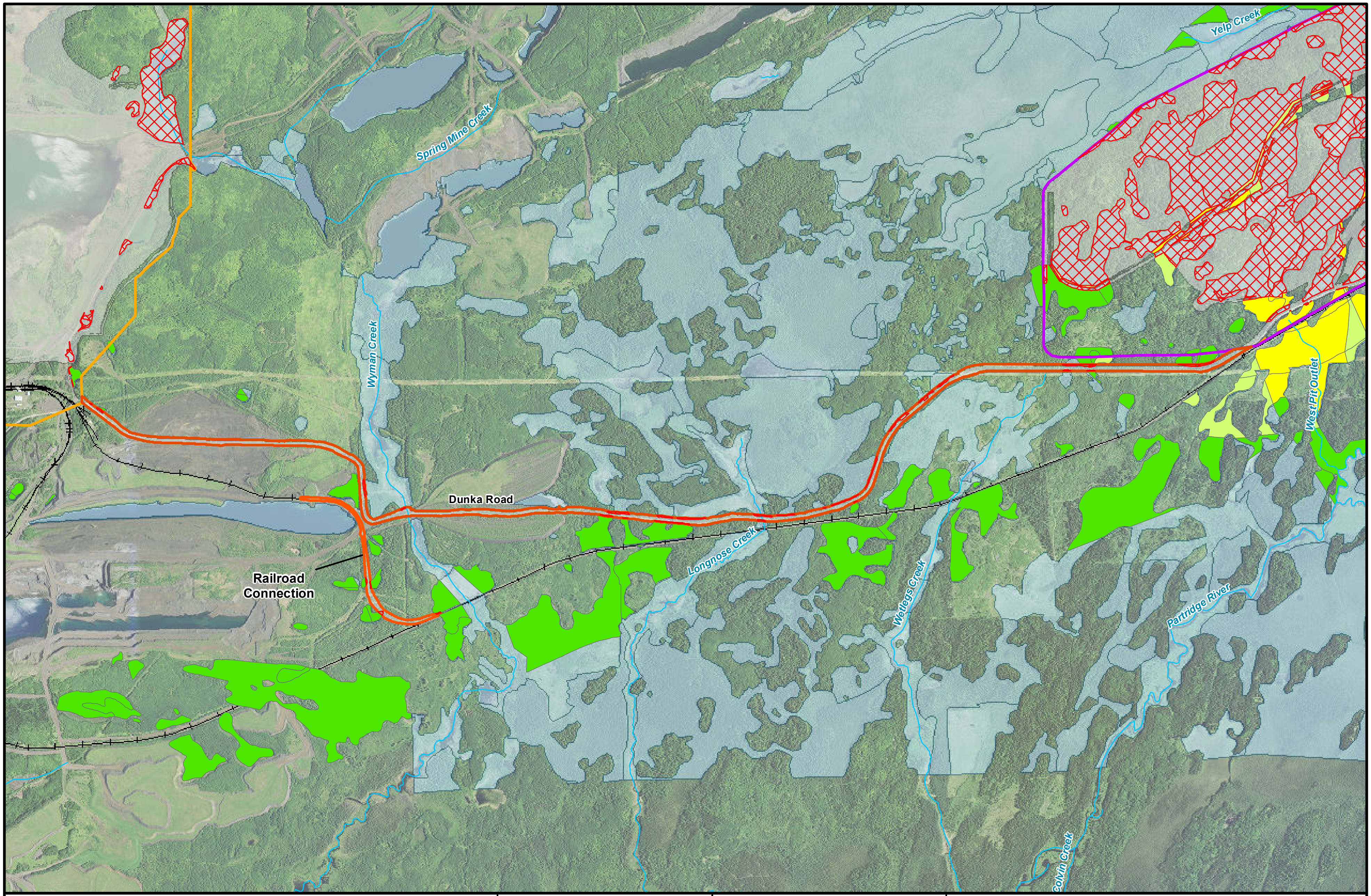

Transportation and Utility Corridor
Mine Site
Plant Site
Direct Wetland Impacts
Disturbed Area
Stream/River
Existing Railroad

Potential Wetland Indirect Impact Factor Rating
4
3
2
1
No Impact

MNDNR
US Army Corps of Engineers St. Paul District

N S W E

0 1,000 2,000 4,000 Feet

Figure 5.2.3-28

Transportation and Utility Corridor Wetlands and Potential Indirect Wetland Effects - Alternate Method

NorthMet Mining Project and Land Exchange FEIS

Minnesota

November 2015

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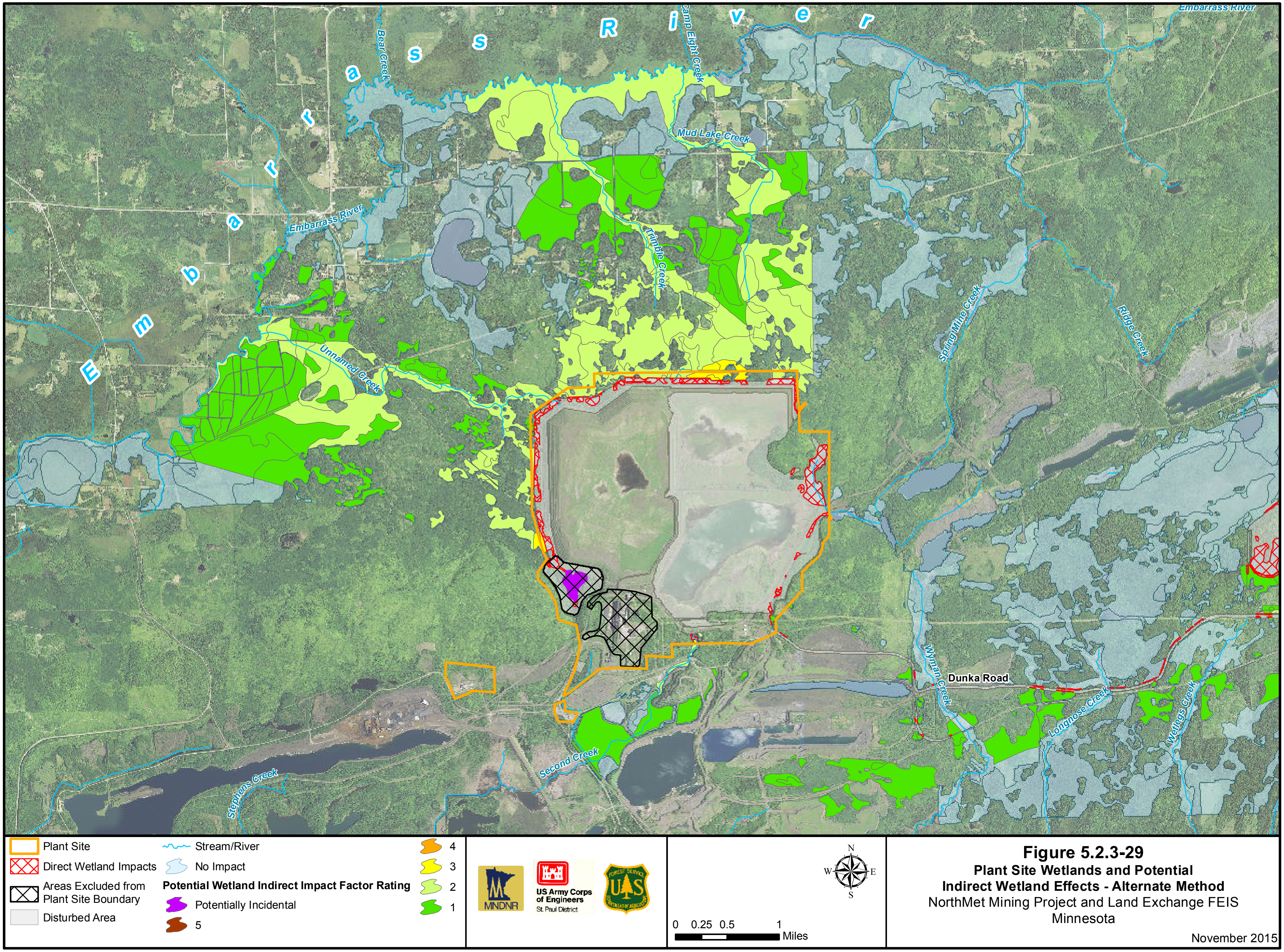

Figure 5.2.3-29
Plant Site Wetlands and Potential Indirect Wetland Effects - Alternate Method
NorthMet Mining Project and Land Exchange FEIS
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Table 5.2.3-15 Summary of Projected Potential Indirect Wetland Impacts for the NorthMet Project Proposed Action

	Total Potential Indirect Wetlands (based on the method of wetlands *crossing* analog impact zones)		**Total Potential Indirect Wetlands (based on the method of wetlands *within* analog impact zones)**	
Rating[1]	**Acres**	**%**	**Acres**	**%**
1	4,305.9	56	3,466.1	53
2	3126.8	41	2,888.4	44
3	245.3	3	206.0	3
4	15.9	<1	8.1	<1
5	0.3	<1	0.3	<1
Total Acres of Potential Indirect Wetland Effect[2]	7,694.2	100	6,568.8	100

Sources: PolyMet 2015b

Notes:

1 A wetland may be potentially indirectly affected by none of the six factors or up to a maximum of six, with different combinations of factors possible. A rating was developed for the wetlands based on the number of factors that may potentially affect it – from No Effect (0 factors) to 6 (all six factors potentially indirectly affecting the wetland).

2 The analyses and assessments were completed using the same set of wetlands that were not directly impacted; therefore, there are wetlands that may be potentially indirectly affected by more than one type of assessed source. The potential indirect wetland affects for each wetland cannot be summed across the analysis as this would likely result in double-counting of wetland acres. The results of the analyses and assessments identify areas to be monitored for potential wetland effects.

As discussed below, wetland mitigation for potential indirect wetland effects would be determined by the agencies during permitting. If the NorthMet Project Proposed Action were to be permitted and it was determined that the NorthMet Project Proposed Action could cause future wetland effects, wetland monitoring would be conducted. Wetland hydrology and vegetation would be monitored, and additional monitoring locations may be considered during permitting. A component of the monitoring plan would be based on those wetlands that would have a high likelihood of indirect effects as a result of groundwater drawdown. The likelihood of potential wetland hydrology effects (low, moderate, and high), based on the method of wetlands crossing analog impact zones, would be 2,147.6 acres, of which 866.9 acres of wetlands (15 percent) would have a high likelihood of wetland hydrology effects. The likelihood of potential wetland hydrology effects (low, moderate, and high), based on the method of wetlands within analog impact zones, would be 733.3 acres, of which 46.4 acres of wetlands (1 percent) would have a high likelihood of wetland hydrology effects. If the monitoring determined that indirect wetland effects had occurred, adaptive management practices to reduce wetland effects would be considered and additional compensation may be required if determined necessary by the permitting agencies.

In the event that the required wetland monitoring identified additional indirect effects, permit conditions would likely include a plan for implementing adaptive management practices such as expanded monitoring and hydrologic controls. Additionally, compensatory mitigation may be required if additional impacts are identified during annual reporting. Permit conditions would likely include an adaptive management plan to account for any additional effects that may be identified in the annual monitoring and reporting.

5.2.3.3 NorthMet Project Proposed Action Wetland Impact Avoidance, Minimization, Mitigation, and Monitoring Measures

This section discusses measures that were taken to avoid and minimize wetland impacts, evaluates PolyMet's proposed wetland mitigation for unavoidable impacts, discusses other potential mitigation measures that may benefit wetlands, and identifies key elements of a wetland monitoring plan. The wetland impact, avoidance, minimization, mitigation and monitoring plan presented in the EIS would be reviewed during permitting; therefore, the mitigation and proposed monitoring could change during permitting.

5.2.3.3.1 Wetland Avoidance and Minimization

Section 404 regulations of the CWA, Minnesota's WCA rules, and Minnesota's water quality standards under *Minnesota Rules*, part 7050.0186 require that impacts to wetlands be avoided and minimized to the extent practicable, and if wetland impacts cannot be avoided and/or minimized, then compensatory mitigation practices would be necessary.

Final regulations and guidelines associated with Section 404 of the CWA require that project proponents eliminate or reduce adverse impacts to waters of the United States by taking certain specific steps during project planning. These include: 1) modify the project to avoid adverse impacts, 2) incorporate measures to minimize adverse impacts, and 3) compensate for unavoidable adverse impacts through restoration, enhancement, creation, or in-lieu fee.

PolyMet proposes to avoid and minimize wetland impacts through a number of measures that are incorporated into the proposed mine plan. Direct wetland impacts at the Mine Site have been reduced during the development of the NorthMet Project Proposed Action. Modifications to the NorthMet Project Proposed Action that have occurred during the development of the EIS have resulted in avoidance and minimization of impacts on wetland resources. To date, these modifications have reduced the acreage of wetlands impacted from 1,257 to 913.8 acres, a 27 percent decrease.

At the Mine Site, waste rock would be placed back into the East Pit and Central Pit after year 11, thereby reducing the need for additional surface stockpile areas that would otherwise affect wetlands. In addition, PolyMet proposes to combine the saturated overburden and temporary stockpiles that contain membrane liners, which were separate in the original NorthMet Project Proposed Action design. The Overburden Storage and Laydown Area would only store peat and unsaturated overburden (PolyMet 2015a). By reducing the footprint of the Overburden Storage and Laydown Area and stockpiles, direct wetland impacts were reduced. Similarly, PolyMet proposes to construct the Category 4 Stockpile in the footprint of the Central Pit, which would be mined later and thus avoid additional direct wetland impacts. Reactive waste rock stockpiles would be lined, and stormwater runoff that contacted reactive rock would be contained to help prevent water quality-related effects on adjacent wetlands. In addition, hydrologic effects would be reduced by the use of seepage control measures, which would be installed at the mine pits to restrict shallow groundwater movement through higher permeability areas and help prevent drawdown of wetland water levels near mine pits. Haul road construction/layout has been re-configured to have fewer haul roads and locations thereby reducing land and wetland disturbance and truck distance to be driven. Haul road construction would include placement of large rocks as a foundation to allow shallow subsurface groundwater flowpaths in the wetlands to be maintained within the active areas of the Mine Site between the pits and stockpiles.

For other elements of the NorthMet Project Proposed Action, utilizing existing Plant Site infrastructure, the existing LTVSMC Tailings Basin, and the Transportation and Utility Corridor all serve as avoidance measures since building these on undeveloped sites could impact at least hundreds of acres of additional wetlands. Reusing existing infrastructure limits wetland impacts from these activities to previously disturbed areas. Additionally, cutoff berms/walls, trenches, and sump and pump systems would be used to collect current and future surface seepage from around the toe of the Tailings Basin (PolyMet 2011b). This surface seepage would ultimately be re-routed to the Tailings Basin, thus avoiding or minimizing discharges to surrounding wetlands. Construction of the containment system, however, would reduce the amount of seepage flowing to four tributaries of the Embarrass River (PolyMet 2015a). Streamflow would be augmented using WWTP effluent so that the target annual average flow that supports existing wetland hydrology would be met.

5.2.3.3.2 Wetland Mitigation

As previously noted, jurisdictional wetlands are regulated under state and federal laws, including the WCA (*Minnesota Rules*, chapter 8420), *Minnesota Rules*, part 7050.0186, and Sections 401 and 404 of the CWA. In addition, some wetlands are also designated as Minnesota Public Waters and subject to the Public Waters Work Permit Rules (*Minnesota Rules*, chapter 6115). However, no public water wetlands would be impacted by the NorthMet Project Proposed Action.

Both the state and federal wetland regulations require that a permit, approval, and/or certification be issued by the regulatory agency for wetland impacts as defined by the respective regulations. The USACE St. Paul District is the permitting authority for the DA permit pursuant to Section 404 of the CWA; the MDNR Division of Lands and Minerals administers the WCA approval process as part of the Permit to Mine (*Minnesota Rules*, part 8420.0200, subpart 1D); and the MPCA has authority under Section 401 of the CWA to certify that discharges authorized under Section 404 comply with water quality standards.

The wetland mitigation planning process relied on the WCA wetland replacement siting rules (*Minnesota Rules*, part 8420.0522), compensatory mitigation requirements under state water quality standards (*Minnesota Rules*, part 7050.0186), and the USACE *St. Paul District Policy for Wetland Compensatory Mitigation in Minnesota* (2009).

Sequencing

The compensatory wetland mitigation site selection for the NorthMet Project Proposed Action began in 2005 and has gone through a rigorous site selection evaluation. Prior to the 2008 Federal Mitigation Rule, the Aitkin and Hinckley sites were selected, initial approval by the federal regulatory agency was received, and substantial investments were made by PolyMet, to develop both sites for compensatory mitigation. The USACE guidance that was utilized prior to the implementation of the 2008 Federal Mitigation Rule was to look for mitigation sites that could provide the following: restoration of historical wetlands, high probability of success, achieves at least partial in-kind mitigation and sites that had ditched and/or tiled peatlands to provide for restoration. When the 2008 Federal Mitigation Rule went into effect, the USACE informed PolyMet of the priority for siting any future compensatory mitigation within the St. Louis River/Great Lakes Basin. The Zim Site was subsequently proposed as a third site. PolyMet, along with, in some cases, state and federal agencies, have conducted and are continuing to conduct extensive efforts to find additional suitable sites within in the Great Lakes Basin for wetland mitigation.

The 2008 Federal Mitigation Rule and 2009 USACE St. Paul District Policy specifies a preferential sequence for compensatory mitigation (i.e., use of mitigation banking credits, use of project-specific compensation that is based on a watershed approach, use of project-specific compensation that is on-site and in-kind, and use of project-specific compensation that is off-site and/or out-of-kind), and aims to select mitigation sites as close as possible to the watershed of impact; however, sometimes this cannot be accomplished. The 2009 USACE St. Paul District Policy accepts out-of-watershed mitigation; however, the USACE's preference is for the mitigation to be within the same watershed as a proposed project. The term "watershed approach" is defined in 33 USC § 332.2 as "an analytical process for making compensatory mitigation decisions that support the sustainability or improvement of aquatic resources in a waters. It involves consideration of watershed needs, and how locations and types of compensatory mitigation projects address those needs…"

As such, the compensatory mitigation approach by PolyMet followed the 2009 USACE St. Paul District Policy in effect at the time the proposed compensation sites were selected. Further, the Zim Site was developed in accordance with a watershed approach. In combination, the proposed compensatory mitigation is appropriate for the siting and scale of the impacts that would result from the NorthMet Project Proposed Action. As noted above for the project-specific compensation, the following compensatory mitigation siting sequence is required: on-site, in the same 10-digit HUC watershed, in the same 8-digit HUC watershed, in the same modified 6-digit watershed, in the same 4-digit HUC watershed, and then statewide.

While on-site replacement of wetlands is listed first in the sequencing, on-site conditions may not be the most suitable for successful wetland mitigation. In fact, 33 USC § 332.3(b) states that compensatory mitigation should be located where it is most likely to successfully replace lost functions and services within the watershed, not specifically on-site. Moreover, the preferred mitigation methodology stated under the 2008 Federal Mitigation Rule begins with the utilization of mitigation banks and in-lieu fee programs within appropriate service areas prior to permittee-responsible mitigation (33 USC § 332.3(b)(2)-(3)). Following the use of mitigation banks and in-lieu fee programs, the 2008 Federal Mitigation Rule states that permittee-responsible mitigation following a watershed approach (i.e., providing for mitigation in the best suitable location within the proposed impact watershed) should be used (33 USC § 332.3(b)(4)). Only after mitigation banks, in-lieu fee programs (where available), and permittee-responsible mitigation under a watershed approach have been exhausted or are infeasible should permittee-responsible mitigation through on-site and in-kind mitigation be considered (33 USC § 332.3(b)(5).

Compensatory mitigation is defined as restoration (reestablishment or rehabilitation), establishment (creation), enhancement, and/or, in certain circumstances, preservation of aquatic resources for the purposes of offsetting unavoidable adverse impacts that remain after all appropriate and practicable avoidance and minimization has been achieved (33 CFR § 332.2). When comparing the alternatives, restoration is the best approach for replacing lost functions; preservation does not replace the lost functions and creation is both slow to replace the functions and has a lower degree of success. Restoration should generally be the first option considered because the likelihood of success is greater and the impacts to potentially ecologically important uplands are reduced compared to establishment. Also, the potential gains in terms of aquatic resource functions are greater, compared to enhancement and preservation (33 CFR § 332.3(a)(2) and 40 CFR § 230.93(a)(2)). Furthermore, the 2009 USACE St. Paul District Policy guidance states that restoration is the preferred compensatory mitigation technique. Restoration sites historically supported wetlands and frequently retain some wetland components (e.g., hydric soils) even after man-made disturbances such as drainage and cropping. Restoration also applies to increasing the functional level of existing, degraded wetlands. Restoration through re-establishment involves techniques for returning wetland functions to a location where no wetland currently exists. This technique results in a gain in both wetland acres and wetland functions.

The primary goal of wetland mitigation is to restore high-quality wetland communities of the same type, quality, and function as those to be impacted to the extent practicable. To achieve that goal, state and federal guidelines were followed during the wetland mitigation planning process, with a preference placed on restoring drained wetlands over creating wetlands. The five main categories of mitigation methods considered appropriate in northern Minnesota by state and federal agencies were: 1) restoration of former or degraded wetlands, 2) enhancement of existing wetlands, 3) wetland preservation, 4) wetland creation, and 5) upland buffers.

USACE Mitigation Ratios and Financial Assurance

The 2009 USACE St. Paul District Policy applies three factors to determine compensation ratios: in-place versus out-of-place, in-kind versus out-of-kind, and in-advance versus not in-advance. These factors are defined as follows:

- In-place mitigation means the replacement of the impacted aquatic site would take place in the same 8-digit Hydrologic Unit Code (HUC) watershed as the proposed impacted resource. The USACE St. Paul District Policy uses the term "in-place" to include on-site, which is defined as an area located on the same parcel of land as the impact site, or on a parcel of land contiguous to the impact site.
- Out-of-place mitigation means the replacement of the impacted aquatic site would take place in a different 8-digit HUC watershed as the proposed impacted resource.
- In-kind mitigation means the replacement of the impacted aquatic site with a resource of a similar structural and functional type to the impacted resource (same species composition).
- Out-of-kind mitigation means the replacement of an impacted aquatic site with a resource of a different structural and functional type from the impacted resource (different species composition).
- In-advance mitigation is a form of mitigation that is designed, permitted, and constructed in advance of a permitted impact.

The temporal loss issue is addressed by the in-advance versus not-in-advance factor. The 2008 Federal Mitigation Rule states that compensation ratios of greater than 1:1 can be applied to account for factors including temporal loss and the difficulty of restoring or establishing certain wetlands/aquatic resources (33 CFR 332.3 (f)).

The 2008 Federal Mitigation Rule also states that "difficult-to-replace" wetlands/aquatic resources include bogs and forested wetlands (33 CFR 3323.3(e)(3) and Preamble, page 19633). The majority of wetlands that would be impacted by the NorthMet Project Proposed Action would be "difficult-to-replace" (coniferous bog, open bog, coniferous swamp, and hardwood swamp) (USACE 2013). The 2008 Federal Mitigation Rule includes a provision for a case-by-case determination of mitigation ratios higher than the minimum 1:1 where necessary to account for the difficulty of restoring or establishing the desired aquatic resource type and functions.

USACE St. Paul District Policy (2009) states that compensation ratios can be raised on a case-by-case basis if the impacted wetland/aquatic resource provides rare or exceptional functions, including plant communities that rate "exceptional" using MnRAM, or have a high rating using a Floristic Quality Assessment. Most of the wetlands that would be impacted by the NorthMet Project Proposed Action would generate high Floristic Quality Assessment scores for those plant community types in Minnesota (Milburn et al. 2007). Therefore, per the 2009 USACE St. Paul District Policy, the District Engineer may determine that a higher compensation ratio would be required to offset losses of wetlands that would be difficult to replace and/or provide an exceptional or high functional level/condition.

The 2009 USACE St. Paul District Policy states a base compensation ratio of 1.5:1 (1.5 credits of compensatory mitigation for every 1 acre of wetland loss), and a minimum of 1:1, with a provision for a case-by-case determination of higher ratios to account for factors including difficult-to-replace, rare, and/or exceptional wetlands/aquatic resources. For low- to moderate-quality wetlands, the 1.5:1 base ratio would apply in accordance with District Policy. For impacts to wetlands that have exceptional or high functional levels/conditions, are difficult-to-replace, and/or where there is a considerable temporal loss in replacing functions (e.g., forested wetlands), the USACE may require additional compensation in accordance with District Policy. The 1.5:1 ratio can be reduced by qualifying for the following incentives, but can be no less than a minimum 1:1 ratio:

- In-place incentive: the project-specific mitigation site is located on site or within the same 8-digit HUC watershed as the authorized wetland impacts or bank credits are purchased within the same bank service area—reduce ratio by 0.25.
- In-kind incentive: the mitigation wetlands are of the same type (same wetland plant community) as the wetlands authorized to be impacted—reduce ratio by 0.25.
- In-advance incentive: 1) a project-specific mitigation site must have wetland hydrology and initial hydrophytic vegetation established at least one full growing season in advance of the authorized wetland impacts provided initial performance standards are met, or 2) USACE-approved bank credits are purchased—reduce ratio by 0.25.

If none of these incentives are met, the minimum mitigation ratio required is 1.5:1. If one of the three incentives is met, the minimum required mitigation ratio is 1.25:1; if two or three are met, the ratio is 1:1. According to USACE St. Paul District's compensatory wetland mitigation policy (USACE 2009), requirements for mitigation can exceed the 1.5:1 mitigation ratio if the impacted wetlands provide rare or exceptional functions.

District guidance on compensatory mitigation emphasizes the consideration of a functional approach to offset proposed project impacts. While bogs and forested wetlands are characterized as difficult-to-replace, the proposed compensation sites for the NorthMet Project Proposed Action (discussed below) would be likely to achieve in-kind compensation to offset functional losses. The proposed mitigation sites were selected based on availability and the high likelihood of meeting performance criteria.

The proposed wetland restoration and enhancement performance criteria place a strong emphasis on ensuring that the proposed mitigation strategy provides for the adequate replacement of lost functions. For purposes of compensatory mitigation, the focus is on functions. The 2008 Federal Mitigation Rule specifically eliminated use of the term "values." An abbreviated MnRAM functional assessment, which was agreed upon by the USACE, was utilized to assess wetland functions for the Mine Site, Transportation and Utility Corridor, and Plant Site. Both the USACE and WCA require functions to be replaced; however, both agencies use a set of defined ratio requirements to determine the number of acres required to replace functions lost as there is currently no suitable quantitative functional assessment method in Minnesota. Based on the findings and where impacts occur (e.g., types of wetlands), the mitigation ratios and credits have been increased to take into account the functions lost due to the NorthMet Project Proposed Action. For example, additional compensatory mitigation (i.e., higher replacement ratios) is proposed to offset loss of bog wetlands, which is a difficult-to-replace wetland type. All of the wetland mitigation proposed would be restoration with a minimal component of wetland preservation; no creation of wetlands would be part of the off-site mitigation.

The USACE St. Paul District has not made a final determination of the compensation ratios that would be required. A decision on whether proposed compensation would qualify for the 0.25 incentive for in-advance requires additional information including: 1) development of performance standards that would specify the hydrology and initial vegetation to be established, and 2) number of growing seasons that wetland compensation sites would be established in advance of authorized impacts. Final determination of compensation ratios and use of incentives would be determined during permitting.

The compensatory mitigation ratios proposed in the FEIS for the NorthMet Project Proposed Action are based on recommended USACE St. Paul District guidance. They assume successful outcomes for the proposed compensatory mitigation sites. Base compensation ratios, as presented in the FEIS, for impacts on high-quality, difficult-to-replace bog and forested wetlands have been increased to 2:1 (USACE 2013). For impacts on low- and moderate-quality wetlands, a base ratio of 1.5:1 would be applied (USACE 2013). In-kind, in-place, and in-advance incentives to reduce the recommended base ratios would be considered at the time of permitting. USACE St. Paul District guidance on recommended compensation ratios takes these incentives into account. The final decision on compensatory mitigation ratios and the use of incentives would be determined at the time of the CWA Section 404 permit decision based on current District guidance.

USACE compensatory wetland mitigation is regulated by 33 CFR 332.3(n), which describes the use of financial assurances. The District Engineer may determine that financial assurances are unnecessary for a compensatory mitigation project if alternate mechanisms are available to ensure a high level of confidence that the mitigation would be provided and maintained.

The CWA Section 404 permit and the Permit to Mine (see below) both have financial assurance mechanisms to ensure successful completion of the: 1) compensatory mitigation (in the case of the CWA Section 404), and 2) NorthMet Project Proposed Action (in the case of the Permit to Mine). Financial assurance can be a condition of a permit under CWA Section 404, and the MDNR has authority to require a performance bond or other instrument that meets criteria in rule for compliance with the conditions of the Permit to Mine. Section 3.2.2.4 provides a discussion of the financial assurance for the NorthMet Project Proposed Action.

The USACE generally requires compensatory mitigation for adverse impacts to aquatic resources under 33 CFR 332.3(n). This regulation establishes standards and criteria for the general compensatory mitigation requirements of the Section 404 permit. Specifically, 33 CFR 332.3(n)(1) addresses financial assurance stating:

> The district engineer shall require sufficient financial assurances to ensure a high level of confidence that the compensatory mitigation project will be successfully completed, in accordance with applicable performance standards.

Financial assurance for the direct wetland impact mitigation would be required until success of the mitigation sites can be assured. While this wetland mitigation would be expected to be approved and constructed in advance of any authorized wetland impacts, it is unclear whether these sites would be well-enough established for financial assurance to be waived. The USACE would also consider the application of financial assurances for potential indirect wetland effects and monitoring. The USACE would require consideration of financial assurances during the permitting process.

State Mitigation Ratios and Financial Assurance

Minnesota Rules, part 7050.0186, requires compensatory mitigation to be sufficient to ensure replacement of the diminished or lost designated uses of the wetland that was physically altered. To the extent prudent and feasible, the same types of wetlands impacted are to be replaced in the same watershed, before or concurrent with the actual alteration of the wetland. In addition, the WCA states that for wetlands in counties where 80 percent or more of pre-settlement wetlands exist, including St. Louis County, minimum replacement ratio requirements are as determined by mitigation location and type (see Table 5.2.3-16). Based on the WCA wetland replacement standards (*Minnesota Rules*, part 8420.0522, subpart 4), the required replacement ratio would be either 1:1 or 1.5:1. For those wetlands that would be replaced in the watershed with the same wetland type, the base replacement ratio that would likely be required is 1:1, and for those wetlands that would be replaced outside of the watershed, the ratio would be increased to 1.5:1. The actual replacement ratios required in permitting may be more than the minimums shown in Table 5.2.3-16, subject to the evaluation of wetland functions.

Table 5.2.3-16 Summary of Wetland Mitigation Ratios

Regulation	Location of Impacts	Replacement	Minimum Replacement Ratio
Minnesota Administrative Rules			
	Minimum Replacement Ratios: Wetland Banking		
	>80% area or agricultural land	Outside bank service area	1.5:1
		Within bank service area	1:1
	Minimum Replacement Ratios: Project-Specific		
	>80% area or agricultural land	Outside major watershed or out-of-kind	1.5:1
		Within major watershed and in-kind	1:1
USACE			
	>80% area	Not in-place, in-kind nor in-advance	1.5:1
		In-place, in-kind and in-advance	1:1

Sources: Wetland Conservation Act (MDNR 1991); USACE 2009.

Minnesota Rules, part 8420.0522 outlines the replacement standards for wetlands as regulated under WCA. *Minnesota Rules*, part 8420.0522, subparts 9(A) and (B) discuss financial assurance requirements for compensatory wetland mitigation stating:

> (A) For wetland replacement that is not in advance, a financial assurance acceptable to the local government unit must be submitted to, and approved by, the local government unit to ensure successful replacement. The local government unit may waive this requirement if it determines the financial assurance is not necessary to ensure successful replacement. The local government unit may incorporate this requirement into any financial assurance required by the local government unit for other aspects of the project.
> (B) The financial assurance may be used to cover costs of actions necessary to bring the project into compliance with the approved replacement plan specifications and monitoring requirements.

Financial assurance for wetland replacement could be waived by the MDNR which has the approval authority under WCA (through the Permit to Mine) to determine if financial assurance is required.

Financial assurance for wetland replacement could be waived by the MDNR which has the approval authority under WCA (through the Permit to Mine) to determine if financial assurance is required. Additionally, the MDNR has the authority through the Permit to Mine process to require a performance bond or other instrument that meets criteria in rule as means to ensure compliance with *Minnesota Rules,* chapter 6130, which includes successful completion of reclamation and closure activities. Please refer to Section 3.2.2.4 for more information on financial assurance.

The financial assurance requirements would be part of the WCA permitting process for the NorthMet Project Proposed Action. Wetland replacement for the NorthMet Project Proposed Action is anticipated to be approved and constructed in advance of any authorized wetland impacts (under WCA approval) and, therefore, may not require financial assurance. Financial assurance requirements for WCA would be determined during permitting.

Section 401 of the CWA requires the MPCA to certify that all projects that receive a federal license or permit are in compliance with state and federal water quality guidelines. Therefore, as part of their review, the MPCA conducts a separate review for compliance with water quality standards and policies and guidelines, which includes mitigation for wetland impacts and approval of the wetland replacement ratios. This review process must be completed before the DA permit pursuant to Section 404 of the CWA can be issued.

Summary of Mitigation Requirements

PolyMet would ultimately need to satisfy both the federal and state mitigation requirements. The number of mitigation credits to be earned by replacement wetlands would be determined during permitting by the appropriate agencies reviewing the wetland mitigation plan. This would be based on the extent to which the sites meet the target goals established during permitting. These include, among other things, restoration of wetland appropriate hydrology and the establishment of a target plant community or type. The NorthMet Project Proposed Action is estimated to directly impact 913.8 acres. Depending on the location, type, and timing of compensatory mitigation, the minimum required amount of replacement wetlands for direct impacts, based upon USEPA recommendations, could potentially range from 913.8 acres up to 1,827.6 acres (i.e., 1:1 up to 2:1 compensation ratios).

The USACE has concluded that the mitigation sites selected and the wetland credits generated at the three mitigation sites would be acceptable for use in compensating for direct wetland losses. The USACE has not made a final decision on the mitigation ratios that would be required to compensate for direct wetland impacts; if fully successful, it is likely these three mitigation sites would generate sufficient credits to compensate for the 940.7 acres of wetlands directly impacted. In the event that not all of the credits generated by these sites are utilized to compensate for direct wetland impacts, any excess credits could be used to compensate for indirect losses (USACE 2015a). The current proposed mitigation presented below shows that PolyMet could have an excess of mitigation credits from the three mitigation sites if the mitigation sites are successful and meet the performance standards. However, it is understood that mitigation sites sometimes are not fully successful; contingency plans (discussed below) would be developed for the NorthMet Project Proposed Action and approved during permitting. In the event that additional wetland mitigation is required for direct impacts, it would be consistent with current USACE guidelines which include a watershed approach. The USACE encourages the development of mitigation for foreseeable indirect effects, and PolyMet is exploring mitigation options for indirect effects.

Financial assurance for the direct wetland impact mitigation would be required until success of the mitigation sites can be assured. While this wetland mitigation is expected to be approved and constructed in advance of any authorized wetland impacts, it is unclear whether these sites would be well enough established for financial assurances to be waived. The USACE would also consider the application of financial assurances for potential indirect wetland effects and monitoring. Both the USACE and state would require consideration of financial assurances during the permitting process.

Wetland mitigation for potential indirect wetland effects would be determined by the agencies during permitting. If the NorthMet Project Proposed Action were to be permitted and constructed, wetland monitoring would be conducted to determine if the NorthMet Project Proposed Action caused future indirect wetland effects. PolyMet is exploring mitigation options for indirect effects. Wetlands hydrology and vegetation would be monitored, and additional monitoring locations may be considered during permitting. A component of the monitoring plan would be based on those wetlands that have a high likelihood of indirect effects as a result of groundwater drawdown. If the monitoring determined that indirect wetland effects had occurred, additional compensation may be required if determined necessary based on the monitoring results. In the event that the required wetland monitoring identified additional indirect effects, permit conditions would likely include a plan for adaptive management practices to be implemented, such as expanded monitoring and hydrologic controls. Additionally, compensatory mitigation may be required if additional impacts are identified during annual reporting.

Wetland Mitigation Study Limits

The NorthMet Project area lies in St. Louis County in the St. Louis River Watershed (#3) within the Lake Superior basin (wetland mitigation Bank Service Area #1). Locations for wetland mitigation projects were evaluated in the following priority order:

- On-site;
- Off-site in the St. Louis River Watershed (same 8-digit HUC);
- Off-site in the Great Lakes Basin (same 4-digit HUC); and
- Off-site in an adjacent 4-digit HUC, selecting an 8-digit HUC as close as possible to the impacted site.

Each of these potential locations areas is described below.

On-site Mitigation

In accordance with the USACE's St. Paul District Compensatory Wetland Mitigation Policy (USACE 2009) and state guidelines, the potential for creating wetlands on-site was considered first. The Wetland Management Plan (PolyMet 2015c) identified the potential for on-site restoration during reclamation. On-site wetland restoration (101.8 acres) is planned in the following areas: temporary Category 2/3 Stockpile, Overburden Storage and Laydown Area, some haul roads and adjacent ditches, and WWTF ponds and process water ponds. Establishment of on-site wetlands is expected to occur during reclamation. Of the 101.8 acres of planned on-site wetland restoration, 72 acres of wetlands may be created at the temporary mine stockpile areas after removal of the Category 2/3 Stockpile and the Overburden Storage and Laydown Area. The remaining acres of wetland restoration would be within the other above mentioned Project areas. Design of wetland restoration areas would be further evaluated in the detailed reclamation design and would include the preservation of upland buffer around the perimeter of the wetland restoration areas. The establishment of the estimated 101.8 acres of on-site wetland restoration is not included in the mitigation credits. The generation of wetland credits in these areas has the potential to be used on a contingency basis, but compensatory credit would not be considered at this time for a variety of reasons, including the fact that any restoration efforts would not occur for many years.

Off-site Mitigation

The initial wetland mitigation study scope focused on the areas containing greater than 80 percent of their historic wetland resources as defined in the WCA. This area was selected as the initial study area to comprehensively cover the priority mitigation areas, with the understanding that suitable opportunities may not be available within each priority area.

Available wetland mitigation banking credits that were available for purchase by PolyMet were evaluated in portions of bank service areas 1 through 6 and found to be insufficient to satisfy the compensatory mitigation requirements for the NorthMet Project Proposed Action. Subsequently, a GIS analysis was performed to identify potential wetland mitigation sites within the defined study area. The primary goal of the analysis was to identify large, potentially drained wetlands located primarily on private or tax-forfeit land within the study area to provide preliminary data for more detailed ground investigations to proceed. To achieve the goal of the mitigation plan, which is to replace lost wetland functions using compensatory wetland types in-kind to the degree practicable, areas where drained wetlands could be restored were preferable over areas where wetlands could be created (Barr 2008m). Other siting criteria used in the GIS analysis included potential wetland enhancement areas, potential wetland preservation areas, and potential wetland creation areas (Barr 2008m). Sites were identified by overlaying and evaluating numerous existing spatial data sources to locate those sites with the greatest mitigation potential. Some of the data sources utilized included the following:

- Geomorphology/soil types (Loesch 1997);
- Land ownership (separated by county/state/federal and private ownership) (MLMIC 1983);
- Land slope/Digital Elevation Model (MLMIC 1999);
- Streams/ditches (MDNR 1980);
- Major watersheds; and
- Land cover (Loesch 1998).

The analysis was conducted by establishing specific filtering criteria to identify potential wetland mitigation sites. The general filtering criteria included the following:

- Land slopes of less than or equal to 1 percent slope;
- Areas mapped as peat or lacustrine geomorphology;
- Private or county tax-forfeit property;
- Areas within 1.1 miles of a ditch; and
- Areas meeting all of the above criteria with at least 100 contiguous acres.

The analysis was limited to sites with more than 100 acres of wetland mitigation potential due to the anticipated difficulties in planning numerous, small wetland mitigation projects, and the desire to identify opportunities that were feasible. In addition, the NorthMet Project Proposed Action represented an opportunity to restore large wetland systems and provide greater public and ecological benefit that are typically not available with smaller projects.

This GIS analysis resulted in the development of a polygon data layer, which contained nearly 900 areas with potential for mitigation in the study area. This analysis resulted in several findings.

First, a large proportion of the study area was in state and federal ownership. Discussions with the various state and federal entities regarding wetland mitigation on their respective properties resulted in the following conclusions:

- The USFS was unable to provide assurances that they would be able to protect restored wetlands on federal lands in perpetuity as required by wetland regulations.
- The State of Minnesota provided general criteria for restoring wetlands on state lands. The criteria required either a justification for how revenue production (i.e., peat mining, forest harvest) would not be affected or provide land in exchange that had a comparable value. PolyMet determined that these were not acceptable criteria and the state provided no certainty that the NorthMet Project Proposed Action would be viable if PolyMet expended 1 to 2 years of effort to meet the imposed criteria. This conclusion was supported in part by an effort to restore wetlands on Site 8362, a partially state-owned site, as discussed below.
- The Board of Water and Soil Resources has oversight regarding the administration of the Minnesota WCA. The Board of Water and Soil Resources provides guidance and interpretation of the WCA rules and has the most extensive experience with application of the rules. The Board of Water and Soil Resources' experience with wetland restoration on tribal lands found that impressing permanent conservation easements granted to the state was not possible to protect the restored wetlands.
- PolyMet had a signed agreement with St. Louis County near Floodwood to restore wetlands as mitigation (see discussion on Site 8362 below) for the NorthMet Project Proposed Action. The agreement was nullified by the state courts. In addition, legal proceedings through the state legislature and state court would have been required for ditch abandonment and for placement of a conservation easement on the land.

Therefore, it was determined that, because of these uncertainties and risks, mitigation on state and federal lands represented a minimal potential for a private enterprise to conduct compensatory wetland mitigation on these lands.

Second, many of the wetland systems within the study area have not been affected by historic drainage or other significant alteration. In areas lacking significant alterations, wetland preservation and establishment of upland buffers constitute the primary methods to generate wetland compensation credits within the study area. Wetlands that meet the criteria for wetland restoration credits include completely drained wetlands, partially drained wetlands, and wetlands with at least a 20-year history of agricultural production (Barr 2008m).

Third, much of the study area was characterized by surface geology that is not indicative of large wetland systems prone to easy drainage. The majority of the Arrowhead region, including Cook, Lake, and much of St. Louis counties, is mapped with surface geology typified by steep, igneous bedrock terrains; rolling surficial deposit plains; and rolling to undulating areas of supraglacial drift (Loesch 1997). These geomorphological associations are also typically associated with steeper land slopes containing few drained or sufficiently altered wetlands.

Opportunities exist for accomplishing the preferred method of wetland compensation—restoration—within the St. Louis River Watershed and northeastern Minnesota in general. Tens of thousands of acres of peatlands are adversely affected by ditch systems. Specific to the St. Louis River Watershed, hundreds of acres of ditched, hydric soils in agricultural use exist in the central portion of the watershed. A determination by the USACE as to the practicality of wetland restoration within one or more of these sites has not been completed. The wetland mitigation opportunities were determined to not be feasible or prudent for one or more of the following different factors: private property, public roads, and active gravel operations that could be hydrologically impacted by wetland restoration; insufficient wetland drainage; insufficient agricultural history; existing public ditches that could not be abandoned; potentially contaminated soils; unwilling landowners; considerable existing upstream drainage through the site; active pursuit of the properties by others; and/or presence of severed mineral rights on many of the lands (Barr 2008m).

St. Louis River Watershed (Same 8-digit HUC)

Approximately 101 potential wetland mitigation areas were identified within the St. Louis River Watershed and other watersheds tributary to Lake Superior. The specific areas identified as having potential for wetland restoration were evaluated in more detail by reviewing NWI maps, plat maps, recent aerial photographs, and USGS topography to find the sites with the highest potential.

The sites with the highest potential were further evaluated by conducting site visits and meetings with various regulatory agencies. The majority of these potential mitigation sites, however, were eliminated from further consideration due to issues that included: lack of wetland drainage or altered land uses that would qualify as wetland restoration or enhancement (e.g., unaltered sites can qualify for regulatory compensation credits such as wetland preservation and upland buffers); infeasibility of planning numerous small projects; potential flooding of private property, roads, or other infrastructure; upstream ditch drainage through the potential wetland restoration areas that would have to be maintained; potential soil contamination; regulatory applicability; complex land ownership; existing peat mining operations; and legal considerations.

For purposes of the CWA regulatory program, the term *highest potential* is not the applicable standard for evaluating compensatory mitigation. Rather, *practicable* is the standard used in conjunction with the fundamental goal of compensatory mitigation: replace lost wetland functions, in-kind and in-place, to the extent practicable. Potential compensation sites are not limited to those that are least difficult and/or least expensive. Sites that have some greater difficulty and/or cost may be practicable, particularly if they are the only sites that would meet the fundamental goal of compensatory mitigation.

The area around Meadowlands and Floodwood appeared to have the most suitable characteristics. Two contiguous areas in this region, covering approximately 270 square miles, were mapped as level peat. The one site found to be initially feasible was designated as Site 8362. Site 8362 was located within the same watershed as the NorthMet Project area, had the greatest potential for wetland restoration with limited peripheral issues, and contained the potential to restore bog wetlands similar to those proposed for effect. Thus, Site 8362 was initially selected for further study and PolyMet signed an agreement with St. Louis County. Approximately 640 acres of the site are owned by the State of Minnesota with the remainder designated as tax-forfeit land. Further pursuit of wetland restoration activities at Site 8362 was halted for a number of reasons that rendered the site impracticable, including the following:

- The district court nullified PolyMet's agreement with St. Louis County in April 2007, thereby not allowing any further study of the site.
- There was a lack of local support, and there was, in fact, broad opposition from local residents.
- Extensive hydrologic monitoring and evaluation was required to document the degree of drainage at the site to support the proposed mitigation credits. This would have required long-term monitoring to adequately demonstrate the drainage and there was uncertainty regarding the outcome of such monitoring. Such monitoring activities were no longer allowed after April 2007 due to the district court action.
- Preservation credits would only be allowed where there was a demonstrable threat that could be eliminated (i.e., peat mining, tree-topping, or all-terrain vehicle activity). There are only about 400 acres of documented minable peat and the County had indicated they were unlikely to agree to limit tree-topping activities. Therefore, the ability to show a demonstrable threat that would meet regulatory criteria appeared unlikely.
- Even if the agreement with the county was reestablished, that agreement would have required ditch-abandonment proceedings in district court with public hearings that would have likely been opposed by local residents.
- The agreement with the County (if it were to be reinstated) would have also required receiving legislative authorization to place a permanent conservation easement over the restoration area. The likelihood of that was uncertain.

One additional wetland restoration area has been further identified since the DEIS within the NorthMet Project area watershed. The Zim Sod (Zim) wetland mitigation site is located in St. Louis County in the St. Louis River major watershed (#3), within the Lake Superior basin (bank service area #1) (see Figure 5.2.3-30).

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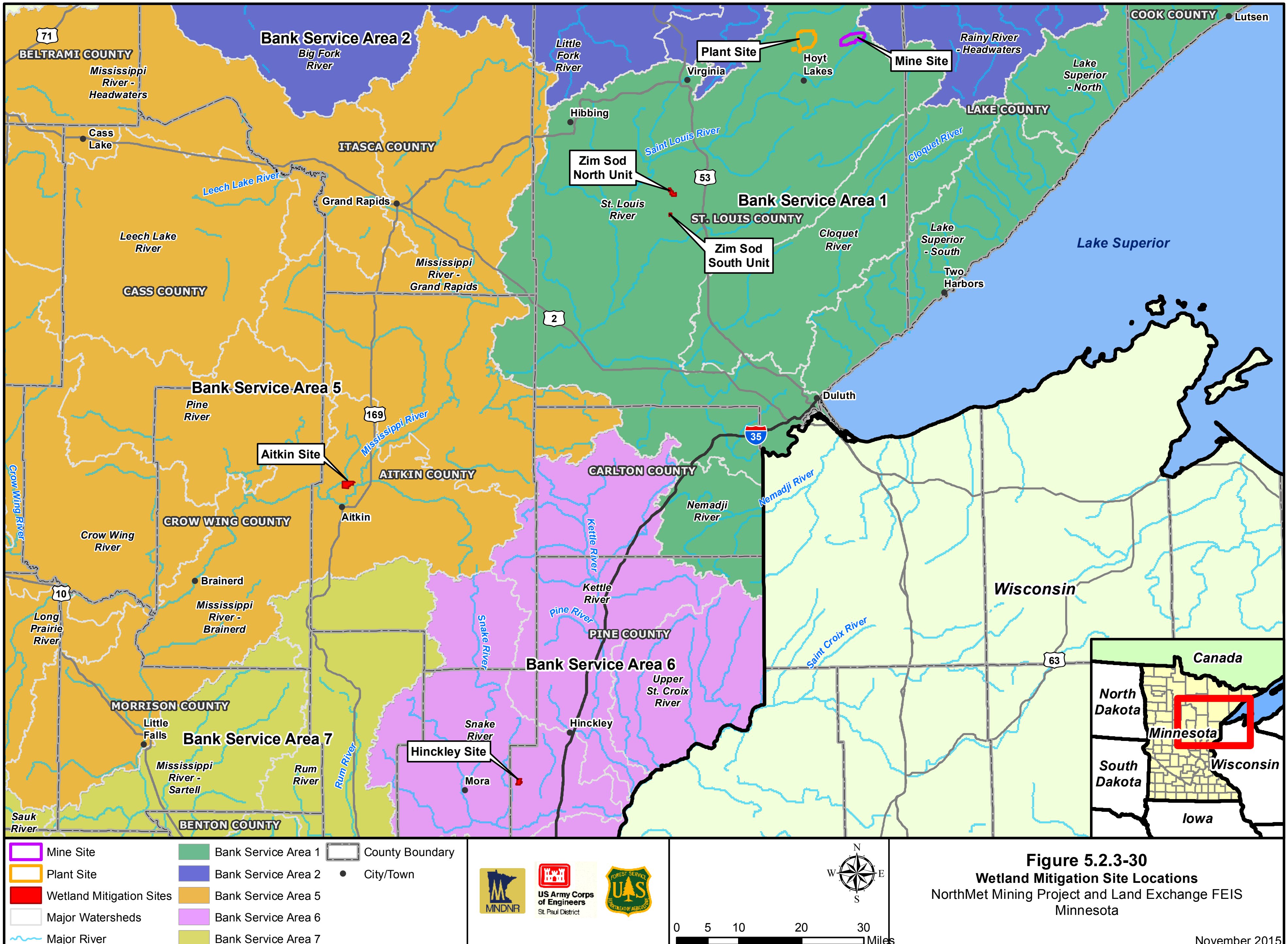

Figure 5.2.3-30
Wetland Mitigation Site Locations
NorthMet Mining Project and Land Exchange FEIS
Minnesota

November 2015

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Great Lakes Basin (Same 4-digit HUC)

With Site 8362 no longer a feasible mitigation option, pursuit of the high-priority sites identified in watersheds adjacent to the St. Louis River Watershed was initiated along with the continued search for existing bank credits, wetland banks in various stages of planning, and various other potential wetland mitigation opportunities located in central and northwestern parts of Minnesota.

Fifteen sites were determined to have high potential for wetland mitigation in watersheds located adjacent to the St. Louis River Watershed. Of these, 10 sites were evaluated in the Mississippi River-Grand Rapids Watershed, three sites were evaluated in the Kettle River Watershed, and two sites were evaluated in the Nemadji River Watershed. After further study, these sites were eliminated from further consideration due to issues that included: lack of wetland drainage or altered land uses that would fit the regulatory requirements for restoration credit; potential flooding of roads or other infrastructure; upstream ditch drainage through the wetland that would have to be maintained; complex land ownership; existing peat mining operations; and legal considerations.

Adjacent 4-digit HUC, Selecting an 8-digit HUC as Close as Possible to the Impacted Site

Ten potential wetland mitigation sites, initially determined to have some potential, were located in watersheds neighboring the watersheds adjacent to the St. Louis River. These sites were evaluated to determine the relative potential for mitigation, the level of risk and uncertainty, and the likely costs. These sites were primarily located in Aitkin County.

Eight of these 10 sites were eliminated from further consideration due to issues that included unwilling landowners, significant private properties that would be hydrologically affected by wetland restoration, insufficient agricultural history, insufficient wetland drainage to qualify for restoration credit, considerable existing upstream drainage through the site, or active pursuit of the properties by others. Two priority properties were identified with willing landowners that had the potential to accomplish compensatory wetland mitigation for nearly the entire NorthMet Project area. These sites are located in watersheds neighboring those adjacent to the St. Louis River and outside the 1854 Ceded Territory. These two sites included the Aitkin mitigation site (Aitkin) and the Hinckley mitigation site (Hinckley). The Aitkin and Hinckley sites are located within the Mississippi River Basin (4-digit HUC) and 8-digit HUC watersheds of Elk-Nokasippi #10 and Snake River #36, respectively (see Figure 5.2.3-30). The Aitkin Site is located in Aitkin County in bank service area #5 and the Hinckley Site is located in Pine County in bank service area #6 (see Figure 5.2.3-30). USACE St. Paul wetland compensatory mitigation replacement ratios are based on three factors: in-place versus out-of-place, in-kind versus out-of-kind, and in-advance versus not in-advance (see Table 5.2.3-16). As previously stated, the USACE St. Paul District and the state have not made a final determination of the compensation ratios that would be required for the NorthMet Project Proposed Action. Base compensation ratios for USACE would be either 2:1 or 1.5:1 and for the state 1.5:1 or 1:1 depending on the location, quality of the wetland, wetland type, and timeframe of the compensation. The final decision on compensatory mitigation ratios would be determined during permitting.

Off-site Wetland Restoration Projects

The off-site wetland restoration projects, as defined in the Wetland Management Plan (PolyMet 2015c), that would provide required mitigation for the NorthMet Project Proposed Action wetland impacts include Hinckley, Aitkin, and the Zim wetland mitigation sites (see Figure 5.2.3-30). As previously noted, the Zim site is located within the NorthMet Project area 8-digit HUC watershed, whereas Aitkin and Hinckley are located outside the 8-digit HUC watershed area. The mitigation would be considered in advance if the initial phases of restoration on all of the proposed off-site wetland mitigation sites would be completed at least one full growing season in advance of the authorized wetland impacts provided initial performance standards are met for which the mitigation would compensate.

The proposed mitigation is expected to compensate for all the direct wetland impacts, as well as the indirect fragmentation impacts—a total of 940.7 acres (see Tables 5.2.3-18 and 5.2.3-19). The majority of the credits would be in-kind mitigation and nearly one-third of the credits would be from within the NorthMet Project area watershed (see Tables 5.23-17, 5.2.3-18, 5.2.3-19). Based on PolyMet’s current mitigation proposal and assuming the mitigation efforts are fully successful and target communities are established, 83 percent of the impacts to coniferous bogs would be mitigated by in-kind and in-place credits, or 439.9 coniferous bog credits; the remaining 17 percent would be replaced out-of-kind. Out-of-kind credits would be used to mitigate impacts on wet meadow, shallow marsh, deep marsh, open bog, and coniferous bog communities; these would not be replaced in-kind because of hydrological and ecological constraints at the proposed mitigation sites. Forty-seven percent of the wetland impacts are currently proposed to be replaced in-kind, in-place, and before the impacts occur on site. An additional 29 percent of the proposed impacts are proposed to be replaced in-kind and before the impacts occur on site. Most of the additional mitigation credits that are proposed outside of the watershed would fulfill mitigation requirements above the minimum 1:1 ratio.

Mitigation credits assumed for calculations include 100 percent credit for restoration of drained/farmed wetlands, 75 percent credit for creation of on-site wetlands, 50 percent credit for partially drained wetlands and ditches, 25 percent credit for upland buffer, and 12.5 percent credit for preservation. The final mitigation credits required to offset the impacts of the proposed NorthMet Project Proposed Action would be determined by the agencies during wetland permitting. The amount of credit generated by the mitigation sites would ultimately be determined by the permitting agencies. This would be based on the extent to which the sites meet the target goals established during permitting. These include, among other things, restoration of wetland appropriate hydrology and the establishment of a target plant community or type.

Aitkin Site

The Aitkin Site is currently an active sod farm that has been drained by ditches and subsurface drain tiles. The overall objective of the restoration plan is to restore the hydrology by removal of the internal drainage system and the construction of outlets that regulate the required hydrological conditions (Barr 2008m). The site has also been used for sod, wheat, soybeans, sunflowers, and wild rice production. The 1,070-acre site is located north of the city of Aitkin, Minnesota, in Aitkin County. The site is in the Elk-Nokasippi major watershed within bank service area #5, adjacent to bank service area #1 where the NorthMet Project area would be located.

The site is located outside of the NorthMet Project area watershed. The proposed wetland mitigation area includes 808.3 acres of wetland restoration and 83.2 acres of upland buffer preservation. Restoration methods on the site are designed to restore the following wetland types: Type 3 (shallow marsh), Type 6 (shrub-carr), Type 7 (hardwood swamp), and Type 7 (coniferous swamp).

Hydrology monitoring at the Aitkin Site began in 2012, as well as at a reference wetland site, to characterize the pre-restoration hydrology, and continued in 2013 and 2014 (PolyMet 2015c). Based on the 3 years of monitoring data at the Aitkin Site, monitoring indicates that the majority of the site no longer has wetland hydrology. Results of 2014 monitoring were submitted to the USACE and the MDNR in 2015 (Barr 2015k). Concurrence of the monitoring results will be conducted by permitting agencies during the permitting process (PolyMet 2015c).The state and federal agencies have not yet made a determination on the drainage status of the mitigation site (i.e., drained, partially drained, etc.); this determination will be made during permitting, including credit ratios.

The minimum replacement ratio that would be allowed by the USACE is 1:1 (USACE 2009) for those wetlands that would be replaced with the same wetland type, and at least one full growing season in advance of the authorized wetland impacts provided initial performance standards are met; however, base compensation ratios for impacts on high-quality, difficult-to-replace bog and forested wetlands would be increased to 2:1 (USACE 2013). For impacts on low- and moderate-quality wetlands, a base ratio of 1.5:1 would be applied (USACE 2013). In-kind, in-place, and in-advance incentives to reduce the recommended base ratios would be considered at the time of permitting (see Tables 5.2.3-17 and 5.2.3-18). Compensation proposed at the Aitkin Site would be expected to meet in-kind compensation, resulting in a compensation ratio for high-quality wetland impacts of 1.75:1, and if in advance, the ratio would be reduced to 1.5:1. For low- to moderate-quality wetlands, the recommended base ratio of 1.5:1 would be required and could be reduced to 1.25:1 if in-kind and 1:1 if also in-advance. Under the Minnesota WCA, the replacement ratio that would likely be required is 1.5:1, because the Aitkin Site wetlands are out of the NorthMet Project area watershed (see Tables 5.2.3-17 and 5.2.3-19).

The site-specific mitigation design proposed by PolyMet includes the following methods of restoration to receive wetland mitigation credits, which would be reviewed and approved determined during permitting:

- Restoration of effectively drained wetland (restoration via reestablishment) on 758.3 acres for 100 percent mitigation credit or 758.3 credits;
- Hydrologic restoration of 50.1 acres of partially drained wetland (restoration via rehabilitation) to receive 50 percent credit or 25.0 credits; and
- Restoration of native vegetation on 83.2 acres of uplands and filled ditches, for 20.8 credits based on the 25 percent credit calculation for upland buffer.

The vegetation and hydrology would likely be restored to the site over a 1- to 2-year construction period, followed by up to 20 years of management, or more if warranted. The restoration work is expected to begin on the site after permit approval such that the initial phases of the restoration would be completed more than one full growing season before the impacts from the NorthMet Project Proposed Action would occur (PolyMet 2013o). Performance standards have been developed for the mitigation site to guide the restoration activities and to monitor whether vegetation and hydrology are meeting the design goals. To protect the site, a permanent conservation easement or deed recording would be prepared and recorded at approval of permit or prior to impact, as required by the permitting agency. The wetland restoration area would be monitored for up to 20 years beginning in the first full growing season after completing hydrologic restoration and ending upon certification by the USACE and MDNR that the wetlands have met performance standards (PolyMet 2013o; PolyMet 2015c).

The objective of the wetland restoration is to restore hydrology within the site by removing the internal drainage system and constructing outlets to establish specific hydrologic conditions that would meet the goals and performance standards established for the site and approved by the appropriate agencies. The hydrology would be restored utilizing broad, rock-lined weirs, and eliminating culverts with the exception of the culverts in a couple of locations. Once hydrology restoration has been achieved, an adaptive management program is proposed to guide development of the restored wetlands to achieve the targeted conditions. The vegetative restoration of the herbaceous layer in each wetland community would be conducted to promote the establishment of characteristic native species that are present in the seed bank or that may be transported to the area from adjacent wetlands. The goal of the restoration is to provide a setting and conditions in which the restoration areas would be restored to naturally self-sustaining and functioning wetlands to the extent feasible. The proposed wetland communities have been planned in areas that appear to match the natural hydrologic characteristics of each community type. However, during the restoration process, it is expected that the defined areas and wetland communities may change to some degree and the plan would allow for adaptation to the conditions. The overall plan for the Aitkin Site includes the following components: general site preparation, natural regeneration in all proposed communities, seeding/planting of shallow marsh and shrub-carr communities, planting hardwood swamp community, seeding/planting of coniferous swamp communities, and upland area establishment. General site preparation would be prior to or concurrent with hydrological restoration activities. Existing, non-native, and invasive vegetation would be removed through mechanical means or herbicide application. Diverse, native wetland vegetation is expected to develop in the restoration wetlands from the existing seed bank and from the wetland vegetation that surrounds the wetland restoration site through vegetative propagation and seed dispersal mechanisms. At the end of the second growing season these areas would be assessed to determine if additional seeding is required. These areas include shallow marsh, emergent fringes, and shrub-carr.

Hardwood swamp communities would require planting of trees in the spring of the second or third year after construction, depending on the success of herbaceous species establishment, the presence of invasive species, and the stability of the hydrology. Coniferous swamp communities would be established initially by direct-seeding tamarack in the spring.

Vegetation in the existing upland areas would be managed to promote natural succession of the existing plant communities. The primary maintenance activity would be control of non-native invasive species and seeding to develop diverse, native communities.

Hinckley Site

The Hinckley Site currently has about 375 acres under agricultural production and has been drained by ditches and sub-surface drain tiles. This 511-acre site is located southwest of the city of Hinckley, Minnesota at the intersection of Sod Road and Highway 107. The mitigation site is located in Pine County in the Snake River major watershed (#36) within bank service area #6, adjacent to bank service area #1 where the NorthMet Project area is located. The overall objective of the Hinckley restoration plan is to restore the hydrologic connection between upstream watersheds and the restoration site and to disable the internal drainage system on-site. The restoration process would start with activities to restore site hydrology (Barr 2008m).

The site is located outside of the NorthMet Project area watershed. The proposed wetland mitigation area includes 286.2 acres of wetland restoration and 91.2 acres of upland buffer preservation. Restoration methods on the site are designed to restore the following wetland types: Type 2 (fresh wet meadow), Type 2 (sedge meadow), Type 6 (shrub-carr), Type 6 (alder thicket), and Type 7 (hardwood swamp).

Hydrology monitoring at the Hinckley Site began in 2014, as well as at two reference wetland sites, to characterize the pre-restoration hydrology (PolyMet 2015c). The monitoring locations did not meet the minimum criteria for wetland hydrology in 2014. Results of 2014 monitoring were submitted to the USACE and the MDNR in 2015 (Barr 2015l). Concurrence of the monitoring results will be conducted by permitting agencies during the permitting process (PolyMet 2015c). The state and federal agencies have not yet made a determination on the drainage status of the mitigation site (i.e., drained, partially drained, etc.); this determination will be made during permitting, including credit ratios.

The minimum replacement ratio that would be allowed by the USACE is 1:1 (USACE 2009) for those wetlands that are replaced with the same wetland type, and at least one full growing season in advance of the authorized wetland impacts provided initial performance standards are met; however, base compensation ratios for impacts on high-quality, difficult-to-replace bog and forested wetlands would be increased to 2:1 (USACE 2013). For impacts on low- and moderate-quality wetlands, a base ratio of 1.5:1 would be applied (USACE 2013). In-kind, in-place, and in-advance incentives to reduce the recommended base ratios would be considered at the time of permitting (see Table 5.2.3-17 and Table 5.2.3-18). Compensation proposed at the Hinckley Site would be expected to meet the in-kind incentive, resulting in a compensation ratio for high-quality wetland impacts of 1.75:1, and if in-advance, the ratio would be reduced to 1.5:1. For low- to moderate-quality wetlands, the recommended base ratio of 1.5:1 would be required and could be reduced to 1.25:1 if in-kind and 1:1 if also in-advance. Under the Minnesota WCA, the replacement ratio that would likely be required is 1.5:1, because the Hinckley Site wetlands are out of the NorthMet Project area watershed (see Tables 5.2.3-17 and 5.2.3-19).

The site-specific mitigation design proposed by PolyMet includes the following methods of restoration to receive wetland mitigation credits, which would be reviewed and approved determined during permitting:

- Restoration of effectively drained wetlands (restoration via reestablishment) on 277.4 acres for 100 percent mitigation credit or 277.4 credits;
- Hydrologic restoration of 8.7 acres of partially drained wetlands (restoration via rehabilitation) to receive 50 percent credit or 4.4 credits; and
- Restoration of native vegetation on 91.2 acres of uplands and filled ditches, for 22.8 credits based on the 25 percent credit calculation for upland buffer.

The vegetation and hydrology would likely be restored to the site over a 1- to 2-year construction period, followed by up to 20 years of management or more, if warranted. The restoration work is expected to begin on the site after permit approval such that the initial phases of the restoration would be completed more than one full growing season before the impacts of the NorthMet Project Proposed Action would occur (PolyMet 2013o). Performance standards have been developed for the mitigation site to guide the restoration activities and to monitor whether vegetation and hydrology are meeting the design goals. To protect the site, a permanent conservation easement or deed recording would be prepared and recorded at the time of permit approval or prior to impact, as required by the permitting agency. The wetland restoration area would be monitored for up to 20 years beginning in the first full growing season after completing hydrologic restoration and ending upon certification by the USACE and MDNR that the wetlands have met performance standards (PolyMet 2013o; PolyMet 2015c).

The objective of the wetland restoration is to restore the hydrologic connection between the upstream watersheds and the site and disable the internal drainage system within the site. The hydrology would be restored by filling ditches and utilizing broad, rock-lined overflow weirs, and eliminating culverts where possible to establish specific hydrologic conditions that would meet the goals and performance standards established for the site and approved by the appropriate agencies. Once hydrology restoration has been achieved, an adaptive management program is proposed to guide development of the restored wetlands to achieve the targeted conditions.

The vegetative restoration of the herbaceous layer in each wetland community would be conducted to promote the establishment of characteristic native species that are present in the seed bank or that may be transported to the area from adjacent wetlands. The goal of the restoration is to provide a setting and conditions in which the restoration areas would be restored to naturally self-sustaining and functioning wetlands, to the extent feasible. The proposed wetland communities have been planned in areas that appear to match the natural hydrologic characteristics of each community type. However, during the restoration process, it is expected that the defined areas and wetland communities may change to some degree and the plan would allow for adaptation to the conditions.

The overall plan for the Hinckley Site includes the following components: general site preparation, natural regeneration in all proposed communities, seeding/planting of sedge/wet meadow and shrub-carr/alder-thicket communities, management of the existing hardwood swamp community, and upland area management. General site preparation would be prior to or concurrent with hydrological restoration activities. Existing, non-native, and invasive vegetation would be removed through mechanical means or herbicide application. Diverse, native wetland vegetation is expected to develop in the restoration wetlands from the existing seed bank and from the wetland vegetation that surrounds the wetland restoration site through vegetative propagation and seed dispersal mechanisms. At the end of the second growing season, these areas would be assessed to determine if additional seeding is required. These areas include sedge and wet meadows and shrub-carr/alder thickets.

The existing hardwood swamp would be managed to minimize the prevalence of non-native, invasive species; however, it is not anticipated that active seeding and planting would be required.

Vegetation in the existing upland areas would be managed to promote natural succession of the existing plant communities. The primary maintenance activity would be control of non-native invasive species such as buckthorn, honeysuckle, reed canary grass, and garlic mustard.

Zim Site

The Zim Site is currently an active sod farm that has been drained by ditches and sub-surface drain tiles. This site is located in two separate units (north and south) on approximately 569 acres of land located southwest of the city of Eveleth, Minnesota. The site is located in St. Louis County in the St. Louis River major watershed (#3), within the Lake Superior basin (bank service area #1). The overall objective of the Zim restoration plan is to restore a native wetland plant community.

The site is located within the NorthMet Project area watershed. The proposed wetland mitigation area includes 508.2 acres of wetland restoration and preservation, and 22.7 acres of upland buffer preservation. Restoration methods on the site would be designed to restore a (Type 8) coniferous bog community; however, developing a bog community is highly dependent on soil and groundwater parameters that are difficult to control. Therefore, a coniferous swamp community would be the contingent community if the soil and groundwater conditions are not adequate for bog regeneration. Coniferous bog or swamp is the target for the whole site; however, where trees do not successfully establish, the target community would be a shallow, open water wetland. If the target community changes, the credit ratios would be recalculated and would be determined during the permitting process.

Hydrology monitoring at the Zim Site, as well as at a reference wetland site, began in 2012 to characterize the pre-restoration hydrology, and continued in 2013 and 2014 (PolyMet 2015c). Based on 3 years of monitoring data at the Zim Site, the sod fields on the site no longer have wetland hydrology. Three of the forested locations on the Zim Site exhibit hydrology representative of partially drained wetlands, and one of the forested monitoring locations does not have wetland hydrology. Results of 2014 monitoring were submitted to the USACE and the MDNR in 2015 (Barr 2015m). Concurrence of the monitoring results will be conducted by permitting agencies during the permitting process (PolyMet 2015c). The state and federal agencies have not yet made a determination on the drainage status of the mitigation site (i.e., drained, partially drained, etc.); this determination, including the determination of credit ratios, will be made during permitting.

The minimum replacement ratio that would be allowed by the USACE is 1:1 (USACE 2009) for those wetlands that are replaced with either the same wetland type, or at least one full growing season in advance of the authorized wetland impacts provided initial performance standards are met; however, base compensation ratios for impacts on high-quality, difficult-to-replace bog and forested wetlands would be increased to 2:1 (USACE 2013). For impacts on low- and moderate-quality wetlands, a base ratio of 1.5:1 would be applied (USACE 2013). In-kind, in-place, and in-advance incentives to reduce the recommended base ratios would be considered at the time of permitting (see Tables 5.2.3-17 and 5.2.3-18). Compensation proposed at the Zim Site would be expected to meet both in-kind and in-place incentives, thereby reducing the compensation ratio for high-quality wetland impacts from 2:1 to 1.5:1. If in-advance, the ratio would be further reduced to 1.25:1. For low- to moderate-quality wetlands, the recommended base ratio of 1.5:1 would be required and could be reduced to 1.25:1 if in-place and 1:1 if also in-advance or in-kind. Under the Minnesota WCA, the replacement ratio that would likely be required is 1:1 for those wetlands that are replaced with the same wetland type and in the same watershed (see Tables 5.2.3-17 and 5.2.3-19).

The site-specific mitigation design proposed by PolyMet includes the following methods of restoration to receive wetland mitigation credits, which would be reviewed and approved determined during permitting:

- Restoration of effectively drained wetlands on 401.5 acres for 100 percent mitigation credit or 401.5 credits;
- Restoration of 8.3 acres of excavated ponds for 100 percent mitigation credit or 8.3 credits;
- Hydrologic restoration of 48.1 acres of partially drained wooded wetlands to receive 50 percent credit or 24.1 credits;
- Restoration of natural surface grade and wetland conditions in 21.5 acres of ditches, which would be filled to receive 50 percent credit or 10.7 credits;
- Restoration of native vegetation on 22.7 acres of upland buffers within drained fields and filled ditches, each of which would remain drained due to open ditches that cannot be filled, for 5.7 credits based on the 25 percent credit calculation for upland buffer; and
- Easement protection of 28.8 acres of native coniferous bog communities at 12.5 percent credit for a total of 3.6 credits for preservation.

The vegetation and hydrology would be restored to the site over a 1- to 2-year construction period, followed by up to 20 years of management or more, if warranted. The restoration work is expected to begin on the site after permit approval such that the initial phases of the restoration would be completed more than one full growing season before the impacts of the NorthMet Project Proposed Action would occur (PolyMet 2013o). Performance standards have been developed for the mitigation site to guide the restoration activities and to monitor whether vegetation and hydrology are meeting the design goals (Barr 2011k). To protect the site, a permanent conservation easement or deed recording would be prepared and recorded at approval of permit or prior to impact, as required by the permitting agency. The wetland restoration area would be monitored for up to 20 years beginning in the first full growing season after completing hydrologic restoration and ending upon certification by the USACE and MDNR that the wetlands have met performance standards (PolyMet 2013o; PolyMet 2015c).

The objective of the wetland restoration is to restore hydrology within the site by filling the interior ditches, leveling the raised berms, and disabling drain tiles to establish specific hydrologic conditions that would meet the goals and performance standards established for the site and approved by the appropriate agencies. Once hydrology restoration has been achieved, an adaptive management program is proposed to guide development of the restored wetlands to achieve the targeted conditions. Coniferous bog or swamp communities would be determined using established and approved bog restoration methods. Native, harvested bog material would be spread throughout the site to facilitate the re-introduction of sphagnum mosses and other bog species that cannot be easily re-introduced by seed. Natural regeneration of the herbaceous ground cover, in combination with the addition of bog harvest materials, would be supported by intensive weed management. Tree and shrub seedlings would be installed by hand throughout the site. The site would be carefully monitored and managed, and supplemental plantings and seeding may be used to encourage development until performance standards are met. The overall plan for the Zim Site includes the following components: general site preparation, site grading and hydrology restoration, bog restoration methods, tree and shrub installation, natural regeneration and bog establishment, and supplemental planting and seeding.

Table 5.2.3-17 Summary of Proposed Wetland Mitigation Credits

Community/Credit Type	Wetland Mitigation Within Project Watershed[1]		Wetland Mitigation Outside Project Watershed[1]			Total Wetland Mitigation Acres[1]	Total Wetland Mitigation Credits[1,6]
	Zim Sod (acres)	Total Credits	Aitkin (acres)	Hinckley (acres)	Total Credits		
Off-site Restoration of Effectively Drained Wetlands[2]							
Type 2 Fresh (Wet) Meadow	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Type 2 Sedge Meadow	0.0	0.0	0.0	51.0	51.0	51.0	51.0
Type 3 Shallow Marsh	0.0	0.0	25.7	0.0	25.7	25.7	25.7
Type 4 Deep Marsh	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Type 5 Shallow, Open Water	8.3	8.3	0.0	0.0	0.0	8.3	8.3
Type 6 Shrub-Carr	0.0	0.0	0.0	113.2	113.2	113.2	113.2
Type 6 Alder Thicket	0.0	0.0	0.0	113.2	113.2	113.2	113.2
Type 7 Hardwood Swamp	0.0	0.0	171.0	0.0	171.0	171.0	171.0
Type 7 Coniferous Swamp	0.0	0.0	561.6	0.0	561.6	561.6	561.6
Type 8 Open Bog	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Type 8 Coniferous Bog	401.5	401.5	0.0	0.0	0.0	401.5	401.5
Off-site Restoration of Partially Drained Wetlands and Ditches[3]							
Type 2 Sedge Meadow	0.0	0.0	0.0	0.8	0.4	0.8	0.4
Type 3 Shallow Marsh	0.0	0.0	13.6	0.0	6.8	13.6	6.8
Type 6 Shrub-Carr	0.0	0.0	36.5	0.0	18.2	36.5	18.2
Type 7 Hardwood Swamp	0.0	0.0	0.0	7.9	4.0	7.9	4.0
Type 8 Coniferous Bog	69.6	34.8	0.0	0.0	0.0	69.6	34.8
Off-site Site Preservation[4]							
Type 8 Coniferous Bog	28.8	3.6	0.0	0.0	0.0	28.8	3.6
Off-site Upland Buffer	22.7	5.7	83.2	91.2	43.6	197.0	49.3
On-site Wetland	---	---	---	---	---	---	---
On-site Upland Buffer5	---	---	---	---	---	---	---
Upland Buffer Total[1]	**22.7**	**5.7**	**83.2**	**91.2**	**43.6**	**197.0**	**49.3**
Wetland Total[1]	**508.2**	**448.2**	**808.3**	**286.2**	**1,065.1**	**1,602.7**	**1,513.3**
Total [1]	**530.9**	**453.9**	**891.5**	**377.3**	**1,108.7**	**1,799.7**	**1,562.5**

Source: PolyMet 2015c.

Notes:
[1] Totals may not add exactly due to rounding.
[2] Credits for restoration of completely drained wetlands are worth 100 percent of the acreage restored based on USACE St. Paul District Policy (Restoration via re-establishment) and the Minnesota WCA Chapter 8420.0526, Subpart 3.

[3] Credits for restoration of partially drained wetlands are worth 50 percent of the acreage restored based on USACE St. Paul District Policy (Restoration via rehabilitation) and the Minnesota WCA Chapter 8420.0526, Subpart 4.

[4] Credits for wetland preservation are worth 12.5 percent of the acreage protected under a conservation easement based on USACE St. Paul District Policy (Preservation) and the Minnesota WCA Chapter 8420.0526, Subpart 9 (per *Minnesota Statute* 103G.2251 modified August 1, 2011).

[5] Credits for upland buffers are worth 25 percent of the acreage of native, non-invasive vegetation established or maintained adjacent to the wetland based on USACE St. Paul District Policy (Preservation) and the Minnesota WCA Chapter 8420.0526, Subpart 1.

[6] The determination of final mitigation credits required to offset the impacts of the proposed NorthMet Project Proposed Action would be determined by the agencies during wetland permitting. This would be based on the extent to which the sites meet the target goals established during permitting. These include, among other things, restoration of wetland appropriate hydrology and the establishment of a target plant community or type.

Table 5.2.3-18 Summary of Proposed Wetland Mitigation for Direct Impacts Utilizing USACE Credits

Wetland or Credit Type	Mitigation Credits Available[1]				NorthMet Project Proposed Action Direct Wetland Impacts in Acres[1,2]			Total Credits Required for Mitigation at Base Ratio[1,9]	No More Than 2 Apply[9]			Total Applied Mitigation Credits[1,6,7,9]	Applied Mitigation Ratio[8,9]
	Zim Sod	Aitkin	Hinckley	Total Mitigation Credits Available	Non-Forested, Non-Bog, and Low or Medium Quality Wetland (Base Ratio 1.5:1)[3]	Bogs, Forested, and High Quality Wetland (Base Ratio 2:1)[4]	Total Impact Acres		Incentive for Credits In-Kind -0.25:1	Incentive for Credits In-Place -0.25:1	Incentive for Credits In-Advance[5] -0.25:1		
Type 2 Fresh (Wet) Meadow	0.0	0.0	0.0	**0.0**	1.4	14.4	15.8	30.9	---	---	---	**30.9**	1.69
Type 2 Sedge Meadow	0.0	0.0	51.4	**51.4**	6.9	17.1	23.9	44.4	(6.0)	---	---	**38.4**	1.61
Type 3 Shallow Marsh	0.0	32.5	0.0	**32.5**	53.1	23.9	77.0	127.5	(8.1)	---	(8.1)	**111.3**	1.44
Type 4 Deep Marsh	0.0	0.0	0.0	**0.0**	74.2	0.1	74.3	111.5	---	---	---	**111.5**	1.50
Type 5 Shallow, Open Water	8.3	0.0	0.0	**8.3**	0.0	0.0	0.0	0.0	---	---	---	**0.0**	---
Type 6 Shrub-Carr	0.0	18.2	113.2	**131.5**	1.4	2.5	3.9	7.1	(1.0)	---	---	**6.1**	1.57
Type 6 Alder Thicket	0.0	0.0	113.2	**113.2**	7.5	103.1	110.6	217.4	(27.6)	---	---	**189.8**	1.72
Type 7 Hardwood Swamp	0.0	171.0	4.0	**175.0**	0.7	12.5	13.2	26.0	(3.3)	---	---	**22.7**	1.72
Type 7 Coniferous Swamp	0.0	561.6	0.0	**561.6**	0.0	84.4	84.4	168.9	(21.1)	---	---	**147.8**	1.75
Type 8 Open Bog	0.0	0.0	0.0	**0.0**	0.0	7.6	7.6	15.3	---	---	---	**15.3**	2.00
Type 8 Coniferous Bog	439.9	0.0	0.0	**439.9**	0.0	530.0	530.0	1,060.0	(110.0)	(110.0)	---	**840.0**	1.58
Wetland Total[1]	448.2	783.3	281.8	**1,513.3**	145.2	795.6	940.7	1,808.9	---	---	---	**1,513.7**	1.61
Upland Buffer	5.7	20.8	22.8	**49.3**	---	---	---	---	---	---	---	**---[10]**	---
Total[1]	**453.9**	**804.1**	**304.6**	**1,562.5**	**940.7**			**1,808.9**	**(117.1)**	**(110.0)** **(295.2)**	**(8.1)**	**1,513.7**	1.61
Total Surplus Wetland Mitigation Credits for NorthMet Project Proposed Action (Total Credit Minus Total Applied Mitigation Credit)[1,9]				**48.8**									

Source: PolyMet 2015c.

Notes:

1 Totals may not add exactly due to rounding.

2 The total includes fragmentation of wetlands that would occur at the Mine Site and Plant Site (26.9 acres).

3 Base ratio 1.5:1 per USACE St. Paul District Policy (USACE 2009) for wetlands that are not considered high-quality or difficult-to-replace, which includes forested wetland and bog communities.

4 Base ratio 2:1 per USACE May 29, 2013 Draft Memorandum (USACE 2013) for wetlands that are high quality or difficult-to-replace, which includes forested wetland and bog communities.

5 Based on USACE May 29, 2013 Draft Memorandum (USACE 2013) for in-advance qualification assuming all mitigation would be constructed one full growing season before wetland impacts were to occur.

6 Total Applied Mitigation Credits = Total Credits Required for Mitigation minus Incentive Credits.

7 Credits applied may include surplus credits from different wetland types.

8 The ratio of credits applied to NorthMet Project Proposed Action impacts (not including the surplus credits).

9 The determination of final mitigation credits required to offset the impacts of the proposed NorthMet Project Proposed Action would be determined by the agencies during wetland permitting. This would be based on the extent to which the sites meet the target goals established during permitting. These include, among other things, restoration of wetland appropriate hydrology and the establishment of a target plant community or type.

10 Includes 0.5 credit of upland buffer, applied from totals listed above.

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Table 5.2.3-19 Summary of Proposed Wetland Mitigation for Direct Impacts Utilizing Minnesota Wetland Conservation Act Credits

Wetland or Credit Type	Mitigation Credits Available[1] Zim Sod	Aitkin	Hinckley	Total Mitigation Credits Available	NorthMet Project Proposed Action Direct Wetland Impacts in Acres[1,2]	Credit Applied for 1:1 Replacement[1,6]	Additional Mitigation Required +0.5:1[3,6]	Total Mitigation Credits Applied	Applied Mitigation Ratio[9]
Type 2 Fresh (Wet) Meadow	0.0	0.0	0.0	**0.0**	15.8	15.8	7.9	23.7	1.5:1
Type 2 Sedge Meadow	0.0	0.0	51.4	**51.4**	23.9	62.7	12.0	35.9	1.5:1
Type 3 Shallow Marsh	0.0	32.5	0.0	**32.5**	77.0	77.0	38.5	115.5	1.5:1
Type 4 Deep Marsh	0.0	0.0	0.0	**0.0**	74.3	74.3	37.1	111.4	1.5:1
Type 5 Shallow, Open Water	8.3	0.0	0.0	**8.3**	0.0	0.0	0.0	0.0	1.5:1
Type 6 Shrub-Carr	0.0	18.2	113.2	**131.5**	3.9	3.9	1.9	5.8	1.5:1
Type 6 Alder Thicket	0.0	0.0	113.2	**113.2**	110.6	110.6	55.3	165.9	1.5:1
Type 7 Hardwood Swamp	0.0	171.0	4.0	**175.0**	13.2	13.2	6.6	19.7	1.5:1
Type 7 Coniferous Swamp	0.0	561.6	0.0	**561.5**	84.4	84.4	42.2	126.6	1.5:1
Type 8 Open Bog	0.0	0.0	0.0	**0.0**	7.6	7.6	3.8	11.5	1.5:1
Type 8 Coniferous Bog	439.9	0.0	0.0	**439.9**	530.0	530.0	45.0	575.0	1:1[4]
Wetland Total[1]	448.2	783.3	281.8	**1,513.3**	940.7	940.7	250.4	1,191.2	---
Upland Buffer	5.7	20.3	22.8	**49.3**	---	---	---	---	---
Total[1]	**453.9**	**804.1**	**304.6**	**1,562.5**	**940.7**	**940.7**	**250.4**	**1,191.2**	1.27:1[5]
Total Surplus Wetland Mitigation Credits for NorthMet Project Proposed Action (Total Credit minus 1:1Credits minus Additional Mitigation Required)[1,6]						**371.4**			
Total Wetland Mitigation Credits Used for NorthMet Project Proposed Action[1,6]						**1,191.2**			

Source: PolyMet 2015c

Notes:
1 Totals may not add exactly due to rounding.
2 The total includes fragmentation of wetlands that would occur at the Mine Site and Plant Site (26.9 acres).
3 Additional mitigation required for mitigation out of the watershed at Aitkin and Hinckley sites. Determined by multiplying 0.5 by Total Impact Area.

[4] Assume 1:1 replacement for 439.9 acres compensated in-kind and in the watershed and 1.5:1 for the remaining 90.1 acres replaced out of the watershed.

[5] The ratio of credits applied to NorthMet Project Proposed Action impacts (not including the surplus credits).

[6] The determination of final mitigation credits required to offset impacts of the proposed NorthMet Project Proposed Action would be determined by the agencies during wetland permitting. This would be based on the extent to which the sites meet the target goals established during permitting. These include, among other things, restoration of wetland appropriate hydrology and the establishment of a target plant community or type.

5.2.3.3.3 Mitigation Summary

Compensatory mitigation is required for the 913.8 acres of wetlands that would be directly impacted. In addition, compensatory mitigation for the 26.9 acres of wetland fragmentation would be provided up front. The overall wetland mitigation strategy for the NorthMet Project Proposed Action is to compensate for unavoidable wetland impacts in-place, in-kind where possible and in-advance of impacts when feasible in order to replace lost wetland functions. Due to both on- and off-site limitations and technical feasibility, it is not practicable to replace all impacted wetland types with an equivalent area of in-kind wetlands. Off-site wetland mitigation projects would be implemented to fulfill the requirements for compensatory mitigation. PolyMet's current off-site mitigation proposal includes the:

- Aitkin Site – 808.3 acres of wetland restoration and 83.2 acres of upland buffer;
- Hinckley Site – 286.2 acres of wetland restoration and 91.2 acres of upland buffer; and
- Zim Site – 508.2 acres of wetland restoration and 22.7 acres of upland buffer.

Off-site wetland compensation of 1,602.7 acres could provide 1,513.3 wetland mitigation credits. In addition, a total of 197.1 acres of upland buffer areas are proposed to be established with native vegetation around the wetland restoration areas. In accordance with USACE guidelines, credit for the upland buffer areas would be at a 4:1 ratio, resulting in an additional 49.3 credits. The total off-site mitigation could provide 1,562.5 wetland mitigation credits. Tables 5.2.3-17, 5.2.3-18, and 5.2.3-19 provide a summary of wetland mitigation. Compensatory mitigation ratios determined in permitting may vary from these assumptions.

Finally, establishment of approximately 101.8 acres of wetland would likely occur during reclamation of the Mine Site; this establishment is not included in the mitigation credits discussed above as credit is not being requested at this time.

In accordance with the 2008 Federal Mitigation Rule, USACE policy, and overall requirements of the CWA, the primary focus of compensatory mitigation is to replace lost wetland functions within the same 8-digit HUC watershed as the impact site—in this case, the St. Louis River Watershed/Great Lakes Basin. Initially, no practicable compensation sites were found in the St. Louis River watershed, but subsequently, the Zim Site was found and incorporated as part of the compensatory mitigation plan. The permanent functional loss of wetlands within the St. Louis River Watershed/Great Lakes Basin would be considered during permitting. This is particularly critical in that 8-digit HUC watersheds adjacent to the Great Lakes—including the St. Louis River Watershed—have been identified as coastal watersheds for purposes of the 2008 Federal Mitigation Rule.

The majority of the credits would be in-kind mitigation, and nearly one-third of the credits would be from within the NorthMet Project area watershed (see Tables 5.2.3-17, 5.2.3-18, 5.2.3-19). Based on PolyMet's current mitigation proposal and assuming the mitigation efforts are fully successful and target communities are established, 83 percent of the impacts to coniferous bogs would be mitigated by in-kind and in-place credits, or 439.9 coniferous bog credits; the remaining 17 percent would be replaced out-of-kind. Out-of-kind credits would be used to mitigate impacts on wet meadow, shallow marsh, deep marsh, open bog, and coniferous bog communities; these would not be replaced in-kind because of hydrological and ecological constraints at the proposed mitigation sites. Forty-seven percent of the wetland impacts are currently proposed to be replaced in-kind, in-place, and before the impacts occur on site. An additional 29 percent of the proposed impacts are proposed to be replaced in-kind and before the impacts occur on site. Most of the additional mitigation credits that are proposed outside of the watershed would fulfill mitigation requirements above the minimum 1:1 ratio. The preferred location of siting any additional compensatory mitigation that may be required for the NorthMet Project Proposed Action would be within the St. Louis River/Great Lakes Basin.

The USACE requires a detailed compensatory mitigation plan for anticipated wetland impacts that would occur during the first 5 years of the NorthMet Project Proposed Action. A detailed mitigation plan must be submitted for each subsequent 5-year increment of wetland impacts to the USACE for approval. The anticipated wetland types to be restored off-site include a combination of the same and different types as the impacted wetlands. Some off-site wetlands would be restored in advance of impacts, while other wetlands would be restored after the impacts.

The change in wetland hydrology from groundwater drawdown at the Mine Site was assessed by two different methodologies; therefore, total indirect potential wetland effects were provided based on both approaches. The NorthMet Project Proposed Action could potentially indirectly affect up to either 7,694.2 acres of wetlands located within and around the NorthMet Project area, based on the method of wetlands crossing analog impact zones, or up to 6,568.8 acres of wetlands located within and around the NorthMet Project area, based on the method of wetlands within analog impact zones (PolyMet 2015b). Regardless of the method used, wetland mitigation for indirect wetland effects would be determined by the agencies during permitting. If the NorthMet Project Proposed Action were to be permitted and constructed, wetland monitoring would be conducted to determine if the NorthMet Project Proposed Action causes future indirect wetland effects. Wetlands and vegetation would be monitored; additional monitoring locations may be considered during permitting. A component of the monitoring plan would be based on those wetlands that have a high likelihood of potential indirect effects as a result of groundwater drawdown. If the monitoring determined that indirect wetland effects had occurred, additional compensation may be required if determined necessary by the permitting agencies. In the event that the required wetland monitoring identified additional indirect effects, permit conditions would likely include a plan for adaptive management practices to be implemented, such as expanded monitoring and hydrologic controls. Additionally, compensatory mitigation may be required if additional impacts are identified during annual reporting. Permit conditions would likely include a plan for implementing adaptive management practices to account for any additional impacts that may be identified in the annual monitoring and reporting.

5.2.3.3.4 Monitoring Plan for Mitigation Sites

Wetland hydrology monitoring has begun at the mitigation sites to assess hydrological conditions prior to the determination about the NorthMet Project Proposed Action and would continue after hydrology restoration is complete to determine whether or not the restored wetland areas are in conformance with performance standards and would determine whether continued monitoring would be required.

The wetland restoration area monitoring would begin during the first full growing season after completing hydrologic restoration. In addition to monitoring of the restored wetlands, one reference wetland of each restoration community type would be monitored within the general area of each restoration site in areas with relatively natural hydrologic conditions similar to that of the proposed target communities. A monitoring plan would be submitted to the appropriate state and federal agencies for review and approval that would include proposed locations of reference wetlands prior to implementing the monitoring program (PolyMet 2013o; PolyMet 2015c).

Vegetative monitoring would entail conducting a detailed vegetation survey at least once per year (typically July to August) in each wetland mitigation community, as well as the reference wetland communities, to evaluate the success of the restoration during the appropriate monitoring period for each community type.

Hydrologic monitoring would involve the installation and periodic monitoring of shallow recording wells at multiple locations sufficient to characterize hydrology. Continuous recording wells that record water table elevations multiple times each day would be utilized to the extent feasible and would be placed throughout the sites sufficient to characterize hydrology. Hydrologic monitoring would be used to measure the success of hydrologic restoration relative to the established performance standards for each community type and to assess the extent of wetlands on each site (PolyMet 2015c; PolyMet 2013o). Water elevations would be recorded at least once per week from May through mid-July and monthly thereafter until the end of the growing season (PolyMet 2015c).

The duration of monitoring would depend on the target wetland communities at each site and the success of establishment of those communities. Bogs and forested wetlands would be monitored for up to 20 years, or more if warranted. Monitoring of emergent and shrub-carr wetland communities would continue for up to 10 years, or more if warranted. Certain components of the monitoring may be discontinued sooner if performance standards were met and approval was provided by the USACE and MDNR (PolyMet 2015c; PolyMet 2013o).

After restoration, the monitoring design may be altered to better characterize restored conditions (PolyMet 2013o). Water levels would be recorded several times each day in the stilling wells for the duration of the growing season; staff gauges would be checked weekly for the first 10 weeks of the growing season and twice monthly thereafter. Hydrology monitoring in saturated soil communities would be completed using shallow water table monitoring wells within each community recorded several times each day for the duration of the growing season (PolyMet 2013o). Hydrologic parameters for Hinckley and Aitkin would be evaluated in the mitigation areas more intensively during the first 2 years and then would be performed at a level appropriate to the hydrologic characteristics of each area thereafter (PolyMet 2014h; PolyMet 2014i; PolyMet 2014j). Reference wells would be established for each community type and monitoring with those wells would continue for the duration of site hydrology monitoring (PolyMet 2013o).

Hydrologic monitoring at the three mitigation sites would generally occur for at least 5 years; however, certain wetland types may be monitored longer. In shrub communities, monitoring would generally be for 8 years, and in forested communities, it would generally be 20 years. Monitoring would begin in the first full growing season after beginning hydrologic restoration to document the progress and condition of the wetland communities at the mitigation site. Monitoring reports would be prepared and submitted to the appropriate agencies, and the frequencies of the reports would be based on permit conditions. The monitoring report completed after the final growing season would assess whether or not the restored wetlands are in conformance with performance standards (PolyMet 2014h; PolyMet 2014i; PolyMet 2014j).

Reports would describe the status of the wetland mitigation, summarize the results of the vegetative and hydrologic monitoring, discuss management activities and corrective actions conducted during the previous period, and discuss activities planned for the following period. The reports would be submitted to the USACE and MDNR by December 31 of each year. Monitoring requirements would be determined during the permitting process.

Contingencies for Unsuccessful Mitigation

If the restored wetland communities at any of the mitigation sites did not meet performance standards, remedial or corrective actions and possibly additional mitigation credits may be required and would be determined by the USACE and state during the permitting process. For example, PolyMet could characterize site conditions relative to the performance standards in each monitoring report and, if the standards were not met, remedial actions would be proposed to meet the standard(s). The following contingencies have been proposed by PolyMet (PolyMet 2013o) and would be finalized and approved during permitting:

- If any planned community type does not meet performance standards for three consecutive years, the status of the community would be analyzed to determine the effect on the approved wetland mitigation credits and PolyMet would proposed an alteration to the wetland mitigation plan, which could include a modification of wetland community type, changes to the proposed credit ratios, and additional wetland mitigation.
- If any wetland community has not developed as planned and as defined in the performance standards after the fifth full growing season after restoration, PolyMet would work with the USACE and MDNR on appropriate alternative plans, including alternative mitigation or revisions to the overall mitigation ratio based on changes to wetland community types.
- Any plan revisions would be submitted to the USACE and MDNR for review and approval prior to implementation.

If it is determined that additional wetland mitigation would be required due to unsuccessful mitigation restoration, PolyMet would first utilize the excess credits (see Tables 5.2.3-18 and 5.2.3-19) and then would identify and pursue wetland mitigation opportunities, including wetland preservation options, within the watershed of the NorthMet Project area. PolyMet would use information from BWSR and other relevant entities that are available at the time it is determined additional wetland mitigation is needed. Information on the wetland mitigation opportunities identified and pursued would be coordinated with and submitted to the USACE and state for review and approval prior to making final decisions on additional mitigation (PolyMet 2013o).

5.2.3.3.5 Monitoring Plan for Mine Site and Plant Site Wetland for Potential Indirect Effects

Wetland monitoring would occur in and around the Mine Site and Plant Site prior to and during construction and operation of the NorthMet Project Proposed Action, if permitted, and would be used to assess whether or not potential indirect effects on wetlands were occurring. If monitoring of wetlands for potential indirect effects did determine effects were occurring, additional compensation may be required, if determined necessary, based on monitoring results. Monitoring is proposed within all wetlands containing a potential indirect wetland impact factor rating of 3 to 5 and a sampling of those wetlands with factor ratings of 1 or 2 (see Figures 5.3.2-31 and

5.2.3-32) (PolyMet 2013o). A component of the monitoring plan would be based on those wetlands that would have a high likelihood of indirect effects as a result of groundwater drawdown. If indirect wetland effects were to occur, PolyMet would be required to work with the USACE and state to respond, which may include the option to provide compensatory mitigation for any documented indirect effects. The monitoring plan would be updated annually based on results from the previous year. A total of 56 monitoring wells and four reference wells are proposed to document potential indirect wetland effects.

The criteria for determining if potential indirect wetland effects are occurring is provided below. In addition, permit conditions would include an adaptive management plan, summarized below, to account for any additional effects that may be identified in the annual monitoring and reporting. To determine if indirect effects occur, hydrology, vegetation, and wetland boundaries would be monitored, documented, and compared with baseline monitoring and reference wetlands.

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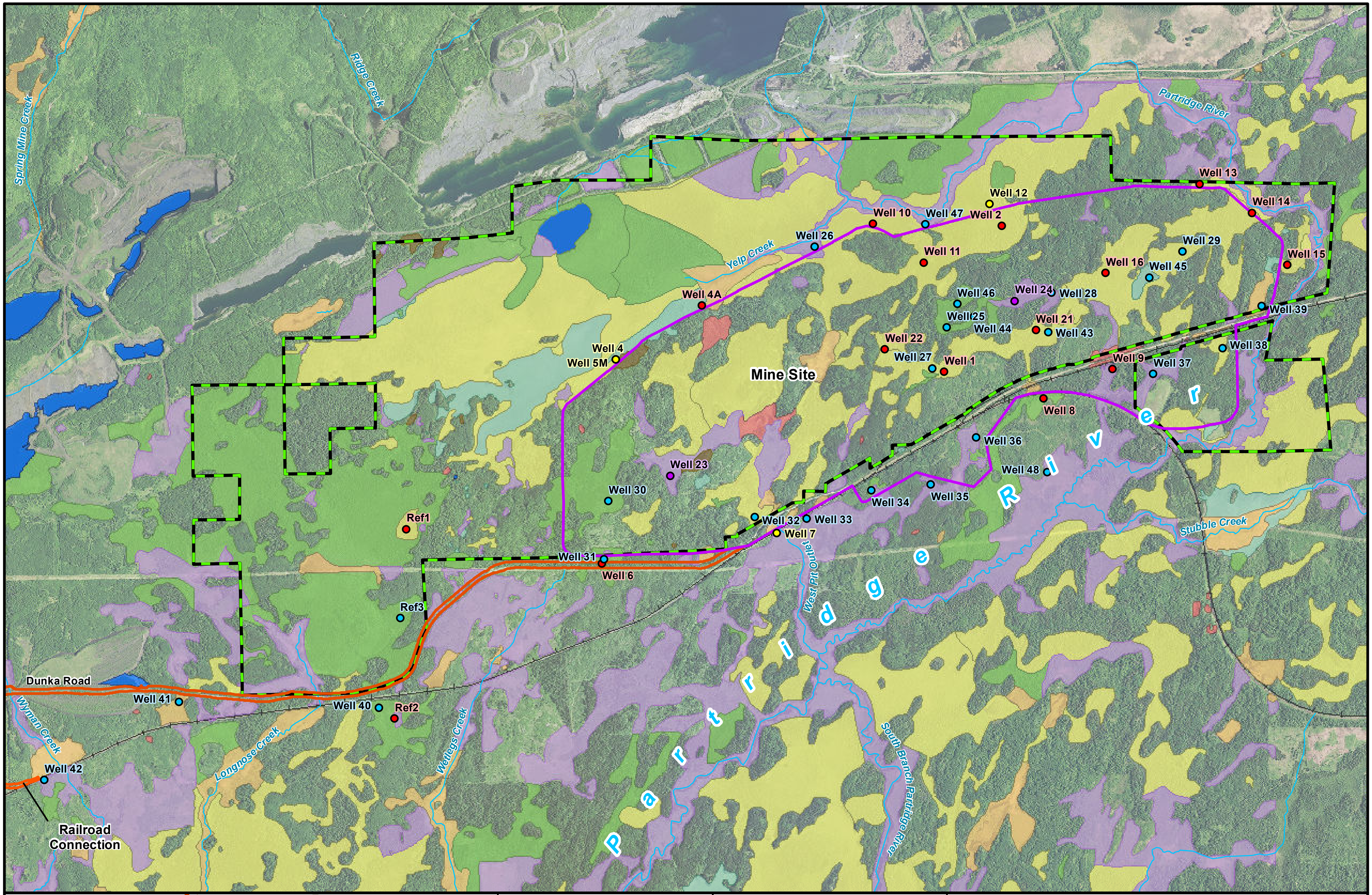

Wetland Hydrology Monitoring Wells
- Installed in 2005
- Installed in 2008
- Installed in 2010
- Installed in 2014
- Mine Site
- Transportation and Utility Corridor
- Railroad Connection
- Federal Lands
- Stream/River
- Wetland Assessment Site

Eggers & Reed Wetland Types
- Coniferous Bog
- Coniferous Swamp
- Deep Marsh & Shallow Marsh
- Hardwood Swamp
- Open Bog
- Sedge Meadow & Wet Meadow
- Shrub Swamps (Alder Thicket & Shrub-Carr)
- Shallow, Open Water & Lake

MNDNR | US Army Corps of Engineers St. Paul District | Forest Service

0 0.25 0.5 1 Miles

Figure 5.2.3-31
Mine Site Wetland Hydrology Monitoring Well Locations
NorthMet Mining Project and Land Exchange FEIS
Minnesota

November 2015

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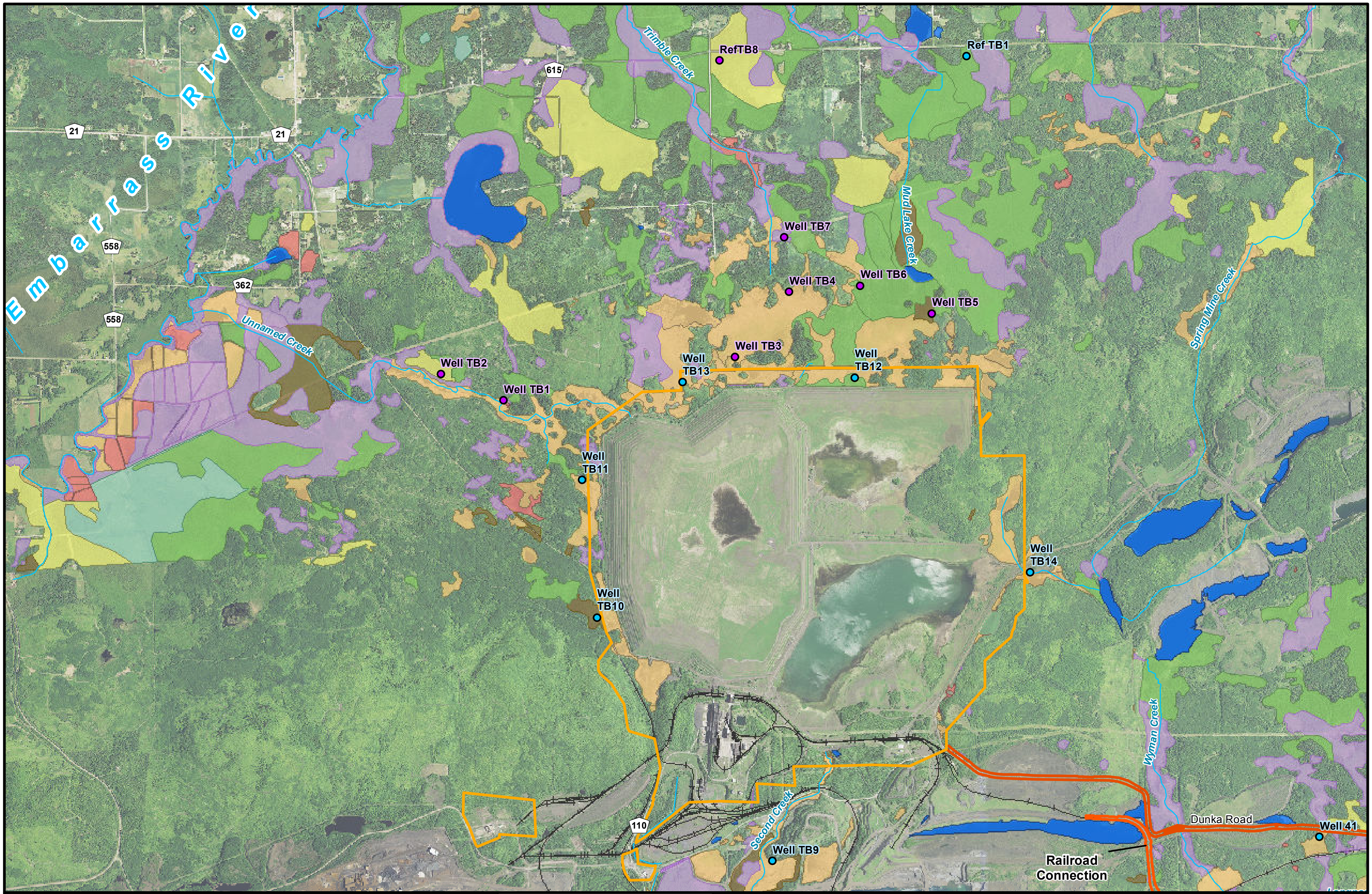

Wetland Hydrology Monitoring Wells
- Installed in 2005
- Installed in 2008
- Installed in 2010
- Installed in 2014
- Plant Site
- Transportation and Utility Corridor
- Stream/River

Eggers & Reed Wetland Types
- Coniferous Bog
- Coniferous Swamp
- Deep Marsh & Shallow Marsh
- Hardwood Swamp
- Open Bog
- Sedge Meadow & Wet Meadow
- Shrub Swamps (Alder Thicket & Shrub-Carr)
- Shallow, Open Water & Lake

MNDNR
US Army Corps of Engineers
St. Paul District

N W E S

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Figure 5.2.3-32
Plant Site Wetland Hydrology Monitoring Well Locations
NorthMet Mining Project and Land Exchange FEIS
Minnesota

November 2015

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Pre-Project Wetland Hydrology Monitoring Sites

In 2005, 20 shallow manual wells and four recording wells were initially installed at 19 locations around the Mine Site. A total of 11 monitoring locations were situated around the perimeter of the Mine Site and are not expected to be affected by the NorthMet Project Proposed Action. The remaining eight monitoring locations are located within the Mine Site and have the potential to be affected by the NorthMet Project Proposed Action. In 2008, two wells were removed because they were within future stockpile locations, two new wells were added at the Mine Site, one well was relocated out of the direct effect area, and two wells were installed in reference wetlands located west of the Mine Site (PolyMet 2015c). Furthermore, in 2008, all monitoring locations were instrumented with recording wells so water levels could be recorded every 2 to 4 hours. In 2010, two wells were relocated because they were determined to be in areas that would be directly impacted by the NorthMet Project Proposed Action. During 2008 through 2010, there were 21 locations monitored at the Mine Site. In 2014, wetland monitoring locations were installed at 25 additional locations at the Mine Site and Transportation and Utility Corridor. In addition, in 2014 another reference wetland was selected, for a total of three reference wetlands to monitor (see Figure 5.2.3-31) (PolyMet 2015c). Pre-project monitoring did not include collection of vegetation or wetland boundaries other than what was completed during the wetland delineation and baseline wetland type evaluation (PolyMet 2015c; PolyMet 2013o).

Shallow monitoring wells were installed at eight locations around the Plant Site in 2010. One of the eight wells was installed in a reference wetland located north of the Plant Site that would not be affected by the NorthMet Project Proposed Action. Two monitoring wells were placed west of the Plant Site along Unnamed Creek; two wells were placed north of the Plant Site, adjacent to a large deep marsh wetland complex; and three wells were placed along the flowpath of Trimble Creek. The monitoring wells were typically placed to a depth of 2 to 5 ft bgs. In 2014, shallow monitoring wells were installed at seven additional locations in the Plant Site area and a second reference wetland was selected (see Figure 5.2.3-32).

The monitoring protocol would continue for the life of the NorthMet Project Proposed Action, if approved, though portions of the monitoring design could be altered to improve the design or to eliminate unnecessary data collection, which would be done in coordination with the appropriate agencies. Pre-project hydrology monitoring of wetlands and groundwater within and surrounding the Mine Site started in 2005 and in 2010 at the Plant Site at well locations approved by the USACE and MDNR, and would continue throughout the NorthMet Project Proposed Action in accordance with the planned study (PolyMet 2015c). The primary objectives of the Mine Site and Plant Site wetland hydrology monitoring studies include the following:

1) Gain a better understanding of the wetland hydrology at the Mine Site and Plant Site (i.e., defining whether specific wetlands are recharging the surficial deposits aquifer or are discharging to surface waters).
2) Collect baseline hydrology data at the Mine Site and Plant Site that could be used to assess the effect of the NorthMet Project Proposed Action on wetland hydrology.
3) Review the data collected at the Mine Site in the hydrogeologic study along with the wetland hydrology data to determine whether specific wetlands within the Mine Site area have perched water tables or are in direct hydrologic connection with the surficial deposits aquifer.

4) Determine the potential for indirect wetland effects at the Mine Site and Plant Site resulting from the NorthMet Project Proposed Action.

The majority of the pre-project monitoring locations would be utilized for future monitoring during mining activities. The monitoring of the well locations would be expanded to include vegetation sampling and wetland boundaries, and additional monitoring locations may be considered during permitting.

Project Wetland Hydrology Monitoring Sites

Wetland hydrology monitoring would be conducted during operation of the NorthMet Project Proposed Action to document indirect wetland effects. Prior to the start of the NorthMet Project Proposed Action, monitoring would be established based on permit conditions, which would describe the purpose, methods, and criteria to be implemented to document indirect wetland effects. As previously stated, the monitoring wells were planned within all wetlands with effect factor ratings of 3 and within a sampling of wetlands with effect factor ratings of 1 and 2 located throughout the areas of potential indirect wetland effects.

As noted in the Section 404 permit application, PolyMet proposes to install shallow water table monitoring wells at each of the proposed wetland monitoring locations shown in Figures 5.2.3-31 and 5.2.3-32. Each monitoring location would have one recording well and one manual well; if any wells were to become damaged, PolyMet would replace the wells as soon as practical to maintain data continuity. Monitoring would continue in all of the existing wells, with the exception of wells #1 and #6. These two wells would be moved outside of areas that would be directly impacted (see Figures 5.2.3-31 and 5.2.3-32). Hydrologic monitoring would continue at the existing and proposed monitoring locations and at reference wetland locations every year throughout the growing season for the life of the mine operation. PolyMet would review the monitoring information and, if it were determined that certain wells were not providing useful information, the monitoring plan could be modified with the concurrence of the USACE and MDNR.

Reference Wetland Hydrology Monitoring Sites

Pre-project monitoring locations would include three reference wetlands, one within each of the three major project areas (see Figures 5.2.3-31 and 5.2.3-32), approved by the USACE and MDNR to document the natural hydrologic fluctuations in wetlands that would not be affected by the NorthMet Project Proposed Action and would facilitate interpretation of the NorthMet Project Proposed Action hydrologic data.

Wetland Vegetation and Boundary Monitoring

In addition to hydrology monitoring, wetland vegetation monitoring would be conducted during the operation of the NorthMet Project Proposed Action. Baseline conditions for wetland vegetation would be established during the first growing season after permit issuance and at 5-year intervals throughout the life of the mine. Data would be used to document potential shifts in vegetation that are inconsistent with changes documented in the reference wetlands. Baseline data already available from existing plots, wetland delineation, monitoring, and other on-site studies may also be used to document baseline conditions if these data may help to determine the cause of changes in vegetation characteristics or to demonstrate natural variability within the wetlands (PolyMet 2013o).

PolyMet has also proposed that portions of the monitored wetlands be reviewed every 5 years, concurrent with the vegetation monitoring, to evaluate wetland boundaries. Wetland boundaries would be field-delineated and located using a GPS with sub-foot horizontal accuracy. The field-based delineation would map at least 25 percent of the wetland boundary at each of the wetlands with monitoring locations. The boundaries would be mapped on a rotating basis to include 25 percent of the wetland boundary every 5 years, including some overlap every 10 years. A transect composed of at least two wetland delineation sample points would be completed along a sections of the boundary reviewed in each of the monitored wetlands (PolyMet 2013o).

The delineation data would be compiled to map the boundary of each of the wetlands with monitoring locations. Based on the portion of the wetland that is delineated, the whole wetland boundary would be mapped using desktop review of current aerial photography, topography (LIDAR or site-specific data), and hydrology monitoring data. The results would be reported to the USACE and MDNR at the end of each year of monitoring (PolyMet 2013o).

Criteria Impacts Threshold Levels

The hydrology, vegetation, and wetland boundary monitoring data collected as part of the proposed monitoring program by PolyMet would be evaluated to determine if adverse, indirect wetland effects occur as a result of the NorthMet Project Proposed Action. PolyMet has proposed the following criteria threshold levels for indicating if an adverse, potential indirect wetland effects are occurring (PolyMet 2013o):

- A 50 percent reduction of the baseline wetland hydrology hydroperiod. Antecedent precipitation and reference wetland hydrology would be considered in the evaluation of wetland hydrology hydroperiod. The hydroperiod of a wetland is equal to the length of time and portion of the year the wetland holds ponded water or saturation within 12 inches of the soil surface. This period of time generally varies from year to year based on climatic conditions. Therefore, the judgment of whether this threshold is surpassed would be made considering the monitoring for each wetland conducted during the pre-project time period and data from reference wetlands of similar community types or hydrologic regime.
- A change in vegetation species composition of 25 percent or greater in one or more strata that is inconsistent with vegetation changes in the reference wetlands. For instance, if stinging nettles (*Urtica dioica*) cover changed from 5 to 30 percent, it may indicate changes in wetland hydrology and would be reviewed carefully relative to the hydrology data. Other factors may contribute to changes in vegetation (disturbances or species introductions) that may be unrelated to changes in wetland hydrology or the nearby NorthMet Project area; such factors would be considered as appropriate.
- Loss of wetland area (as defined by the wetland boundary determination) that is inconsistent with wetland area loss at reference wetlands.

The above criteria have been proposed by PolyMet as part of its Section 404 permit application, and permit conditions would indicate the final criteria thresholds if the NorthMet Project Proposed Action were approved. The criteria would also be considered and need to be approved during the WCA permitting process and Section 401 certification process. These criteria or those that are approved during permitting would be evaluated by PolyMet with consideration of the NorthMet Project Proposed Action activities and likelihood that such activities are responsible for the changes. Should adverse, indirect wetland effects be identified during the monitoring program, an estimation of such effects would be included in the monitoring report in the year that they are first detected. The data for hydrology, vegetation, and wetland boundary monitoring would be compiled in a report, including methods, results, and evaluation of potential adverse indirect wetland effects; this report would be submitted to the USACE and MDNR by the end of each monitoring year.

Indirect Effects Mitigation

If it is determined that indirect wetland effects occurred based on the criteria effects threshold levels, PolyMet would work with the appropriate agencies to respond, which could require PolyMet to provide compensatory mitigation for any documented indirect effects. If indirectly affected wetlands require compensatory mitigation, the acreage would be calculated by community type and provided in annual monitoring reports to the appropriate agencies. Compensatory mitigation would be based on WCA requirements and the USACE St. Paul District Policy for wetland mitigation, as well as that identified below.

In the event that not all of the credits generated by the mitigation sites are utilized to compensate for direct wetland impacts, and the sites are successful and meet the performance standards any excess credits could be used to compensate for indirect losses (USACE 2015a). The excess wetland mitigation credits could then be expected to be available to compensate for potential indirect wetland effects. PolyMet would follow, if necessary, the general planning approach described above and below for contingencies for unsuccessful mitigation to identify, plan, and receive the USACE and state approval of mitigation plans to develop additional mitigation credits. If additional mitigation credits were needed, site selection would be consistent with USACE and WCA guidance. PolyMet is proposing to mitigate the compensatory loss of wetland areas as a result of potential indirect effects in accordance with the mitigation ratios that were utilized for direct wetland impacts. In addition, PolyMet has proposed in the Section 404 permit application that partial drainage or other changes to the wetlands that do not result in the wetland loss, but exceed the threshold levels identified above, could be mitigated at a lower ratio depending on the extent and degree of the changes to wetland function. The minimum ratio of mitigation credit PolyMet is proposing to use would be 0.25:1.

Wetlands Adaptive Monitoring Plan

PolyMet has, in their Section 404 permit application, proposed utilizing an adaptive monitoring plan approach to evaluate the most effective monitoring strategy for potential indirect effects. Their proposed wetland adaptive monitoring plan outlined below needs to be reviewed and approved prior to permitting. As proposed, it contains the following items:

- The monitoring plan would be updated annually based on results from the previous year.
- Monitoring plan criteria would be included in the Wetland Management Plan, which would contain all criteria and permit conditions.
- If indirect impacts were observed, additional monitoring may be developed to focus in those areas and/or to focus on a specific impact factor.
- Additional monitoring may include new monitoring locations in other wetlands and more detailed delineation and vegetation data collection.

PolyMet's current proposed adaptive monitoring plan includes two phases. Phase I would be broad-based monitoring to identify changes to wetlands or changes that may affect wetlands or surface waters; Phase II monitoring may be implemented to provide a more detailed assessment in a given area to analyze a potential impact factor. If necessary, the Phase II monitoring would be designed and implemented as needed to address the changes identified during Phase I monitoring. Phase II would be used to determine the need for additional mitigation or to develop a plan to control the changes identified during Phase I and minimize future effects on wetlands. The adaptive monitoring plan would be reviewed and approved during permitting.

5.2.3.3.6 Reporting

Reports would be compiled to document pre-project hydrology conditions and restoration outcomes from the three mitigation sites as well as for the hydrology monitoring at the NorthMet Project areas, which would be implemented to fulfill the requirements for compensatory mitigation.

Off-site Monitoring Reports for Wetland Restoration

Reports have been prepared to document the activities that would be conducted at the off-site wetland mitigation sites. These reports include information regarding existing conditions at the site, construction activities, management activities, wetland restoration goals, performance standards, schedules, and monitoring plans (PolyMet 2014h; PolyMet 2014i; PolyMet 2014j). These plans were developed to comply with WCA rules (*Minnesota Rules*, chapter 8420), Section 404 of the CWA as administered by the USACE, and *Minnesota Rules*, part 7050.0186 (wetland mitigation) as administered by the MPCA.

Project-specific wetland mitigation plans for three mitigation sites were prepared that describe the compensatory wetland mitigation that would be used to replace unavoidable wetland impacts associated with the NorthMet Project Proposed Action. The wetland mitigation plans were updated and submitted to the USACE in May 2014 for the three sites.

PolyMet would submit progress monitoring reports for the wetland mitigation sites as determined during permitting to document restoration outcomes. Wetland restoration construction progress would be tracked along with compliance with permit conditions. The reports would describe the status of the wetland mitigation, summarize the results of the vegetation and hydrology monitoring, discuss management activities and corrective actions conducted during the previous year, and discuss activities planned for the following year. The monitoring report completed after the tenth growing season would assess whether or not the restoration were sufficiently complete and if additional monitoring and reporting were warranted (PolyMet 2015c).

Reporting on Mine Site and Plant Site Wetland Hydrology for Potential Indirect Effects

Pre-project wetland hydrology monitoring reports, generated to meet reporting requirements, have been compiled and document 5 years of pre-project planning and monitoring at the Mine Site (2005 to 2009). PolyMet has continued to conduct wetland hydrology monitoring since 2009 at the Mine Site. Pre-project wetland hydrology monitoring at the Plant Site has also been conducted in 2010, 2011, and 2012 at the Plant Site and is ongoing. Future project wetland hydrology monitoring reports would be submitted in accordance with any permit issued.

Monitoring data would be submitted to the USACE and MDNR annually for the life of the mine. Hydrology data would be presented every year to show monitoring locations, hydrographs, and analysis of wetland hydrologic conditions in the context of precipitation conditions. Vegetation and wetland boundary data would be presented every 5 years and would be used to determine the acreage of impacts and potential indirect effects that were not evident based on hydrologic data. Indirect effects would be assessed in the annual reports to the extent possible. Acreage of indirect effects, if any, would be determined and would be used to determine the requirements for wetland mitigation credits, if such credits were needed. If compensatory mitigation were necessary, credits would be proposed in the annual report as described above (PolyMet 2013o).

5.2.4 Vegetation

This section describes the environmental consequences of the NorthMet Project Proposed Action to vegetation, which include direct effects on land cover types, native plant community types, MBS Sites of Biodiversity Significance, and rare or sensitive plant species, as well as effects from existing or introduced invasive non-native species.

Summary

The NorthMet Project Proposed Action would disturb 1,718.6 acres of the Mine Site and have the greatest effect on upland conifer forest land cover types. Approximately 2,189.7 acres of the Plant Site would be disturbed by the NorthMet Project Proposed Action, with most effects occurring in already disturbed areas and tailings ponds. All land within the Transportation and Utility Corridor would be affected (120.2 acres), the majority of which is already disturbed.

The NorthMet Project Proposed Action would affect approximately 1,719 acres that are mapped by the MDNR as MBS Sites of High Biodiversity Significance. Within these Sites of High Biodiversity Significance, several native plant communities are mapped that would be affected by the NorthMet Project Proposed Action, including 698.2 acres with a conservation status rank of “imperiled-vulnerable” (conservation status rank S2 or S3) or “vulnerable” (conservation status rank S3), 92.6 acres with a conservation status rank of “apparently secure” (conservation status rank S4), and 178.9 acres with a conservation status rank of “widespread and secure” (conservation status rank S5).

Disturbed areas would be reclaimed during operations and at closure. Reclamation objectives would include rapidly establishing a self-sustaining plant community, controlling air emissions, controlling soil erosion, providing wildlife habitat, and minimizing the need for maintenance. Seed mixes and methodologies would be designed to minimize the introduction of invasive species. Reclamation seed mixes would be approved during permitting.

There are no federally listed plant species at the NorthMet Project area. There are 10 state-listed plant species, all at the Mine Site; 8 species would be directly affected and two would potentially be indirectly affected by the NorthMet Project Proposed Action.

Indirect effects from the NorthMet Project Proposed Action could include dust deposition on vegetation, hydrology changes, ore spillage along the Transportation and Utility Corridor, and erosion on the Tailings Basin. Mitigation measures would be in place for each of these potential effects.

5.2.4.1 Methodology and Evaluation Criteria

This section compares the types of data presented in Section 4.2.4 for the NorthMet Project area. Specifically, GIS data were obtained from the MDNR regarding GAP land cover types, native plant communities, MBS Sites of Biodiversity Significance, and listed ETSC plant species within the NHIS. Data were obtained from the USFS regarding MIH types, forest stand age classes, RFSS, invasive non-native species, and landscape ecosystems. Separate NorthMet Project area-specific listed species survey reports were also utilized to supplement MDNR NHIS data and estimate effects on populations.

GIS analysis was used to calculate effects on the data layers mentioned above. The effects were calculated for habitat types, classifications, and species where they overlap the NorthMet Project area footprints.

Direct effects on natural features (e.g., vegetative cover types, plant communities, MBS Sites of Biodiversity Significance, and rare species) occur through clearing, filling, and other construction activities. A direct effect on an ETSC plant species occurs when the action results in the removal or loss (i.e., taking) of an individual plant or entire plant population. Direct effects are those that are a result of the NorthMet Project Proposed Action and that are immediate and often last for years.

An indirect effect occurs when a cover type, plant community, Site of Biodiversity Significance, or rare species experiences a change in vegetative composition. Indirect effects can occur over time or after the action is completed and can occur on- or off-site. Indirect effects on vegetation may include changes in hydrology, deposition of particulate matter (dust), changes in successional stage, alteration of microclimate (e.g., tree removal resulting in drier soil conditions), loss of pollinators or loss of fungal associates in the rooting zone, erosion and sedimentation, and invasion of non-native species. Indirect effects were estimated by comparing the proximity of the NorthMet Project area infrastructure footprints to existing natural features (e.g., habitat types, plant species present). Typically, indirect effects are more likely to occur and/or are more likely to be evident in vegetation communities that are closer to NorthMet Project components and other infrastructure (e.g., roads). Indirect effects tend to diminish with increasing distance from NorthMet Project components and other infrastructure.

5.2.4.2 NorthMet Project Proposed Action

This section describes the effects of NorthMet Project Proposed Action construction, operation, and closure on vegetation cover types and plant species. Potential effects from invasive non-native species are discussed separately.

5.2.4.2.1 Mine Site

Effects on Cover Types

Habitat Types

Construction and operation of the NorthMet Project Proposed Action at the Mine Site would directly affect 1,718.6 acres (57 percent of the Mine Site) of land with various MDNR GAP land cover designations as a result of excavating the mine pits and creating overburden and waste rock stockpiles and associated internal haul roads and drainage ditches. As shown in Table 5.2.4-1, these effects would include 62 percent (741.9 acres) of the upland conifer forest at the Mine Site. Other high-acreage directly-affected cover types include lowland coniferous forest (437.2 acres) and upland deciduous forest (354.7 acres). Approximately 1,295.9 acres, or about 43 percent of the Mine Site, would not be disturbed. The wetland field assessment indicated a high level of wetland quality. Section 5.2.3 provides a more detailed discussion of wetland effects.

Table 5.2.4-1 Direct Effects on Cover Types at the Mine Site

Cover Types	Affected Acres	Non-affected Acres[1]	Total Cover Type Acres	Percent of Cover Type Affected
Upland coniferous forest	741.9	453.6	1,195.5	62
Lowland coniferous forest	437.2	344.0	781.2	56
Upland deciduous forest	354.7	293.3	648.0	55
Shrubland	133.0	108.7	241.7	55
Disturbed	44.0	84.0	128.0	34
Aquatic environments	6.0	6.7	12.7	47
Upland conifer-deciduous mixed forest	1.5	0.9	2.4	63
Cropland/grassland	0.2	4.7	4.9	4
Lowland deciduous forest	0.0	0.1	0.1	0
Total [2]	1,718.6	1,295.9	3,014.5	57

Source: MDNR 2006b.

Notes:
1 Areas of cover types not directly affected by mine pits, stockpiles, roads, or other infrastructure.
2 Total acres may be more or less than presented due to rounding.

Minnesota Biological Survey

Approximately 353.6 acres of the One Hundred Mile Swamp MBS Site of High Biodiversity Significance and 1,364.9 acres of the Upper Partridge River MBS Site of High Biodiversity Significance would be affected by the NorthMet Project Proposed Action. The portions of these two MBS sites that are within the Mine Site area represent a small portion of the mapped Sites of High Biodiversity Significance in St. Louis County (2 percent) and the State of Minnesota (less than 1 percent). Habitat effects associated with the NorthMet Project Proposed Action would not result in a large percentage decline in statewide areas ranked as high by the MBS (MDNR 2008a).

Approximately 698.2 acres of the "imperiled-vulnerable" or "vulnerable" native plant communities—the black spruce-Jack pine woodlands (FDn32c; 495.5 acres; 20 percent of community within Laurentian Uplands subsection) and rich black spruce swamp (FPn62a; 202.7 acres; 1 percent of community within Laurentian Uplands subsection)—would also be affected. Approximately 92.6 acres of the "apparently secure" native plant communities—i.e., black spruce bog: treed subtype (APn80a1; 77.7 acres; 4 percent of community within Laurentian Uplands subsection) and poor tamarack-black spruce swamp (APn81b; 14.9 acres; less than 1 percent of community within Laurentian Uplands subsection)—would be affected. Approximately 178.9 acres of "widespread and secure" native plant communities would also be affected, including alder (maple-loosestrife) swamp (FPn73a; 42.5 acres; 3 percent of community within Laurentian Uplands subsection), aspen-birch forest: balsam fir subtype (FDn43b1; 101.1 acres; less than 1 percent of community within Laurentian Uplands subsection), and poor black spruce swamp (APn81a; 35.3 acres; less than 1 percent of community within Laurentian Uplands subsection).

Some of the native plant communities identified at the NorthMet Project area are wetlands. WCA rules (including those parts applicable to mining projects under *Minnesota Rules*, part 8420.0930) include a special consideration for wetlands that are rare natural communities (*Minnesota Rules*, part 8420.0515, subpart 3). Guidance developed by MDNR and BWSR on rare natural communities (MDNR and BWSR 2011) identifies that rare natural communities are native plant communities having a conservation status rank of S1, S2, or S3, or any native plant community that is contained within an area mapped or determined by MBS to be eligible for mapping as an area of outstanding or high biodiversity significance ranking. Figure 4.2.4-2 depicts these Sites of Biodiversity Significance.

The Permit to Mine would address special consideration of wetlands that include rare natural communities. Additional information on rare natural communities would be included in the wetland permit application as part of the Permit to Mine process for further refinement of site-specific conditions.

Culturally Important Plants

Potential effects on wild rice as a result of the NorthMet Project Proposed Action would vary by location. The CEC modeling scenario concentrations exceed the sulfate evaluation criterion at PM-13. However, under project conditions, the project would not cause or add to an exceedance of the 10 mg/L sulfate evaluation criterion for the Embarrass River at PM-13, since the Tailings Basin containment and seepage collection system would capture seepage presently going to the Embarrass River tributaries. Sulfate concentrations currently exceed 10 mg/L in the Partridge River at SW-005. GoldSim results predict that for all situations where a theoretical impact could be attributed to the NorthMet Project Proposed Action, the expected increase in sulfate concentration at SW-005 (and SW-006) would be less than or equal to 0.1 mg/L, and this would be superimposed on typical annual fluctuations of several mg/L. A practical consequence of this result is that the effects of the NorthMet Project Proposed Action would not be identifiable by even the most robust field monitoring program. Effects, as well as water quality standards, are discussed more thoroughly in Section 5.2.2.

While a distinct list of plant species important to the Bands is not available, Sections 4.2.9.3.3 and 5.2.9.2.2 discuss more broadly the effects on the ecological subsections, large landscapes, and connected ecosystems.

Indirect Effects

In addition to the direct effects mentioned above, potential indirect effects on remaining vegetative cover types at the Mine Site could be associated with dust from road traffic and mining operations and with changes in hydrology. Dust on leaves can affect the rates of photosynthesis and respiration, which both influence plant growth. If sulfide-containing dust is deposited on leaves, it could react with oxygen in the air and water from precipitation to create sulfates over a period of weeks to months. This residual build-up in the soil could inhibit growth by slowly acidifying the soil conditions. The distance dust travels depends on wind speed, antecedent weather conditions, dust particle size, and vegetation density near the source. Section 5.2.7.2.6 states that the NorthMet Project Proposed Action is not expected to have a significant effect on sulfate deposition in the state, and so no threat to sensitive vegetation is expected. PolyMet proposes to implement various dust-control measures such as stabilizing disturbed soils by temporarily establishing vegetation and water spraying during dry periods (consistent with *Minnesota Rules,* part 6132.2800). As Section 5.2.7 further describes, fugitive dust control measures would result in 90 percent control at the Mine Site. These measures, which are standard practice for existing taconite mines on the Mesabi Iron Range, have proven to be adequate to minimize potential indirect effects from fugitive dust. The Mine Site AERA did not assess potential local mercury deposition because potential emissions are less than 1.0 lb/yr

(Barr 2011g). However, the mercury deposition on terrestrial environments would be expected to be not significant when compared to variability in background mercury concentrations.

As Section 5.2.3 explains, vegetation located within zones with a high likelihood of hydrology effects would be more likely to have community changes than those with no or low likelihood of effect.

Reclamation

Reclamation activities help to offset a portion of the effects of a project. Reclamation and revegetation at the Mine Site would promote cover development and initiate vegetative succession on stockpiles, the combined East Central Pit, and Mine Site infrastructure footprints. Fertilizer would be applied at rates recommended for each group of species planted, and would be worked into the soil to a depth of 8 inches on the level and 4 inches on all slopes (PolyMet2015g, Attachment A). Soil testing would be completed, as needed, to evaluate fertilizer requirements. On areas to be mulched after seeding, no more seed would be sown than could be mulched the same day. Seed would be sown via mechanical Truax native seed drills or hydrospreading at specified rates of application, unless inaccessible or wet areas dictate the use of hand-operated spreaders. Seedbeds would be firmed using cultipackers, or seeds would be covered before mulching. Six different types of mulch could be applied, depending on the situation. As nutrients and organic matter are returned to the soil, the conditions on the reclaimed areas would become more suitable for migration of nearby native herbaceous and woody species.

The Category 1 Stockpile would be incrementally and progressively reclaimed throughout the life of the mine, starting in year 14, to minimize erosion of the outer slopes, promote post-closure land use, and minimize the need for active site care and maintenance during the post-closure period. Prior to construction of the cover system, the stockpile surfaces would be graded for long-term stability, to promote vegetation growth and erosion control, and to develop a surface drainage network over the stockpile (PolyMet 2015h). After grading, an engineered geomembrane system would be constructed. The geomembrane system would consist of, from top to bottom: 18 inches of rooting zone soil consisting of on-site unsaturated overburden mixed with peat, as needed, to provide organic matter; 12 inches of granular drainage material with drain pipes to facilitate lateral drainage of infiltrating precipitation and snowmelt off the stockpile cover; a 40 mil geomembrane barrier layer; and a 6-inch soil bedding layer below the geomembrane (PolyMet 2015a). The stockpile would then be locally contoured to provide some topographic variety to the surface. Finally, the stockpile would be seeded with a certain selection of grasses/forbs at the top and bench flats and a potentially different group of species for the slopes, depending on the availability and suitability of the species (PolyMet 2015g, Attachment A). The three groups of species designated for the top and benches would include a native, slow-growth mix; a non-native, rapid-growth mix; and a mix of both native and non-native species. The species mix for the stockpile slopes would contain the same native species as the stockpile bench and flats, and a slightly modified group of non-native species. The cover would store precipitation within the loose layer during the period when vegetation is dormant. The trapped water would then be removed from the cover system by transpiration of the plants during the growing season and evaporation. Vegetation would also aid in stabilizing the cover from wind and rain erosion (Polymet 2015h).

Both the Category 2/3 Stockpile and the Category 4 Stockpile would be temporary and would be removed at closure. Temporary stockpile reclamation would begin during operations. The material in these stockpiles would be relocated to the East Pit starting in year 11 (PolyMet 2015a). After removal of the material, the footprint of the Category 2/3 Stockpile and portions of the Category 4 Stockpile that do not become the Central Pit would be reclaimed by subsequent seeding and planting of grass and forb species similar to those planted for the Category 1 Stockpile top and benches (PolyMet 2015g, Attachment A). Depressions in both temporary stockpile footprints with sufficient hydrology and soil conditions would be seeded with a different group of native grasses (e.g., fringed brome, bluejoint, Virginia wild rye, tall manna grass, fowl bluegrass, tussock sedge, pointed broom sedge, dark green bulrush, and woolgrass) and forbs (e.g., Canada anemone, marsh milkweed, flat-topped aster, common boneset, grass-leaved goldenrod, spotted Joe Pye weed, blue monkey flower, giant goldenrod, and Eastern panicled aster) suitable for wet soils. The West Pit would become open water, while the combined East Central Pit would be partially filled with material from the Category 2/3 Stockpile and Category 4 Stockpile to support wetland vegetation with species discussed above for the removed stockpile depressions (see Table 5.2.4-2). The pit wall overburden slopes would be planted with the same mix mentioned for stockpile slopes above (PolyMet 2015g, Attachment A). The acres reclaimed (see Table 5.2.4-2) do not equal the acres disturbed as some haul roads and buildings would remain after cessation of operations.

Following demolition of Mine Site buildings and parking areas, suitable overburden would be placed over the footprint, to a depth of 2 ft., and revegetated (PolyMet 2015g). Mine Site roads deemed unnecessary for future access by the MDNR would be scarified and revegetated, as well. Disturbed areas, building sites, and reclaimed roads would all be seeded with a similar mix of grass and forb species as that planted on the Category 1 Stockpile top and benches (PolyMet 2015g, Attachment A).

Table 5.2.4-2 Proposed Vegetation Types and Acreages for Reclaimed Stockpiles and Pits at the Mine Site

Type	Proposed Reclamation Vegetation	Acres
Category 1 Stockpile	Grassland/herbaceous	526
Category 2/3 Stockpile (Removed)	Wetland; Grassland/herbaceous	180
Category 4 Stockpile (Removed)	Wetland; Grassland/herbaceous	57*
Ore Surge Pile (Removed)	Wetland; Grassland/herbaceous	31
Overburden Storage and Laydown Area (Removed)	Wetland; Grassland/herbaceous	41
Combined East Central Pit	Wetland	207*
West Pit	Open pit lake	321
Roads, Parking Areas, Buildings	Grassland/herbaceous	88

Sources: PolyMet 2015g, Attachment A; PolyMet 2015a; PolyMet 2015h; PolyMet 2014q; Barr, Pers. Comm., February 6, 2013.

*The Central Pit would be mined at the location of the temporary Category 4 Stockpile after it is removed. The reclamation acres for the Category 4 Stockpile and the Combined East Central Pit overlap.

Effects of Invasive Non-native Plants

Disturbances associated with the construction of the Mine Site would result in exposed soil surfaces that would have the potential for colonization by invasive species. PolyMet proposes to temporarily vegetate and stabilize disturbed areas during operation and permanently reclaim during closure by spreading seeds. Species proposed for revegetation on most disturbed areas and the Category 1 Stockpile top and benches include native and non-native species. There are native grass species (e.g., fringed brome, switchgrass, Canada wild rye, bluejoint, poverty oatgrass, slender wheatgrass, fowl bluegrass, and false melic) and native forb species (e.g., common yarrow, pearly everlasting, flat-topped aster, tall cinquefoil, large-leaved aster, stiff goldenrod, smooth wild rose, black-eyed susan, gray goldenrod, upland white aster, Lindley's aster, smooth aster, and American vetch). According to the PolyMet Reclamation Seeding and Mulching procedure (PolyMet 2015g, Attachment A), preference would be given to establishing native plant communities, and the introduction of invasive plant species would be avoided to the extent practicable. Reclamation objectives include rapidly establishing a self-sustaining plant community, controlling air emissions, controlling soil erosion, providing wildlife habitat, and minimizing the need for maintenance.

Non-native species that could be planted include: oats, winter wheat, alfalfa, timothy, redtop, alsike clover, white clover, Canada bluegrass, intermediate wheatgrass, cicer milkvetch, birdsfoot trefoil, perennial ryegrass, smooth brome grass, meadow brome, and red fescue. These species are known to establish quickly and form a nearly complete groundcover, which can help prevent erosion, maintain water quality, and increase soil stability on more susceptible areas. The legume species listed would also fix atmospheric nitrogen into the soil to help re-establish soil nutrients. Generally, these species would be planted as temporary cover crops until the native species developed and could out-compete them. However, some of the proposed species are considered invasive (e.g., birdsfoot trefoil, redtop, smooth brome grass, Canada bluegrass). Section 5.2.4.2.4 discusses suggested mitigation measures for non-native or invasive species.

The proposed Type 1 mulch (hay, straw, and agricultural grass/legume cuttings) would be relatively free of seed-bearing stalks or propagules of noxious weed species, as defined by the rules and regulations of the Minnesota Department of Agriculture (PolyMet 2015g, Attachment A).

The introduction of invasive non-native species would be more detrimental to the relatively high-quality vegetation communities at the Mine Site than to those at the Plant Site, which is already heavily disturbed. Introduction of invasive non-native species could result in decreased diversity of plant species and habitats available to wildlife species. Several ETSC plant species at the Mine Site may be susceptible to increased competition from invasive non-native species. There are already a few occurrences of yellow sweetclover and bladder campion at the Mine Site, which may invade future disturbed areas.

Minnesota's noxious weed law (*Minnesota Statutes* § 18.75-18.91) contains procedures for controlling and eradicating noxious weeds on all lands within the state. None of the species proposed to be potentially planted are considered state-prohibited noxious weeds. The MDNR has made recommendations for non-invasive species for the seed mix and the final seed mix would be approved during permitting.

Effects on Threatened and Endangered Plant Species

The MDNR NHIS and separate rare species surveys were utilized to map known ETSC species locations using GIS data. Updated MDNR Element Occurrence attribute data were used to estimate the NorthMet Project area and statewide population numbers of a species, per MDNR guidance (MDNR, Pers. Comm., February 13, 2012). An individual is defined here as a single plant of a species. A colony (observation) is a group of individual plants of one species in a distinct geographic location. A population is a group of individuals or colonies of one species that may be separated geographically, but are close enough geographically to interbreed and persist over time.

No federally listed threatened or endangered plant species occur at the Mine Site. However, the NorthMet Project Proposed Action would have both direct (eight species) and potential indirect (two species) effects on state-listed ETSC plant species at the Mine Site, affecting 1 percent of the known statewide populations for these 10 species. Table 5.2.4-3 summarizes the direct and indirect NorthMet Project Proposed Action effects on each of the ETSC plant species that are located in the vicinity of the Mine Site, which includes some of the Transportation and Utility Corridor. These numbers may overestimate the actual effects as a proportion of the number of actual populations in the state. Intensive surveys, such as those performed at the Mine Site, have not been performed throughout the state; therefore, the actual number of statewide populations may be larger than that identified in the MDNR NHIS.

Rulemaking was conducted with the intent to update the list of ETSC species (*Minnesota Rules*, parts 6134.0100–6134.0400), with new listings becoming effective on August 19, 2013 (MDNR 2013h). This FEIS considers any new listings, or changes in the previous listings, associated with the updated list.

Table 5.2.4-3 Effects on Known State-listed ETSC Plant Populations in the Vicinity of the Mine Site, Including the Transportation and Utility Corridor

	Known Mine Site Populations					Known Statewide Populations				
Plant Species (state status/ global status[1])	**Total Populations[2,7]**	**Total Individuals**	**Direct Effects[3] (Populations)**	**Indirect Effects[4] (Populations)**	**Unaffected Populations**	**Total Known Populations[5,7]**	**Average Individuals per Population[6]**	**Percent Directly Affected (Populations)**	**Percent Indirectly Affected (Populations)**	**Total Percent Affected (Populations)**
Botrychium campestre (SC/G3)	1	1	1	0	0	69	unknown	1	0	1
Botrychium pallidum (SC/G3)	1	21	1	0	0	99	15	1	0	1
Botrychium rugulosum (SC/G3)	1	4	1	0	0	72	14	1	0	1
Botrychium simplex (SC/G5)	3	1,580	3	0	0	210	25	1	0	1
Caltha natans (E/G5)	1	56	1	0	0	15	unknown	7	0	7
Eleocharis nitida (SC/G4)	1	~1,562 ft^2	1	0	0	49	450	2	0	2
Juncus stygius var. *americanus* (SC/G5)	1	1	0	1	0	30	unknown	0	3	3
Platanthera clavellata (SC/G5)	1	3	0	1	0	123	unknown	0	1	1
Ranunculus lapponicus (SC/G5)	1	~919 ft^2	1	0	0	83	51	1	0	1
Torreyochloa pallida (SC/G5)	1	~25 ft^2	1	0	0	74	unknown	1	0	1
Total	13	NA	11	2	0	982	NA	NA	NA	NA

Sources: MDNR 2011k; MDNR 2014d.

Notes:

[1] The state status is E – Endangered; T – Threatened; and SC – Species of Special Concern. The global ranks range from G1 to G5. A lower global ranking (e.g., G3) indicates a species at higher global risk than higher ranking (e.g., G5) (NatureServe 2014b).

[2] Populations are interpreted from MDNR NHIS data using Element Occurrence, which differs from the DEIS, which used colonies as the population estimate.

[3] Direct effects are expected for those populations that would be removed or buried by mine activities. Effects are calculated for populations rather than individuals because of the large variation and inaccuracies in the estimates of number of individuals per population.

[4] Indirect effects may occur to those populations within or near the Mine Site. These populations may be affected by changes in hydrology, water quality, dust, or inadvertent activities. As above, effects are given for populations rather than individuals.

[5] Statewide population data provided by Lisa Joyal (MDNR) on March 26, 2013.

[6] Population estimates are approximate and used for comparative purposes only. The number of individuals is based upon populations for which data exist.

[7] Data included here were provided by the Division of Ecological Resources, MDNR, and were current as of August 5, 2014. These data are not based on an exhaustive inventory of the state. The lack of data for any geographic area shall not be construed to mean that no significant features are present

The NorthMet Project Proposed Action would directly affect 8 of the 10 state-listed ETSC plant species found at or in the immediate vicinity of the Mine Site (see Table 5.2.4-3). Most of the direct effects would involve the complete loss of colonies within a population as a result of excavation of the mine pits, burial under stockpiles, or disturbance during infrastructure construction.

The NorthMet Project Proposed Action would potentially indirectly affect 2 of the10 state-listed ETSC plant species found at or in the immediate vicinity of the Mine Site (see Table 5.2.4-3). The NorthMet Project Proposed Action may also result in indirect effects on some colonies of the directly affected state-listed ETSC plant species at the Mine Site. These indirect effects may occur as a result of changes in hydrology or water quality, deposition of particulate matter (dust), application of road salts, or weed incursion. Individual species appear to differ in their response to these indirect effects. For example, several of the ETSC plant species typically occur along or in old tailings ponds or along roadsides where disturbance and dust are frequent. To a certain extent, each species' sensitivity to disturbance can be inferred from currently occupied habitats. Habitats were considered "disturbed" if they consisted of tailings ponds, gravel pits, landing pads, logging roads, ditches, or roadsides. Several species may not actually be disturbance-tolerant, as much as they are able to colonize previously disturbed sites. Repeated soil disturbance near these species may have an effect on such populations in the short term. Overall, less than 1 percent of the known statewide populations for these state-listed ETSC species would potentially be indirectly affected by the NorthMet Project Proposed Action. In some cases, potential indirect effects on ETSC plant species that would be near, but outside, the footprint of these facilities could be avoided or reduced by fencing or flagging ETSC populations to prevent disturbance.

Minnesota's endangered species law (*Minnesota Statute,* § 84.0895) and associated rules (*Minnesota Rules,* parts 6212.1800–6212.2300 and 6134) impose a variety of restrictions, permits, and exemptions pertaining to ETSC species. "The law and rules prohibit taking, purchasing, importing, possessing, transporting, or selling" endangered or threatened plants, including their parts or seeds, without a permit (MDNR 2013h). "Taking," as it relates to plants includes picking, digging, or destroying. There is the potential that PolyMet would need to seek a Taking Permit from the MDNR for state-listed ETSC plant species. If it is determined by the MDNR that there are no feasible alternatives to taking, the applicant must pursue compensatory mitigation. Transplantation is generally not considered by the MDNR to be acceptable mitigation for taking of endangered or threatened species (MDNR 2013h). The MDNR suggests that typical compensatory mitigation for taking endangered or threatened species in Minnesota include the following:

- Funding state acquisition of another site where the species occurs that is currently unprotected and vulnerable to destruction,
- Funding additional survey work to locate other sites, and/or
- Funding research to improve our understanding of the habitat requirements or protection needs of the species (MDNR 2011k).

A discussion of the effects on each individual ETSC species is provided below.

Prairie moonwort populations are commonly observed on sparsely vegetated mineral soil from sediments of iron mine tailings ponds and grassy railroad embankments (NatureServe 2014b). Of the 69 known populations statewide, one colony of one population within the Mine Site area, along Dunka Road, could be directly affected by pipeline construction and road improvements/maintenance as part of the NorthMet Project Proposed Action (1 percent affected) (see Table 5.2.4-3). This species is less tolerant of disturbance than other *Botrychium* species; however, since it prefers sparsely vegetated areas, it may actually expand into disturbed areas along Dunka Road in the future. At the Mine Site, grassland areas would not be affected, but around 34 percent of previously disturbed areas would be affected, resulting in potentially reduced on-site habitat for this species (see Table 5.2.4-1).

Botrychium pallidum (pale moonwort) populations are most commonly observed on mine tailings basins and along roadsides. Of the 99 known populations statewide, three colonies of one population within the Mine Site, along Dunka Road, could be directly affected by pipeline construction and road improvements/maintenance as part of the NorthMet Project Proposed Action (1 percent affected) (see Table 5.2.4-3). One separate colony is located near the railroad track and may be indirectly affected. This species, however, appears to be semi-tolerant of disturbance since sites that are kept open by regular disturbance are particularly suitable (NatureServe 2014b). Colonies may actually expand into newly disturbed areas along Dunka Road and at the Mine Site. Grassland areas at the Mine Site would not be affected, but around 34 percent of previously disturbed areas would be affected, resulting in reduced on-site habitat for this species (see Table 5.2.4-1).

Botrychium rugulosum (ternate, or St. Lawrence, grapefern) often occurs on tailings basins, along roadsides, and in shaded wetland forests. Of the 72 known extant populations in Minnesota, one population (with four individuals) occurs along Dunka Road at the Mine Site (1 percent affected) (see Table 5.2.4-3). This population may be directly affected by vehicle operation or road improvements and maintenance as part of the NorthMet Project Proposed Action. This species appears to be semi-tolerant of disturbance and populations. At the Mine Site, around 62 percent of upland conifer forests and around 55 percent of upland deciduous forests would be affected, resulting in much less on-site habitat for this species (see Table 5.2.4-1).

Botrychium simplex (least moonwort) frequently occurs in shrublands, forests, tailings basins, and along roadsides. Of the 210 known populations statewide, three occur at the Mine Site, all of which are expected to be directly affected (see Table 5.2.4-3). Of these populations, 21 colonies are expected to be directly affected—seven from stockpiles and mine pits, and another 14 from construction of the haul roads, water pipeline, ditches, railroad track, or transmission line (1 percent affected). The colonies affected by stockpiles and mine pits would be removed, while the colonies affected by construction of pipelines or ditches may be reduced in the short term. Depending on proximity to construction activities, some of these colonies would likely recover by expanding along Dunka Road and at the Mine Site post-closure, as this species appears to be semi-tolerant of disturbance. At the Mine Site, around 34 percent of disturbed areas and around 55 percent of shrublands would be directly affected, resulting in less on-site habitat for this species (see Table 5.2.4-1).

Caltha natans (floating marsh-marigold) is found primarily in relatively undisturbed habitats and is not likely to be tolerant of disturbance. Of the15 known populations statewide, one population, which consists of 13 colonies, occurs at the Mine Site (see Table 5.2.4-3). One colony is expected to be directly affected by stockpile development. Two other colonies are located close to Dunka Road and could be potentially indirectly affected by road construction or improvements. Ten other colonies are located in the vicinity of, but outside, the Mine Site, several of which occur along the Partridge River. Since water from the West Pit would be discharged downstream of these colonies, it is unlikely there would be indirect effects on them. Effects would not occur to all thirteen colonies of the Mine Site population as indicated in Table 5.2.4-3 because direct and indirect effects due to the NorthMet Project Proposed Action would be limited to three of the thirteen colonies. All known Minnesota populations occur in St. Louis County; one in the northern third of the county, two in the southern third, and twelve in the central third. A few of the statewide populations contain many more individuals (thousands) than the population at the Mine Site. Since the known statewide population for this species is smaller than the other species present, the effect on its population in Minnesota would be correspondingly larger (seven percent affected). As mentioned, however, due to the size of other statewide populations, and since three out of thirteen colonies of the Mine Site population could be affected, the actual percent affected would be smaller than seven percent (using available data, approximately less than one percent). The mitigation measures mentioned above, particularly the purchase of an unprotected site with a population of the species, should be assessed. At the Mine Site, around 47 percent of aquatic environments would be directly affected, resulting in reduced on-site habitat for this species (see Table 5.2.4-1).

Eleocharis nitida (neat spike-rush) at the Mine Site is primarily observed in roadside ditches along Dunka Road with gravel or sandy substrates. Of the 49 known populations in the state, one occurs on the Mine Site (2 percent affected) (see Table 5.2.4-3). Of this population, eight colonies are found along Dunka Road, and three colonies are located along the railroad tracks. All of the eight Dunka Road colonies are likely to be directly affected by ditch construction. The other three colonies may be potentially indirectly affected by changes in hydrology or water quality. This species seems to be semi-tolerant of disturbance since it has inhabited roadside ditches. At the Mine Site, around 47 percent of aquatic environments and 34 percent of disturbed areas would be directly affected, resulting in less on-site habitat for this species (see Table 5.2.4-1).

Juncus stygius var. *americanus* (bog rush) has 30 known populations in the state, none of which occur at the Mine Site; however, one population is located upgradient of the Mine Site within the One Hundred Mile Swamp (see Table 5.2.4-3). This population would not be directly affected, but it may be potentially indirectly affected by changes in hydrology (3 percent affected). However, Section 5.2.3 indicates there would likely be no wetland hydrology effects in this area. At the Mine Site, around 56 percent of lowland coniferous forests would be directly affected, resulting in reduced habitat nearby for this species (see Table 5.2.4-1).

Platanthera clavellata (club-spur orchid) has 123 known populations in the state, none of which occur at the Mine Site; however, one population is located upgradient of the Mine Site within the One Hundred Mile Swamp (see Table 5.2.4-3). This population would not be directly affected, but three colonies may be potentially indirectly affected by changes in hydrology, since the species is sensitive to this type of change (1 percent affected). However, Section 5.2.3 indicates there would likely be no wetland hydrology effects in this area. At the Mine Site, around 56 percent of lowland coniferous forests would be directly affected, resulting in reduced habitat nearby for this species (see Table 5.2.4-1).

Ranunculus lapponicus (lapland buttercup) is found in conifer/sphagnum bogs on the Mine Site. Of the 83 known populations statewide, one population occurs at the Mine Site (1 percent affected) (see Table 5.2.4-3). Of this population, three colonies are expected to be directly affected by construction of a waste rock stockpile. The other four colonies may be potentially indirectly affected by changes in hydrology, water chemistry, or dust. This species may face short- and long-term effects at the Mine Site since it is most likely intolerant of disturbance. At the Mine Site, around 56 percent of lowland coniferous forests would be directly affected, resulting in much less on-site habitat for this species (see Table 5.2.4-1).

Torreyochloa pallida (Torrey's manna-grass) is often seen along roadsides and may be semi-tolerant of disturbance. Of the 74 known populations statewide, one occurs at the Mine Site (1 percent affected) (see Table 5.2.4-3). Of this population, one colony along Dunka Road may be directly affected by construction of a transmission line. The remaining three colonies are located away from any proposed construction and may be sufficiently removed from potential direct and indirect effects of the NorthMet Project Proposed Action. At the Mine Site, around 47 percent of aquatic environments and 56 percent of lowland coniferous forests would be directly affected, resulting in less on-site habitat for this species (see Table 5.2.4-1).

Regional Foresters Sensitive Species

The USFS RFSS data layer indicates there are no known RFSS plants on the federal lands, which include the majority of the Mine Site. However, several state-listed ETSC plant species known to exist on the Mine Site are also listed as RFSS plants in the Superior National Forest. Six of these species would be affected by the NorthMet Project Proposed Action, including *Botrychium pallidum*, *Botrychium rugulosum*, *Botrychium simplex*, *Caltha natans*, *Eleocharis nitida*, and *Juncus stygius* var. *americanus*.

MIH types are not fully mapped for the Mine Site since not all of it consists of federal land, but MIH types are mapped for the federal lands located within the Mine Site. On this portion of the Mine Site, upland forest (MIH 1; approximately 531 acres affected) would be affected the most of all MIH types, which means RFSS plant species listed under the upland forest category (see Table 4.2.4-5) could be most affected by the NorthMet Project Proposed Action. However, since there are suitable habitats for each RFSS species within each MIH type, a direct correlation between loss of MIH and loss of RFSS plants cannot be made. Upland conifer forest (MIH 5; approximately 505 acres affected) lands would be the next group most affected, though there is overlap of this category with upland forest since upland conifer forest occurs within upland forest types. Some RFSS species that occupy upland forest may also be affected by this category. Lowland black spruce-tamarack forest (MIH 9; approximately 483 acres affected) would be subject to effects comparable to upland conifer forest, and some of the RFSS species listed in this category would be affected similarly. The lowland emergent wetland type would be affected (approximately 11 acres affected), but likely only one of the five RFSS plant species listed for that type may be minimally affected. Aquatic habitat (MIH 14) is not mapped at the Mine Site; however, there are some aquatic habitats on the parcel that would be affected and, thus, some of the RFSS species listed in this category may be affected. Section 5.2.6 provides further discussion of effects on aquatic habitats and species.

The one RFSS plant not listed as an ETSC species but that is known to occur on the Mine Site, according to MDNR NHIS data, is *Botrychium michiganense*, which is very closely related to *Botrychium hesperium*. *B. hesperium* typically occurs in western states, while *B. michiganense* typically occurs around the Great Lakes states. One population is known to occur on the Mine Site, of which five colonies would be affected by stockpile development, haul road placement, or the Transportation and Utility Corridor immediately adjacent to the Mine Site (MDNR 2014d). It often occurs in grassy roadsides and fields, and requires at least somewhat open habitat created by natural disturbance events. While anthropogenically disturbed areas have been observed to harbor reasonably large numbers of individuals, habitat created in this way has not been proven to support long-term viable populations (NatureServe 2013). At the Mine Site, grassland areas would not be affected, but around 34 percent of previously disturbed areas would be affected, resulting in potentially reduced on-site habitat for this species (see Table 5.2.4-1).

The USFS determined that the NorthMet Project Proposed Action would not affect 20 RFSS plants on the Superior National Forest. These 20 species include: alpine milkvetch, *Arctoparmelia centrifuga*, *Arctoparmelia subcentrifuga*, Braun's holly fern, creeping rush, Chilean sweet-cicely, Douglas' hawthorn, white mountain saxifrage, largeleaf sandwort, little goblin moonwort, Northern arnica, maidenhair spleenwort, muskroot, nodding saxifrage, Oakes' pondweed, Scotch false asphodel, short sedge, smooth woodsia, triangle grapefern, and Wain's cup lichen. In addition, the NorthMet Project Proposed Action may affect individuals, but are not likely to cause a trend to federal listing or loss of viability for the remaining 38 RFSS plants on the Superior National Forest. The Biological Evaluation is included in Appendix D for more information about effects on RFSS plants.

5.2.4.2.2 Transportation and Utility Corridor

Effects on Cover Types

Habitat Types

Construction and transportation activities within the Transportation and Utility Corridor, as part of the NorthMet Project Proposed Action, would affect all 120.2 acres of the MDNR GAP land cover designations (see Table 5.2.4-4). The majority of effects would be on formerly disturbed (94.4 acres) and grassland areas (9.8 acres).

Table 5.2.4-4 Direct Effects on Cover Types along the Transportation and Utility Corridor

Cover Types	Affected Acres	Non-affected Acres	Total Cover Type Acres	Percent of Cover Type Affected
Disturbed	94.4	0	94.4	100
Cropland/grassland	9.8	0	9.8	100
Shrubland	7.7	0	7.7	100
Aquatic environments	2.7	0	2.7	100
Upland deciduous forest	2.7	0	2.7	100
Upland coniferous forest	2.6	0	2.6	100
Lowland coniferous forest	0.2	0	0.2	100
Lowland deciduous forest	0.0	0	0.0	100
Upland conifer-deciduous mixed forest	0.0	0	0.0	100
Total [1]	120.2	0	120.2	100

Source: MDNR 2006b.

Note:
[1] Total acres may be more or less than presented due to rounding.

Minnesota Biological Survey

The NorthMet Project Proposed Action would affect 22.5 acres of MBS Sites of High Biodiversity Significance (2.9 acres of the One Hundred Mile Swamp and 19.6 acres of the Upper Partridge River) within the Transportation and Utility Corridor. Similar to the Mine Site, this 22.5-acre area represents a very small portion of the mapped Sites of High Biodiversity Significance in St. Louis County (less than 1 percent) and the State of Minnesota (less than 1 percent). Habitat effects associated with the NorthMet Project Proposed Action would not result in a large percentage decline in those areas ranked as high by the MBS.

NorthMet Project Proposed Action activities within the corridor would also affect approximately 2 acres of "widespread and secure" native plant communities, including 2 acres of the aspen-birch forest: balsam fir subtype (FDn43b1; less than 1 percent of community within Laurentian Uplands subsection), and less than 0.1 acre of the low shrub poor fen (APn91a; less than 1 percent of community within Laurentian Uplands subsection).

Indirect Effects

Potential indirect effects on vegetative cover types remaining along the Transportation and Utility Corridor could include those caused by dust from road traffic or spillage from rail cars. Section 5.2.4.2.1 provides further discussion on the effects of dust. PolyMet plans to use the existing but currently decommissioned fleet of LTVSMC side-dump rail ore cars. These cars are a different design than the bottom-dump rail pellet cars that are used across the Iron Range and during past LTVSMC operations. Prior to the start of operations, PolyMet would refurbish these ore cars, which would include tightening or replacement of the couplings and linkages to minimize gaps along the hinges and joint areas where spillage could occur. Refurbishment of these cars would largely reduce the potential for spillage along the Transportation and Utility Corridor (PolyMet 2014a). Larger pieces of ore that are spilled from the cars would be recovered during routine maintenance of the track, thus minimizing indirect effects. As Section 5.2.7 further describes, no significant reactive airborne fugitive dust from the rail transport is expected. Smaller effects in already-disturbed areas could occur along Dunka Road near the Mine Site. A water pipeline for treated water and a transmission line would be constructed along Dunka Road on previously disturbed land. Construction of the pipeline and transmission line would expose soil during construction and could bury vegetation under rock fill.

Reclamation

Dunka Road would not be reclaimed after the NorthMet Project area is closed, since it is an existing private road. Railroad track and ties that are not used by common carriers would be removed and recycled (PolyMet 2015a). The Treated Water Pipeline between the Mine Site and Plant Site would be removed (PolyMet 2015g).

Effects of Invasive Non-native Plants

The Transportation and Utility Corridor is already disturbed, and contains several non-native and/or invasive species. Disturbance associated with the widening of Dunka Road and installation of the water pipeline, transmission line, and rail line would result in exposed soil surfaces that would have the potential for colonization of invasive species. Therefore, the general effects of invasive non-native plant species along the Transportation and Utility Corridor would be the same as the Mine Site or Plant Site.

Effects on Threatened and Endangered Plant Species

No federally listed threatened or endangered plant species occur within the Transportation and Utility Corridor. The NorthMet Project Proposed Action would have both direct and potential indirect effects on the same state-listed ETSC plant species as those found at the Mine Site. Since some of the populations occur along Dunka Road near or overlapping the Mine Site, they are discussed in Section 5.2.4.2.1 along with the effects on plant populations at the Mine Site. Table 5.2.4-3 summarizes the direct and indirect effects of the NorthMet Project Proposed Action on each of those ETSC plant species. For the ETSC species located within the Transportation and Utility Corridor not adjacent to the Mine Site (*Botrychium pallidum*), effects are discussed below (see Table 5.2.4-5). As mentioned for the Mine Site, these numbers may overestimate the actual effects as a proportion of the number of actual populations in the state.

Rulemaking was conducted with the intent to update the list of ETSC species (*Minnesota Rules*, parts 6134.0100–6134.0400), with new listings becoming effective on August 19, 2013 (MDNR 2013h). This FEIS considers any new listings, or changes in the previous listings, associated with the updated list.

Table 5.2.4-5 Effects on Known State-listed ETSC Plant Populations in the Transportation and Utility Corridor

	Known Mine Site Populations					Known Statewide Populations				
Plant Species (state status/ global status[1])	**Total Populations**	**Total Individuals**	**Direct Effects[2] (Populations)**	**Indirect Effects (Populations)**	**Unaffected Populations**	**Total Known Populations[3]**	**Average Individuals per Population[4]**	**Percent Directly Affected (Populations)**	**Percent Indirectly Affected (Populations)**	**Total Percent Affected (Populations)**
Botrychium pallidum (SC/G3)	3	16	3	0	0	99	15	3	0	3
Total	3	16	3	0	0	99	NA	NA	NA	NA

Source: Barr 2012n.

Notes:

1 The state status is E – Endangered. The global ranks range from G1 to G5. A lower global ranking (e.g., G3) indicates a species at higher global risk than higher ranking (e.g., G5) (NatureServe 2014b).

2 Direct effects are expected for those populations that would be removed or buried by road improvement activities. Effects are calculated for populations rather than individuals because of the large variation and inaccuracies in the estimates of number of individuals per population.

3 Statewide population data provided by Lisa Joyal (MDNR) on March 26, 2013. Statewide population data does not include the three populations of *B. pallidum* found during NorthMet Project Proposed Action-specific survey (Barr 2012n), as these were not included in NHIS data, thus inflating effects on statewide population.

4 Population estimates are approximate and used for comparative purposes only. The number of individuals is based upon populations for which data exist.

The NorthMet Project Proposed Action would directly affect the one state-listed ETSC plant species (*Botrychium pallidum*) found within the Transportation and Utility Corridor not adjacent to the Mine Site (see Table 5.2.4-5). The direct effects would involve the complete loss of populations as a result of disturbance during road construction and improvement activities. Section 5.2.4.2.1 above discusses Minnesota's endangered species law, as well as permits and mitigation for ETSC species.

Botrychium pallidum (pale moonwort) populations are most commonly observed on mine tailings basins and along roadsides. Of the 99 known NHIS populations statewide, six colonies of three populations along Dunka Road could be directly affected by road improvements or maintenance as part of the NorthMet Project Proposed Action (3 percent affected) (see Table 5.2.4-5). These populations were found during a separate species survey and are not included in the NHIS data. In addition, without the NHIS element occurrence attribute, it was estimated that there are three distinct populations by virtue of three separate locations of the six colonies. Thus, the effects on statewide populations are slightly inflated. All of the grassland and previously disturbed areas along the Transportation and Utility Corridor would be affected, resulting in reduced on-site habitat for this species (see Table 5.2.4-4).

5.2.4.2.3 Plant Site

Effects on Cover Types

Habitat Types

Construction, operation, and closure of the NorthMet Project area at the Plant Site would have fewer effects on native vegetation than at the Mine Site because much of the Plant Site (61 percent) has already been heavily disturbed or is barren (see Table 4.2.4-8). Most of the effects of the NorthMet Project Proposed Action are on disturbed areas or tailings ponds, but other affected areas include isolated stands of forest or shrublands (see Table 5.2.4-6). Other effects on MDNR GAP land cover types at the Plant Site are smaller. Approximately 2,189.7 acres (48 percent) of the Plant Site would be affected by NorthMet Project Proposed Action activities. A description of the potential effects on wetlands north of the Tailings Basin is presented in Section 5.2.3.

Table 5.2.4-6 Direct Effects on Cover Types at the Plant Site[1]

Cover Types	Affected Acres	Non-affected Acres [2]	Total Cover Type Acres	Percent of Cover Type Affected
Disturbed	1,104.0	1,651.5	2,755.5	40
Aquatic environments	573.0	63.8	636.8	90
Upland deciduous forest	295.1	352.5	647.6	46
Shrubland	144.9	188.9	333.8	43
Upland coniferous forest	52.0	47.8	99.8	52
Lowland coniferous forest	20.7	21.2	41.9	49
Cropland/grassland	0.0	0.0	0.0	0
Lowland deciduous forest	0.0	0.0	0.0	0
Upland conifer-deciduous mixed forest	0.0	0.0	0.0	0
Total	2,189.7	2,325.8	4,515.4	48

Source: MDNR 2006b.

Notes:
1 This table reflects only those effects on plant communities occurring within the boundaries of the Plant Site. The table does not include the potential indirect effects on the wetlands north of the Tailings Basin due to hydrology changes.
2 Areas of cover types not within a 50-ft buffer of buildings, Tailings Basin/spillway reclamation area, or railroad connection.

Minnesota Biological Survey

There are no MBS Sites of Biodiversity Significance or native plant communities identified at the Plant Site.

Indirect Effects

In addition to the direct effects mentioned above, potential indirect effects on vegetation at and surrounding the Plant Site could include dust or erosion. Vegetation would be established on tailings dams during construction to minimize erosion and fugitive dust (PolyMet 2015n). Water level would be managed in the Tailings Basin to limit the amount of exposed beach, which would minimize dust. Additionally, other fugitive dust control measures (e.g., mulching, temporary seeding, and dust suppressants) would be applied to inactive beaches. As Section 5.2.7 further describes, fugitive dust control measures would result in an 80 percent reduction of emissions at the Plant Site. Section 5.2.7.2.6 states that the NorthMet Project Proposed Action is not expected to have a significant effect on sulfate deposition in the state, and so no threat to sensitive vegetation is expected. Potential mercury emissions at the Plant Site are expected to be 4.6 lb/yr. Overall, about 95 percent of the mercury originating in the ore is expected to remain within—or be adsorbed to—the tailings and the hydrometallurgical residue, where it would remain isolated from further transport to the environment. The mercury deposition on terrestrial environments would be expected to be not significant when compared to variability in background mercury concentrations. In the event erosion occurs on the Tailings Basin, it would be corrected and re-vegetated; if necessary for repetitive or excessive erosion, channels or outfall structures would be designed to address the issue.

Reclamation

At closure, the buildings and other infrastructure at the Plant Site would be removed, and foundations would be razed and buried to a minimum depth of 2 ft. with overburden material suitable for vegetation. Plant Site roads that are not deemed necessary for access by the MDNR would be scarified and vegetated, and asphalt from paved surfaces would be removed and recycled. These disturbed areas would be seeded with the same potential three mixes (native, non-native, or mixed) as those mentioned for disturbed areas in Section 5.2.4.2.1 (PolyMet 2015g, Attachment A).

The Tailings Basin would be incrementally reclaimed by a qualified professional pursuant to *Minnesota Rules*, part 6132.2700. As dams are constructed, exterior slopes would be stabilized and vegetated in accordance with requirements in the Fugitive Emissions Control Plan (PolyMet 2015l). Inactive interior beach areas would be temporarily vegetated as necessary for fugitive dust control, using oats, winter wheat, annual ryegrass, white clover, redtop, and alsike clover, or some combination of these species for various times of the year (PolyMet 2015g, Attachment A). The exterior dam faces would be permanently vegetated by a qualified reclamation contractor according to requirements of the Reclamation Seeding Plan. Upland areas would be planted with permanent vegetation and mulched to control potential fugitive dust in accordance with requirements in the Fugitive Emissions Control Plan. Upland beach areas would be planted with the same potential three mixes (native, non-native, or mixed) as that mentioned for disturbed areas in Section 5.2.4.2.1, while the dam slopes and benches would be planted with the same mix as that mentioned for the slopes of the Category 1 Stockpile (PolyMet 2015g, Attachment A). Interior portions would be graded to provide a gently sloping surface that effectively routes storm water runoff to the interior of the Tailings Basin and promotes wetlands creation between the beach and pond areas. Exposed beach areas would be amended with bentonite to limit oxygen infiltration into the tailings. The cover layer of tailings would be replaced and vegetated in accordance with requirements of the Reclamation Seeding Plan (PolyMet 2013l). Wet soils near the Tailings Basin pond would be planted with the same mix as that mentioned for the East Pit backfill and depressions in the temporary stockpile footprints (see Section 5.2.4.2.1) (PolyMet 2015g, Attachment A). Establishment of dense vegetative cover and root mass is among the most effective methods to minimize erosion, so the quality and density of the vegetation would be periodically reviewed after final reclamation construction is complete. Areas where vegetation does not become well established would receive additional seeding and/or fertilizer and other amendments in accordance with requirements of the Reclamation Seeding Plan. Reclamation areas would be inspected in spring and fall to repair erosion areas and failed seeding areas, until MDNR determines that the areas are stable and self-sustaining.

Reclamation of the Hydrometallurgical Residue Facility would include removal of ponded water from the cell surface, removal of pore water from the residue, construction of the cell cover system, and establishment of vegetation and surface water runoff controls. The exterior slopes of the Hydrometallurgical Residue Facility dams would be incrementally reclaimed throughout the life of the mine. This would include stabilization and vegetation in accordance with *Minnesota Rules*, part 6132.3200. Final reclamation would generally consist of grading the cell area into a gently sloping surface. The cover would consist of a layer of LTVSMC tailings immediately above the drained residue. This would be topped, if necessary, with a non-woven needle-punched geotextile fabric. Next, a geosynthetic clay barrier layer and a 40 mm LDPE or similar MPCA-approved geomembrane barrier layer would be placed (PolyMet 2015a). Additional LTVSMC coarse tailings and/or common borrow and cover soils would be placed on top of the barrier layer to create a surface capable of sustaining a vegetated cover (PolyMet 2012e). The Hydrometallurgical Residue Facility dam slopes and benches would be planted with the same mix as that mentioned for the Category 1 Stockpile slopes in Section 5.2.4.2.1 (PolyMet 2015g, Attachment A). Turf and final cover would be inspected and maintained by mowing once per year or as needed, fertilizing when visual inspection indicates poor vegetation growth, and implementing repairs.

The Colby Lake Water Pipeline Corridor would not be subject to any additional disturbance or effects as a result of the NorthMet Project Proposed Action. Maintenance activities would likely continue to occur on the pipeline.

Effects of Invasive Non-native Plants

The revegetation plan following closure at the Plant Site is similar to what is planned at the Mine Site as described above. Use of the proposed seed mix could introduce invasive non-native species, depending on which species are included in the mix, to an area of primarily native vegetation that surrounds the Plant Site. However, the existing LTVSMC Tailings Basin and most of the Plant Site are already heavily disturbed, and several invasive non-native species currently inhabit these areas (e.g., smooth brome grass, reed-canary grass, yellow sweetclover). These species, once introduced, are difficult to remove and could spread to and colonize susceptible areas following future disturbance (e.g., blowdown, logging, fire). These species may reduce diversity, out-compete native vegetation, and provide lower quality habitat for some specialist animal species. Generally, dominance by invasive non-native species would reduce the quality of native cover types and habitat remaining at the Plant Site. The MDNR has made recommendations for non-invasive species for the seed mix and the final seed mix would be approved during permitting.

Effects on Threatened and Endangered Plant Species

The NorthMet Project Proposed Action would likely have no effect on federal or state ETSC plant species at the Plant Site or Colby Lake Water Pipeline Corridor because none are known to occur within the boundaries of these areas, according to MDNR NHIS data. However, no site-specific studies have been conducted at the Plant Site and so potential species not reported in the NHIS data may not be represented.

5.2.4.2.4 Potential Mitigation Measures

Mine Site Mitigation Measures

A preferred mitigation measure would be to reseed with the native species, provided they can perform as effectively as the non-native species. In some areas where erosion control would be critical to prevent slope failures, non-native species may be needed. Temporary stabilization efforts using non-native species should use non-invasive plant species to minimize the long-term risk to surrounding plant communities. In the event invasive non-native species are introduced, an additional mitigation measure would be to implement a monitoring and control program for invasive species (including noxious weeds) to ensure these species do not overtake surrounding native communities. Additionally, the purchase of an unprotected site with a population of *Caltha natans* should be assessed as mitigation, since the statewide population is lower than the other ETSC species affected.

Plant Site Mitigation Measures

The measures outlined in the Mine Site Mitigation Measures section above should be applied to the Plant Site as well. Another recommended mitigation measure may also benefit vegetation at the Plant Site specifically. The addition of organic amendments (peat) to the top foot of the Tailings Basin would improve soil and water quality and promote the development of shoreline and near-shore wetland vegetation.

5.2.4.3 NorthMet Project No Action Alternative

5.2.4.3.1 Effects on Cover Types

Under the NorthMet Project No Action Alternative, the Mine Site would not be developed, the Transportation and Utility Corridor would not be disturbed beyond routine maintenance, and the Plant Site would have no additional tailings added to the existing LTVSMC Tailings Basin. Forest-harvesting would continue to occur on the federal land portions of the Mine Site under the Forest Plan. While timber harvests would result in the immediate loss of some habitat types, permanent changes are not expected. The Forest Plan calls for an increase in older-age stands, which would likely come at the expense of younger-age stands in the long term. The majority of the federal lands are designated as General Forest – Longer Rotation Management Area, which correlates with the increase in older-age stands overall. The former LTVSMC processing plant would be reclaimed and revegetated in accordance with its separate closure plan sooner than under the NorthMet Project Proposed Action. Direct and indirect effects of the NorthMet Project No Action Alternative on cover types are considered minimal, as the Mine Site and portions of federal lands would continue to be managed in the same way they have been, and the Transportation and Utility Corridor and Plant Site have been disturbed in the past.

5.2.4.3.2 Effects of Invasive Non-native Plants

Invasive or non-native species may still invade the Mine Site as a result of logging, mineral exploration, vehicle traffic, and natural disturbances, but are likely to do so much more slowly than under the NorthMet Project Proposed Action. Invasive non-native species already exist along the Transportation and Utility Corridor and Plant Site, but they would likely spread more slowly under the NorthMet Project No Action Alternative than under the NorthMet Project Proposed Action due to less disturbance.

5.2.4.3.3 Effects on Threatened and Endangered Plant Species

Under the NorthMet Project No Action Alternative, colonies of state-listed ETSC plant species would not be affected. Timber harvests are expected to continue to occur on the federal land portions of the Mine Site. The NorthMet Project area has historically been logged and the state-listed ETSC plant species present on site have persisted. It is unlikely that continued logging, which now is more likely to employ best management practices to minimize detrimental effects, would affect the species in the long term. Potential indirect effects under the NorthMet Project No Action Alternative could come from increased competition as succession proceeds to older-age forest stands or with invasive non-native species. Effects of increased competition could include reduced spore production and consequently reduced population size in the early successional plant species (e.g., *Botrychium* spp.). Continued maintenance would likely occur along Dunka Road and the railroad where several of the *Botrychium* populations occur. Long-term succession at these locations is unlikely due to this maintenance, and these populations could persist given available habitats. The Transportation and Utility Corridor and Plant Site contain no occurrences of state-listed ETSC plant species and so the NorthMet Project No Action Alternative is not expected to have any effects.

The USFS determined that the NorthMet Project No Action Alternative would have no effect on all 58 RFSS plants on the Superior National Forest. A Biological Evaluation has been prepared that contains further information about RFSS. The Biological Evaluation is included in Appendix D.

5.2.5 Wildlife

This section describes the environmental consequences of the NorthMet Project Proposed Action to wildlife including direct effects such as the loss of individuals/ populations of affected species or a decrease in habitat, as well as indirect effects such as displacement, competition, or changes in the greater regional area.

Summary

The NorthMet Project Proposed Action is expected to affect three federally listed species, the Canada lynx, gray wolf, and northern long-eared bat. The Canada lynx would likely be affected through localized direct decrease and fragmentation of designated critical habitat and the increased potential (albeit low) for incidental take resulting from vehicular collisions due to increased NorthMet Project Proposed Action-related traffic. Restoration of disturbed areas as part of mine closure would potentially create lynx habitat, although this successional process could take decades. The gray wolf would likely be affected through loss of habitat and the increased potential (albeit low) for incidental take resulting from vehicular collisions due to increased NorthMet Project Proposed Action-related traffic. The northern long-eared bat would likely be affected through loss of potential summer roost habitat and foraging areas. The NorthMet Project Proposed Action is not likely to affect the bald eagle, which is also protected under federal law (although not a federally listed endangered or threatened species). Eight additional state-listed and special concern species, which include eastern heather vole, moose, little brown bat, eastern pipistrelle, northern goshawk, boreal owl, wood turtle, and yellow rail, may be affected by the NorthMet Project Proposed Action. It is expected that the Laurentian tiger beetle, taiga alpine butterfly, Freija's grizzled skipper butterfly, Nabokov's blue butterfly, and Quebec emerald dragonfly would not be affected. SGCN, RFSS, and other wildlife species, including those considered tribally or culturally significant, may be affected by human activity, noise and vibration, rail and vehicle traffic, and decrease of habitat.

5.2.5.1 Methodology and Evaluation Criteria

This section uses data presented in Section 4.2.5 to analyze effects on wildlife. Specifically, survey reports and GIS data were obtained regarding land cover and habitat types, forest stand age classes, listed ETSC, SGCN, RFSS, and other wildlife species. GIS analysis was used to calculate direct and indirect effects on these resources.

The analysis of direct effects included the potential of a take of federally or state-listed species. Pursuant to the federal ESA, *take* is defined as "to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct." Take of an individual or population could occur for various reasons such as traffic collisions, habitat destruction, or change in an individual or population's habitat use due to noise, other disturbance, or contamination of food or water sources. Take of a listed species would be considered a significant effect. The USFWS can issue a permit for the incidental take of a federally listed wildlife species consistent with the goal of conservation of the species. Permit applicants must design, implement, and demonstrate availability of funding for a conservation plan that minimizes and mitigates harm to the affected species during the proposed project. Without a permit, the take of a federally listed protected species is punishable by fines or imprisonment. Permitting for taking of a state-listed species is regulated by the MDNR.

Analysis was also conducted for potential indirect effects on federally or state-listed species, such as increased competition for resources or habitat due to displacement of individuals from the affected area into the territory of other animals, or other indirect effects that cause mortality or reduced breeding and recruitment in the future population.

In addition to listed species, analysis was completed of potential direct and indirect effects on habitat types that affect population size and long-term viability for other species potentially at risk (SGCN, RFSS, and species of cultural concern). Direct effects could include vegetation removal by clearing, burial, or other destructive activity. Indirect effects could include changes within larger ecological units (e.g., the Laurentian Uplands or Partridge River Watershed), but not necessarily at the Mine Site or Plant Site, that could occur at a later point in time, such as a change in long-term vegetation composition or dominance, habitat conversion due to hydrologic changes, invasion by non-native species, or disruption of natural disturbance regimes (e.g., the annual natural hydrological cycle). Depending on the magnitude of the effect, direct effects may require mitigation.

5.2.5.2 NorthMet Project Proposed Action

This section describes the effects on wildlife due to construction and operation activities.

5.2.5.2.1 Federally Listed Species

As required under Section 7 of the ESA, the USACE and the USFS have initiated consultation with the USFWS regarding potential effects on federally listed species to ensure that actions they authorize or permit would not jeopardize listed species or designated critical habitats. Consultation is currently ongoing and will continue throughout the EIS process.

A Biological Assessment has been prepared that contains further information about federally listed species. The Biological Assessment is included in Appendix D. The Biological Assessment analyzes effects on the Canada lynx, gray wolf, and northern long-eared bat. The organization of the methodologies and discussion in the Biological Assessment may be different from the FEIS. The Biological Assessment also contains a determination of effects for the three species.

The Co-lead Agencies met with the USFWS several times during informal consultation. The USACE, USFS, and USFWS initiated informal consultation on February 26, 2010, when the agencies met to discuss the NorthMet Project. The USACE subsequently met with the USFWS on May 3, 2011, September 1, 2011, and February 28, 2013 to discuss it further. The USACE, USFS, and USFWS met on July 9, 2014 to identify tasks to be accomplished in the development of the Biological Assessment. Specifically, the northern long-eared bat and habitat were discussed, which led to further USFS bat survey work being proposed. The USACE, USFS, and USFWS met on October 29, 2014, February 5, 2015, and March 23, 2015, to discuss comments received on the draft Biological Assessment and potential mitigation measures. The Co-lead Agencies signed the cover letter to the BA to initiate formal consultation with USFWS on August 21, 2015.

Canada Lynx

In 2009, it was estimated that there were likely fewer than 200 lynx in Minnesota (Moen 2009). However, individuals can travel well beyond their home range, specifically when prey is scarce, at times more than 1,000 km (Moen 2010). Three individual lynx have been harvested in

Ontario, approximately 400 road miles from their known locations in Minnesota. Of the 55 incidental take records the USFWS has documented from 2001 through 2013, two of the records involved lynx killed by trains, and seven of the records involved lynx struck by vehicle traffic along roads (USFWS 2013).

The NorthMet Project area is currently within the 8,065 square mile designated critical habitat for the Canada lynx (USFWS 2009), which includes much of St. Louis, Lake, and Cook counties. Surveys identified at least 20 different individual lynx were identified within 18 miles (ENSR 2006), and lynx sign was observed on the Mine Site in 2010. A collared and studied lynx, L11, was identified adjacent to the NorthMet Project area, south of Dunka Road. This animal may have been using the NorthMet Project area for forage and travel as part of her home range between when she was collared in early 2004 and when she was trapped in Ontario, Canada in 2006. Lynx tracks were observed at the Mine Site in 2010, and there have been multiple observations of lynx sign within 5 miles of the federal lands (USFS 2013).

Site clearing and mining activities associated with the NorthMet Project Proposed Action would potentially affect lynx by reducing available habitat and increasing habitat fragmentation. The total effect from increased activity is not known, as lynx have been known to habituate to increased human activity (Sunde et al. 1998). The NorthMet Project Proposed Action mining activities would disturb approximately 2 square miles (1,454.0 acres) of suitable lynx habitat, currently a mix of upland forest and lowland forest and bog. Restoration of disturbed areas as part of mine closure would eventually create potential lynx habitat, although this successional process could take decades. Potential lynx habitat would be lost for the duration of mine operations (over 20 years) and an additional 20 years or more after closure before suitable lynx habitat would again occur at the Mine Site (ENSR 2006).

Assuming that the territory of a resident lynx is 58 square miles for males and 28 square miles for females, the reduction of habitat at the Mine Site corresponds to a reduction of three to seven percent of an individual’s territory (ENSR 2006). Territory size expands in response to periods of reduced snowshoe hare density, and the related lynx and snowshoe hare populations tend to loosely follow a 10-year cycle, though other factors contribute to lynx population shifts. ENSR 2006 surveys for the NorthMet Project Proposed Action were done during a low point in the lynx/snowshoe hare density cycle.

Though no lynx were identified during the ENSR 2006 surveys, those that may currently be using the Mine Site could expand their territory into surrounding areas. Surveys conducted in 2006 by Moen et al. found evidence of at least 20 individuals within 18 miles of the NorthMet Project area, and lynx sign has been observed on the Mine Site by the USFS. Lynx density in the vicinity is considered low relative to the rest of the Minnesota lynx range (ENSR 2006). Individuals displaced from the Mine Site may be affected by increased stress and potential mortality due to utilization of unfamiliar territory and competition with other lynx or predator species. Although the NorthMet Project Proposed Action would result in a reduction and fragmentation of lynx habitat at the Mine Site, little to no effect on statewide lynx populations would occur as it is unlikely that an individual lynx or pair of lynx would be affected by the habitat decrease.

According to the USFS, LAUs are land areas identified for purposes of analysis and development of conservation measures for lynx (USFS 2004b). They range in size from just under 17,000 acres up to more than 91,000 acres. As discussed in Section 4.2.5.2.1, the federal lands (including the Mine Site) are located within LAU 12.

The USFS determined that approximately 2,737 acres, or 4.0 percent of LAU 12 is currently unsuitable for lynx use (USFS 2013). As noted above, the NorthMet Project Proposed Action would disturb 1,454 acres of lynx habitat, making them unsuitable for lynx. The percent of LAU 12 unsuitable for lynx would increase to 6.1 percent. This percentage is well within the Forest Plan guideline (G-WL-3) that unsuitable habitat not exceed 30 percent of the LAU.

The increased vehicle traffic associated with the NorthMet Project Proposed Action mining activities could affect species such as the lynx. An average of 2,066 miles per day of vehicular traffic is expected within the Mine Site, primarily to haul ore to the rail siding and waste rock to the stockpiles (see Table 5.2.5-1).

Table 5.2.5-1 Vehicle Traffic within the Mine Site Only

Vehicle type	Vehicle Weight (Tons)	Speed (Average MPH)	Total Road Miles in Mine Site	Annual Vehicle Miles Traveled (Estimated)	Estimated Average Total Miles Per Day (Estimated)
Haul Trucks and Construction Vehicles	81.5-425	12-14	15.3	61,400-979,000	2,066.0

Source: Barr 2012g.

Although there is the potential for incidental take as a result of vehicle collisions with lynx, haul traffic at the Mine Site would likely have little direct effect on lynx. Current lynx use of the Mine Site appears to be very low; in the future, the area would be heavily affected by mining operations and not likely to be used by lynx.

The NorthMet Project area is currently within designated critical habitat for the Canada lynx (USFS 2008a). Lynx may be affected by increased vehicle and train traffic. Lynx are highly mobile and lynx habitat can be found immediately adjacent to the corridor. The increased vehicle traffic associated with the NorthMet Project Proposed Action, including train and small vehicle traffic between the Mine Site and Plant Site, could potentially result in vehicle collisions with lynx (see Table 5.2.5-2). The NorthMet Project Proposed Action would generate 1,734.9 miles of vehicle traffic between the Mine Site and Plant Site each day. This traffic would consist primarily of light trucks and maintenance vehicles traveling 30 to 45 mph and a few large fuel trucks, waste/supply trucks, and trains traveling 15 to 40 mph.

Table 5.2.5-2 Vehicular and Train Traffic Volume along the Transportation and Utility Corridor

Vehicle Type	Vehicle Weight (Tons)	Speed (Min – Max MPH)	Total Miles (Per Day)
Light Cars, Trucks, and Vans – primarily Mine Site to Area 2 Shops	2	30-45	961.1
Fuel Trucks, Supply and Waste Trucks	40	25-40	346.7
Haul Trucks	81.5 – 240	35	9.1
Trains	3,000	15-25	418.0
Total			1,734.9

Source: Barr 2012g.

Though vehicle traffic increases the chance of incidental lynx mortality, this species does not rely strictly upon roads for long-distance travel, though they use less energy doing so (Moen 2010). Straight-line movement of collared lynx through the roadless BWCAW suggests that when roads are not available, lynx will still travel in a line where possible. As such, while lynx may be affected by vehicle traffic along the Transportation and Utility Corridor, the flat terrain near the NorthMet Project area would allow lynx to travel through the area.

Evidence of lynx was not found during surveys of the Plant Site. Approximately 76 percent of the Plant Site cover/habitat type is disturbed or aquatic, which is considered unsuitable lynx habitat. Lynx are unlikely to utilize the Plant Site, but may forage in the surrounding area. As such, activities at the Plant Site are unlikely to affect the Canada lynx.

State and federal forest lands near the Mine Site or Plant Site would continue to provide refuge for lynx, and it is likely lynx would favor these areas over those affected by mining for the duration of mine operations. Overall, the effects on the Canada lynx described above would result in the localized direct decrease and fragmentation of habitat, including designated critical habitat, and the increased potential (albeit low) for incidental take resulting from vehicular collisions; however, these effects are not anticipated to threaten the overall species population level and abundance in Minnesota. The Biological Assessment concludes that the NorthMet Project Proposed Action would be likely to adversely affect the Canada lynx and would be likely to adversely affect Canada lynx critical habitat.

Gray Wolf

As noted in Section 4.2.5, the Mine Site and Plant Site are likely part of a territory occupied by a single pack of wolves. The footprint of the Mine Site would remove approximately 2 square miles (1,454 acres) of habitat, or 1 percent to a maximum of 10 percent of a single wolf pack territory. This reduction in available habitat is small and is not expected to affect the highly mobile wolf population in the region, which is considered healthy by the MDNR. After closure, this area would again be available and suitable as wolf habitat, but, as described above for the lynx, this would not occur for 40 to 45 years.

Vehicle collisions are a cause of wolf mortality (Fuller and Harrison 2005). The increased vehicular activity associated with the NorthMet Project Proposed Action could potentially result in vehicle collisions with wolves. The haul road network would increase the road density (linear miles of road per square mile of habitat) at the Mine Site; however, mining operations would disturb the Mine Site such that it would reduce habitat availability for the gray wolf. Therefore, the haul road network itself would not influence the overall effects of the NorthMet Project Proposed Action on the gray wolf.

State and federal forest lands near the Mine Site or Plant Site would continue to provide refuge for wolves, and it is likely wolves would favor these areas over those affected by mining for the duration of mine operations. The gray wolf population in Minnesota (estimated at 2,423 gray wolves) is considered fully recovered by the MDNR as it has surpassed the federal delisting goal of 1,251 to 1,400 wolves. However, the gray wolf was re-listed as federally threatened by the U.S. District Court on December 19, 2014.

Overall the effects described above would result in the direct decrease and fragmentation of habitat suitable for the gray wolf, the increased potential for incidental take from vehicular collisions, and indirect decline in prey species due to habitat decrease. Together these factors are not anticipated to threaten the overall species population level and abundance in Minnesota. The Biological Assessment concludes that the NorthMet Project Proposed Action would be likely to adversely affect the gray wolf. It also concludes that the NorthMet Project Proposed Action would be likely to adversely affect gray wolf critical habitat.

Northern Long-Eared Bat

Northern long-eared bats were detected in surveys throughout much of northeastern Minnesota (USFS 2014b; Grandmaison et al. 2013; USFS 2014c). The most prominent threat to the northern long-eared bat is white-nose syndrome. The fungus known to cause white-nose syndrome, *Pseudogymnoascus destructans*, has been observed in the Tower/Soudan Mine, a hibernacula for several bat species located about 15 miles northwest of the NorthMet Project area. White-nose syndrome has advanced geographically from New York in 2006, causing 99 percent decreases in population numbers in the northeast United States (USFWS 2013b).

Bats may forage along the forest edge habitat along the Transportation and Utility Corridor, but there are no caves or mine shafts present that may be used for hibernation. Abel (2011) generally found that bat foraging activity is highest near aquatic features. Forest edges along utility corridors are also used for bat foraging, and they may forage along these features more frequently than in interior forest habitat. Generally, the West Pit, water treatment ponds, and Tailings Basin pond would not offer suitable habitat for emerging insects. Bats would be unlikely to use the wide open exposures of the West Pit and Tailings Basin and were not found during surveys within the Tailings Basin. Additionally, the pit lake would likely be too deep and have too little littoral area to sustain insect life. The treatment ponds would have a substrate not conducive to plant growth or invertebrate activity, the water would be low in organic carbon and nutrients, and the ponds would generally not be productive systems for invertebrates. Bats would be more likely to forage above natural wetlands that support more insect activity. Bats have been observed in Plant Site buildings, but do not hibernate or roost in great numbers at the Plant Site. Approximately eight percent of the Plant Site also contains possible tree roosting habitat that would be affected.

At the Mine Site, 1,718.6 acres would be disturbed due to the NorthMet Project Proposed Action, of which approximately 90 percent would be upland or lowland deciduous/coniferous forests and aquatic areas that could be utilized by the northern long-eared bat. Forest clearing activities at the Mine Site are likely to affect northern long-eared bat individuals as there would be a loss of potential summer roost habitat and foraging areas. The interim 4(d) rule (50 CFR Part 17, April 2, 2015) specifies that forest clearing activities may not occur within the summer maternity roosting season within one quarter mile of known occupied roost trees. Tree removal outside of the summer maternity roosting season (June 1 through July 31) would help mitigate and reduce lethal take of northern long-eared bat individuals.

Resuming operations at the Plant Site buildings would likely disrupt the bat's use of them for roosting. The NorthMet Project Proposed Action is not expected to affect bat hibernacula, as none have been observed on the Mine Site, Transportation and Utility Corridor, or Plant Site, but would reduce potential roosting and foraging habitat. The Biological Assessment concludes that the NorthMet Project Proposed Action would be likely to adversely affect the northern long-eared bat. The Biological Assessment contains additional details on effects to the northern long-eared bat.

5.2.5.2.2 State-listed Species

Rulemaking was conducted with the intent to update the list of ETSC species (*Minnesota Rules*, part 6134.0100 to 6134.0400), with new listings becoming effective on August 19, 2013 (MDNR 2013h). This FEIS considers any new listings, or changes in the previous listings, associated with the updated list.

Moose

There is habitat available for the moose on the Mine Site, and individuals and their sign (e.g., tracks, droppings, browsing evidence, etc.) have been observed on it. This is in close proximity to the Transportation and Utility Corridor and Plant Site. Due to the primarily disturbed nature of these latter areas, it is likely that moose occur but unlikely that they utilize the areas often. Habitat fragmentation and loss, climate change, disease, and predation are all potential factors in moose population decline (MDNR 2013d). The key habitat types considered moose habitat include mature forest, grassland/brushland, and aquatic environments. A total of 2,785.9 acres of these key habitat types would be directly affected by the NorthMet Project Proposed Action (see Table 5.2.5-3). As such, the NorthMet Project Proposed Action would likely affect moose individuals in the vicinity through habitat loss and fragmentation, though not likely at a population level.

Little Brown Bat

The little brown bat is known to occur at the Mine Site, Transportation and Utility Corridor, and Plant Site. As a habitat generalist, it has suitable foraging and potential roosting habitat in these three areas. Of the bats observed in the NorthMet Project area and in northeastern Minnesota, the majority are little brown bat (USFS 2014b; Grandmaison et al. 2013; USFS 2014c). The most prominent threat to the little brown bat is white-nose syndrome. The fungus known to cause white-nose syndrome, *Pseudogymnoascus destructans*, which has been observed in the Tower/Soudan Mine, a hibernacula for several bat species located about 15 miles northwest of the NorthMet Project area. As discussed above in Section 5.2.5.2.1 for the northern long-eared bat, white-nose syndrome has caused 99 percent decreases in bat populations throughout the northeast U.S. where it originated (USFWS 2013b). No known hibernacula sites would be disturbed as a result of the NorthMet Project Proposed Action. It is expected that the reduction of foraging and potential summer roosting habitat would affect individuals, but likely not at a population level.

Eastern Pipistrelle

Potential summer roosting habitat is available for the eastern pipistrelle at the Mine Site, Transportation and Utility Corridor, and Plant Site. However, no individuals have been observed or detected within any of these areas during field surveys. USFS surveys from the Kawishiwi District in 2013 and St. Louis/Lake counties in 2014 did not detect eastern pipistrelle (Grandmaison et al. 2013; USFS 2014c). As with the bats discussed above, the most prominent threat to the eastern pipistrelle is white-nose syndrome. It is unlikely that the species would be affected by the NorthMet Project Proposed Action, as none are known to occur in the area, and no known hibernacula sites would be disturbed.

Northern Goshawk

The northern goshawk may occasionally be present at the Mine Site, since nest sites have been identified by the USFS approximately 0.75 mile west of the Mine Site and near the proposed East Pit and Central Pit areas. Two northern goshawk territories have been identified at or near the Mine Site, as they have nested on the Mine Site and adjacent federal lands in 2000, 2009, 2011, and 2013 (USFS 2013). The One Hundred Mile Swamp northern goshawk territory, which is within the Mine Site, is no longer considered active. The Wetlegs Creek northern goshawk territory, located on the federal lands adjacent to the Mine Site, is still considered active and is being monitored. The NorthMet Project Proposed Action would directly affect one of the two known nest site areas. The northern goshawk may be occasionally present along the Transportation and Utility Corridor, due to the proximity of the active northern goshawk territory. No nests are known to occur at the Plant Site. Because the northern goshawk has nested in the NorthMet Project area and was identified during calling surveys, activities at the Mine Site may affect the northern goshawk due to loss of habitat. The NorthMet Project Proposed Action would not likely affect individual goshawks protected under the MBTA, but may affect habitat and nest sites used by northern goshawks.

Boreal Owl

There is suitable habitat available for the boreal owl at the Mine Site and along the Transportation and Utility Corridor. An individual was heard along Dunka Road in 1988 to 1989, but none were observed in subsequent surveys. Since the Minnesota NHIS does not contain any occurrences within 10 miles of the NorthMet Project area, and they have not been observed since 1988 to 1989, it is unlikely that boreal owls utilize the Mine Site, Transportation and Utility Corridor, or Plant Site often. The NorthMet Project area is located at the southern edge of its range. The removal of mixed forest habitats at the Mine Site and along the Transportation and Utility Corridor is unlikely to jeopardize the boreal owl's presence in Minnesota. The NorthMet Project Proposed Action would not likely affect individual owls protected under the MBTA, but may affect habitat used by boreal owls.

Wood Turtle

There is no habitat suitable for wood turtles at the Mine Site and no individuals are known to occur. Individuals could potentially use the southern riparian fringe of the Mine Site though no wood turtles are currently known to occur in the fringe areas that would be affected by the project. The fringe areas would also not be affected by activities at the Transportation and Utility Corridor. There is no suitable habitat for wood turtles at the Plant Site and no individuals are known to occur.

The predicted small decrease in Upper Partridge River flow during active mining is not likely to negatively affect the wood turtle. The most likely effect of a decrease in water level would be to expose additional nesting areas. Over the long term, the exposed soil on the lower bank would be overtaken by vegetation from the upper bank and become less suitable habitat for the wood turtle.

Wood turtles are not likely to be affected by project activities because there would be no direct loss of individuals, populations, or suitable habitat and the NorthMet Project Proposed Action would have no indirect effects on downstream habitat.

Eastern Heather Vole

The eastern heather vole has not been observed within 10 miles of the Mine Site nor has it been found in small mammal surveys in the region (Christian 1993; Jannett 1998). The NorthMet Project area is at the southern edge of its range. Approximately 1,445 acres of potentially suitable habitat exist at the Mine Site (see Table 4.2.4-1), and there is potentially suitable habitat for the species along the Transportation and Utility Corridor. Additionally, there is potentially suitable habitat for the eastern heather vole at the Plant Site, 45 percent of which may be affected by the NorthMet Project Proposed Action (see Table 5.2.4-6). The eastern heather vole could be present at the NorthMet Project area, but, if so, it is likely to be in very small numbers. Given the lack of known occurrences of eastern heather vole in the area, the habitat effects are unlikely to jeopardize the presence of eastern heather vole in Minnesota.

Yellow Rail

The yellow rail was not found during PolyMet's surveys at the Mine Site and was not reported in the NHIS database within 10 miles of the NorthMet Project area. Small, scattered areas of its preferred habitat, sedge/wet meadow, are present at the Mine Site, but the minimum nesting patch size used by rails (54 acres) (Goldade et al. 2002) exceeds the total amount of suitable habitat available (39.5 acres at the Mine Site and 1.5 acres at the Plant Site; refer to Section 4.2.3). Since the yellow rail was not detected in surveys and patches of its preferred habitat are smaller than the reported minimum patch size for nesting, it is not expected that the NorthMet Project Proposed Action would affect the yellow rail. As a result, the yellow rail and its habitat would not likely be affected under the MBTA.

Laurentian Tiger Beetle

The lack of suitable habitat and any NHIS recorded observations in the NorthMet Project area for the tiger beetle suggest that the species does not occur at the Mine Site, Plant Site, or Transportation and Utility Corridor. Therefore, the NorthMet Project Proposed Action should have no effect on the tiger beetle.

Taiga Alpine

The taiga alpine butterfly was not observed during surveys and the NHIS has no records of one occurring within 10 miles of the NorthMet Project area. The preferred habitat types (black spruce bogs and swamps) do occur on the Mine Site and in proximity to the Transportation and Utility Corridor and Plant Site. The NorthMet Project Proposed Action may affect individuals but would not likely have any effect on the species at a population level.

Freija's Grizzled Skipper

The Freija's grizzled skipper butterfly was not observed during surveys and the NHIS has no records of the species occurring within 10 miles of the NorthMet Project area. The only known Minnesota occurrence is in Lake County. The preferred habitat types (forest openings bordered by black spruce and tamarack swamps) do occur on the Mine Site and in proximity to the Transportation and Utility Corridor and Plant Site. The NorthMet Project Proposed Action may affect individuals but would not likely have any effect on the species at a population level.

Nabokov's Blue

The Nabokov's blue butterfly was not observed during surveys and the NHIS has no records of one occurring within 10 miles of the NorthMet Project area. The preferred habitat type for the larval butterfly (open woodlands with abundant dwarf bilberry) potentially occurs on the Mine Site, Transportation and Utility Corridor, or Plant Site. The NorthMet Project Proposed Action may affect individuals but would not likely have any effect on the species at a population level.

Quebec Emerald

The Quebec emerald dragonfly inhabits poor fens, a wetland type not identified at the Mine Site but similar to the sedge/wet meadow that is present. Approximately 38.2 of the existing 39.5 acres of wet meadow/sedge meadow at the Mine Site would be affected by mining activities. There are no poor fens found along the Transportation and Utility Corridor or Plant Site, though approximately 1.5 acres of sedge/wet meadow are present at the Plant Site, and 1.4 acres would be affected by activities. There has only been one documented occurrence of this species in Minnesota (Lake County in 2006, more than 20 miles east of the NorthMet Project area) (Minnesota Odonata Survey Project 2012); therefore, the likelihood of observing Quebec emerald dragonfly individuals or populations within the vicinity of the NorthMet Project area is low. As such, this species is not expected to be affected.

5.2.5.2.3 Species of Greatest Conservation Need

Along with federally and state-listed species, the NorthMet Project Proposed Action would affect SGCN at the Mine Site as a result of increased human activity and noise, collisions with vehicular and rail traffic, and decrease of habitat. Due to the number of SGCN species identified (see Table 4.2.5-1) effects are classified below by the type of disturbance.

Increased Human Activity

SGCN would be directly affected through increased human activity due to mining activities. Factors such as noise, dust, light, and vehicle traffic may frighten some species and discourage their use of otherwise suitable habitat. In general, suitable habitat is available in the area adjacent to the NorthMet Project area and most mobile wildlife species would be displaced. Following migration to new areas, displaced individuals could increase the competition for resources in their new habitat. Displaced species could also suffer increased mortality due to foraging in new areas. Less mobile species, such as herptiles (e.g., frogs, turtles), would likely incur relatively high mortality rates since they cannot quickly migrate from the area and would be more susceptible to changing habitat conditions. During the winter, a combination of plowing and sand, gravel, or salt (magnesium chloride) applications would be used to keep roadways passable. The potential exists for sand and salts to accumulate in the trenches adjacent to the roadways and affect less mobile species. These areas are not considered high quality habitat and are not likely to affect wildlife.

Effects on wildlife due to trapping and hunting are minimal because public access would be restricted. Through the Land Exchange Proposed Action, NorthMet Project area lands would enter into private ownership and would not be accessible for public use. As discussed in Section 5.2.11.2.1, public access is limited and would remain limited during mining operations and following mine closure. As such, wildlife species are not likely to be affected by changes in hunting and trapping activity.

Ground-nesting bird species and some raptor species have been known to utilize cliff areas for nesting and foraging. The SGCN include the northern goshawk, common nighthawk, and northern harrier. These birds could be affected by disturbance if they were to nest along the cliffs created by the pit rims.

Noise Effects

The Biological Assessment concludes that noise effects on wildlife are largely unknown and the assessment of effects is subjective. However, noise associated with mining activities, including noise from vehicle and rail traffic, would likely affect wildlife. Mammals can be sensitive to sound levels below the range of human hearing, which is 20-16,000 hertz. The sensitivity thresholds for animals are generally lower, some below 20 hertz (US FHWA 2011). Effects due to acute noise (such as blasting) are not well studied, but would likely cause animals to startle and would interrupt forage or nesting activities (Larkin 1994). Noise does not appear to seriously affect invertebrates or fish, but does result in some disturbance to mammals (such as startling, forage interruption, and avoidance of the area of potential effect [Larkin 1994]). Bird communication would be masked by noise if the vocalizations are less than 18-20 dB above noise levels in the environment (US FHWA 2011). Changes in communication have been known to result in decreased reproduction and anomalies in learned vocalizations (Larkin 1994). Songbird populations have been shown to decrease with noise levels as low as 35 dB (Forman and Alexander 1998). Section 5.2.8 provides further discussion on the noise modeling predictions for the NorthMet Project area. Though wildlife species are likely to be sensitive to changes in noise levels, there are no local, national, or international standards or limits that are applicable to the NorthMet Project Proposed Action. Wildlife species may be affected by noise in the NorthMet Project area, though adjacent habitat is available.

Vehicular and Rail Traffic Effects

Wildlife mortality generally increases with increasing traffic volumes and vehicle speed. In general, highly mobile species and habitat generalists (species that utilize a wide variety of habitats) are known to have higher road mortalities.

As discussed above, vehicular traffic would average 2,066 miles per day within the Mine Site (see Table 5.2.5-1). Traffic effects from collisions with wildlife depend upon factors such as traffic volume, traffic speed, and the species involved. The potential for road effects increases if the roads are bordered by high-quality habitat or are crossed by wildlife travel corridors. The high density of affected wetlands at the Mine Site bordering the haul roads may result in a relatively high rate of amphibian and reptile effects. Shrubs and trees near roadsides can increase road crossings by deer and birds. The barrier effect of roads is greater for small mammals, amphibians, and reptiles than for birds and large mammals (Kaseloo 2004). Species that utilize the small preserved forest island remnants between haul roads at the Mine Site would be most affected. Indirect effects from vehicle activities are expected locally at the Mine Site for SGCN species but would not be measurable at the scale of the Nashwauk and Laurentian Uplands or the Partridge River Watershed.

Effects at the Transportation and Utility Corridor are primarily related to vehicle and rail traffic. Travel between the Mine Site and Plant Site is expected to average 1,735 miles per day with travel speeds averaging between 15 and 45 mph, with trains, fuel, and waste/supply trucks traveling somewhat slower (see Table 5.2.5-2). SGCN may be affected by noise and light associated with vehicle and rail traffic, and by collisions with vehicles or trains.

Transportation effects at the Plant Site are primarily related to vehicle traffic associated with construction of the NorthMet Project Proposed Action. Typical daily operations at the Plant Site would generate approximately 828 miles of vehicle traffic, primarily light trucks. Though noise and light may affect SGCN at the Plant Site, the disturbed nature of the area would mean that effects would be negligible.

Wildlife Habitat Effects

The direct effect on wildlife habitat (and by inference on SGCN species) was assessed by evaluating the acres of habitat types that would be lost under the NorthMet Project Proposed Action (see Figure 4.2.4-4). The changes in cover type are summarized in Table 5.2.5-3. The NorthMet Project Proposed Action would not likely affect individual migratory songbirds or other bird species protected under the MBTA, but would likely affect habitat and nest sites used by them.

Table 5.2.5-3 Direct Effects on Key Habitat Types

Key Habitat Types	Total Acres[1] of Cover Type Present at Mine Site (Total Acres[1] of Cover Type Directly Affected)	Total Acres[1] of Cover Type Present at Transportation and Utility Corridor (Total Acres[1] of Cover Type Directly Affected)	Total Acres[1] of Cover Type Present at Plant Site (Total Acres[1] of Cover Type Directly Affected)
Mature Upland Forest, Continuous Upland/Lowland Forest (MIH1-13)	2,627.2 (1,535.3)	5.5 (5.5)	789.3 (367.8)
Open Ground, Bare Soils (no MIH)	128.0 (44.0)	94.4 (94.4)	2,755.5 (1,104.0)
Grassland and Brushland, Early Successional Forest (no MIH)	246.6 (133.2)	17.5 (17.5)	333.8 (144.9)
Aquatic Environments (MIH 14)	12.7 (6.0)	2.7 (2.7)	636.8 (573.0)
Total	**3,014.5 (1,718.6)**	**120.1 (120.1)**	**4,515.4 (2,189.7)**

Data from Tables 5.2.4-1, 5.2.4-4, and 5.2.4-6.

Note:
1 Total acres may be more or less than presented due to rounding.

Mature Upland/Lowland Forest

At the Mine Site, approximately 1,535 acres (58 percent) of the mature forest would be lost as a result of the NorthMet Project Proposed Action. All of the SGCN found in this mature upland forest habitat are birds (see Table 4.2.5-1), which would be displaced, but likely not injured or killed, during mine construction and operation. Nesting birds could be affected during the breeding season, especially during brooding and until fledglings become independent. Reclamation of the Mine Site would include revegetating nearly all disturbed ground according to *Minnesota Rules*, part 6132.2700.

Of the 5.5 acres of mature upland/lowland forest along the Transportation and Utility Corridor, all 5.5 acres would be affected. As such, activities would affect SGCN in mature upland/lowland forest habitat along the Transportation and Utility Corridor, though effects would be narrow and primarily located along the corridor.

Most of the Plant Site is developed or disturbed with only approximately 17 percent (789 acres) consisting of forest habitat (see Table 5.2.5-3). Approximately 368 acres of this forest habitat at the Plant Site would be disturbed, most of which is in small or isolated patches of aspen-birch forest that are in poor to fair condition (MDNR 2013a). Therefore, activities at the Plant Site would not have an effect on SGCN using mature upland/lowland forest habitat.

Reclamation and revegetation of the NorthMet Project area would initiate vegetative succession on stockpiles, the East Pit and Central Pit, and Mine Site infrastructure (PolyMet 2015h). The Category 1 Stockpile would be incrementally and progressively reclaimed throughout the life of the mine through contouring the stockpile to provide topographic variety, covering with a layer of evapotranspiration soil, and finally seeding of grasses and forbs.

Reclamation and re-vegetation of the NorthMet Project area would improve wildlife habitat relative to conditions during mine operations; however, the quality of habitat for SGCN is likely to remain degraded for some decades after closure relative to pre-mining operations due to conversion of high-quality habitat to lower-quality habitat.

Open Ground/Bare Soils

The likelihood of SGCN using open ground or bare soils at the Mine Site, Transportation and Utility Corridor, or Plant Site is small. These areas were the result of past mining activity, are generally of low-quality, and are expected to decrease after mine closure as a result of reclamation.

Therefore, NorthMet Project Proposed Action effects on open ground/bare ground habitat should result in little effect on wildlife.

Brush/Grassland

Approximately 133 of the 247 total acres (54 percent) of brush/grassland at the Mine Site would be directly affected by the NorthMet Project Proposed Action. Brush and grassland (including early successional forest) at the Mine Site and Plant Site consist of small vegetative patches that are generally not suitable for SGCN. Young trees (less than 4 inches dbh) make up most of this habitat type (ENSR 2005). One SGCN associated with this habitat type, the American woodcock, was observed by USFS personnel at the Mine Site. The least weasel may occur as well. Most of the other SGCN (see Table 4.2.5-1) are associated with large patches of grassland and savanna habitats, which are not present at the Mine Site.

Stands of brush/grassland (including early successional forest) along the Transportation and Utility Corridor consist of small vegetative patches that are generally not suitable to SGCN. Young trees (less than 4 inches dbh) make up most of this habitat type (ENSR 2005). Most of the other SGCN (see Table 4.2.5-1) are associated with large patches of grassland and savanna habitats. Though all 17.5 acres of brush/grassland along the Transportation and Utility Corridor would be directly affected, activities along the Transportation and Utility Corridor would not affect grassland/brush SGCN based on the fragmented nature of this habitat.

Similar to the Mine Site, brush/grassland (including early successional forest) at the Plant Site consists of small vegetative patches that are generally not suitable to SGCN. Young trees (less than 4 inches dbh) make up most of this habitat type (ENSR 2005). Most of the other SGCN (see Table 4.2.5-1) are associated with large patches of grassland and savanna habitats. Approximately 145 of the 334 acres of brush/grassland at the Plant Site would be directly affected by the activities at the Plant Site. The reclaimed Plant Site, specifically the Tailings Basin, would be revegetated with grassland vegetation species. Overall, the NorthMet Project Proposed Action would have no adverse effects on grassland/brush SGCN.

During reclamation, PolyMet would remove or cover portions of the existing road, railroad, and ditch and dike systems and restore them. Reclamation of these areas, which currently constitute poor wildlife habitat, would ultimately enhance wildlife habitat when compared to current conditions. Some SGCN, such as the eastern meadowlark, northern harrier, and common nighthawk would most likely use the grasslands until they are replaced by early successional forest about 20 to 50 years after closure. Early successional forests are likely to support the two following SGCN: white-throated sparrow and American woodcock.

Open Water

SGCN such as the black duck, American bittern, and swamp sparrow utilize open water habitats. The NorthMet Project Proposed Action would create approximately 321 acres of open water at the Mine Site by eventually flooding the West Pit, which is estimated to fill between year 40 and 45. The West Pit would be fenced as a deterrent to wildlife species even though this habitat is not likely to provide high quality foraging habitat for waterfowl because of a lack of emergent or submerged vegetation along the pit fringes. Ponds at the wastewater treatment facilities would also be fenced to prevent wildlife from using the water. At the Plant Site, open water habitat primarily occurs in the existing LTVSMC Tailings Basin. None of the SGCN targeted during a 2005 survey were observed on open water during the survey (ENSR 2005); however, common waterfowl and water birds were observed at the Tailings Basin during migration, in particular Canada goose and ducks. Existing open water habitat would be maintained during operations, though the acreage of open water would fluctuate according to processing needs.

Wildlife, specifically aquatic birds, may utilize open water habitat created by the NorthMet Project Proposed Action. Wildlife species have been observed utilizing the existing LTVSMC Tailings Basin, as well as other Mesabi Iron Range tailings basins, specifically during migration. Unlike arid states such as Nevada, pit lakes and tailings basins are not the only readily available source of open water for wildlife use. Minnesota has over 13 million acres of lakes and wetlands, and the NorthMet Project Proposed Action would result in less than one hundredth of a percent increase in habitat. Though adjacent habitat is readily available, wildlife species may still utilize the Tailings Basin.

Some wildlife species, specifically those that feed on aquatic prey, may be susceptible to mercury exposure (USEPA 1997) directly from open water sources such as the pit lake and Tailings Basin pond, and indirectly at the Partridge River and Embarrass River. Effects to aquatic species are discussed in Section 5.2.6.2. Specific species such as loons, osprey, mink, and otter may be affected. As discussed in Section 5.2.5.2.2, eagles may be less likely to be affected by mercury. While wildlife use of open water created by the NorthMet Project Proposed Action may be limited due to fencing and available habitat, wildlife species may be affected.

Surface water quality standards do not apply to the pit lake or Tailings Basin. Any discharge water, such as the pit lake overtopping, would be treated in order to meet water quality standards and, as such, would not likely affect wildlife species.

Wetlands

Of the wetland-related SGCN, the marbled godwit and olive-sided flycatcher were surveyed for, but not found (ENSR 2005). The bog copper butterfly also was not found during surveys and there are no known NHIS records of any sightings within 12 miles of the Mine Site. As discussed above, the black duck, American bittern, and swamp sparrow are not likely to be present because they require open water and non-forested wetlands, which are relatively scarce at the Mine Site. The red-backed salamander is primarily an upland species, but may be present along the edges of mixed hardwood swamps. The taiga alpine butterfly may inhabit the black spruce bogs of the Mine Site and is historically known to occur in the Laurentian and Nashwauk Uplands (MDNR 2006d).

Based on the site-specific wetland delineation, the NorthMet Project Proposed Action would directly affect 758.2 acres of wetlands at the Mine Site, primarily coniferous bog (508.3 acres directly affected), shrub swamp (97.8 acres directly affected), and coniferous swamp (70.3 acres directly affected). These wetland types are common in the Partridge River Watershed. Consequently, the decrease of this habitat at the Mine Site is expected to displace wildlife into surrounding similar habitat, which would be large enough to absorb the displaced wildlife.

There are 7.2 acres of wetlands/open water along the Transportation and Utility Corridor, and those 7.2 acres would be affected by activities along the corridor. There are 148.4 acres of affected wetland at the Plant Site. On-site wetland use by the SGCN described above may be limited, and these wetlands are generally considered to be of low quality.

Wetland mitigation is proposed off-site at three mitigation sites (see Section 5.2.3). Off-site mitigation would consist of 1,602.7 acres of wetland restoration and preservation and 197.1 acres of upland buffer areas of various habitat types at the three sites. In addition, approximately 101.8 acres of wetland may be restored on-site; however, this would not result in mitigation credits at this time.

Multiple Habitats

Species using multiple habitats and known to occur on or near the NorthMet Project area (e.g., gray wolf, Canada lynx, least flycatcher, Connecticut warbler) are discussed above. Most multiple-habitat SGCN use mature/continuous and early successional forest. NorthMet Project Proposed Action effects are therefore largely limited to the mature/continuous forest habitats described above.

Wildlife Corridors

There is one wildlife corridor located approximately 0.5 mile northwest of the Mine Site (see Figure 6.2.5-2). Mine Site operations, which provide a source of disturbance from noise and mining activity, would indirectly affect the corridor by reducing the effective, undisturbed size of the large habitat block southeast of the corridor. These activities would limit access to the corridor in the vicinity of the Mine Site; however, the corridor would continue to be accessible north of the Mine Site and from south and southwest of the corridor. Vegetative restoration of the stockpiles and disturbed areas, as proposed during closure, would mitigate some of the effects of habitat loss in this large habitat block in the long term. Not all of the Mine Site would be available for habitat restoration due to fencing around the mine pits and the open water in the West Pit.

Rail and vehicular traffic between the Mine Site and Plant Site would increase as a result of the NorthMet Project Proposed Action. While the Transportation and Utility Corridor is outside of wildlife corridors, they run parallel and perpendicular to the wildlife corridors and would potentially affect wildlife use. Tepper (2011) demonstrates the importance of road ecology, which studies the barrier effect of roads on plant and animal ecology. Tepper cites several examples of road underpasses (i.e., tunnels) or overpasses to provide corridors for plant and wildlife movement without having to cross the roadways. However, these wildlife crossings generally require a large financial cost to construct. Leete and Alcott (2011) stated that Minnesota's relatively flat topography would not be suitable for large wildlife crossings, and suggested instead utilizing multiple low cost wildlife-friendly mitigation designs rather than one large crossing. Examples of such low-cost mitigation measures include passage benches under bridges, various sizes of fencing effective on small herptiles to large mammals, and offset culverts. Mitigation measures for wildlife species would be considered during the Endangered Species Act Section 7 consultation process.

Additionally, there is one wildlife corridor located approximately 1 mile southeast of the existing Plant Site. The existing LTVSMC Tailings Basin provides poor habitat, is not likely to be heavily used by wildlife, and currently obstructs animal movement. Because current use is already limited, increased activity at the Tailings Basin would likely have minimal effect on wildlife movement through the corridor. The proposed vegetative restoration of the Tailings Basin and adjacent processing plant at closure may increase the value of the corridor by improving habitat to the northwest. The mining features surrounding this corridor would not be complete barriers to wildlife movement (Barr 2009a).

5.2.5.2.4 Regional Forester Sensitive Species

A Biological Evaluation has been prepared that contains further information about RFSS. The Biological Evaluation is included in Appendix D. Similar to the Biological Assessment, the organization of the methodologies and discussion in the Biological Evaluation may be different from the FEIS. The Biological Evaluation also contains determinations of effect for RFSS species.

The USFS determined that the NorthMet Project Proposed Action may affect individuals but is not likely to cause a trend to federal listing or loss of viability for 18 RFSS terrestrial wildlife species on the Superior National Forest.

Of the 18 terrestrial RFSS on the 2011 list for the Superior National Forest, 12 of these are also federally- or state-listed ETSC species (gray wolf, eastern heather vole, northern long-eared bat, little brown bat, eastern pipistrelle, northern goshawk, boreal owl, wood turtle, taiga alpine butterfly, Freija's grizzled skipper butterfly, Nabokov's blue butterfly, and Quebec emerald) and are discussed above. Three other RFSS (the olive-sided flycatcher, bay-breasted warbler, Connecticut warbler) are on the SGCN list and are discussed by habitat type or disturbance type in Section 5.2.5.2.3 above. Three other species, including the bald eagle, great gray owl, and three-toed woodpecker are discussed below.

Bald Eagle

Bald eagles typically nest in large trees within 500 ft of lakes or rivers (Guinn 2004). There are no large lakes or rivers at the Mine Site that would provide optimal nesting/ foraging habitat, though the Partridge River (approximately 0.5 mile south of the Mine Site) would provide some, though less-than-optimal, habitat. The Partridge River is 4.9 miles south of the Plant Site, and the Embarrass River is 2.5 miles north and west. The USFWS National Bald Eagle Management Guidelines (USFWS 2007) suggest that human activity within 0.25 mile to 2 miles can be seen or heard by eagles and, depending on the level of screening and habituation of individual eagles, may cause them to abandon a nest. Generally, the closer the activity is, the greater the effect. If eagles were to nest on the portion of the Partridge River or the Embarrass River near the NorthMet Project area, they could be within the 2-mile disturbance range. The nearest recorded bald eagle nest to the Mine Site is approximately 6.5 miles to the southeast (MDNR 2013a).

Bald eagle nesting territories in Minnesota generally have a 10-mile radius that varies with habitat quality (Guinn 2004). Bald eagle nests near the NorthMet Project area are on average 5.7 miles apart (3.8 to 9.4 mile range), which is less than the average territory radius. This suggests that the area is densely populated with bald eagle nesting territories and that no new eagles are likely to move into the area (MDNR 2014d). As eagles become more numerous, any eagles seeking to establish new territories in the area would need to select lower quality habitat and/or move into closer proximity to human activity.

Surface water contaminants (e.g., mercury) that are absorbed by prey species such as waterfowl via dietary exposure (e.g., through the consumption of fish) could lead to ingestion of contamination by eagles (Marr 2008). However, bald eagles are relatively insensitive to the toxic effect of mercury exposure through their food (Judd 2013). In addition, waterfowl and some birds of prey demethylate mercury, which reduces their potential exposure.

In summary, the NorthMet Project Proposed Action is not likely to affect bald eagles because the known nesting sites are more than 2 miles from the NorthMet Project area; optimal habitat for nesting and foraging bald eagles is not present at the Mine Site, Plant Site, or Transportation and Utility Corridor; and bald eagles are not sensitive to mercury exposure. As a result, the bald eagle and its habitat would not likely be affected under the MBTA.

Great Gray Owl

During owl surveys (AECOM 2009a), one great gray owl was observed foraging along the Transportation and Utility Corridor near the Mine Site. A great gray owl had used a historic goshawk nest at the Mine Site. Great gray owls nested in the NorthMet Project area in 2006 (AECOM 2009a), 2010, and 2011 (USFS 2013). Owls are sensitive to disturbance, so populations would be unlikely to use the NorthMet Project area during mine operations, though the species may be affected by the NorthMet Project Proposed Action as it has been observed and has nested in the area. The NorthMet Project Proposed Action would not likely affect individual owls protected under the MBTA, but may affect habitat and nest sites used by great gray owls.

Three-Toed Woodpecker

Systematic survey data for three-toed woodpeckers are lacking; however, one bird was observed during overall field surveys (ENSR 2000) and by USFS personnel in 2007. Generally, the young age of the forest habitat at the Mine Site is not suitable for three-toed woodpeckers, and populations or individuals in the area are not likely to occur. Woodpeckers are sensitive to disturbance and would not be expected to use the Mine Site during mining operations. Though not surveyed, the Transportation and Utility Corridor and Plant Site lack the old-growth forest or recent burn habitat preferred by the three-toed woodpecker. Woodpeckers are sensitive to disturbance and would not be expected to use the Transportation and Utility Corridor or Plant Site. Though existing populations are estimated to be low, and prime habitat is not available, the three-toed woodpecker may be affected by loss of overall forest habitat in the NorthMet Project area. The NorthMet Project Proposed Action would not likely affect individual birds protected under the MBTA, but may affect habitat used by three-toed woodpeckers.

5.2.5.2.5 Other Wildlife Species

Other wildlife species in the NorthMet Project area, including common and/or game species (such as white-tailed deer, bear, fox, porcupine, etc.) would likely be affected in ways similar to special status species. Mobile individuals would avoid direct effects but may be indirectly affected by a decrease of habitat. Given the adjacent habitat available to these species, local effects are expected due to competition from migrating individuals, but these would not threaten overall populations. The NorthMet Project Proposed Action would not likely affect individual migratory songbirds or other bird species protected under the MBTA, but would likely affect habitat and nest sites used by them. Effects on wildlife species important to the Bands are discussed in Section 5.2.9 on a connected ecosystems level.

Due to the relative stability in population and harvest levels for white-tailed deer and bear (MDNR 2013b, MDNR 2013c), along with the limited hunting access at the NorthMet Project area and available adjacent habitat, the NorthMet Project Proposed Action is not likely to threaten deer or bear populations or hunting opportunities. Model estimates show that changes in the average annual flow of the Partridge and Embarrass rivers would be within naturally occurring annual variations. As a result, effects to amphibians or sensitive wildlife species due to hydrologic changes in these systems would be limited.

5.2.5.3 NorthMet Project No Action Alternative

5.2.5.3.1 Mine Site

Under the NorthMet Project No Action Alternative, mining would not occur. As described in Section 5.2.4.3.1, forest harvesting would continue to occur in portions of the federal lands, including the Mine Site. While timber harvests would result in the immediate decrease of some habitat types, permanent changes are not expected and conversion from one habitat type to another would benefit some species. Direct and indirect effects of the NorthMet Project No Action Alternative on wildlife and their habitat types are not expected, as the federal lands would continue to be managed as they currently are. Species individuals may still be affected due to existing land use (timber harvest, exploration, vehicle traffic, etc.) but effects are less than those expected under the NorthMet Project Proposed Action. The use of privately owned land at the Mine Site would also determine effects on wildlife under the NorthMet Project No Action Alternative.

5.2.5.3.2 Plant Site and Transportation and Utility Corridor

Under the NorthMet Project No Action Alternative, the former LTVSMC processing plant would be reclaimed and areas revegetated in accordance with the Reclamation Plan (PolyMet 2015g) much sooner than under the NorthMet Project Proposed Action. Revegetation would restore habitat for some species. Species individuals may still be affected due to disturbances related to reclamation, but effects are less than those expected under the NorthMet Project Proposed Action. The Transportation and Utility Corridor would remain in private ownership and would likely continue to be used in a similar manner as under existing conditions. Wildlife could be affected along the Transportation and Utility Corridor by noise and light associated with vehicle traffic, and by collisions with vehicles. However, impacts would be fewer than under the NorthMet Project Proposed Action due to a lower frequency of vehicle activity along these routes.

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5.2.6 Aquatic Species

This section describes the potential effects of the NorthMet Project Proposed Action on fish and aquatic macroinvertebrate communities, especially special status species, associated with waterbodies found in the NorthMet Project area. These potential effects include changes in physical habitat (including flow), riparian and aquatic connectivity, and water quality.

Summary

The NorthMet Project Proposed Action could affect aquatic physical habitat via changes in flow, affect riparian and aquatic connectivity via construction activities within the riparian zone, affect water quality by increasing solute concentrations above Class 2B standards, and, as a result of these changes, potentially affect aquatic species including special status species (i.e., federally or state-listed threatened and endangered species, RFSS, and MDNR SGCN).

The NorthMet Project Proposed Action would reduce annual daily mean flow in the Partridge River at SW-004a by a maximum of about 4 percent (Section 5.2.2.3.2) and reduce average annual flow in the Embarrass River at PM-13 by a maximum of about 3 percent (Section 5.2.2.3.3), and generally change flows in several tributary streams draining to the Partridge River and Embarrass River by a maximum of about plus or minus 20 percent, which would fall into the range of annual natural variability in terms of precipitation (Section 5.2.2.3). These reduced flows are not anticipated to result in any measurable effect on available aquatic habitat in any streams in the NorthMet Project area, as long as seasonal flow variation is also maintained. Studies conducted by the USGS in streams and rivers indicated that the severity of flow alteration had a direct correlation on the community alteration of fish and macroinvertebrates (Carlisle et al. 2013).

The NorthMet Project Proposed Action activities would not occur within the riparian buffer of any streams; therefore the NorthMet Project Proposed Action would not affect the extent of natural vegetative cover along riparian areas and would not result in a decrease in the RCI. The NorthMet Project Proposed Action would also not result in any new dams, bridges, or culverts within perennial or intermittent streams; therefore, the NorthMet Project Proposed Action would not affect the hydrologic connectivity along streams and would not result in a decrease in the ACI. In the general vicinity of the NorthMet Project area, there are numerous case histories of dewatered mine pits in wetland areas. The historical information clearly indicates that there has not been extensive loss (i.e., drying up) of wetlands next to these pits except perhaps within 100 ft or so of the pit rim. This may be explained by the hydrogeology, which typically consists of a thin and moderately permeable surficial unit overlying low-permeability bedrock. Even when the pit water level is well below the top of bedrock, the low-permeability bedrock limits the amount of surficial groundwater that can drain downward into the pit and there is sufficient recharge to the surficial unit to maintain wetland conditions. It is anticipated that riparian zones (wetlands) adjacent to the Partridge River would not experience any measurable groundwater drawdown, particularly coupled with minimal surface water flow change due to the NorthMet Project Proposed Action.

Water quality modeling (see Section 5.2.2) predicts that the NorthMet Project Proposed Action would meet all Class 2B (aquatic life) water quality standards with the possible exception of aluminum in Embarrass River tributaries draining the Tailings Basin. For aluminum, ambient water quality, at times, already exceeds the Class 2B standard in both the Partridge River and

Embarrass River. In the Partridge River, the NorthMet Project Proposed Action would not measurably increase aluminum concentrations relative to the CEC Scenario results (Section 5.2.2.3.2). In the Embarrass River, the increase in concentration relative to the CEC Scenario would not be the result of increased aluminum loadings from the NorthMet Project Proposed Action, but rather the result of mass loading from surface runoff and the loading from other minor sources (Section 5.2.2.3.3). Although all other solutes are predicted to meet evaluation criteria or not cause or add to exceedances of evaluation criteria, the aggregate of these solutes, primarily metals, has the potential to affect aquatic biota.

In terms of special status species, there are no federal or state-listed threatened or endangered fish or macroinvertebrate species known to occur in the NorthMet Project area (USFWS 2011). There are four special status aquatic species (i.e., RFSS and SGCN) that have not been found in the NorthMet Project area, but suitable habitat is likely to occur and the species could be present.

The NorthMet Project area encompasses several waterbodies within both the Partridge and Embarrass River watersheds that provide a variety of habitats for aquatic biota. Predicted effects on aquatic biota from the NorthMet Project Proposed Action are possible due to changes in water chemistry, including increases in heavy metals. Effects on the success of fish spawning in tributary streams would be addressed by maintenance of seasonal, bankfull flows over the life of the NorthMet Project Proposed Action, especially when stream-related flow augmentation occurs within the Embarrass River Watershed.

5.2.6.1 Methodology and Evaluation Criteria

The operation, reclamation, and closure of the NorthMet Project Proposed Action may result in changes in the physical aquatic habitat or water quality that would result in effects on fish and aquatic species. To assess these effects, predicted changes in water quality and flow, as presented in Section 5.2.2, were used in combination with data on existing aquatic biota conditions, as discussed in Section 4.2.6, to determine potential effects on aquatic biota in surface waterbodies located in the NorthMet Project area.

The following criteria were considered in this evaluation:

- Physical alteration of stream conditions and the effect on fish and macroinvertebrate assemblages;
- Numeric water quality standards established for the protection of aquatic life in affected waterbodies;
- The structure or function of the aquatic species assemblages in affected stream segments; and
- Effects on one or more protected aquatic species or their habitat.

With respect to mercury, the evaluation criteria is an increase in the body burden of mercury in aquatic biota since this is the primary mechanism through which mercury affects aquatic life.

5.2.6.2 NorthMet Project Proposed Action

5.2.6.2.1 Partridge River

This section describes the potential effects of the NorthMet Project Proposed Action on aquatic resources in the Partridge River Watershed, including effects on physical habitat, riparian and aquatic connectivity, and water quality.

Physical Habitat Effects

Hydrologic changes often have effects on fish and aquatic macroinvertebrates. While many aspects of the hydrologic regime can be important to the maintenance of fish and macroinvertebrate assemblages, reduction in baseflow (the portion of streamflow from groundwater) is particularly relevant because it represents a loss of habitat.

In the Partridge River, results of the water modeling (described in Section 4.2.2)—as predicted at monitoring stations SW-002, SW-004, and SW-004a—were used to describe predicted flow for the upper Partridge River Watershed within the vicinity of the Mine Site. These monitoring stations were selected due to their geographical location (see Figure 5.2.6-1), and likely represent the area that would best describe potential maximum effects along the Partridge River.

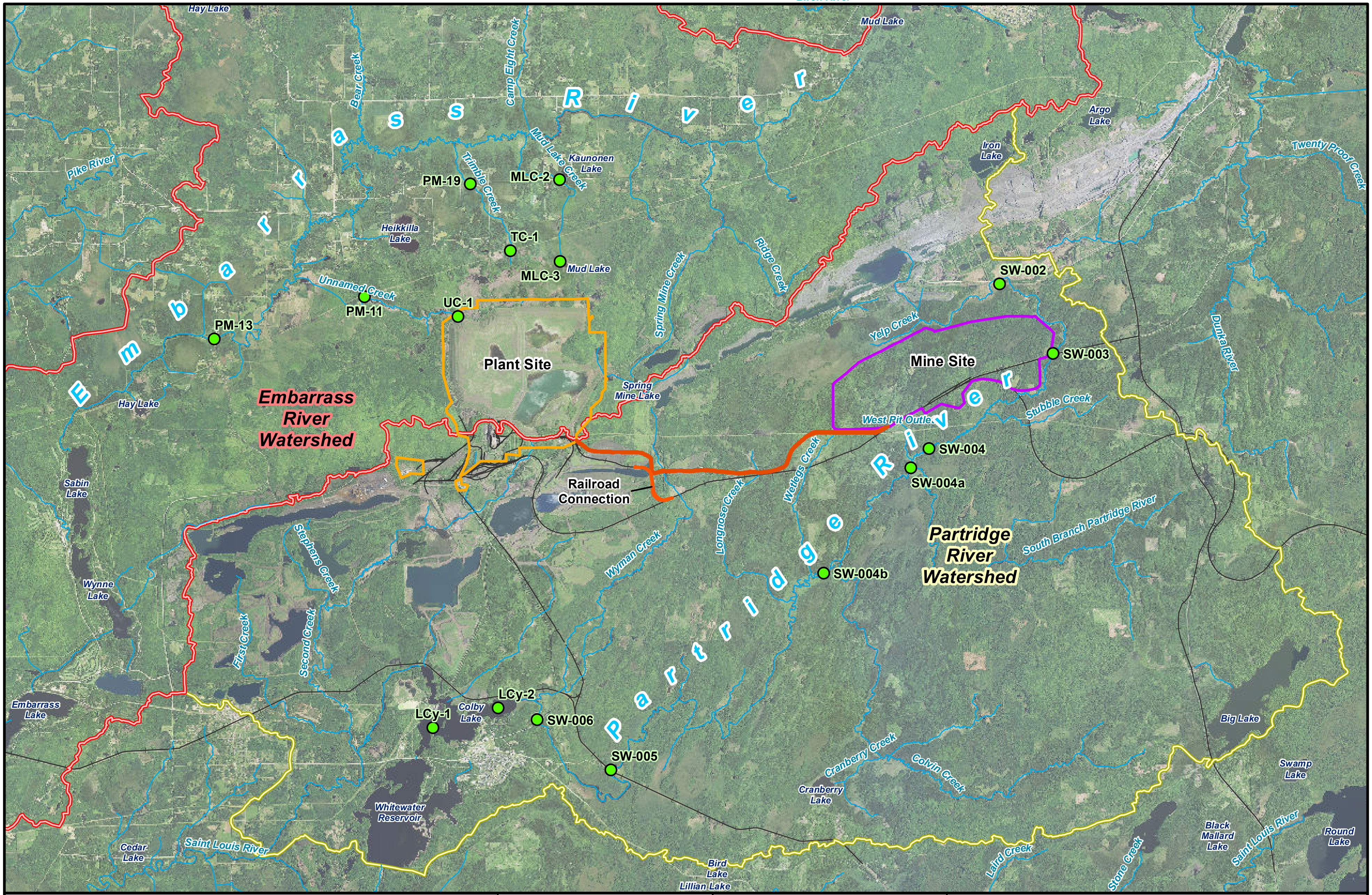
At SW-002, SW-004, and SW-004a, baseflow (i.e., average 30-day annual low flow) gradually decreases during the first 11 years of mining, but in the worst case only represents a 4 to 5 percent reduction and a 0.3 to 1.6 cfs reduction in absolute flow (year 11). In terms of long-term closure, the average annual 30-day minimum flow is estimated to decrease from 0.41 cfs (existing conditions) to 0.40 cfs at SW-002 and from 0.92 cfs (existing conditions) to 0.89 cfs at SW-004. At SW-004a, the average annual 30-day minimum flow is estimated to increase from 2.44 cfs (existing conditions) to 2.98 cfs (see Table 5.2.6-1). The annual daily mean flow would follow similar trends as the 30-day annual low flow, with a maximum decrease of 5 percent at year 11 and remain approximately the same as existing conditions for long-term closure (PolyMet 2015m, Attachment J). Most of these changes in flow are too small to be measurable and, therefore, hydrologic alteration is not expected to degrade physical aquatic habitat by destabilizing the stream channel.

The effects from the NorthMet Project Proposed Action on seasonal flow would be negligible and, therefore, no adverse effects on aquatic habitat or species are anticipated.

Flow monitoring methods have been determined by the MDNR based on professional judgement and accumulated data. Monitoring would be conducted at a minimum of three sites for each of the impacted streams whenever there is a 20 percent fluctuation in watershed area or an addition / reduction of flow that exceeds 20 percent of the mean annual flow located: 1) within 2,000 ft of each outflow; 2) at the endpoint of impact; and 3) midway between the two points (Chisholm 2006).

Flows within the Partridge River would be reduced by a maximum 4 percent. Varying degrees of hydrologic alteration can be tied to ecological condition using the Limits of Hydrologic Alteration (LOHA) Method, which is intended to provide a better articulation of the aspects of flow rate and timing thought to be most important to ecological condition, and provide more elaboration on the ecological changes that are associated with increasing degrees of hydrologic alteration. Research in review lists 10 percent, 20 percent, and greater than 20 percent flow alteration as setting the ecological condition of “natural,” “minimally altered,” and “moderately altered," respectively (Chisholm 2006). A review of case studies (Richter et al. 2011) found that recommendations for flow protection are quite consistent, typically resulting in a range of allowable cumulative depletion of 6 percent to 20 percent of normal to low flows, but with occasional allowance for greater depletion in seasons or flow levels during which aquatic species are thought to be less sensitive. This review supports the conclusion that flow reductions in the Partridge River Watershed due to the NorthMet Project Proposed Action are anticipated to be generally within the natural ecological condition and less likely to have significant impacts to ecosystem function and aquatic species.

Proposed flow monitoring details would be finalized during the permitting process to ensure average annual flow standards are being met during mine operations, reclamation, and post-closure maintenance phases (see Table 5.2.2-53).



Water Sampling Location
Embarrass River Watershed
Partridge River Watershed
Stream/River
Mine Site
Plant Site
Transportation and Utility Corridor
Existing Railroad

Minnesota Department of Natural Resources
US Army Corps of Engineers St. Paul District
Forest Service U.S. Department of Agriculture

N S E W

0 0.5 1 2 3 Miles

Figure 5.2.6-1
Partridge and Embarrass River Watershed Surface Water Evaluation Locations
NorthMet Mining Project and Land Exchange FEIS
Minnesota

November 2015

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Table 5.2.6-1 Partridge River Flow Modeling Results for Evaluation Locations SW-002, SW-004, and SW-004a

	SW-002							SW-004							SW-004a						
Statistic (Unit)	**Existing Conditions**	**Year 1**	**Year 2**	**Year 11**	**Year 20**	**West Pit Filling**	**Long-term Closure**	**Existing Conditions**	**Year 1**	**Year 2**	**Year 11**	**Year 20**	**West Pit Filling**	**Long-term Closure**	**Existing Conditions**	**Year 1**	**Year 2**	**Year 11**	**Year 20**	**West Pit Filling**	**Long-term Closure**
Annual Daily Mean (cfs)	6.09	5.84	5.84	5.79	6.12	6.09	6.09	13.97	13.51	13.52	13.37	13.70	14.08	14.07	38.33	37.74	37.62	36.66	37.32	37.10	38.72
October Mean (cfs)	22.76	21.81	21.83	21.63	22.86	22.75	22.75	52.43	50.60	50.64	50.07	51.26	52.74	52.73	144.03	141.74	141.25	137.55	140.03	139.19	143.92
November Mean (cfs)	4.59	4.33	4.32	4.27	4.47	4.46	4.46	11.68	10.77	10.77	10.66	10.91	11.16	11.16	31.61	30.45	30.35	29.68	30.14	30.02	31.64
December Mean (cfs)	1.7	1.64	1.64	1.62	1.71	1.70	1.70	4.43	4.02	4.02	3.97	4.06	4.16	4.16	12.85	12.33	12.29	12.02	12.19	12.13	13.80
January Mean (cfs)	0.57	0.54	0.54	0.54	0.56	0.56	0.56	1.37	1.26	1.26	1.25	1.28	1.31	1.31	3.95	3.83	3.81	3.72	3.78	3.76	4.60
February Mean (cfs)	1.06	1.01	1.01	1.00	1.06	1.05	1.05	2.40	2.32	2.32	2.30	2.35	2.42	2.42	6.59	6.48	6.46	6.29	6.41	6.37	7.02
March Mean (cfs)	1.44	1.38	1.38	1.37	1.45	1.44	1.44	3.10	3.04	3.04	3.01	3.08	3.18	3.18	8.50	8.42	8.39	8.15	8.32	8.26	8.59
April Mean (cfs)	30.58	29.23	29.24	28.96	30.56	30.41	30.42	71.41	68.77	68.80	68.04	69.66	71.58	71.58	200.60	197.10	196.46	191.58	194.90	193.79	198.90
May Mean (cfs)	7.36	7.04	7.06	7.01	7.46	7.43	7.43	17.52	16.90	16.92	16.74	17.17	17.66	17.66	49.01	48.33	48.20	46.98	47.88	47.55	49.58
June Mean (cfs)	11.55	11.15	11.17	11.08	11.70	11.65	11.65	25.56	25.32	25.38	25.11	25.78	26.45	26.45	67.75	67.46	67.23	65.54	66.77	66.44	69.71
July Mean (cfs)	5.97	5.78	5.78	5.74	6.06	6.04	6.04	13.54	13.23	13.22	13.10	13.43	13.75	13.75	35.56	35.14	34.92	34.04	34.67	34.46	36.68
August Mean (cfs)	3.00	2.89	2.89	2.87	3.03	3.03	3.03	6.40	6.41	6.39	6.33	6.48	6.67	6.67	16.71	16.64	16.75	16.32	16.62	16.53	17.48
September Mean (cfs)	8.93	8.62	8.61	8.52	9.02	8.97	8.97	20.14	19.47	19.43	19.24	19.70	20.19	20.18	52.93	51.97	51.64	50.26	51.20	50.83	53.44
Average Annual 30-day Max (cfs)	25.59	22.58	22.60	22.39	23.67	23.57	23.58	54.01	52.46	52.49	51.91	53.19	54.70	54.70	150.46	148.47	148.21	144.46	147.03	146.24	149.90
Average Annual 90-day Max (cfs)	13.71	13.14	13.14	13.02	13.77	13.71	13.71	31.66	30.66	30.66	30.33	31.07	31.95	31.94	87.78	86.48	86.26	84.06	85.58	85.07	87.62
Average Annual 30-day Min (cfs)	0.41	0.39	0.39	0.38	0.40	0.40	0.40	0.92	0.86	0.86	0.85	0.87	0.89	0.89	2.44	2.38	2.36	2.30	2.33	2.32	2.98
Average Annual 90-day Min (cfs)	0.63	0.60	0.60	0.60	0.62	0.62	0.62	1.46	1.35	1.35	1.34	1.36	1.39	1.39	3.87	3.76	3.73	3.64	3.70	3.68	4.50
Avg. Hydrograph Increase (cfs/day)	3.94	3.84	3.85	3.86	4.04	4.03	4.01	6.93	6.91	6.96	6.89	7.14	7.40	7.40	20.61	20.82	20.87	20.17	20.47	20.65	20.92
Avg. Hydrograph Decrease (cfs/day)	1.49	1.44	1.45	1.44	1.52	1.51	1.51	2.46	2.49	2.50	2.47	2.56	2.64	2.65	7.06	7.18	7.19	7.04	7.13	7.18	7.25

Source: PolyMet 2015m, Attachment J (Partridge River Hydrologic Impact Assessment Results).

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No effects on aquatic resources are anticipated from hydrologic changes at the Partridge River tributary streams, Colby Lake, or Whitewater Reservoir, from the NorthMet Project Proposed Action. On an annual average basis, inflow to Colby Lake would be reduced about 1.7 percent during operations (in mine year 11) and have virtually no change during closure (see Section 5.2.2.3.2) (PolyMet 2015m). Withdrawals at Colby Lake would create an average annual water level fluctuation of about 3.6 ft, compared to 3.9 ft for zero withdrawal. Withdrawals at the Whitewater Reservoir would create an annual fluctuation of about 4.2 ft compared to 2.9 ft for zero withdrawal. Effects on Colby Lake and Whitewater Reservoir are expected to be negligible as they would be well within the range of effects experienced during the former LTVSMC taconite mining operations.

Approximately 227 gpm of surface water seepage flows from the existing LTVSMC Tailings Basin to the headwaters of Second Creek. Under the current LTVSMC Consent Decree, most of this seepage is captured and pumped back to the Tailings Basin, resulting in a net reduction in base flow to Second Creek. The NorthMet Project Proposed Action would continue pumping this seepage back to the Tailings Basin for water quality protection reasons, but would augment flows in Second Creek at approximately 80 percent of the current seepage volume (i.e., about 184 gpm) with WWTP effluent throughout NorthMet Project Proposed Action operations, reclamation, and long term closure. With these augmentation flows, total flow volume in Second Creek would be equivalent to at least 80 percent of historic flow volume and fluctuations through the year would mimic the natural hydrograph (PolyMet 2015j); therefore, the designed flow augmentation to Second Creek is not expected to affect the available aquatic species habitat by degrading the habitat with decreased flow to the headwater portions of this stream and would in fact help mitigate the hydrologic effect associated with the current pump back requirements.

Riparian and Aquatic Connectivity

The NorthMet Project Proposed Action activities would not occur within the riparian buffer of any streams; therefore, the NorthMet Project Proposed Action would not affect the extent of natural vegetative cover along riparian areas and would not result in a change in the RCI for the Partridge River.

The NorthMet Project Proposed Action would not result in any new dams, bridges, or culverts within perennial or intermittent streams; therefore, the NorthMet Project Proposed Action would not affect the hydrologic connectivity along streams and would not result in a change in the ACI for the Partridge River.

Water Quality Effects

Surface water chronic standards, specifically the Class 2B standards, were developed to be protective of aquatic life and to promote the “propagation and maintenance of a healthy community of cool or warm water sport or commercial fish and associated aquatic life, and their habitats” (*Minnesota Rules*, part 7050.0222). The chronic standards reflect “the highest water concentration of a toxicant to which organisms can be exposed indefinitely without causing chronic toxicity” (*Minnesota Rules*, part 7050.0218, subpart 3, item I).

As described in more detail in Section 5.2.2, the GoldSim water quality model results were initially screened to compare the single highest monthly P90 water quality prediction from among 2,400 months covered over the 200 year Mine Site model period, CEC Scenario values, and the water quality evaluation criteria (see Section 5.2.2.1). The screening analysis indicates that the NorthMet Project Proposed Action would not exceed evaluation criteria with the exception of aluminum (see Table 5.2.6-2).

The results indicate aluminum would exceed the evaluation criterion (125 µg/L) at all evaluation locations. Maximum aluminum P90 values for the NorthMet Project Proposed Action ranged from a low 306 µg/L (SW-006) to a high of 313 µg/L (SW-002). However, Partridge River concentrations at the same locations for the CEC Scenario are nearly identical, also exceeding the evaluation criterion. Therefore, the NorthMet Project Proposed Action would not worsen existing conditions relative to aluminum concentrations in the Partridge River (see Table 5.2.2-31).

Mercury was not included in the GoldSim model for either the Mine Site or the Plant Site, as insufficient data and unique modeling requirements for mercury dynamics prevented modeling mercury like the other solutes. Regardless, the NorthMet Project Proposed Action would still need to demonstrate that the mercury evaluation criteria would be protected (see Section 5.2.2.1). Therefore, a simple mass balance model estimation method was used. This simple estimation method was preferred over a detailed mechanistic model because it incorporated the important input and removal processes for mercury, was very transparent with regard to data inputs, and allowed for easy assessment of the effects of changing parameter values on mercury concentrations. For the Mine Site, this method, in combination with analog data from existing natural and mine pit lakes in the region, was used to assess future mercury concentrations in the West Pit lake and in the overflow water. Mercury air emissions and subsequent mercury deposition were not assessed for the Mine Site because potential emissions are less than 1.0 lb/yr (PolyMet 2015e). Information pertaining to mercury deposition is discussed in Section 5.2.7.2.5. The NorthMet Project Proposed Action is also estimated to result in a net decrease in mercury loadings to the Partridge River (see Sections 5.2.2.3.4 and 6.2.2.4).

As described in detail in Section 5.2.2.3.4, adding sulfate to aquatic systems where sulfate is limiting can stimulate sulfate-reducing bacteria activity, leading to increased mercury methylation as the sulfate is consumed (Gilmour et al. 1992; Harmon et al. 2004; Branfireun et al. 1999; Branfireun et al. 2001). The MPCA and MDNR recognize the important role of sulfate in methylmercury production, as well as the uncertainties regarding site-specific relationships between sulfate discharges and water body impairment. The MPCA has set forth a strategy (MPCA 2006a) for addressing the effects of sulfate on methylmercury production that encompasses technical, policy, and permitting issues. In response to this policy, as well as to comply with sulfate standards that apply to waters recommended as supporting the production of wild rice, PolyMet has proposed several significant changes to the NorthMet Project Proposed Action design from that proposed in the DEIS. These changes would significantly reduce sulfate loadings, and they would include a surface and groundwater seepage containment system around the Category 1 Stockpile and a WWTF to treat the West Pit overflow at the Mine Site and a containment system around the Tailings Basin and a WWTP to treat tailings seepage at the Plant Site. Effluent from the WWTF would be discharged at a water quality-based effluent limit concentration that protects the sulfate standard for waters used for the production of wild rice (10 mg/L), beginning when the West Pit is predicted to flood around year 55. Sulfate concentrations in this range coupled with the oxygenated hydrologic environment to which the effluent would be discharged would not be expected to promote mercury methylation; therefore, impacts to aquatic species are not anticipated. Potential cumulative impacts to fish from mercury and methylmercury are discussed in Section 6.2.6.3.3.

An exceedance of aluminum could potentially affect aquatic species by causing pulmonary problems, developmental issues, and osmoregulatroy disturbances (Soucek 2006). However, given the similarity between the CEC Scenario and the NorthMet Project Proposed Action aluminum values at Partridge River evaluation locations, impacts from aluminum to aquatic species due to the NorthMet Project Proposed Action are not anticipated.

Table 5.2.6-2 Partridge River Maximum P90 Solute Concentration Over Entire 200-Year Simulation at Each Evaluation Location Based on GoldSim Probabilistic Model

Parameter	Evaluation Criteria	Units	SW-002		SW-004		SW-004a	
			NorthMet Project Proposed Action	CEC Scenario	NorthMet Project Proposed Action	CEC Scenario	NorthMet Project Proposed Action	CEC Scenario
General								
Chloride	230	mg/L	16.9	16.9	16.8	16.7	16.8	16.9
TDS[2]	700[3]	mg/L	207	207	204	204	214	204
Metals Total								
Aluminum	125	µg/L	**313**	**313**	**312**	**311**	**310**	**315**
Antimony	31	µg/L	0.25	0.3	0.26	0.3	4.2	0.3
Arsenic	53	µg/L	2.6	2.6	2.6	2.6	2.7	2.6
Boron	500	µg/L	200	199	198	197	200	202
Cadmium	NA[1]	µg/L	0.17	0.17	0.16	0.16	0.93	0.17
Chromium	11	µg/L	1.4	1.4	1.4	1.4	1.7	1.5
Cobalt	5	µg/L	1.3	1.3	1.3	1.3	3.1	1.3
Copper	NA[1]	µg/L	3.5	3.5	3.4	3.4	5.8	3.5
Lead	NA[1]	µg/L	0.94	0.94	0.92	0.92	1.9	0.97
Nickel	NA[1]	µg/L	4.3	4.3	4.3	4.3	26.7	4.4
Selenium	5	µg/L	1.5	1.5	1.5	1.5	1.5	1.5
Silver	1	µg/L	0.11	0.11	0.11	0.11	0.16	0.11
Thallium	0.56	µg/L	0.12	0.12	0.11	0.11	0.11	0.12
Zinc	[1]NA[2]	µg/L	25.4	25.4	25.5	25.4	48.7	25.4

Sources: PolyMet 2015m; PolyMet 2014v.

Notes:
Bolded numbers show exceedances at the P90 modeled concentrations.

For each constituent at each location, the maximum solute concentration over the entire 500-year simulation period is recorded for each of 500 realizations of the Monte Carlo run. At the end of the Monte Carlo run, there is a list of 500 maximum concentration values for each constituent at each location. Each list is converted to a cumulative frequency distribution. Each value in this table is the 90th percentile concentration from the associated distribution.

[1] Parameter has a hardness-based evaluation criterion and is screened using a different procedure (see Table 5.2.2.-42).
[2] TDS is calculated as the sum of 90th-percentile alkalinity, calcium, magnesium, sodium, potassium, chloride, sulfate, and fluoride using the formula provided in PolyMet (2015m; Section 6.2.6.2).

Colby Lake

As discussed in Section 5.2.2 and exhibited in Table 5.2.6-3, Colby Lake would exceed the evaluation criteria for aluminum, arsenic, iron, and manganese under the NorthMet Project Proposed Action. Potential effects of aluminum on aquatic species are discussed in Section 5.6.2.2.1. Exceedances of arsenic could potentially result in poor growth rates and mortality in aquatic species; however, adverse effects have only been reported in water containing concentrations between 19 and 48 µg/L (Eisler 1988a). However, comparing the evaluation criteria exceedances to the CEC Scenario indicates no effects on aquatic species would result from the NorthMet Project Proposed Action, as modeled values are nearly identical under the No Action Continuation of Existing Conditions Scenario.

Table 5.2.6-3 Maximum P90 Surface Water Concentrations for Colby Lake

Parameter	Colby Lake Evaluation Criteria	Units	CEC Scenario (Max P90 Value)	NorthMet Project Proposed Action (Max P90 Value)
General				
Chloride	230	mg/L	15.3	15.3
Metals Total				
Aluminum	125	µg/L	**266**	**266**
Antimony	5.5	µg/L	0.26	0.48
Arsenic	2	µg/L	**2.44**	**2.46**
Cadmium	NA[1]	µg/L	0.17	0.20
Chromium	100	µg/L	1.28	1.28
Cobalt	2.8	µg/L	1.22	1.26
Copper	NA[1]	µg/L	9.83	9.88
Iron	300	µg/L	**5,043**	**5,034**
Lead	NA[1]	µg/L	1.26	1.31
Manganese	50	µg/L	**207**	**202**
Nickel	NA[1]	µg/L	4.42	5.43
Selenium	5	µg/L	1.29	1.29
Silver	1	µg/L	0.11	0.11
Thallium	0.28	µg/L	0.07	0.08
Zinc	NA[1]	µg/L	26.7	27.6

Source: PolyMet 2014v.

Note: Bold font indicates an exceedance of the Class 2B water quality standards evaluation criteria.

Special Status Species

There are no federally listed or state-listed threatened or endangered fish or macroinvertebrate species known to occur in the Partridge River (USFWS 2011). There are four special status aquatic species that have not been found in the NorthMet Project area, but suitable habitat is likely to occur and the species could be present, including:

- Quebec emerald dragonfly – RFSS species,
- Ebony boghaunter – RFSS species,

- Creek heelsplitter mussel – SGCN and RFSS species, and
- Northern brook lamprey – SGCN and RFSS species.

Since the NorthMet Project Proposed Action is not predicted to result in any measurable changes in low flows and negligible changes in average flows, no effects on RCI and ACI, and no change in water quality for any of the Class 2B water quality standards, no effects on aquatic special status species is expected within the Partridge River Watershed.

Furthermore, aquatic species on the Superior National Forest, which include lake sturgeon, nipigon cisco, and shortjaw cisco, will not be impacted as the species are not included in the NorthMet Project area. In addition, the NorthMet Project Proposed Action may affect individuals, but would not likely cause a trend to federal listing or loss of viability for the remaining six RFSS aquatic species, discussed in Section 4.2.6, on the Superior National Forest. Please see the Biological Evaluation included in Appendix D for more information about effects on RFSS aquatic species.

5.2.6.2.2 Embarrass River Watershed

This section describes the potential effects of the NorthMet Proposed Action on aquatic resources in the Embarrass River Watershed, including effects on physical habitat, riparian and aquatic connectivity, and water quality.

Physical Habitat Effects

The NorthMet Project Proposed Action could potentially affect flows in the three tributary streams draining the Tailings Basin (i.e., Mud Lake Creek, Trimble Creek, and Unnamed Creek) and flow in the Embarrass River downstream of these tributary effects (i.e., PM-13). As discussed in Section 5.2.2, the NorthMet Project Proposed Action includes engineering controls that would capture nearly all seepage from the Tailings Basin, and mitigate this effect by augmenting flows to two of the three Embarrass River tributary streams, Unnamed Creek and Trimble Creek, and a Partridge River tributary, Second Creek, with WWTP effluent to maintain average annual flows within 20 percent of existing conditions (see Table 5.2.6-4). Mud Lake Creek would be augmented via a drainage swale on the east side of the Tailings Basin. The tributary streams flow augmentation would result in only about a 3 percent reduction in average annual flow at PM-13 in the Embarrass River. Changes in average annual flow of this magnitude (less than 20 percent) would fall into the range of annual natural variability in terms of precipitation and would have minimal impacts to ecosystem function and aquatic species within the Embarrass River Watershed; however, seasonal flow data was not available for this watershed—in particular the tributaries. Flow monitoring details under the NorthMet Project Proposed Action would be finalized during the permitting process to ensure average annual flow standards are being met during mine operations, reclamation, and post-closure maintenance phases (see Table 5.2.2-54).

Dampening of the hydrologic curve could have an adverse effect on aquatic biota due to stream destabilization, including aggredation, degradation, and resultant loss of habitat. Maintenance of spring bankfull flow is particularly important for the success of fish spawning in tributaries because high flows trigger spawning runs and maintain spawning habitat. Effects on the success of fish spawning in tributary streams would be addressed by maintenance of seasonal, bankfull flows over the life of the NorthMet Project Proposed Action, especially when stream-related flow augmentation occurs within the Embarrass River Watershed.

Table 5.2.6-4 WWTP Minimum Flow Requirements for Stream Augmentation

Tributary	Historical Average Annual Flow (gpm)	WWTP Minimum Flow Requirements for Stream Augmentation (gpm)[1]
Second Creek	227	184
Trimble Creek	1,888	1,178
Unnamed creek	1,180	336
Total	**3,295**	**1,698**

Source: PolyMet 2015i.

Note:
[1] The value is the minimum flow of treated water the WWTP has to discharge on an average annual basis to each of the three streams that require augmentation to compensate for the river flow that would be cut off from the containment system, thereby maintaining plus or minus 20 percent of the current mean annual flow.

Water Quality Effects

Heavy metals have a wide spectrum of adverse effects on aquatic life that could include impacts to reproduction, growth, behavior, and metabolism. These effects are dependent upon such factors as species, age, weight, sex, trophic level, concentration of the metal, and ambient water conditions such as pH, salinity, hardness, temperature, and dissolved oxygen (Girgin et al. 2010). The bioavailability of heavy metals such as cadmium, copper, nickel, lead, and zinc generally decreases with increasing hardness in freshwater systems (Girgin et al. 2010). See Section 5.2.2.1.2 for details regarding the relationship between heavy metals and hardness. Exceedances of mercury could cause adverse impacts such as reproduction, growth, and osmoregulation issues in aquatic organisms. Mercury rapidly accumulates in aquatic biota and can inhibit fish reproduction at water concentrations as low as 0.03 µg/L (Eisler 1987); however, seepage water from the Tailings Basin is expected to be less than 0.001 µg/L. Conversely, lead does not bioaccumulate and tends to decrease with increasing trophic levels in freshwater habitats. Exposure to high levels of lead could result in muscular and neurological degeneration and destruction, growth inhibition, reproductive problems, paralysis, and mortality in fish. It could also negatively affect invertebrate reproduction as well as reduce growth, photosynthesis, mitosis, and water absorption in aquatic plants (Eisler 1988b).The NorthMet Project Proposed Action is designed to capture metals with engineering controls and adaptive management. Water monitoring (see Table 5.2.2-54) would ensure that water quality standards would be met with engineering controls and adaptive management. In addition, spill prevention plans would be implemented. These measures would minimize any potential impacts to aquatic species.

As described in more detail in Section 5.2.2, the Plant Site GoldSim water quality model results were initially screened to compare the single highest monthly P90 water quality prediction from among 6,000 months covered over the 500-year model period with the CEC Scenario modeled values and the water quality evaluation criteria (see Section 5.2.2.1). The initial screening analysis indicates that the NorthMet Project Proposed Action would not exceed surface water evaluation criteria with the exception of aluminum (see Table 5.2.6-5). In addition, surface water constituents that have hardness-based evaluation criteria were screened. It was not possible to develop a single evaluation criterion to which the GoldSim-predicted solute concentrations could be compared. The secondary screening approach was therefore based on evaluating the frequency and magnitude of potential impacts. Aluminum surface water concentrations were the only values that did not pass secondary screening (Section 5.2.2.3.3).

The results indicate the maximum P90 values of aluminum would exceed the Class 2B standard (125 µg/L) at all evaluation locations except TC-1 for both the CEC Scenario and the NorthMet Project Proposed Action. Maximum aluminum P90 values for the NorthMet Project Proposed Action ranged from a low 112 µg/L (TC-1) to a high of 189 µg/L (MLC-3). As discussed in Section 5.2.2, however, the predicted increases in aluminum are not the result of increased aluminum loadings from the NorthMet Project Proposed Action, but rather the result of mass loading from surface runoff and the loading from other minor sources. Given the similarity between the CEC Scenario and the NorthMet Project Proposed Action aluminum values at Embarrass River evaluation locations, impacts from aluminum to aquatic species due to the NorthMet Project Proposed Action are not anticipated.

As discussed in Section 5.2.2.3.3, NorthMet Project Proposed Action lead concentrations at PM-11 are generally higher than CEC Scenario concentrations. However, it is concluded that due to the expected performance of the WWTP, it is likely that actual lead concentrations at PM-11 would have acceptably low frequencies of exceedance. Therefore, impacts from lead to aquatic species due to the NorthMet Project Proposed Action are not anticipated.

Although maximum solute P90 concentrations are expected to meet Class 2B water quality standards for solutes other than aluminum, the NorthMet Project Proposed Action is projected to alter the existing water quality of the Embarrass River by increasing some solute concentrations from 2 to almost 30 times the existing level (Tables 4.2.2-32 and 5.2.2-45). Non-contact surface runoff and the addition of WWTP effluent to Unnamed Creek, Trimble Creek, and Second Creek as part of the augmentation program is projected to contribute to these loading increases.

Mercury was not included in the GoldSim model for either the Mine Site or the Plant Site, as insufficient data and unique modeling requirements for mercury dynamics prevented modeling mercury like the other solutes. Regardless, the NorthMet Project Proposed Action would still need to demonstrate that the mercury evaluation criteria would be protected (see Section 5.2.2.1). Therefore, a simple mass balance model estimation method was used. This simple estimation method was preferred over a detailed mechanistic model because it incorporated the important input and removal processes for mercury, was very transparent with regard to data inputs, and allowed for easy assessment of the effects of changing parameter values on mercury concentrations. For the Plant Site, this method, in combination with analog data from existing natural and mine pit lakes in the region, was used to assess future mercury concentrations in seepage, discharge from the WWTP, and volatilization from the Tailings Basin pond (this mechanism is discussed in Section 5.2.7, Air Quality). Mercury air emissions and subsequent mercury deposition were assessed for the Plant Site, whereby the output from the mercury air emissions was included in the simple mass balance model (Polymet 2015j). Information pertaining to mercury deposition is discussed in Section 5.2.7.2.5. The NorthMet Project Proposed Action is predicted to result in a net increase in mercury loadings to the Embarrass River (see Sections 5.2.2.3.4 and 6.2.2.4). This is primarily attributable to the redirection of surface runoff diverted via the drainage swale constructed east of the Tailings Basin East Dam directly to Mud Lake Creek as part of the Tailings Basin expansion to the Embarrass River.

Table 5.2.6-5 Embarrass River Maximum P90 Solute Concentration Over Entire 500-Year Simulation Period Based on GoldSim

			PM-13		PM-11		PM-19		MLC-2	
Parameter	**Evaluation Criteria**	**Units**	**NorthMet Project Proposed Action**	**Continuation of Existing Conditions**	**NorthMet Project Proposed Action**	**Continuation of Existing Conditions**	**NorthMet Project Proposed Action**	**Continuation of Existing Conditions**	**NorthMet Project Proposed Action**	**Continuation of Existing Condition**
Chloride	230	mg/L	9.7	13.1	8.8	22.1	7.5	22.2	10.2	20.7
TDS[2]		mg/L	257	479	131	919	138	667	213	531
Metals Total										
Aluminum	125	µg/L	**180**	**179**	**159**	**151**	**135**	**129**	**187**	**158**
Antimony	31	µg/L	9.2	0.40	19.6	0.68	19.0	0.49	0.40	0.44
Arsenic	53	µg/L	5.8	4.2	10.0	3.6	9.8	4.0	4.4	4.4
Boron	500	µg/L	151	225	356	**517**	349	370	94.5	282
Cadmium	NA[1]	µg/L	1.0	0.15	2.0	0.26	1.9	0.19	0.16	0.17
Chromium	86	µg/L	4.1	1.7	7.5	1.5	7.4	1.3	1.8	1.6
Cobalt	5	µg/L	3.0	2.6	5.0	4.7	4.9	2.7	2.7	2.5
Copper	NA[1]	µg/L	5.7	2.6	9.0	5.2	8.9	3.3	2.2	2.7
Lead	NA[1]	µg/L	1.7	0.59	3.0	0.42	2.9	1.1	1.4	1.3
Nickel	NA[1]	µg/L	28.4	4.5	50.0	9.8	49.1	5.8	4.1	4.5
Selenium	5	µg/L	2.74	0.76	4.99	0.93	4.87	0.77	0.87	0.76
Silver	1	µg/L	0.18	0.14	0.32	0.25	0.32	0.18	0.13	0.15
Thallium	0.56	µg/L	0.17	0.15	0.23	0.16	0.23	0.18	0.17	0.19
Vanadium	NA	µg/L	6.5	3.7	9.5	1.0	9.3	3.7	5.2	4.8
Zinc	NA[1]	µg/L	57.0	18.5	99.9	15.8	98.2	15.3	19.2	18.1

Source: PolyMet 2014w and PolyMet 2015j.

Notes:
For each constituent at each location, the maximum solute concentration over the entire 500-year simulation period is recorded for each of 500 realizations of the Monte Carlo run. At the end of the Monte Carlo run, there is a list of 500 maximum concentration values for each constituent at each location. Each list is converted to a cumulative frequency distribution. Each value in this table is the 90th percentile concentration from the associated distribution.
Bold value indicates exceedance of the evaluation criterion at the P90 modeled concentrations.
[1] Parameter has a hardness-based evaluation criterion and is screened using a different procedure (see Table 5.2.2.-42).
[2] TDS is calculated as the sum of 90th-percentile alkalinity, calcium, magnesium, sodium, potassium, chloride, sulfate, and fluoride using the formula provided in PolyMet (2015m, section 6.2.6.2).

Special Status Species

There are no federally listed or state-listed threatened or endangered fish or macroinvertebrate species known to occur in the Embarrass River (USFWS 2011). There are four special status aquatic species that have not been found in the NorthMet Project area, but suitable habitat is likely to occur and the species could be present, including:

- Quebec emerald dragonfly – RFSS species;
- Ebony boghaunter – RFSS species;
- Creek heelsplitter mussel – SGCN and RFSS species; and
- Northern brook lamprey – SGCN and RFSS species.

The NorthMet Project Proposed Action is not predicted to result in any measurable changes in low flows, and there would be negligible changes in average annual flows, no effects on RCI and ACI, and no change in water quality for any of the Class 2B water quality standards.

Similarly for the Embarrass River, as stated above for the Partridge River, aquatic species on the Superior National Forest, which include lake sturgeon, nipigon cisco, and shortjaw cisco, will not be impacted as the species are not included in the NorthMet Project area. In addition, the NorthMet Project Proposed Action may affect individuals, but would not likely cause a trend to federal listing or loss of viability for the remaining six RFSS aquatic species, discussed in Section 4.2.6, on the Superior National Forest.

5.2.6.3 NorthMet Project No Action Alternative

Under the NorthMet Project No Action Alternative, the NorthMet Project Proposed Action would not occur and associated effects on fish and other aquatic life would not occur.

Although under the No Action Alternative, the NorthMet Project Proposed Action, including the proposed Tailings Basin seepage collection and water treatment engineering controls, would not occur, the No Action Alternative would not necessarily be static. In this case, it is anticipated that the water quality of seepage from the existing LTVSMC Tailings Basin would improve over time as a result of natural attenuation and/or possible additional mitigation measures pursuant to the Consent Decree between the MPCA and Cliffs Erie, new requirements in reissued permits, or other state or federal remediation requirements.

5.2.7 Air Quality

This section assesses the effects of the NorthMet Project Proposed Action on air quality. Procedures for air quality assessments vary depending upon the level of emissions from a proposed project. The USEPA defines sources as "major" or "minor," depending on their emissions levels of regulated pollutants (250 tpy of any criteria pollutant, 100,000 tpy of GHGs, 10 tpy of a single HAP, or 25 tpy of all HAPs). As presented in this section, the NorthMet Project Proposed Action has been defined as a synthetic minor source according to this definition, since the project would limit its emissions through permit restrictions to less than the emission levels stated above. However, at the request of several state and federal agencies, much of the analyses were conducted to address requirements for major sources. Discussions of the air quality assessment methodologies, air quality effects, and potential mitigation measures are addressed for criteria pollutants, air toxics, and amphibole fibers.

Summary

The NorthMet Project Proposed Action has been designed so that it is considered a synthetic minor source for air permitting purposes. However, the evaluation of the NorthMet Project Proposed Action in this FEIS has treated it as a major source due to its sensitive nature. Compliance with state and federal ambient air quality standards and growth increments, designed to protect human health and the environment, were evaluated using generally accepted state and federal threshold criteria. The NorthMet Project Proposed Action has been shown to not cause or contribute to significant air quality effects. Local and regional effects, up to 300-km from the project facilities, were evaluated to incorporate federally sensitive, pristine area resources such as BWCAW and Voyageurs National Park. Effects of dust from mining and ore transport are generally confined to areas disturbed by project activities. The effects of reactive dust emissions on wetlands are discussed in Section 5.2.3. Control technologies similar to federal Best Available Control Technologies (termed BACT-like) were evaluated and applied to the project equipment in order to minimize the potential for air emissions. In particular, BACT-like controls were incorporated to reduce mercury emissions to levels that would not impede current State of Minnesota mercury emissions reduction goals. BACT-like fine-particulate matter emission controls were also incorporated to specifically control the release of more than 99.9 percent of amphibole fibers in the ore.

5.2.7.1 Methodology and Evaluation Criteria

The following subsections describe the air quality standards used in the assessments, local and federal regulations that affect the NorthMet Project Proposed Action, and modeling methodologies and specific modeling assessments conducted, as well as the evaluation criteria used to define significant effects from operation of the NorthMet Project Proposed Action.

5.2.7.1.1 Regulatory Setting

Air Quality Standards

The USEPA has established NAAQS for seven criteria air pollutants including NO_2, SO_2, CO, O_3, PM_{10}, $PM_{2.5}$, and lead. Primary standards are established to protect the public health; secondary standards are set to protect public welfare, including protection from damage to animals, crops, vegetation, visibility, and buildings. It should be noted that Title 42, Chapter 85, Subchapter I, Part A, Section 7408 (a)(2) of the CAA directs the USEPA to develop air quality criteria for air pollutants that have identifiable effects on public health or "welfare." The term "welfare" in the context of the CAA includes the protection of vegetation, and the secondary NAAQS are designed to be protective of plant life including the effects of both concentration and deposition of material.

The MPCA has also promulgated ambient air standards for the State of Minnesota, known as the MAAQS. In addition to the criteria pollutants, the MAAQS contain standards for TSP and hydrogen sulfide (H_2S). As with the NAAQS, the MAAQS primary standards are established to protect the public health; secondary standards are set to protect public welfare, including protection from damage to animals, crops, vegetation, visibility, and buildings.

The NAAQS and MAAQS are summarized in Table 5.2.7-1.

Table 5.2.7-1 Summary of NAAQS and MAAQS

Pollutant	Averaging Period	Standard Value (ppm)	Standard Value (µg/m³)	Standard Type[1]	Notes
Carbon Monoxide	1-Hour	35	40,000	Primary	Not to be exceeded more than once per year
	1-Hour[2]	30	35,000	Primary	
	8-Hour	9	10,000	Primary and Secondary	
Nitrogen Dioxide	Annual Arithmetic Mean	0.05	100	Primary and Secondary	Not to be exceeded
	1-Hour	0.10	188	Primary	Not to exceed the 98th percentile of the Maximum Daily 1-hour Values averaged over a 3-year period
Ozone	8-Hour	0.075	147	Primary and Secondary	4th highest daily maximum 8-hour average
Lead	Quarterly		0.15	Primary and Secondary	Rolling 3-month average
Total Suspended Particulate (TSP)[2]	Annual Geometric Mean		75 60	Primary Secondary	Not to be exceeded
	24-Hour		260 150	Primary Secondary	Not to be exceeded more than once per year
PM_{10}	Annual Arithmetic Mean[2]		50	Primary and Secondary	Not to be exceeded
	24-Hour		150	Primary and Secondary	Not to be exceeded more than once per year on average over 3 years

Pollutant	Averaging Period	Standard Value (ppm)	Standard Value (µg/m³)	Standard Type[1]	Notes
$PM_{2.5}$	Annual Arithmetic Mean		12	Primary and Secondary	Not to exceed the 3-year average of the weighted annual mean concentrations
	24-Hour		35	Primary and Secondary	Not to exceed the 3-year average of the 98th percentile of 24-hour concentrations
Sulfur Dioxide	Annual Arithmetic Mean	0.03 0.02	80 60	Primary Secondary[2]	Not to be exceeded
	24-Hour	0.14	365	Primary and Secondary	Not to be exceeded more than once per year
	3-Hour	0.5	1,300	Primary and Secondary	
	3-Hour[2]	0.35	915	Secondary	
	1-Hour[2]	0.5	1,300	Primary	
	1-Hour	0.075	196	Primary	Not to exceed the 99th percentile of the Maximum Daily 1-hour Values averaged over a 3-year period
Hydrogen Sulfide[2]	½-Hour	0.05	70	Primary	Not to be exceeded over 2 times per year
	½-Hour	0.03	42	Primary	Not to be exceeded over 2 times in any 5 consecutive days

Source: MPCA 2013b; USEPA 2013.

Notes:
1 Primary standards set limits to protect human health; secondary standards set limits to protect public welfare.
2 MAAQS only.

Federal Regulations

Attainment Status

Under the CAA, the USEPA has defined all areas within the United States as one of two classifications, attainment or non-attainment. “Attainment areas” are those areas that either have collected ambient air quality data to demonstrate that they are in compliance or do not have demonstrated non-compliance with the NAAQS, and so they are known as “unclassified areas.” An area that does not meet NAAQS is considered to be a “nonattainment area” for that pollutant, and the USEPA requires the state to develop state implementation plans to control existing and future emissions in order to bring the area into compliance with the NAAQS. The NorthMet Project area has been designated by the USEPA as attainment or unclassified for all air quality pollutants.

Prevention of Significant Deterioration Review

Under the CAA, the federal Prevention of Significant Deterioration (PSD) requirements provide for a pre-construction review and permit process for the construction and operation of a new or modified major stationary source in attainment areas. The review includes the following:

- BACT demonstration;
- Ambient air quality analysis to assess potential project effects with NAAQS and PSD increments;
- An assessment of Air Quality Related Value (AQRV) of the direct and indirect effects of a Project on general growth, soil, vegetation, and visibility for Class I regions within 300 km;
- An ambient monitoring program if no representative data are available; and
- Public comment.

The USEPA's PSD program allows all attainment areas various levels of air quality protection and growth depending upon its designated class. Class I areas are special areas of natural wonder and scenic beauty—such as national parks, national monuments, and wilderness areas—where air quality should be given special protection. Class II areas are non-Class I areas that are allowed moderate growth and air quality degradation with Class II incremental limits. Class III areas are all non-Class I areas that are deemed unclassified and allow maximum growth and air quality degradation with no incremental limits. Although states and other governing bodies can petition USEPA for reclassification of non-statutory Class I or Class II areas to the Class III designation, there are no Class III areas at this time; therefore, the Class III increments are not included in this discussion. For attainment areas, the USEPA has promulgated PSD increments for four pollutants (NO_2, SO_2, PM_{10}, and $PM_{2.5}$) for both Class I and Class II regions. The increments are designed to allow for ambient concentrations within an area to increase by the maximum allowable amount above baseline concentrations. Class I PSD increments are designed to keep pristine areas clean and have more restrictive allowable increment thresholds. Class II PSD increments are designed to allow further growth within the rest of the country. Table 5.2.7-2 provides a summary of the Class I and Class II PSD increments.

Table 5.2.7-2 Summary of Allowable Prevention of Significant Deterioration Class I and Class II Increments

Pollutant, Averaging Period	Allowable Increment (µg/m^3) Class I Region	Class II Region
SO_2, 3-hour	25	512
SO_2, 24-hour	5	91
SO_2, Annual	2	20
NO_2, Annual	2.5	25
PM_{10}, 24-hour	8	30
$PM_{2.5}$, 24-hour	2	9
$PM_{2.5}$, Annual	1	4

The NorthMet Project area is located within a Class II attainment area, as designated by the USEPA. In relation to the NorthMet Project Proposed Action, the federal CAA defines a source as a major source in an attainment area if it has any criteria pollutant emissions above 250 tpy or

100,000 tpy of GHG emissions. Because the NorthMet Project Proposed Action is proposing to limit its actual emissions below "major source" thresholds for the federal PSD program, the NorthMet Project Proposed Action is not subject to PSD requirements and, thus, modeling of PSD increment consumption requirements do not specifically apply for permitting. For the purposes of this FEIS, NorthMet Project Proposed Action effects have been compared to the PSD Class I (generally pristine areas) and Class II (remaining areas) increments, as requested by several agencies, to ensure that the NorthMet Project Proposed Action is not contributing to any significant air quality effects.

Air Quality Related Values

In addition to PSD increments, major PSD sources that are located within 186 miles (300 km) of a Class I area may be required by the FLM to evaluate effects on AQRVs, which may include flora/fauna, visibility, water quality, soils, and odor for a specific Class I area. The NorthMet Project area is within 186 miles (300 km) of four Class I areas: BWCAW and Rainbow Lakes Wilderness (administered by the USFS) and Voyageurs National Park and Isle Royale National Park (under the administration of the National Park Service). Although the NorthMet Project Proposed Action is agreeing to emission limits to avoid being a major PSD source, an evaluation of the applicable AQRV was conducted for comparison in this FEIS. Table 5.2.7-3 provides the distances to each Class I area from the NorthMet Project area.

Table 5.2.7-3 NorthMet Project Setting Relative to Class I Regions

Class I Region	Distance from NorthMet Project Area (km/mi)
BWCAW	34/21
Voyageurs National Park	82/51
Rainbow Lakes Wilderness	142/88
Isle Royale National Park	218/135

New Source Performance Standards

The federal New Source Performance Standards are technology-based standards that are applicable to new or modified stationary sources of regulated emissions. The New Source Performance Standards program has defined emission limitations for approximately 70 source categories that are designated by size, as well as type of process. A comprehensive list of the applicable regulations for this facility would be included as part of the air quality permit. The following is a partial list of standards that apply to the NorthMet Project Proposed Action; these could vary depending on the final assessment of the permit application by the MPCA:

- Subpart A – General Provisions, which provides for general notification, recordkeeping, and monitoring requirements.
- Subpart LL – Standards of Performance for Metallic Minerals Processing Plants, which covers particulate and opacity emission limits for any new, modified, or reconstructed sources.
- Subpart OOO – Standards of Performance for Nonmetallic Mineral Processing Plants, which limits particulate emissions and opacity from new, modified, or reconstructed sources processing nonmetallic mineral (e.g., limestone or construction rock).

- Subpart IIII – Standards of Performance for Stationary Compression Ignition Internal Combustion Engines, which limits NO_x, PM, CO, fuel oil sulfur content, and opacity for new, modified, and reconstructed stationary compression ignition internal combustion engines.
- Subpart Dc – Standards of Performance for Small Industrial-Commercial-Institutional Steam Generating Units which, depending on fuel type, can regulate PM and/or SO_2 emissions from new, modified, or reconstructed boilers.

Air Conformity Determination

A conformity determination must be conducted by the lead federal agency if a federal action would generate emissions exceeding the conformity threshold levels (de minimis) of the pollutant(s) for which a Class I or Class II region is designated as a nonattainment area or as a maintenance area. Since the NorthMet Project area is classified as in attainment for all criteria pollutants, a General Conformity Determination is not required.

<u>State of Minnesota Regulations</u>

Nonferrous Mineland Reclamation rules, *Minnesota Rules*, part 6132.800, administered by the MDNR, require the control of dust from areas disturbed specifically by mining operations.

Also, the MPCA has promulgated rules concerning the control and permitting of all sources (not just for mining operations) throughout Minnesota. The following regulations are evaluated for the NorthMet Project Proposed Action.

Prevention of Significant Deterioration Review

Minnesota Rules, part 7007.3000, incorporate by reference the federal PSD requirements that provide for a pre-construction review and permit process for the construction and operation of a new or modified major stationary source in attainment areas.

The NorthMet Project Proposed Action is designed to limit emissions below major source thresholds (i.e., to be permitted as a synthetic minor source). Thus, for permitting purposes, the NorthMet Project Proposed Action would not be considered a major source for PSD (BACT demonstration, PSD increment assessment, and AQRV assessment would not be required via *Minnesota Rules*, part 7007.3000). However, a comprehensive analysis of NAAQS, MAAQS, PSD Class I and II increments, and AQRV is allowed, under Minnesota Rules, part 7007.0100(7)(k) and (v), as part of the evaluation of effect. An evaluation of pollution control technology was conducted for the Mine Site and Plant Site (PolyMet 2014m, PolyMet 2014n, PolyMet 2015e).

Minnesota Standards of Performance

A comprehensive list of Minnesota Standards of Performance would be identified in the air quality permit. The following is a list of Minnesota Standards of Performance applicable to the NorthMet Project Proposed Action. This list may change, depending upon the final assessment of the permit application by the MPCA.

Control of Fugitive PM (*Minnesota Rules*, part 7011.0150), which applies to bulk material handling operation, roads, and other fugitive sources. The rule prohibits the release of "avoidable amounts" of PM, and facilities are required to take reasonable precautions to prevent the discharge of visible fugitive emissions beyond the property line.

Standards of Performance of Stationary Internal Combustion Engines (*Minnesota Rules*, part 7011.2300). This applies to the emergency fire water pumps and the emergency generators, and limits SO_2 emissions to 0.5 pound per million British thermal units (lb/MMBTU) heat input.

Standards of Performance for Post-1969 Industrial Process Equipment (*Minnesota Rules*, part 7011.0715). This would apply to all new ore-handling equipment and other new sources that would generate PM emissions for which a standard of performance has not been promulgated in a specific rule. Due to the remote location of the NorthMet Project area (i.e., any source that is not in the Minneapolis-Saint Paul Air Quality Control Region or the City of Duluth, and which is located not less than 0.25 mile from any residence or public roadway), the required control equipment efficiency standard would be 85 percent.

Standards of Performance for Existing Indirect Heating Equipment (*Minnesota Rules*, part 7011.0510). The rule limits the PM emissions to between 0.4 and 0.6 lb/MMBTU, limits SO_2 emissions to between 1.6 and 4.0 lb/MMBTU, and limits opacity to 20 percent. This may apply to existing indirect heaters if used in the mining and processing operations.

Standards of Performance for New Indirect Heating Equipment (*Minnesota Rules*, part 7011.0515). The rule limits emissions of PM to between 0.1 and 0.4 lb/MMBTU, SO_2 emissions to between 0.8 and 4.0 lb/MMBTU, NO_x emissions to between 0.2 to 0.7 lb/MMBTU, and opacity to 20 percent. This may apply to new indirect heaters that may be used in the mine processing operations.

Standards of Performance for Fossil-Fuel-Burning Direct Heating Equipment (*Minnesota Rules*, part 7011.0610). The rule limits PM emissions based upon process throughput and limits opacity to 20 percent. This may apply to process heaters that may be used in the mine processing operations.

Standards of Performance for Pre-1969 Industrial Process Equipment (*Minnesota Rules*, part 7011.0710). The rule limits mass PM emissions based upon process weight and limits opacity to 20 percent. Alternatively, due to the remote location of the NorthMet Project area, compliance can be demonstrated with a pollution control equipment efficiency of 85 percent. This may apply to existing ore-handling equipment that may be used in the mine processing operations.

Standards of Performance for Stationary Compression Ignition Internal Combustion Engines (*Minnesota Rules*, part 7011.3520). The rule incorporates federal Standards of Performance for Stationary Compression Ignition Internal Combustion Engines under 40 CFR, Part 60, Subpart IIII. This may apply to fire water pumps and emergency generators that may be used in the mine processing operations.

Stationary Reciprocating Internal Combustion Engines (*Minnesota Rules*, part 7011.8150). The rule incorporates federal National Emissions Standards for Hazardous Air Pollutants under 40 CFR, Part 63, Subpart ZZZZ. This may apply to fire water pumps and emergency generators that may be used in the mine processing operations.

5.2.7.1.2 Evaluation Criteria

Various state and federal air quality standards and emissions standards have been established to minimize degradation of air quality. The criteria used for the evaluation of potential effects on air quality from the NorthMet Project Proposed Action or an alternative are whether it would cause an exceedance of NAAQS or MAAQS.

In addition to legally applicable statutory or regulatory requirements, the following criteria also were considered in evaluating effects from the NorthMet Project Proposed Action:

- Consumption of PSD increments as defined by the CAA Title I, PSD rule;
- Adverse effects on visibility in Class I areas;
- Adverse effects on other AQRV in Class I areas; and
- Adverse effects on human health as determined by an Air Emissions Risk Analysis (AERA) (MPCA 2013b).

5.2.7.1.3 NorthMet Project Proposed Action Emissions

From an air quality perspective, emissions from the NorthMet Project Proposed Action would be expected to occur from the mining operations at the Mine Site and ore/concentrate processing at the Plant Site. Although the emission generating activities at these two sites are separated geographically, they are joined by the rail line that would be used to transport ore from the Mine Site to the Plant Site. As such, the three components constitute a single project for permitting purposes, and, thus, the total emissions from both sites are summed for the purposes of this analysis.

The indirect non-GHG emissions from electrical purchases are not estimated for the NorthMet Project Proposed Action. If additional electrical capacity were required, over and above the current maximum operating capacity which required construction of new equipment, the electrical generating units would be subject to environmental permitting and regulation and would need to meet stringent emission limits for both criteria and non-criteria pollutants. In addition, no direct emissions of odor-causing compounds from the Mine Site or Plant Site are anticipated.

At the Mine Site, emissions were estimated for material handling sources associated with excavation, portable crushing and screening operations, blast hole drilling, use of unpaved roads, and vehicle exhaust.

Material handling includes the loading of overburden, waste rock, lean ore, and ore into trucks with shovels or loaders. After it is hauled, the ore would be dumped into the Rail Transfer Hopper and the overburden, waste rock, and lean ore would be unloaded at the appropriate stockpile or pit. The crushing and screening operations would be used to break up and separate the larger rocks from soil and gravel in the overburden to produce rock suitable for construction purposes. Haul trucks would travel over unpaved roads from the excavation site to the rail loading and stockpiling areas. Fugitive emissions would be generated as part of these operations. In order to minimize fugitive emissions, the NorthMet Project Proposed Action would utilize several control measures. These include minimization of drop distances for ore-screening, truck loading/unloading, and rail-loading; water and other dust suppressants on haul roads (90 percent control); water sprays for rock crushing and screening; down-hole watering during blasting operations; and environmental observations and recording. In addition, two PM10 air quality monitors are proposed to be placed at the Mine Site to monitor fugitive emissions.

At the Plant Site, point source emissions are predicted to occur from the crushing plant, flotation operation autoclaves and other hydrometallurgical processes, process consumables handling, and combustion. In addition, fugitive emissions are expected to occur from raw materials handling, Plant Site roads, the Tailings Basin, and from vehicle use of Dunka Road. Water spraying or other dust suppression would be used on all unpaved roads at the Plant Site, resulting in an 80 percent reduction in associated fugitive emissions.

PolyMet is proposing to accept emission limits below the major source threshold (stationary sources less than 250 tpy for criteria pollutants) so as to be classified as a synthetic minor PSD source and therefore not be subject to PSD requirements including modeling attainment with PSD increments for permitting purposes. As demonstrated in Table 5.2.7-4, below, the NorthMet Project Proposed Action does not have projected controlled emissions above major PSD thresholds on an annual basis. PSD required modeling analyses, however, were performed for this FEIS to assess its effect to ensure that the minor-source NorthMet Project Proposed Action does not cause or contribute to significant effects.

Criteria Pollutants

Criteria pollutant emissions are expected from both the Mine Site and Plant Site. Detailed information on the emission calculations for each site source is available as separate documents (MPCA 2012e; PolyMet 2015e). Table 5.2.7-4 summarizes the NorthMet Project Proposed Action maximum emissions for the Mine Site, Plant Site, and total emissions from PSD-regulated stationary sources for comparison with PSD Major Source Thresholds.

Table 5.2.7-4 Annual Criteria Air Pollutant Emissions for Prevention of Significant Deterioration-regulated Stationary Sources

Pollutant	Plant Site Projected Controlled Emissions (tpy) (controlled potential)	Mine Site Projected Controlled Emissions (tpy) (controlled potential)	Total Projected Controlled Emissions (tpy) (controlled potential)	PSD Major Source Thresholds (tpy)
NO_x	117	5	122	250
SO_2	7	0.8	8	250
TSP	201	9	210	250
PM_{10}	192	4	196	250
$PM_{2.5}$	190	2	192	250
VOC	50	0.2	50	250
Lead	0	0	0	250
CO	127	2	129	250

Note:
[1] The Plant Site emissions shown in Table 5.2.7-4 are the basis for the air dispersion modeling an impact assessment for the Project; however, planned changes to the Plant Site unit operations and configuration result in lower emissions of all criteria pollutants; therefore, additional air dispersion modeling analysis is not necessary because the worst case emissions were modeled.

In accordance with PSD permitting requirements, for this assessment, mobile emissions and fugitive emissions sources are not included in the determination of a major source. Under PSD requirements, fugitive sources are only included if the stationary source is defined as one of 28 named source categories. The NorthMet Project Proposed Action is not included in any of the USEPA-listed source categories; therefore, fugitive sources are not included in the determination of a major source. However, to assess modeled air effects, mobile and fugitive emissions from the operations were evaluated. The non-PSD-regulated mobile source emissions and fugitive emissions are summed in Table 5.2.7-5. Due to the size of the ore rock being transported, the design of the railcars, and the short distance of transport from the Mine Site to the Plant Site, the ore fines are expected to be coarse in nature. Thus, no significant reactive airborne fugitive dust from the rail transport is expected (MDNR et al. 2011) and is not included in the fugitive emissions. Any spillage of the ore fines is expected to be within 2 meters of the rail line, along the path, and any effects of the reactive ore on the ground has been addressed in Section 5.2.3.

Table 5.2.7-5 Annual Air Pollutant Emissions for non-Prevention of Significant Deterioration-regulated Mobile Sources and Fugitive Sources

Pollutant	Plant Site Projected Controlled Emissions (tpy)	Mine Site Projected Controlled Emissions (tpy)	Total Projected Controlled Emissions (tpy)
NO_x	58	321	379
SO_2	0	2	2
PM_{10}	238	462	700
$PM_{2.5}$	31	77	108

Hazardous Air Pollutants Emissions

Small amounts of potentially toxic compounds, which are referred to as HAPs, are expected to be associated with the NorthMet Project Proposed Action. Table 5.2.7-6 provides the estimate of HAP emissions for the NorthMet Project Proposed Action stationary sources. These emission levels reflect potential emissions taking into account the proposed pollution control equipment for the NorthMet Project Proposed Action (controlled). As seen in the table, total emissions of a single HAP are below 10 tpy and the combined HAP emissions are below 25 tpy, indicating that the HAP emissions would not exceed USEPA major source thresholds for HAPs. Although HAP emissions from mobile sources were not included in the table to address emission thresholds, these emissions were used in assessing the potential effects on human health. The AERA itself is not limited to an assessment of HAPs, but is inclusive of any air toxic pollutant that screened in during the scoping process.

Table 5.2.7-6 Annual Hazardous Air Pollutant Emissions

Pollutant	Plant Site Projected Controlled Emissions (tpy) (controlled potential)	Mine Site Projected Controlled Emissions (tpy) (controlled potential)	Total Projected Controlled Emissions (tpy) (controlled potential)	Major Source Threshold (tpy)
Single HAP[1]	4	1	5	10
Combined HAPs	14	3	17	25

Note:
[1] Nickel is the HAP with the highest emissions for the Plant Site (4 tpy); manganese has the highest emissions at the Mine Site (2 tpy). Highest single HAP emissions for the NorthMet Project Proposed Action (Plant Site plus Mine Site) are the nickel emissions, so the Single HAP values in Table 5.2.7-6 reflect nickel emissions for both the Plant Site and the Mine Site.

Greenhouse Gas Emissions

Direct and indirect GHG emissions would be associated with the NorthMet Project Proposed Action. Direct emissions are emitted from project sources; indirect emissions are from sources that are not part of the project, but are generated from activities that support the project (e.g., off-site electrical needs). These gases include primarily carbon dioxide (CO_2), N_2O, and methane (CH_4). GHG emissions are estimated based upon their global warming potential and are expressed in carbon dioxide equivalents (CO_2e). Global warming potential is the relative effect a specific compound has on the overall global warming effects. The global warming potential factors for the three pollutants are 1, 310, and 21, respectively. For this assessment, the CO_2e is estimated by multiplying the specific emissions by its global warming potential factor and then summing the results. Table 5.2.7-7 summarizes the controlled direct GHG emissions for the NorthMet Project Proposed Action. As seen from the table, total direct GHG emissions are less than 100,000 tpy of CO_2e and would not exceed the USEPA major source thresholds for GHGs.

Table 5.2.7-7 Annual Greenhouse Gas Emissions for Prevention of Significant Deterioration-regulated Stationary Sources[2]

Pollutant	Plant Site Projected Controlled Emissions (tpy)	Mine Site Projected Controlled Emissions (tpy)	Total Projected Controlled Emissions (tpy)	Major Source Threshold (tpy)
CO_2	75,532	1,740	77,232	-
N_2O	0.9	0.08	1.0	-
CH_4	0.5	0.02	0.5	-
Total CO_2e[1]	**75,836**	**1,764**	**77,600**	**100,000**

Notes:
[1] CO_2e is used to assess PSD applicability and considers only emissions from stationary sources. The PSD applicability is based on short tons of emissions and the Table 5.2.7-7 values are all in short tons per year.
[2] The values in Table 5.2.7-7 are not proposed permit limits.

Estimated annual maximum potential emissions of the NorthMet Project Proposed Action are based as it is currently proposed running at maximum capacity (potential) (see Table 5.2.7-7). Potential annual GHG emissions from the NorthMet Project Proposed Action, as opposed to maximum potential emissions, are shown below in Table 5.2.7-8. Potential emissions are the sum of direct and indirect GHG emissions. Potential GHG emissions from the NorthMet Project Proposed Action are calculated using The Climate Registry General Reporting Protocol (Climate Registry 2008) and the MPCA General Guidance for Carbon Footprint Development in Environmental Review (MPCA 2011e). Emissions are calculated using default emission factors for specific fuels from the two documents. The annualized carbon footprint is summarized in Table 5.2.7-8; the lifetime carbon footprint is provided in Table 5.2.7-9.

For this analysis, emission estimates for the direct and indirect source equipment used generally accepted emission factors and estimation methods from the World Resource Institute Greenhouse Gas Protocol Standard, the Intergovernmental Panel on Climate Change (IPCC), and the MPCA General Guidance on Carbon Footprint in Environmental Review (MPCA 2009d). Emissions estimates from secondary emissions sources generally utilized emissions factors that would represent estimates greater than actual values (high estimation) or best estimates of actual values based upon literature review (central tendency) (PolyMet 2015e).

Table 5.2.7-8 NorthMet Project Proposed Action Annual Greenhouse Gas Emissions

Pollutant	Potential Direct Emissions[1] (CO_2e – mtpy)[2]	Potential Indirect Emissions[3] (CO_2e – mtpy)	Potential Total Emissions (CO_2e – mtpy)
Mine Site Point Source	1,600	--	--
Mine Site Mobile Source	38,086	--	--
Plant Site Point Source	138,641	--	--
Plant Site Mobile Source	8,014	--	--
Terrestrial Carbon Loss	10,000		
Totals	**196,341**	**511,000**	**707,342**

Notes:
1 Maximum Potential Direct Emissions are all emissions from sources that are under direct control of the NorthMet Project Proposed Action and full maximum capacity.
2 CO_2e is in metric tons per year (mtpy). Emission estimates are expressed as metric tons per year in Table 5.2.7-8 because that unit is the international discussion of CO_2e emissions.
3 Indirect emissions: Emissions that are a consequence of the activities of the reporting entity, but that occur at sources owned or controlled by another entity. For example, emissions that occur at a power plant as a result of electricity being generated and subsequently used by the NorthMet Project Proposed Action.

Table 5.2.7-9 NorthMet Project Proposed Action Lifetime Greenhouse Gas Emissions

Pollutant	Potential Direct Emissions[1] (CO_2e – mt)[2]	Potential Indirect Emissions (CO_2e – mt)[6]	Potential Total Emissions (CO_2e – mt)
Mine Site Emissions[3]	793,734		
Plant Site Emissions[3]	2,933,181		
Construction Emissions[4]	94,186		
Reclamation Emission[5]	1,549,688		
Subtotals	**5,370,789**	**10,220,000**	**15,590,789**
Terrestrial Carbon Loss[7]	199,963	-	199,963
Totals	**5,570,752**	**10,220,000**	**15,790,752**

Notes:
1 Maximum Potential Direct Emissions are all emissions from sources that are under direct control of the NorthMet Project Proposed Action and full maximum capacity.
2 CO_2e is in metric tons (mt).
3 Based upon maximum annual emissions occurring for 20 years.
4 Includes Phase I (flotation concentration production only) and Phase II (Hydrometallurgical Plant) construction.
5 Based on 20-year closure period and 30-year long-term closure period for the WWTF and WWTP.
6 Indirect emissions: Emissions that are a consequence of the activities of the reporting entity, but that occur at sources owned or controlled by another entity. For example, emissions that occur at a power plant as a result of electricity being generated and subsequently used by the NorthMet Project Proposed Action.
7 Terrestrial carbon loss includes: wetland carbon loss, 20 years of emissions from stockpiled peat, and emission from peat used in reclamation.

5.2.7.1.4 Predictive Modeling Approach

Detailed air dispersion modeling was conducted to evaluate compliance with NAAQS and MAAQS, to support PSD increment analysis, and to identify other potential effects on Class I and Class II areas. Although the NorthMet Project Proposed Action is not considered a major source for PSD considerations, the modeling analysis was conducted pursuant to the PSD regulations. The methods used for modeling are summarized below.

NAAQS, MAAQS, and Class II Increment Modeling Approach

To assess the effects on air quality, air dispersion modeling techniques were utilized. The MPCA prefers the AERMOD modeling system, and USEPA has included AERMOD as an approved guideline model. Meteorological data (2006 to 2010) from the Hibbing station and concurrent International Falls mixing height data, suitable for input to AERMOD, were used to evaluate the NorthMet Project Proposed Action. The AERMINUTE meteorological processor was used to develop the meteorological dataset for AERMOD.

The air quality modeling addressed individual point sources, as well as all sources of fugitive particulate matter. The modeling was conducted to determine the extent of effects from criteria pollutant emissions on ambient air quality and to identify the significant impact area for each pollutant. Modeling was conducted for PM_{10}, $PM_{2.5}$, NO_2, and SO_2 and their respective applicable averaging times at both the Mine Site and Plant Site (PolyMet 2014m; PolyMet 2014n). Ozone emissions were not modeled or analyzed for NAAQS due to the regional nature of ozone formation involving complex interaction of multi-pollutants. It should be noted that ozone is not emitted directly from any mining or ore-processing source. Emissions of lead and CO were not modeled for the NorthMet Project Proposed Action following the MPCA-approved modeling protocols for the Plant Site and Mine Site. NorthMet Project Proposed Action emissions were initially modeled and compared to their respective Significant Impact Limit (SIL), as provided in Table 5.2.7-10 for each of the pollutants and averaging times. The SIL is the threshold for a given pollutant and averaging time, where no further modeling analysis is required. Modeled concentrations above the SIL do not define a significant effect in the context of the EIS; rather, where the modeled concentrations are above the SIL, more refined modeling is required in order to evaluate compliance with PSD increments and NAAQS. The farthest distance from the source where the concentration is above the SIL defines the circular region that would require further affect modeling.

All point and fugitive sources associated with the Mine Site and Plant Site were included in the source input files for PSD Class II increment modeling, with the exception of the Plant Site unpaved roads, which were in operation at the baseline date. Additionally, data on the following nearby major increment-consuming (or increment-expanding) sources, which were determined and provided by the MPCA, were also included as source input:

- Mesabi Nugget;
- Mesabi Mining Project;
- Cliffs Erie pellet yard; and
- Former LTVSMC processing plant.

It should be noted that the Northshore Mine was determined to be permitted before the PSD baseline date, and is not an increment-consuming source; therefore, it was not included in the increment modeling.

Model inputs for these sources were provided by the MPCA. For comparison to the NAAQS, a background concentration was added to the modeled concentration. PM_{10} background concentrations represent the 2008 to 2010, 3-year average concentrations for the high-second-high 24-hour concentration and maximum annual average concentration from the Virginia, Minnesota air quality monitoring site. $PM_{2.5}$ background concentrations represent the 2008-2010 average concentrations for the highest 2nd high (H2H) 24-hour and annual average concentrations from the same station. Hourly SO_2 and NO_2 background concentrations are from 2008-2010 MPCA update data for use in modeling assessments (MPCA 2012i) for sites outside Minneapolis.

Project design modifications were made to the NorthMet Project Proposed Action since modeling was undertaken. These modifications include the addition of a SAG Mill, relocation of the Coal Ash Landfill, installation of cement deep soil mixing, and construction of a water containment system on the eastern side of the Tailings Basin. The Co-lead Agencies considered information provided by PolyMet pertaining to these project modifications and determined that the existing air dispersion modeling was representative and additional modeling was not required for the EIS but may be required for permitting.

Class I Area-Related Modeling Approach

An air quality modeling analysis was conducted to estimate effects of the NorthMet Project Proposed Action on air quality in Class I areas. The Class I AQRV analyses addressed PSD Class I increments for SO_2, PM_{10}, NO_2, sulfur and nitrogen deposition, and visibility impairment. Regional haze is addressed in Section 6.2.3.8.8. The dispersion modeling analysis used standard USEPA long-range transport modeling methodologies and followed guidance as presented in: 1) USEPA's Guideline on Air Quality Models, the Interagency Workgroup on Air Quality Modeling Phase 2 report; 2) the Federal Land Managers' Air Quality Related Values Work Group (FLAG) Phase I report (revised November 2010); and 3) the "FLM Recommendations on Class I Area Analyses." The analyses also incorporated suggestions and guidance received from the USFS and the National Park Service. The California Puff (CALPUFF) air quality modeling system (version 5.8, June 23, 2007 release) was used for all Class I area analyses.

Input options and data utilized in the models generally corresponded to default or USEPA-recommended values along with representative, NorthMet Project Proposed Action-specific source input parameters. The CALPUFF modeling analysis used refined meteorological fields from the CALMET subprogram of CALPUFF, developed from the 5th Generation NCAR/Penn State Mesoscale Model prognostic meteorological data for the available years 2002, 2003, and 2004. These were refined using concurrent surface, upper air, and precipitation data as outlined in the Final SDD. CALMET settings were based on the USEPA Office of Air Quality Planning and Standards memorandum "Clarification on EPA-FLM Recommended Settings for CALMET" (August 31, 2009) (USEPA 2009a). Hourly surface data from approximately 88 stations and precipitation data from 99 stations were used along with upper air data from four stations. No cloud data were used.

Pollutant emissions modeled in CALPUFF were SO_2, NO_x, PMC (coarse particulate matter), PMF (fine particulate matter), elemental carbon, secondary organic aerosols, and SO_4. Additionally, the pollutants SO_4, NO_3, and HNO_3 were modeled as products of the chemical transformation of SO_2 and NO_x. For the AQRV analysis, the MESOPUFF II scheme was used for the chemical mechanism to compute chemical transformation rates based on user-supplied background values for ozone and ammonia. Per MPCA guidance, the MESOPUFF II algorithm and secondary particulate formation were not used in the PM_{10} increment consumption evaluation. Finally, the CALPOST and POSTUTIL post-processing programs were used to generate values of pollutant concentration, deposition, and visibility.

For the increment consumption analysis, emissions were modeled as the worst case over the expected life of the NorthMet Project Proposed Action. For the AQRV analysis, four emissions scenarios, representing emissions at different stages of the NorthMet Project Proposed Action, were modeled. The scenarios differ only in mobile source emissions (which were not included in the increment analysis). The effects of all four scenarios on visibility within the Class I areas are presented in Section 5.2.7.2.1.

5.2.7.2 NorthMet Project Proposed Action

This section describes effects that may occur on local and regional air quality from implementing the NorthMet Project Proposed Action. Potential effects on visibility that could occur from increases in project emissions are also discussed. The results of the modeling are used to represent an upper bound for assessing potential effects from the NorthMet Project Proposed Action.

5.2.7.2.1 NAAQS and Prevention of Significant Deterioration Increment Impact Analysis

State and federal air quality rules prohibit emissions from a new facility that cause or contribute to an exceedance of MAAQS or NAAQS. To demonstrate NorthMet Project Proposed Action effects relative to NAAQS and PSD increments, an air dispersion modeling analysis for the NorthMet Project Proposed Action was conducted (PolyMet 2014m; PolyMet 2014n; PolyMet 2015e).

Initial Significant Impact Limit Analysis

The Mine Site and Plant Site are located 8 miles apart, but are connected by a private railway that was originally constructed to transport iron ore pellets from Cliffs Erie's process plant to their ore dock. A portion of this railway is proposed to be used for the transportation of ore from the Mine Site to the Plant Site. Although the site may be permitted as a single facility, the Mine Site and Plant Site emission sources are not adjacent to each other but rather separated by a substantial (8 miles) distance. Therefore, it is appropriate and informative to perform individual air dispersion modeling for two distinct sets of receptors, one set surrounding the Mine Site and the second surrounding the Plant Site. For the Mine Site receptor grid, both Mine Site and Plant Site emissions were modeled explicitly. However, for the Plant Site receptor grid, only the emissions from the Plant Site were included, since previous modeling of the Mine Site emissions showed that effects were below the SIL in the region encompassing the Plant Site receptor grid. SILs have been established by the USEPA such that concentrations below these levels are not anticipated to contribute to a change in the overall effect when combined with other nearby source effects. The MPCA approved the exclusion of the Mine Site emissions in assessing the effects at the Plant Site receptor grid locations, as they would not likely contribute to a change in the overall effects. The results are discussed below.

The Plant Site PM_{10} emissions were modeled with all sources operating at full capacity in a single modeling run. This conservatively predicts (overestimates) the effects, as not all sources would be capable of operating simultaneously at full capacity. PM_{10} and $PM_{2.5}$ are the primary pollutants emitted from the Plant Site. Emissions of SO_2 and NO_x would be relatively small because the process is conducted at relatively low temperatures and would not include any continuously operating fuel combustion sources. The Mine Site emission rates are based on a daily average mining rate of 32,000 tons of ore.

Table 5.2.7-10 shows modeled effects at the Mine Site and Plant Site receptors compared to the SIL. The maximum modeled effects are maximums from either the Mine Site or the Plant Site analyses, since each analysis includes all NorthMet Project emissions, as defined above. The USEPA has developed SILs as a way to screen out, from further PSD analysis, pollutants that are not expected to cause any significant contribution to existing air quality levels. The emissions included are at 100 percent capacity for each averaging period.

The overall effects within the Plant Site receptor grid predicted higher maximum concentrations than the effects within the Mine Site receptor grid for all pollutants modeled. As seen in the table, maximum PM_{10} and $PM_{2.5}$ concentrations in both regions (and for all averaging periods) were above their respective SILs, so further analysis in those regions, for those pollutants, was conducted. For NO_2 and SO_2, the effects in the Plant Site receptor grid exceed their SILs for all averaging periods and additional analysis was conducted for this receptor region. The NO_2 and SO_2 effects in the Mine Site receptor grid are all below each respective SIL, and, thus, no additional analysis was conducted.

Table 5.2.7-10 Highest NorthMet Project Proposed Action Effects and Prevention of Significant Deterioration Class II Significant Impact Limits

Pollutant	Averaging Time	PSD Class II Significant Impact Limits (μg/m^3)	Plant Site Area Modeled Effects (μg/m^3) [1]	Mine Site Area Modeled Effects (μg/m^3)[1]
SO_2	1-hour	7.83	***103***	0.7
	3-hour	25	***85***	0.5
	24-hour	5	***35***	0.1
	Annual	2	***6***	0.01
PM_{10}	24-hour	5	***44***	***30***
	Annual	1	***12***	***6.3***
$PM_{2.5}$	24-hour	1.2	***17***	***10***
	Annual	0.3	***6***	***2.2***
NO_2	1-hour	7.52	***88***	5.3
	Annual	1	***3***	0.1

Note:
[1] Bold and italicized values exceed SIL.

Prevention of Significant Deterioration Class II Increment Analysis

Based upon the results of the SIL analysis, PSD Class II increment analyses were completed for PM_{10} for both the Mine Site and Plant Site receptor grid locations. In addition, a PSD Class II increment analysis was conducted for NO_2 and SO_2 only at the Plant Site receptors. Even though maximum $PM_{2.5}$ concentrations exceed the SILs, the minor source baseline date for increment analysis in St. Louis County has not been set. Therefore, no increment analysis can be conducted for this pollutant. However, modeling of $PM_{2.5}$ was conducted for comparison with the $PM_{2.5}$ NAAQS; the results are presented later in this section. The modeling included all NorthMet Project Proposed Action increment-consuming sources at maximum emission rates plus all nearby increment-consuming (and expanding) emissions sources, including the Cliffs Erie pellet yard, the former LTVSMC processing plant, and Mesabi Nugget. The results of the increment analyses are shown in Table 5.2.7-11, along with a comparison to the allowable Class II PSD increments.

Table 5.2.7-11 Results of Class II Prevention of Significant Deterioration Increment Analysis

Pollutant	Averaging Time	Plant Site Receptor Grid Modeled Effects (μg/m³)[1,3]	Mine Site Receptor Grid Modeled Effects (μg/m³)[1,3]	PSD Increment Limits (μg/m³)
SO_2	3-hour	85	NA	512
	24-hour	35	NA	91
	Annual	6	NA	20
PM_{10}[(2)]	24-hour	27	27, 29	30
	Annual	-0.1	6	17
NO_2	Annual	3.2	NA	25

Notes:
1 SO_2 concentrations were not modeled due to negligible incremental effect.
2 Modeled PM_{10} concentrations are based on operating scenarios at year 8 and year 13.
3 Plant Site modeled emissions include expansion credit and are evaluated at Plant Site boundary. Mine Site modeled emissions include Plant Site, Mesabi Nugget, Cliffs Erie pellet yard, and former LTVSMC processing plant and existing LTVSMC Tailings Basin.

The table displays the maximum predicted concentrations for each pollutant of concern and each averaging period for both the Mine Site and Plant Site receptor grid locations. Since the receptor grid locations for the Mine Site and Plant Site represent separate distinct regions, the maximum modeled effect for each modeling region is compared separately with the PSD Class II increment limit to assess potential significant effects. Overall, all modeled effects are below their respective PSD Class II limits; however, the maximum 24-hour PM_{10} effects in the Mine Site and Plant Site modeling regions approach the Class II increment (27 μg/m³ versus 30 μg/m³).

Mine Site Receptors Analysis

The PM_{10} modeling was conducted for two operating scenarios corresponding to the temporary stockpile phase and the in-pit disposal/stockpile reclamation phase that would occur over the 20-year life of the mine. The worst case years for temporary stockpile phase waste rock (year 8) and in-pit disposal (year 13) were chosen to represent the worst case for the entire mine life. Due to the low modeled concentrations and constant emission rates for NO_x and SO_2, only one scenario (year 8) was modeled for these two criteria pollutants. The modeling results for the Mine Site receptors, including sources from the haul road, material handling, mine pits, and diesel locomotives indicate that the highest modeled 24-hour H2H PM_{10} concentration was 27 μg/m³ for the year 8 operating scenario and 29 μg/m³ for the year 13 operating scenario (shown on Table 5.2.7.11). The H2H corresponds to not exceeding a standard more than once per year, as defined by the applicable standard. NO_2 and SO_2 effects from the NorthMet Project Proposed Action at the Mine Site were below the SILs, so no additional modeling including nearby sources was performed.

Plant Site Receptors Analysis

The Plant Site PM_{10} emissions were modeled with all sources operating at full capacity in a single modeling run (independent of operating year). This conservatively predicts (overestimates) the effects, as not all sources would be capable of operating simultaneously at full capacity. The operation at the Plant Site, including fugitive sources, building vents, limestone material handling, and vehicular traffic on unpaved roads results in a maximum increment concentration for PM_{10} of 27 μg/m³ on the Plant Site boundary receptor grid, based on the 24-hour H2H modeling. Modeled effects for SO_2 and NO_x at the Plant Site receptors are also below the PSD Class II increments thresholds.

The data in Table 5.2.7-11 summarize the PSD increment modeling results and demonstrate that the NorthMet Project Proposed Action, in conjunction with all other neighboring PSD sources, would satisfy all state and federal increment requirements. The maximum concentrations for the Mine Site receptor grid and the Plant Site receptor grid are presented separately. Since the two receptor grids represent two separate AOCs, the maximum concentrations are not additive.

NAAQS and MAAQS Impact Analysis

The NAAQS modeling predicted the maximum effect of development at the Mine Site and Plant Site combined with activities at other regional sources. The highest total effects modeled, plus background concentrations, are compared to applicable MAAQS and NAAQS. Maximum emission rates were modeled for all NorthMet Project Proposed Action sources and key criteria pollutants (i.e., NO_x, SO_2, PM_{10}, and $PM_{2.5}$).

Table 5.2.7-12 summarizes the results of the NAAQS model analysis for the Mine Site and Plant Site separately and with both sites modeled together. The modeled concentration from either the Mine Site receptors or the Plant Site receptors was added to the ambient background to assess total effect, since, in each area, modeling analysis included the entire NorthMet Project area and nearby sources. The highest 6^{th} high (H6H) PM_{10} concentration for the 5-year modeling period was used for comparison to the NAAQS PM_{10} 24-hour standard. The highest 8^{th} high (H8H) 1-hour NO_2 and 24-hour $PM_{2.5}$ concentration for the 5-year modeling period was used for comparison to the NAAQS NO_2 1-hour standard and the $PM_{2.5}$ 24-hour standard, respectively. The H8H concentration represents the 98^{th}-percentile daily maximum concentrations modeled over a 5-year period, as defined by each standard. The highest 4^{th} high (H4H) 1-hour SO_2 concentration for the 5-year modeling period was used for comparison to the 1-hour SO_2 NAAQS. The H4H concentration represents the 99^{th}-percentile daily maximum 1-hour concentrations modeled over a 5-year period, as defined by the standard. The H2H 3-hour and 24-hour SO_2 concentrations were used for comparison with the 3-hour and 24-hour SO_2 NAAQS. Maximum annual average concentrations for NO_2, SO_2, PM_{10}, and $PM_{2.5}$ were compared against their respective annual average NAAQS.

Mine Site

The analysis for the Mine Site included potential emissions from the nearby sources included in the NAAQS analysis, specifically Mesabi Nugget, Cliffs Erie Pellet Yard, Northshore Mine, and the Plant Site. The sources to the west of the Mine Site (Mesabi Nugget, Cliffs Erie Pellet Yard, and the Plant Site) were modeled collectively in a separate modeling run to determine their maximum modeled effect on the Mine Site receptor grid (PolyMet 2015b).

The PM_{10} NAAQS modeling results conservatively added the maximum modeled emissions from the Mine Site and Plant Site and the maximum modeled effect from the other nearby sources to background concentrations for comparison to the NAAQS. Cumulative modeling and further analyses for NO_2 and SO_2 were not performed because the NO_2 and SO_2 concentrations at the Mine Site were shown to be well below the SILs.

The maximum effects from the Mine Site analysis are slightly higher for PM_{10} and slightly lower for $PM_{2.5}$ than the effects from the Plant Site summarized below in Table 5.2.7-12. The maximum predicted annual $PM_{2.5}$ concentration (Mine Site contribution plus background) was 10 µg/m^3 or approximately 83 percent of the corresponding NAAQS. The maximum predicted 24-hour $PM_{2.5}$ concentration was 32 µg/m^3 or approximately 91 percent of the short-term $PM_{2.5}$ standard. All other predicted concentrations are at or below 60 percent of the allowable levels, which demonstrates compliance with MAAQS and NAAQS.

Table 5.2.7-12 Results of Class II NAAQS Modeling

Pollutant	Averaging Time	Maximum Modeled – Plant Site (µg/m^3)[1,2]	Maximum Modeled – Mine Site (µg/m^3)[1]	Total (µg/m^3)[2,3]	NAAQS and MAAQS (µg/m^3)
SO_2	1-hour	***109***	NA	109	1,300[(4)]
	1-hour	***109***	NA	*109*	196[(5)]
	3-hour	***97***	NA	97	915
	24-hour	***40***	NA	40	365
	Annual	*7*	NA	7	60
PM_{10}	24-hour	80	***88***	88	150
	Annual	***26***	29	29	50[(6)]
$PM_{2.5}$	24-hour	***34***	32	34	35
	Annual	***11***[(7)]	10	11	12
NO_2	1-hour	***177***	NA	*177*	188[(8)]
NO_2	Annual	***21***	NA	21	100

Notes:
1 Maximum concentrations include background.
2 Concentrations exceeding the standard are bolded and italicized.
3 Total concentration displayed is the maximum modeled concentration, from either the Plant Site receptors or Mine Site receptors, added to the background concentration.
4 MAAQS for 1-hour SO_2.
5 NAAQS for 1-hour SO_2.
6 The annual NAAQS for PM_{10} was rescinded on October 17, 2006.
7 The maximum modeled Plant Site concentration was calculated as the maximum design value as defined by the USEPA guidance (USEPA 2013).
8 NAAQS for 1-hour NO_2.

Plant Site

The NAAQS modeling on the Plant Site ambient boundary included all Plant Site sources plus emissions from the Tailings Basin and unpaved roads. Maximum predicted concentrations were added to background values to calculate maximum ambient air concentrations. All predicted concentrations are below allowable levels, and the results demonstrate compliance with all MAAQS and NAAQS.

5.2.7.2.2 Prevention of Significant Deterioration Class I Modeling Analysis

Modeling analysis was conducted to assess the effects from the emissions of the NorthMet Project Proposed Action in four USEPA-designated Class I areas within the NorthMet Project area. Modeled effects were assessed against the PSD Class I Increment and AQRVs.

Prevention of Significant Deterioration Class I Increment Modeling Results

Maximum pollutant concentrations within the BWCAW, Voyageurs National Park, Isle Royale National Park, and Rainbow Lakes Wilderness Class I areas were estimated for each of three years and are provided in Table 5.2.7-13. As shown in the table, all of the concentrations, except for the maximum 24-hour PM_{10} concentration at BWCAW, are below their respective Class I SIL threshold. This indicates that the NorthMet Project Proposed Action contribution to increment consumption would be considered de minimis relative to other sources. The exceedance of the PM_{10} 24-hour Class I SIL at BWCAW triggers an additional cumulative modeling analysis, including all nearby increment consuming and expanding PM_{10} sources. The cumulative analysis for this pollutant and averaging period are discussed in Section 6.2.7.

Table 5.2.7-13 Summary of Prevention of Significant Deterioration Class I Increment Analysis

Pollutant	Averaging Period	Year Evaluated 2002	2003	2004	Max (μg/m³)	Class I Inc (μg/m³)	Class I SIL (μg/m³)
Boundary Waters Canoe Area Wilderness							
SO_2	3-Hour	0.106	0.082	0.088	0.106	25	1
	24-Hour	0.020	0.025	0.021	0.025	5	0.2
	Annual	0.001	0.001	0.001	0.001	2	0.1
NO_2	Annual	0.037	0.036	0.029	0.037	2.5	0.1
PM_{10}	24-Hour	0.331	0.263	0.278	**0.331**	8	0.3
	Annual	0.016	0.020	0.015	0.020	4	0.2
Voyageurs National Park							
SO_2	3-Hour	0.014	0.010	0.020	0.020	25	1
	24-Hour	0.004	0.005	0.004	0.005	5	0.2
	Annual	0.000	0.000	0.000	0.000	2	0.1
NO_2	Annual	0.004	0.005	0.005	0.005	2.5	0.1
PM_{10}	24-Hour	0.072	0.131	0.081	0.131	8	0.3
	Annual	0.004	0.004	0.004	0.004	4	0.2
Isle Royale National Park							
SO_2	3-Hour	0.001	0.001	0.001	0.001	25	1
	24-Hour	0.001	0.000	0.000	0.000	5	0.2
	Annual	0.000	0.000	0.000	0.000	2	0.1
NO_2	Annual	0.002	0.001	0.001	0.002	2.5	0.1
PM_{10}	24-Hour	0.031	0.018	0.019	0.031	8	0.3
	Annual	0.002	0.001	0.001	0.002	4	0.2
Rainbow Lakes Wilderness							
SO_2	3-Hour	0.003	0.003	0.003	0.003	25	1
	24-Hour	0.001	0.001	0.001	0.001	5	0.2
	Annual	0.000	0.000	0.000	0.000	2	0.1
NO_2	Annual	0.002	0.002	0.002	0.002	2.5	0.1
PM_{10}	24-Hour	0.030	0.033	0.021	0.033	8	0.3
	Annual	0.002	0.001	0.002	0.002	4	0.2

In 2010, the USEPA promulgated a Class I increment for $PM_{2.5}$. However, the minor source baseline date for $PM_{2.5}$ has not been triggered for the NorthMet Project area. Therefore, a comparison of $PM_{2.5}$ concentration with the $PM_{2.5}$ Class I increment and SILs is not required and was not performed.

Class I Areas – Air Quality Related Values Impact Analysis

An air quality modeling analysis was conducted to estimate the effect of the NorthMet Project Proposed Action on air quality in Class I areas. The analysis addressed visibility impacts on the BWCAW, Rainbow Lakes Wilderness, Voyageurs National Park, and Isle Royale National Park.

The Class I AQRV analyses also included sulfur and nitrogen deposition and SO_2 effects on soils, water, and vegetation. The results are discussed below.

Class I Visibility Analysis

A visibility impact analysis was carried out for BWCAW, Voyageurs National Park, and Isle Royale National Park. The Rainbow Lakes Wilderness does not have an AQRV for visibility. The recommended methodology for assessing visibility impacts, according to FLAG guidance, involves the use of CALPOST to process the data on concentrations of pollutants from the CALPUFF modeling of 24-hour emissions. In CALPOST, a daily value of light extinction is defined by the concentrations of each pollutant that can affect visibility, taking into account the efficiency of each particle type in scattering light and the relative humidity, which influences the size of sulfates and nitrates. The FLM has established threshold changes in light extinction (Δb_{ext}) as a percentage of natural background that represent potential adverse effects on visibility. These thresholds are 5 percent (a potentially detectable change) and 10 percent (a level that may represent an unacceptable degradation). In the revised FLAG guidance of 2010, the FLM also lists a threshold of less than 5 percent as "presumptive no adverse impact" when compared to the highest 98^{th} percentile daily predicted impact.

The FLAG 2010 guidance indicates that CALPOST Method 8 is now the preferred visibility impact calculation method for Class I AQRV analysis. Method 8 uses Class I area-specific monthly average relative humidity to calculate light extinction. Method 8 also compares visibility impacts with the 20 percent best pristine days. The previous preferred methodology, Method 2, used the CALPUFF-generated hourly relative humidity data to calculate light extinction. Method 2 compares visibility impacts on annual average pristine conditions. Since previous NorthMet Project Proposed Action modeling used the FLAG 2000 guidance, NorthMet Project Proposed Action visibility impact results calculated using both Method 8 and Method 2 are presented below for comparison.

Table 5.2.7-14 presents results of the initial CALPUFF visibility analysis following the previous FLAG methodology, Method 2, for each NorthMet Project Proposed Action scenario. The maximum change in light extinction for Voyageurs National Park and Isle Royale National Park is below the 5 percent threshold with changes predicted at 4.50 percent and 1.23 percent, respectively. The maximum change in light extinction at the BWCAW for the three years modeled was predicted to be 11.08 percent. The data in Table 5.2.7-14 indicate that calculated visibility impacts greater than 5 or 10 percent could occur at some point within the BWCAW on a small number of days each year.

Table 5.2.7-14 Class I Area Visibility Results for NorthMet Project Proposed Action (Method 2 Analysis)

Class I Area and Meteorological Data Year	Days with ≥5% Visibility Impact	Days with ≥10% Visibility Impact	Maximum Δb_{ext} (%)
Scenario 1			
BWCAW 2002/2003/2004	8/1/0	1/0/0	11.08/7.88/4.66
Voyageurs National Park 2002/2003/2004	0/0/0	0/0/0	2.28/4.50/2.76
Isle Royale National Park 2002/2003/2004	0/0/0	0/0/0	1.12/1.13/1.23
Scenario 2			
BWCAW 2002/2003/2004	7/1/0	1/0/0	10.88/7.75/4.56
Voyageurs National Park 2002/2003/2004	0/0/0	0/0/0	2.23/4.41/2.72
Isle Royale National Park 2002/2003/2004	0/0/0	0/0/0	1.10/1.11/1.20
Scenario 3			
BWCAW 2002/2003/2004	7/1/0	1/0/0	10.99/7.82/4.61
Voyageurs National Park 2002/2003/2004	0/0/0	0/0/0	2.26/4.46/2.74
Isle Royale National Park 2002/2003/2004	0/0/0	0/0/0	1.11/1.12/1.22
Scenario 4			
BWCAW 2002/2003/2004	3/1/0	0/0/0	9.44/6.80/3.97
Voyageurs National Park 2002/2003/2004	0/0/0	0/0/0	1.84/3.80/2.39
Isle Royale National Park 2002/2003/2004	0/0/0	0/0/0	0.93/0.93/0.99

Table 5.2.7-15 presents results of the initial CALPUFF visibility analysis following the current FLAG methodology, Method 8, for each NorthMet Project Proposed Action scenario. Method 8 requires the eighth-highest visibility impact to be compared with the 5 percent and 10 percent thresholds. The eighth-highest changes in light extinction for the BWCAW, Voyageurs National Park, and Isle Royale National Park are below the 5 percent threshold with changes predicted at 4.86 percent, 1.11 percent, and 0.44 percent, respectively, and demonstrate no expected adverse visibility impacts compared to pristine conditions. These results of the NorthMet Project Proposed Action reflect emission reduction measures to reduce the potential for visibility impacts in the BWCAW, which include: upgrades to the insulation in the existing Crusher and Concentrator buildings, utilization of low-NO_x space heating equipment, a plan to phase in vehicles that meet Tier 4 emission standards, use of efficient gen-set locomotives, the reduction of dust collector exhaust for heating demand reductions, use of appropriate pollution control equipment, and use of lower emitting fuels where feasible.

Table 5.2.7-15 Class I Area Visibility Results for NorthMet Project Proposed Action (Method 8 Analysis)

Class I Area and Meteorological Data Year	98% Days with ≥5% Visibility Impact	98% Days with ≥10% Visibility Impact	8th Highest Δb_{ext} (%)
	Scenario 1		
BWCAW 2002/2003/2004	0/0/0	0/0/0	4.86/3.92/3.85
Voyageurs National Park 2002/2003/2004	0/0/0	0/0/0	0.89/1.11/0.97
Isle Royale National Park 2002/2003/2004	0/0/0	0/0/0	0.44/0.21/0.23
	Scenario 2		
BWCAW 2002/2003/2004	0/0/0	0/0/0	4.74/3.83/3.80
Voyageurs National Park 2002/2003/2004	0/0/0	0/0/0	0.85/1.09/0.96
Isle Royale National Park 2002/2003/2004	0/0/0	0/0/0	0.43/0.19/0.22
	Scenario 3		
BWCAW 2002/2003/2004	0/0/0	0/0/0	4.80/3.87/3.83
Voyageurs National Park 2002/2003/2004	0/0/0	0/0/0	0.86/1.09/0.97
Isle Royale National Park 2002/2003/2004	0/0/0	0/0/0	0.43/0.20/0.22
	Scenario 4		
BWCAW 2002/2003/2004	0/0/0	0/0/0	4.21/3.45/3.42
Voyageurs National Park 2002/2003/2004	0/0/0	0/0/0	0.74/0.97/0.82
Isle Royale National Park 2002/2003/2004	0/0/0	0/0/0	0.36/0.17/0.19

Effects on Soils, Waters, and Vegetation

<u>Deposition of Nitrogen and Sulfur</u>

Potential effects on soils, waters, and vegetation in Class I areas due to deposition of sulfur and nitrogen were evaluated based upon model-predicted annual deposition for the NorthMet Project Proposed Action emissions from the Mine Site and Plant Site. Impacts were evaluated according to the USFS publication "Screening Procedures to Evaluate Effects of Air Pollution on Eastern Wildernesses Cited as Class I Air Quality Areas." Criteria for assessment of deposition impacts are different for USFS areas (BWCAW and Rainbow Lakes Wilderness) and National Park System areas (Voyageurs National Park and Isle Royale National Park). The National Park Service has established a Deposition Analysis Threshold (DAT) of 0.01 kilograms per hectare per year (kg/ha/yr) for both sulfur and nitrogen deposition for Class I areas in the eastern United States. The DAT is a level below which adverse effects from a new or modified source are not anticipated and are considered insignificant. The USFS has established Green Line Values for assessing impacts of deposition at BWCAW and Rainbow Lakes Wilderness, which account for soil conditions and water chemistry in development of safe levels. The Green Line values represent the total pollutant loading below which there are no adverse effects (PolyMet 2015e). As such, for BWCAW and Rainbow Lakes Wilderness, background deposition levels are added to the maximum NorthMet Project Proposed Action impacts from all scenarios to assess against Green Line Values. The current background nitrogen deposition for Rainbow Lakes Wilderness (5.88 kg/ha/yr) is at the Green Line Value range for nitrogen (5 to 8 kg/ha/yr). All other background deposition values for BWCAW and Rainbow Lakes Wilderness are below their respective Green Line Values (see Table 5.2.7-16).

The CALPUFF results for each of the Class I areas were processed with CALPOST to calculate total annual deposition of sulfur and nitrogen at each receptor as a result of the NorthMet Project Proposed Action maximum annual average emissions. Total sulfur deposition is calculated from the wet (rain, snow, fog) and dry (particle, gas) deposition of SO_2 and sulfate; total nitrogen is represented by the sum of nitrogen from wet and dry fluxes of nitric acid, nitrate, ammonium sulfate, and ammonium nitrate, and the dry flux of NO_x.

Terrestrial effects of nitrogen and sulfur deposition for the Class I areas are shown in Table 5.2.7-16. As stated earlier, Green Line Values (Wilderness Areas) are compared to the maximum modeled NorthMet Project Proposed Action deposition plus background; the DAT values (National Parks) are compared to the modeled NorthMet Project Proposed Action effects only. As seen from the table, the maximum predicted total sulfur and nitrogen deposition are all below Green Line Value ranges for BWCAW. The maximum predicted total sulfur deposition is also below the Green Line Value for Rainbow Lakes Wilderness. However, the maximum predicted total nitrogen deposition at Rainbow Lakes Wilderness (5.9 kg/ha/yr) is within the Green Line Value range of 5 to 8 kg/ha/yr. The nitrogen deposition contribution from the NorthMet Project Proposed Action emissions is 0.02 percent of the total nitrogen deposition impact (0.001 kg/ha/yr). Table 5.2.7-16 also compares the ambient annual and 3-hour SO_2 concentrations due to the NorthMet Project Proposed Action to the Green Line Values. Modeled concentrations of SO_2 in both wilderness areas are below the Green Line Values for SO_2 concentration.

Finally, Table 5.2.7-16 compares terrestrial impacts of sulfur and nitrogen deposition in the Class I areas to the DAT values. The maximum predicted total sulfur and nitrogen values are below the DAT value of 0.01 kg/ha/year.

Table 5.2.7-16 Terrestrial Effects of Annual Deposition of Sulfur and Nitrogen from the NorthMet Project Proposed Action in Class I Areas

Class I Area	Proposed Action Effects	Background Level	Total (Proposed Action + Background)	Terrestrial Green Line Value	Deposition Analysis Threshold
BWCAW					
Annual avg. SO_2 ($\mu g/m^3$)	0.001	1.2	1.2	5 $\mu g/m^3$	NA
3-hour max. SO_2 ($\mu g/m^3$)	0.105	10.8	10.9	100 $\mu g/m^3$	NA
Sulfur (kg/ha/yr)	0.000	2.85	2.9	5-7 kg/ha/yr	NA
Nitrogen (kg/ha/yr)	0.009	4.75	4.8	5-8 kg/ha/yr	NA
Rainbow Lakes Wilderness					
Ann. avg. SO_2 ($\mu g/m^3$)	0.000	1.6	1.6	5 $\mu g/m^3$	NA
3-hour max. SO_2 ($\mu g/m^3$)	0.003	14.4	14.4	100 $\mu g/m^3$	NA
Sulfur (kg/ha/yr)	0.000	2.98	3.0	5-7 kg/ha/yr	NA
Nitrogen (kg/ha/yr)	0.000	5.88	5.9	5-8 kg/ha/yr	NA
Isle Royale National Park					
Sulfur	0.000	NA	NA	NA	0.01 kg/ha/yr
Nitrogen	0.000	NA	NA	NA	0.01 kg/ha/yr
Voyageurs National Park					
Sulfur	0.000	NA	NA	NA	0.01 kg/ha/yr
Nitrogen	0.001	NA	NA	NA	0.01 kg/ha/yr

Table 5.2.7-17 summarizes the aquatic effects from sulfur and nitrogen deposition for the Class I areas. Green Line Values for aquatic effects at the wilderness areas are based upon total sulfur deposition, as well as total sulfur deposition plus 20 percent of the total nitrogen deposition (sulfur + 20 percent nitrogen). Maximum predicted values for these two measures for all scenarios were below the Green Line Value ranges for BWCAW. The maximum predicted total sulfur deposition and total sulfur plus 20 percent nitrogen deposition for Rainbow Lakes Wilderness are just below the Green Line Value, and nearly all of the effects are associated with the current background level. Aquatic effects at the National Parks are also compared to the DAT values. The modeled maximum annual nitrogen and sulfur deposition effects due to the NorthMet Project Proposed Action have levels below the respective National Park Service DAT levels for both Voyageurs National Park and Isle Royale National Park. The highest effects are predicted in Voyageurs National Park, with values approximately one-tenth of the incremental DAT level for sulfur and one-fifth of the incremental nitrogen DAT level.

Table 5.2.7-17 Aquatic Effects of Deposition of Sulfur and Nitrogen from the NorthMet Project Proposed Action in Class I National Park Areas

Class I Area	Proposed Action Effects (kg/ha/yr)	Background Level (kg/ha/yr)	Total (Proposed Action + Background) (kg/ha/yr)	Aquatic Green Line Value (kg/ha/yr)	Deposition Analysis Threshold (kg/ha/yr)
BWCAW					
Total Sulfur	0.000	2.85	2.85	7.5-8.0	NA
Total S + 20% of Total N	0.002	3.80	3.80	9-10	NA
Rainbow Lakes Wilderness					
Total Sulfur	0.000	2.98	2.98	3.5-4.5	NA
Total S + 20% of Total N	0.000	4.16	4.16	4.5-5.5	NA
Isle Royale National Park					
Total Sulfur	0.000	NA	NA	NA	0.01
Total N	0.000	NA	NA	NA	0.01
Voyageurs National Park,					
Total Sulfur	0.000	NA	NA	NA	0.01
Total N	0.001	NA	NA	NA	0.01

SO_2 Effects on Flora and Fauna

Potential SO_2 effects on flora and fauna in Class I areas were evaluated using the model-predicted concentrations from NorthMet Project Proposed Action emissions. The USFS has set screening criteria for potential air pollution effects on vegetation for SO_2 as a total annual average ambient concentration of 5 $\mu g/m^3$. As stated earlier, Green Line screening values "were set at levels at which it was reasonably certain that no significant change would be observed in ecosystems that contain large numbers of sensitive components."

Though the USFS screening levels were established specifically for Class I areas administered by the USFS (i.e., BWCAW and Rainbow Lakes Wilderness) the same criteria were applied to Voyageurs National Park and Isle Royale National Park, which are administered by the National Park Service but do not have published standards similar to the USFS. Table 5.2.7-18 compares maximum CALPUFF NorthMet Project Proposed Action impacts from all scenarios and existing background concentrations to the Green Line screening levels for each Class I area. The summation of the NorthMet Project Proposed Action and background contributions is well below the Green Line levels so no threat to sensitive vegetation in Class I areas is expected from direct SO_2 emissions produced by the NorthMet Project Proposed Action.

There are no established screening criteria for NO_2 and PM_{10} for effects on flora and fauna. As shown in Class I increment modeling results (PolyMet 2015e), modeled maximum annual concentrations of NO_2 and PM_{10} from the NorthMet Project Proposed Action are below the secondary NAAQS standards (protecting vegetation), so it is not expected that there would be impacts on the Class I areas from these pollutants.

Table 5.2.7-18 Comparison of Projected Class I SO_2 Concentrations to Green Line Screening Criteria for Vegetation Effects

Class I Area	Background Air Concentration (μg/m^3)	Max. Modeled Proposed Action Contribution (μg/m^3)	Total Proposed Action Air Concentration (μg/m^3)	Green Line Concentration (μg/m^3)
	Annual	Annual	Annual	Annual
BWCAW	1.2	0.001	1.2	5
Isle Royale National Park	2.0	0.000	2.0	5
Rainbow Lakes Wilderness	1.6	0.000	1.6	5
Voyageurs National Park	0.7	0.000	0.7	5

5.2.7.2.3 Potential Estimated Human Health Risk from the Plant and Mine Sites Air Emissions

This section includes the assessment of potential human health effects from the NorthMet Project Proposed Action. Separate AERAs were conducted for the Mine Site and Plant Site due to the large distances (approximately 6 miles) between the Mine Site and Plant Site sources. It should be noted that AERAs from the Mine Site and Plant Site are also considered cumulatively in Section 6.7.5.

Estimations of additional lifetime cancer risk, potential for non-cancer effects from chronic exposures, and potential non-cancer health effects from short-term exposures were conducted for hypothetical residents, farmers, off-site workers, and/or for short-term visitors. The hypothetical individuals were assumed to breathe outdoor air for the entire exposure duration. Inhalation exposures were assessed for an approximate lifetime (approximately 70 years) for the resident and farmer; a maximum hour for the short-term visitor; and 8-hour days, 250 days per year for 25 years for the off-site worker (USEPA 1993). Hypothetical short-term and off-site worker ingestion exposures were not assessed. The farmer ingestion exposure was assessed for a 40-year duration and the resident ingestion exposure was assessed for a 30-year duration. When both ingestion and inhalation risks were assessed, these were summed for a total multi-pathway risk. This screening procedure is conservative and is intended as a regulatory tool to define whether more detailed analysis is warranted rather than estimating risk levels for actual individuals.

<u>Mine Site Air Emissions Risk Analysis</u>

An AERA was conducted for the Mine Site in January 2008 for the DEIS. A Supplemental AERA was conducted as part of the project changes defined with the current NorthMet Project Proposed Action (Barr 2013i). The screening human health risk analysis followed the MPCA-accepted November 2011 Work Plan (PolyMet 2015e). Sulfuric acid aerosol emissions were screened out of the quantitative assessment for potential acute inhalation effects by scaling the Plant Site 2005 modeled acute inhalation hazard quotients to the current potential sulfuric acid emissions. As identified in the Mine Site AERA, the quantitative evaluation identified 11 chemicals for evaluation (CFEs), which are summarized in Table 5.2.7-19. The identified CFEs include six risk-driver chemicals from the 2008 AERA (dibenzo(a,h)anthracene, indeno(1,2,3-cd)pyrene, manganese compounds, nickel compounds, NO_2, and dioxins/furans). The remaining five compounds are from the 2008 AERA that now have toxicity values (acetaldehyde, arsenic compounds, cobalt compounds, crystalline silica, and diesel particulate).

Table 5.2.7-19 Chemicals for Evaluation of the Incremental Human Health Risk Assessment for the Mine Site

Chemical	Total Mine Site Maximum Hourly Emission Rate (Year 8) (g/sec)	Total Mine Site Annual Emission Rate (Year 8) (g/sec)	Total Mine Site Maximum Hourly Emission Rate (Year 13) (g/sec)	Total Mine Site Annual Emission Rate (Year 13) (g/sec)
Acetaldehyde	2.44E-05	1.40E-06	2.44E-05	1.40E-06
Arsenic	0.0013	0.0004	0.0014	0.0005
Cobalt	0.0036	0.0025	0.0040	0.0027
Crystalline Silica	0.5820	0.3952	0.6467	0.4339
Dibenzo(a,h)anthracene	2.92E-06	2.57E-06	2.92E-06	2.57E-06
Diesel Particulate Matter	0.2276	0.2237	0.2276	0.2237
Indeno(1,2,3-cd)pyrene	3.41E-06	2.99E-06	3.41E-06	2.99E-06
Manganese	0.0638	0.0450	0.0702	0.0488
Nickel	0.0245	0.0152	0.0266	0.0166
Oxides of Nitrogen	12,5173	9.2554	12,5173	9.2254
Dioxins/Furans (as 2,3,7,8-TCDD TEQ)	4.12E-10	3.73E-10	4.12E-10	3.73E-10
Number of CFEs	11			

Note:
g/sec = gram(s) per second

Estimations of additional lifetime risk and potential non-cancer effects from chronic (long-term) exposures were conducted for both inhalation and ingestion exposures for the hypothetical resident and farmer. The resident is assumed to inhale outdoor air and ingest soil and produce grown at a site of maximum air concentration. The farmer scenario assumed inhalation of outdoor air and ingestion of soil and produce, and also includes ingestion of meat and dairy products grown at the location of maximum air concentration.

Air dispersion modeling was conducted for the Mine Site to estimate maximal annual and hourly air concentrations for the CFE using the AERMOD model with 5 years of hourly meteorological data from the Hibbing weather station. The assessment was conducted for the years 8 and 13, which were determined to be the years of highest air emissions. Direct (inhalation) and indirect (ingestion) risk estimates were made for inhalation and bioaccumulative toxic pollutant ingestion, respectively, using the MPCA Risk Analysis Screening Spreadsheet, which estimates potential incremental cancer and noncarcinogenic human health effects for long-term exposures.

Acute inhalation risks were estimated for the ambient air at and beyond the Mine Site property boundary (see Large Figure 4 in PolyMet 2015e). Because of the historical and present mining and industrial land use around the Mine Site, the reasonable future land use for residential and farming was considered in assessing chronic risks for areas (i.e., receptors) outside of the Mineral Mining/Industrial District air boundary (see Large Figure 5 in PolyMet 2015e). The Mineral Mining/Industrial District air boundary encompasses an area approximately 1 km beyond the Mine Site air boundary and no farmers or residents are expected to be present within this area either presently or for the foreseeable future.

The results of the Mine Site assessment demonstrate that the chronic additional lifetime cancer and non-cancer effects, as well as the potential acute non-cancer health effects from direct exposure (inhalation) at the Mine Site property boundary for off-site workers were below guidance levels (PolyMet 2015e). The MEI inhalation pathway additional lifetime cancer risk at the Mine Site ambient air boundary was estimated from the assessment of year 13 emissions with a maximum value of 5E-06, which is below the MDH guideline value of 1E-05. The maximum potential sub-chronic and acute non-cancer risk estimates were calculated to be 0.2 and 0.8 respectively, which are both below the guidance level of 1.0.

The multi-pathway cancer risk for the hypothetical farmer was estimated to be 1E-05. This is at the MDH additional lifetime cancer risk guidance level of 1E-05. The major risk drivers were dioxins and dibenzo(a,h)anthracene associated with potential emissions from mine vehicles. It should be noted that maximum multi-pathway additional lifetime cancer risk is located at the Mining/Industrial District boundary. The nearest small farms are located 6.5 miles from the Mine Site.

The multi-pathway additional lifetime cancer risk for a hypothetical nearby resident at the Mining/Industrial District boundary was 8E-07, which is below the MDH guidance value of 1E-05. The major risk drivers for cancer endpoints for this receptor were nickel compounds, arsenic compounds, and dioxins.

The non-cancer chronic multi-pathway hazard indices (HIs) for the farmers and residents were each calculated to be 0.04, which is below the MDH guidance value of 1.0. Due to the variation (i.e., each compound has a unique concentration where health effects are expected for a target organ) in estimating the health effects for noncarcinogenic effects, the HI is the sum of the individual ratios of the maximum concentration divided by the chemicals' health benchmark. This ratio is then compared to a general guidance value of 1.0. Thus, the chronic non-cancer results for both the hypothetical farmer and resident were approximately 4 percent of the guidance value where health effects become more likely to occur.

The acute non-cancer HI was predicted at the Mine Site operating boundary with a value of 0.8, as compared to the MDH's acute HI guidance level of 1.0. This screening value sums all of the acute HIs for all pollutants regardless of their toxic endpoint (specific target organ) and the specific locations of maximum modeled air concentrations of the compounds. The risk driver for acute inhalation was NO_2 from the diesel fuel combustion. When adjusting HIs for the various locations of the maximum modeled annual average air concentration for risk-driver pollutants (i.e., risk-driver pollutant concentrations differ in space), the maximum acute HI for the off-site worker was reduced to 0.8, below the acute guidance level. Table 5.2.7-20 provides a summary of the Mine Site risk assessment.

Table 5.2.7-20 Summary of the Incremental Human Health Risk Assessment for the Mine Site

Exposure Route	Exposure Scenario	Location and Type of Receptor	Potential Non-cancer Health Effects (HI)[1]	Potential Cancer Effects (Risk Estimate)[2]
Inhalation Exposure Only	Acute (1-hour)	Mine Site Property Boundary	0.80	NA
	Chronic (~lifetime)	Mine Site Property Boundary	0.20	5E-06
Multi-pathway Exposure	Chronic (~lifetime)	Farmer	0.04	1E-05
		Resident	0.04	8E-07

Notes:
[1] HI is the sum of individual non-cancer chemical quotients for acute or chronic exposure. Incremental non-cancer (chronic and acute) guideline value is 1.0.
[2] Potential human health risks from carcinogenic chemicals (summed for all chemicals) were estimated using the MPCA's Risk Assessment Screening Spreadsheet. Incremental cancer risk guideline value is 1E-05.

Plant Site Air Emission Risk Analysis

As with the Mine Site, an AERA was conducted for the Plant Site and results were reported in the scoping EAW (May 2005). The 2005 AERA included specific chemicals for potential evaluation as defined in MPCA's AERA Guidance. NorthMet Project Proposed Action changes since May 2005 resulted in the AERA being revised for the DEIS. A Supplemental AERA was conducted, as part of the changes defined with the FEIS NorthMet Project Proposed Action (PolyMet 2015e) and although some project modifications have been made to the Plant Site since the SDEIS (Section 3.2), the Supplemental AERA is adequate for the FEIS (PolyMet 2015e). The screening human health risk analysis followed the MPCA-accepted August 2011 Work Plan (PolyMet 2015e). Sulfuric acid aerosol emissions were screened out of the quantitative assessment for potential acute inhalation effects by scaling the 2005 modeled acute inhalation hazard quotients to the current potential sulfuric acid emissions. As identified in the Plant Site AERA, the quantitative evaluation identified 10 CFEs, which are summarized in Table 5.2.7-21. The identified CFEs include three risk-driver chemicals from the 2007 AERA (arsenic compounds, nickel compounds, and NO_2) and four compounds from the 2007 AERA that now have toxicity values (acetaldehyde, cobalt compounds, crystalline silica, and diesel particulate). The remaining three were added either because of increased emissions (hydrochloric acid and manganese) or new emissions from mobile diesel sources included in the analysis (dioxins/furans).

Table 5.2.7-21 Chemicals for Evaluation of the Incremental Human Health Risk Assessment for the Plant Site

Chemical	Maximum Hourly Emission Rate 2012 (g/sec)	Annual Emission Rate 2012 (g/sec)
Acetaldehyde	1.66E-05	9.49E-07
Arsenic	3.03E-03	7.75E-04
Cobalt		5.44E-03
Crystalline Silica		1.30E+00
Diesel Particulate Matter		4.47E-02
Hydrochloric Acid	2.45E+00	2.90E-02
Manganese		5.91E-02
Nickel	1.33E-01	1.36E-01
Oxides of Nitrogen	1.10E+01	
Dioxins/Furans (as 2,3,7,8-TCDD TEQ)		1.12E-10
Number of CFEs		10

Note:
g/sec = gram(s) per second

Similar to the Mine Site AERA, air dispersion modeling was conducted to estimate air concentrations for the CFE, using the AERMOD model with 5 years of hourly meteorological data from the Hibbing weather station. Direct and indirect risk estimates were made for inhalation and bioaccumulative toxic pollutant ingestion, respectively, using the MPCA Risk Analysis Screening Spreadsheet, which estimates potential incremental cancer and noncarcinogenic human health risks for both acute and long-term effects.

Acute risks were estimated for the ambient air at and beyond the NorthMet Project area ownership boundary for off-site workers. Because of the historical and present mining and industrial land use around the Plant Site, the reasonable future land use for residential and farming was considered in assessing chronic risks for areas (i.e., receptors) outside of the former LTVSMC processing plant air boundary. The former LTVSMC processing plant ambient air boundary encompasses most of the industrial land use in the Hoyt Lakes area and no farmers or residents are expected to be present within this area for the foreseeable future.

Initially, a screening level human health risk is conducted where all CFEs maximum concentrations are assumed to occur at the same location. A refinement to the risk assessment is the calculation of maximal potential health effects paired in both space and time. That is, when the health effect impacts are calculated for all pollutants at each receptor and meteorological condition modeled. The results of the Plant Site assessment demonstrate that the chronic additional lifetime cancer and noncarcinogenic effects are at or below guidance levels and the acute noncarcinogenic health effects are also below the guidance level, when adjusted for locational differences (PolyMet 2015e).

The multi-pathway (ingestion and inhalation) additional lifetime cancer risk at the former LTVSMC processing plant ambient air boundary was estimated to be 1E-05 for farmers and 5E-06 for a hypothetical nearby residents, which is below the MDH guidance level value of 1E-05. Similarly, the off-site worker inhalation additional lifetime cancer risk at the NorthMet Project area boundary was predicted at 1E-05, also at the MDH additional lifetime cancer risk guidance level. The major risk drivers for these estimated cancer endpoints were cobalt, nickel, and dioxins/furans (farmers only).

The non-cancer chronic multi-pathway HI for the farmers and residents were each calculated to be 0.2, primarily from the potential nickel emissions. Due to the variation (i.e., each compound has a unique concentration where health effects are expected for a target organ) in estimating the health effects for noncarcinogenic effects, the HI is the sum of the individual ratios of the maximum concentration divided by the chemicals' reference exposure level and compared to a general guidance value for chronic HI as 1.0. Thus, the chronic non-cancer results for both the hypothetical farmer and resident were approximately 20 percent of the chronic guidance level, below which health effects would not occur. The chronic HI for the hypothetical off-site worker was estimated to be 1, which is at the chronic guidance level.

The acute inhalation HI at the former LTVSMC processing plant ambient air boundary was 0.5, as compared to the MDH's acute HI guidance level of 1.0. This boundary was the location assessed in consideration of a potential resident. This HI is a summation of all of the acute hazard quotients for all pollutants regardless of their toxic endpoint (specific target organ) and the specific locations of maximum modeled air concentrations of the compounds. The risk drivers for the acute inhalation pathway at the location of a potential resident were NO_2 emissions from the natural gas combustion and nickel from the Hydrometallurgical Plant. When adjusting HIs for the various locations of the maximum modeled annual average air concentration for risk-driver pollutants (i.e., risk-driver pollutant concentrations differ in space), the acute inhalation HI for the off-site worker was 1.0, at the acute guidance level. Table 5.2.7-22 provides a summary of the Plant Site risk estimates.

Table 5.2.7-22 Summary of the Incremental Human Health Risk Impacts for the Plant Site

Exposure Route	Exposure Scenario	Location and Type of Receptor	Potential Non-cancer Health Effects (HI)[1]	Potential Cancer Effects (Risk Estimate)[2]
Inhalation Exposure Only	Acute (1-hour)	Off-Site Worker Plant Site Property Boundary	1.0	NA
	Acute (1-hour)	Resident at former LTVSMC ambient air boundary	0.5	NA
	Chronic (~ lifetime)	Plant Site Property Boundary	1.0	1E-05
Multi-pathway Exposure	Chronic (~ lifetime)	Farmer	0.2	1E-05
		Resident	0.2	5E-06

Notes:
1 HI is the sum of individual non-cancer chemical risks for acute or chronic exposure. Incremental non-cancer (chronic and acute) guideline value is 1.0.
2 Potential human health risks from carcinogenic chemicals (summed for all chemicals) were estimated using the MPCA's Risk Assessment Screening Spreadsheet. Incremental cancer risk guideline value is 1E-05.

5.2.7.2.4 Greenhouse Gases Impact Analysis

The science, policy, and regulatory frameworks regarding GHGs are continually evolving and are often subject to differing interpretation. For the purposes of the FEIS, the information presented below is intended to provide the current understanding through June 15, 2012 with subsequent information regarding climate change updated in the FEIS.

Global Effects

According to the IPCC, since preindustrial times, human activities, particularly the burning of fossil fuels, have resulted in increases in the concentrations of GHGs in the earth's atmosphere (Solomon et al. 2007). It is estimated that 40 percent of a pulse emission of CO_2 remains in the atmosphere for approximately 100 years. Approximately 15 to 30 percent of the emissions are expected to remain after 1,000 years and 10 to 15 percent are expected to remain after 10,000 years. The estimated mean lifetime of emitted fossil CO_2 is between 30,000 and 50,000 years (Archer 2005). As such, the atmospheric GHG levels are likely to continue to rise over the next few decades. GHGs absorb in the infrared part of the electromagnetic spectrum. At elevated atmospheric concentrations, they act to warm the lower atmosphere and surface of the earth. The IPCC's most recent report (Solomon et al. 2007) found that, under a business-as-usual scenario, globally averaged surface temperature would increase 2.5 to 10.4°F between 1990 and 2100.

Globally, an "unequivocal" warming of 1.3°F (plus or minus 0.3°F) occurred between 1905 and 2005 (Solomon et al. 2007). Other data have shown that the global average temperature has increased by about 1.2 to 1.4°F since 1890, with the 14 warmest years of the past century occurring between 1997 and 2012 (Hansen et al. 2013). The observed increases in global average surface temperature may also be seen in the records of average annual temperatures at the regional and state level. Over the past century, temperatures in the United States have risen at an average rate of 0.11°F per decade, with the past 25 years showing temperature increases of approximately 0.56°F per decade (NOAA 2007). The annual average temperature of Minnesota has increased approximately 1°F in the last century, from 43.9°F (1888 to 1917 average) to 44.9°F (1963 to 1992 average) (MPCA 2009a). The winter season has brought even more dramatic increases of up to five degrees in parts of northern Minnesota (MPCA 2009a). Much of the warming observed in Minnesota has occurred over the last few decades. The observed rate and total increase in temperatures appear more extreme when the more recent years on record are averaged.

Climate changes can involve changes in temperature as well as changes in other meteorological conditions, such as precipitation patterns and shifts in seasons. These changes could affect forest ecosystems, water resources, other unique ecosystems, agriculture, and human health over the next century. Future emissions scenarios, using an ensemble of results from multiple global climate models, suggest an increase in annual precipitation of 10 to 15 percent over the next 70 to 90 years in the Great Lakes Region (USGCRP 2009), although regional results from these models are more uncertain than global results. The current modeling also suggests that winter and spring precipitation would increase 20 to 25 percent; summer rainfall declines 5 to 10 percent in the model results.

Although the degree of effect is uncertain, particularly when analyzed at the regional and local levels, water resources could be affected by changes in climate patterns. Due to increased temperature, evaporation would likely increase which could reduce levels in lakes, rivers, and streams up to 12 inches (MDNR 2009). Increased precipitation could also affect flooding conditions. In addition, severe weather patterns could be affected, resulting in more frequent maximum 25- and 100-year precipitation events and flood patterns. Warmer temperatures may shorten winter seasons, resulting in decreased ice cover on the lakes and streams, as well as early ice breakup in the spring.

If Minnesota's climate becomes drier, forest areas near the prairie-forest border could be replaced with grassland ecosystems (Frelich and Reich 2009). Minnesota's forested areas could decrease by 50 to 70 percent (MPCA 2003). On the other hand, if increased precipitation occurs, resulting in a wetter climate, over long periods of time the current conifers would be replaced with hardwood trees. Pine, birch, and maple forests would be replaced with oak, elm, and ash.

Minnesota's wetland and bog ecosystems may also face changes due to increased precipitation. Variation in wet periods, dry periods, and severe storm frequency could lead to changes in wetland type and distribution that includes wetland losses in some areas and wetland gains in other areas.

Due to the negative effects of peak daytime temperatures during anthesis and grain filling on crop growth, climate change could have a dramatic effect on agriculture. However, climate change would also lengthen the growing season of certain crops within the region, leading in some instances to increased, rather than decreased, agricultural productivity. Droughts, floods, and damage from insects and invasive weeds, could increase the challenges by farmers in the day-to-day management of farms and livestock.

Increased temperatures could increase the potential for heat-related illnesses and insect-borne diseases. Changes in air quality health effects could occur due to the increased temperatures. Higher VOC and ozone levels may occur, as increased temperatures may increase duration and frequency of stagnation conditions that would allow air pollution to build up.

Regulatory Actions

The USEPA has issued regulations under the CAA, and in some cases other statutory authorities, to address issues related to climate change. In addition, MPCA has recently modified its air permit rules to incorporate new federal permit requirements for GHG emissions and currently requires an evaluation of GHG emissions in the environmental review process for projects that must obtain stationary source air permits.

On October 30, 2009, the Final Mandatory Greenhouse Gas Reporting Rule was published requiring suppliers of fossil fuels or industrial GHGs, manufacturers of vehicles and engines, and facilities that emit 25,000 or more mtpy of GHGs to submit annual emission reports to USEPA. The gases covered by the emissions reporting rule are CO_2, CH_4, N_2O, HFCs, PFCs, SF_6, and other fluorinated gases including nitrogen trifluoride and hydrofluorinated ether. The rule required that the first annual GHG emission report be submitted on March 31, 2011, for 2010 emissions. The first reporting deadline was extended to September 20, 2011.

In response to the 2007 United Stated Supreme Court ruling in Massachusetts v EPA, 549 US 497 (2007), on April 17, 2009 the USEPA Administrator signed a Proposed Endangerment and Cause or Contribute Findings for Greenhouse Gases under the Section 202a of the CAA. The Administrator found that current and projected concentrations of the mix of six key GHGs in the atmosphere threaten the public health and welfare of current and future generations. The Administrator further found that the combined emissions of CO_2, CH_4, N_2O, and HFCs from motor vehicles and motor vehicle engines contribute to rising atmospheric concentrations of these key GHGs and hence are a threat to public health and welfare. These findings were a prerequisite to finalizing the GHG standards for light-duty vehicles. On April 1, 2010, USEPA and the DOT's National Highway Safety Administration issued the first national rule limiting GHG emissions from cars and light trucks. This rule confirmed that January 2, 2011 was the first date that a 2012 model year vehicle meeting these rule requirements may be sold in the U.S.

Based upon the above and USEPA's "PSD Interpretive Memo" (identifying that a pollutant is subject to regulation either by a specific provision in the CAA or a regulation adopted by USEPA), USEPA issued a final rule on May 13, 2010 that set GHG thresholds for permits for new and existing sources under New Source Review PSD permit and Title V operating permit requirements, known as the Greenhouse Gas Tailoring Rule. Under the rule and beginning on July 1, 2011, new sources, such as the NorthMet Project Proposed Action, with greater than 100,000 tpy of GHG or existing facilities that increase their GHG emissions by more than 75,000 tpy are subject to PSD and would require BACT for GHG emissions.

Concurrent with USEPA actions, a series of Congressional proposals were developed that, had they been passed, would have changed the U.S. climate policy. GHG emissions legislation considered during the 109th and 110th sessions (January 2005 to January 2007, and January 2007 to January 2009, respectively) of the U.S. Congress ranged from carbon taxes to cap-and-trade and from energy efficiency requirements to moratoriums on coal-fired power plant approvals. Of the legislation proposed during the 109th and 110th Congresses, notable legislative actions include the following:

- Lieberman-Warner Climate Security Act of 2007 (S. 2191);
- Boxer-Lieberman-Warner Climate Security Act Substitution Amendment of 2008 (S. 3036);
- American Clean Energy and Security Act of 2009 (Waxman-Markey – H.R. 2454);
- Clean Energy Jobs and American Power Act of 2009 (Kerry-Boxer (S. 1733)); and
- Kerry-Lieberman American Power Act of 2010.

None of these bills have passed both houses of Congress.

At the state level, efforts to curb statewide and regional GHG emissions are underway. More than half of U.S. states have joined in regional efforts to reduce GHG emissions. In 2007, as part of the Midwestern Greenhouse Gas Reduction Accord, Minnesota committed (along with Illinois, Iowa, Kansas, Michigan, Wisconsin, and the Province of Manitoba, Canada) to long-term GHG reduction targets of 60 to 80 percent below 2005 emission levels. Participants have agreed to pursue the implementation of a regional cap-and-trade system as well as a consistent regional GHG emissions tracking system.

In May 2008, the Governor of Minnesota signed legislation requiring the Minnesota Department of Commerce (MDC) and the MPCA to track and report GHG emissions. In 2007 legislation was passed and signed into law that established GHG emissions reduction targets for 2015 and 2025 of 15 percent and 30 percent, respectively, and directed the Department of Commerce to develop interim reduction recommendations through a length stakeholder process. The 2015 and 2025 goals were designed as milestones toward meeting the State's goal of reducing GHG emissions to a level at least 80 percent below 2005 levels by 2050. Developments in Minnesota's climate change and GHG policy would likely continue as Minnesota strives to meet the goals established in the Next Generation Energy Act of 2007.

On January 13, 2013, the MPCA adopted permanent rules to implement the new GHG permit requirements set by the USEPA. These rules set Part 70 permit thresholds for GHGs at 100,000 tpy. The rule changes also modify requirements for capped and registration permits and insignificant activities. The MPCA has implemented USEPA's final decision to defer including biogenic CO_2 emissions in permitting through permanent rulemaking for biogenic sources for PSD and Title V purposes.

In addition to policies directed at reducing statewide GHG emissions, Minnesota has instituted policies requiring the evaluation of GHG emissions as a part of the environmental review process for certain proposed actions that require stationary source air emissions permits. In July 2008, MPCA issued a General Guidance for Carbon Footprint Development in Environmental Review. The MPCA guidance requests that proposers, in the course of environmental review under MEPA, prepare a GHG inventory for proposed actions that would require stationary source air emissions permits.

Finally, on August 3, 2015, USEPA published the final Clean Power Plan (CPP) rules. These rules set standards for CO_2 emissions from existing fossil fuel-fired electrical generating units. These standards air to reduce CO_2 emissions by 32 percent by 2030. This means that there will be less GHG emissions associated with mine electrical purchases in the future as the CPP is implemented.

NorthMet Project Proposed Action and Climate Change

The NorthMet Project Proposed Action results in direct on-site emissions of GHGs and off-site indirect emissions associated with power generation. There are no analytical or modeling tools to reliably evaluate the incremental effect of a proposed action's discrete GHG emissions on the global and regional climate. In addition, there are no analytical or modeling tools to reliably evaluate any cascading effects, or cumulative effects, from a particular proposed action's GHG emissions on natural ecosystems and human economic systems in a given state or region.

The total potential direct annual emissions from the NorthMet Project Proposed Action are projected to be 196,342 mtpy of CO_2e. This is 0.12 percent of the statewide emissions for Minnesota, 0.003 percent of the United States emissions, and 0.00038 percent of the annual global emission estimations. Combining the direct and indirect emissions from the NorthMet Project Proposed Action (697,342 mtpy CO_2e), the total represents 0.44 percent, 0.01 percent, and 0.0014 percent of the annual statewide, U.S., and global emissions, respectively (PolyMet 2015e). It is possible that, due to global demand for copper, nickel, and precious metals, some of these emissions would occur regardless of the development of the NorthMet Project Proposed Action.

With climate change, average annual temperatures in Minnesota may increase 3 to 5°F over the lifetime of the facility. There may also be a 5 to 15 percent increase in precipitation over the life of the operation (20 years) and reclamation (60 years) (NOAA 2013). Increased temperatures and precipitation may have effects on wetlands, forests, and other cover types that are likely to affect carbon storage and sequestration in these ecosystems. There could be localized impacts due to meteorological changes. Even though a quantitative assessment of the effects could not be conducted, proposed reclamation and mitigation activities described in Section 5.2.7.4.3 can offset some of the carbon emissions caused by NorthMet Project Proposed Action.

5.2.7.2.5 Mercury Deposition Impact Analysis

Total potential mercury emissions to air are estimated to be 4.6 lbs/year from the Plant Site. The primary sources of air emissions are expected to be two emission units that are part of the hydrometallurgical process: the autoclave vent and the autoclave flash vent. The combined air emissions from these two units are estimated to be 4.1 lbs/year. Most of the remaining estimated mercury emissions (0.4 lb/year) are from natural gas used to fuel a package boiler and for space heating. Less than 0.1 lb/year are estimated to be released by the mining, crushing, and milling processes and through wind erosion from the Tailings Basin. Additional information regarding each of these emission sources is summarized in *Mercury Emission Control Technology Review Version 2* (Barr 2012k). Overall, about 95 percent of the mercury originating in the ore is expected to remain within—or be adsorbed to—the tailings and the hydrometallurgical residue, where it would remain isolated from further transport to the environment. Mine Site mercury air emissions would contribute a maximum of 0.17 lbs/year from Tailings Basin construction vehicles (diesel fuel combustion emissions) and approximately 0.6 lbs/year from diesel fuel combustion during normal operations (PolyMet 2015e). For comparison, Minnesota's statewide mercury air emissions were estimated to be 3,011 pounds in 2005 and about 2,835 pounds in 2011 (PolyMet 2015e).

The low percentage of estimated mercury released to the air is primarily because the oxidizing conditions in the autoclave would cause most of the mercury that is released from the concentrate into the exhaust gas to be in either the oxidized (Hg^{+2}) or particle-bound (Hg(p)) form. Oxidized mercury is water soluble and would be captured in the facility's wet scrubber system. Particle bound mercury would be collected in any device designed to control particulate emissions, such as the autoclave scrubber system. Speciation of mercury air emissions from the autoclave stack (after pollution controls) is uncertain, but expected to be primarily in the elemental (Hg^0) form (PolyMet 2015e). Detailed calculations for all Plant Site emission units are provided in UpdatedCalcsPlant Ver7.0_2_26_13 (PolyMet 2015e). The estimated 4.1 lb/yr of Hg^0 emitted from the Plant Site would add to the estimated 19,580,000 pound atmospheric mercury loading and would ultimately return to the terrestrial environment through long-range transport and atmospheric processes (Gaffney and Marley 2014).

The MMREM was used to conduct an evaluation for the potential deposition of mercury related to the Plant Site air emissions to assess the NorthMet Project Proposed Action's potential effects on mercury concentrations in fish and the potential health risks to a hypothetical recreational fisher, as well as a subsistence fisher consuming locally caught fish. The analysis was conducted for five nearby lakes: Heikkila Lake, Colby Lake, and Whitewater Lake (located within 10 km of the Plant Site) and Wynne Lake and Sabin Lake (located within 12 km of the Plant Site). The analysis used the MMREM to assess the potential incremental change in fish mercury concentrations and the potential incremental risks to human health.

Only the Plant Site's potential mercury air emissions were evaluated, as they represent essentially all of the NorthMet Project Proposed Action-related mercury air emissions (PolyMet 2015e). The Mine Site AERA did not assess potential local mercury deposition because potential emissions are less than 1.0 lb/yr (PolyMet 2015e).

Because of uncertainty in speciation of emissions associated with autoclave operations, two speciation scenarios were used for assessing potential effects for the local impacts assessment (PolyMet 2015e). The results of the analysis from the two mercury speciation scenarios on the five nearby lakes estimated that the potential incremental increase in mercury concentrations in the top predator fish would range from 0.002 ppm (Scenario 2, Whitewater Lake) to 0.016 ppm (Scenario 1, Wynne Lake), depending upon the lake and scenario evaluated (see PolyMet 2015e, Attachment T). Scenario 1 assumed that the oxidized and particle-bound mercury released would be 50 percent and 25 percent of the total mercury, respectively. Scenario 2 assumed maximum control efficiency for these fractions, reducing the total percentage released to 10 percent for each. It should be noted that due to the conservatively higher oxidized and particle-bound mercury speciation assumption in Scenario 1, the effects for Scenario 1 are greater than the mercury effects for Scenario 2 for each lake evaluated. These are small compared to the existing Hg concentrations in the top predator fish (95^{th} percentile), which range from 0.35 ppm at Whitewater Lake to 1.34 ppm at Wynne Lake. The NorthMet Project Proposed Action incremental risk quotients for a recreational fisher ranged from 0.013 (Scenario 1) at Whitewater Lake to 0.081 at Wynne Lake; both are below the incremental risk guideline level of 1.0. The incremental risk quotients for subsistence and tribal anglers ranged from 0.098 (Whitewater Lake) to 0.606 (Wynne Lake) for Scenario 1, also below the incremental risk guidance level. Finally, the incremental risk quotients for the subsistence fisher (Treaty Protected catch rate) ranged from 0.132 (Scenario 1, Whitewater Lake) to 0.538 (Scenario 1, Wynne Lake), again below the incremental risk guidance level. Additional information pertaining to fish mercury concentration and the specific Hazard Quotients summarized in the report *Cumulative Impacts Analysis: Local Deposition and Bioaccumulation in Fish* (Barr 2012b) have been included in Section 6.2.6.3.3 summarizing the cumulative effects assessment for mercury deposition. It should be noted that all of the lakes' mercury background concentrations result in a background risk quotient above 1.0 without any incremental increase from the NorthMet Project Proposed Action, which is a common occurrence in Minnesota lakes. Widespread contamination of fish from atmospheric pollution is why Minnesota established a statewide mercury TMDL. The TMDL seeks to reduce atmospheric deposition everywhere in the state in order to make the state's lakes and streams fishable, as required by federal regulations.

In September 2009, the MPCA published Guidelines for New and Modified Mercury Air Emission Sources. The guidelines were developed to limit the mercury emissions from new and expanding sources in order to meet the TMDL goal of total statewide mercury emissions of 789 lbs/year by 2025. In 2012, MPCA revised the guidelines (MPCA 2012h), which includes the following requirements that apply to the NorthMet Project Proposed Action:

- Define and employ BACT on mercury emitting sources. If best controls reduce emissions by less than 90 percent, the new source would be subject to periodic review for opportunities for improved control efficiency and must comply with TMDL requirements.
- Complete environmental review as required by Minnesota law, including for a proposed action and associated cumulative effects.
- For facilities where the MPCA determines a project's mercury emissions would not impede the statewide mercury emissions reduction goals within the mercury TMDL, an emissions limit would be placed into the facility's permit and the project is not be required to submit a mitigation plan.

The NorthMet Project Proposed Action mercury air emissions are about 0.16 percent of 2011 estimated statewide emissions and about 0.6 percent of the TMDL statewide target emissions. The NorthMet Project Proposed Action selected a two-stage mercury control system that is expected to achieve 25 percent control for elemental mercury and 90 percent control for particle bound and oxidized mercury (PolyMet 2015e). Because the total mercury control is less than 90 percent, PolyMet moved forward with the remaining TMDL requirement. In addition, PolyMet has conducted a cumulative effects analysis on the local mercury deposition and bioaccumulation in fish (PolyMet 2015e) and the assessment of the cumulative effects is provided in Section 6.2.6.4.3.

The MPCA has conducted a review of the NorthMet Project Proposed Action mercury emissions and has determined that it would not impede the reduction goals (MPCA 2013l). Thus, no minimization and mitigation plan would be required for the NorthMet Project Proposed Action.

5.2.7.2.6 Sulfur Deposition and Potential Indirect Effects on Mercury Methylation

The Ecosystem Acidification report, in support of the Minnesota Steel EIS, indicates that up to 90 percent of the sulfate deposition in Minnesota is due to out-of-state emissions of SO_2 and that sulfate deposition has been on a downward trend since the mid-1980s. Given the current downward trend of sulfate deposition in Minnesota and the relatively small contribution from Minnesota sources to sulfate deposition in Minnesota, the NorthMet Project Proposed Action is not expected to have a measurable effect on sulfate deposition in the state. The trend of decreasing sulfate deposition in Minnesota is expected to continue into the future due to foreseeable regulatory actions that are expected to further reduce sulfur dioxide emissions on a national basis as well as from specific Minnesota sources. A supplemental assessment of the potential additional sulfur from stack and fugitive dust air emissions was conducted to evaluate the NorthMet Project Proposed Action's effects from sulfate as related to mercury methylation and fish concentrations. Sulfur related emissions include SO_2, sulfuric acid mist (SAM), reduced sulfur compounds and sulfur in particulate (e.g., sulfur in the mineral matrix of the ore). Because the estimated Plant Site and Mine Site emissions for each of these are below the PSD permitting thresholds and Significant Emission Rate (SER), no further consideration of these sources were required for environmental impact purposes (Barr 2015f). However, a summary of each is included in Section 4.0 of the document *Mercury Overview a Summary of Potential Mercury Releases from the NorthMet Project and Potential Effects on the Environment* (Barr 2015f). The evaluation estimates the potential sulfur deposition to the Partridge River (Colby Lake) and Embarrass River (Sabin Lake) watersheds and is summarized below.

Sulfur Dioxide

Plant Site stack SO_2 emissions are estimated at about 7 tpy, while stack emissions of SO_2 at the Mine Site are estimated at about 1.9 tpy. The values are too small for PSD air permitting and therefore are not required to be modeled and are not considered to have significant impacts according to the PSD program. Nevertheless, air concentrations of SO_2 were modeled for the Plant Site Class II Air Quality Air Dispersion Modeling Report (Barr 2012j) and can be used to estimate a potential deposition of sulfur related to SO_2 air emissions. Average watershed air concentrations for SO_2 are based on Class II modeling and reflect the Class II modeling receptor grid (Barr 2012j).

Because SO_2 emissions are in the gas phase and are emitted from a taller stack, they tend to disperse further, and therefore represent a more reasonable approximation of a potential air concentration. Additional inputs such as deposition velocity, lake surface area, and water mixing zone were included for evaluation. Based on the results of the modeling, the potential deposition over the Partridge River (Colby Lake) would be 0.003 $g/m^2/yr$ or about 2 percent of background, with a potential surface water concentration from deposition to the lake surface of 0.03 mg/L. The potential deposition over the Embarrass River (Sabin Lake) would be 0.002 $g/m^2/yr$ or about 2 percent of background), with potential surface water concentration from deposition to the lake surface of 0.02 mg/L. With conservative estimates of potential air concentrations and general overestimates of potential deposition associated with screening equations, potential sulfur deposition from SO_2 emissions is a small percent of background sulfur deposition for both the Embarrass River and Partridge River watersheds.

Sulfuric Acid Mist

The revised air concentration estimate for SAM is 0.12 $\mu g/m^3$, as adjusted for the current estimate of SAM emissions of 5.02 tpy (PolyMet 2015e). Additional inputs such as deposition velocity, lake surface area, and water mixing zone were included for evaluation. Based on the results of the modeling, the potential deposition over the Partridge River (Colby Lake) would be 0.0005 $g/m^2/yr$ or about 0.4 percent of background, with a potential surface water concentration from deposition to the lake surface as 0.005 mg/L. The potential deposition and estimated potential incremental sulfate concentration for Embarrass River (Sabin Lake) would also be 0.0005 $g/m^2/yr$ and 0.005 mg/L, respectively. Overall, the deposition from SAM emissions is a small percentage of background sulfur deposition to both the Embarrass River and Partridge River watersheds.

Reduced Sulfur Compounds

Potential NorthMet Project Proposed Action emissions of total reduced sulfur (TRS) compounds, includes hydrogen sulfide (1.88 tpy) and carbon disulfide (5.1 tpy) as estimated to be 6.98 tpy. All of the TRS emissions are from the Plant Site (PolyMet 2015e). No modeling of TRS emissions was required for ambient air quality purposes or the Supplemental Plant Site AERA. However, the potential deposition of sulfur is estimated to be small due to factors such as the ability to remain as a gas under normal environmental conditions, further transport from an emissions source due to oxidation by molecular oxygen and hydroxyl radicals, residence times ranging from 1 day to 40 days, and gas phase at ambient temperatures reacting with photochemically produced hydroxyl radicals (Barr 2015f). Overall, the potential local deposition of sulfur from TRS compounds is uncertain, but it is not expected to exceed evaluation criteria.

Sulfur in Particulate Matter

The estimate of potential sulfur deposition from sulfur in particulate was calculated using the air concentration for the annual averaging time period of 5.8 $\mu g/m^3$ at the Plant Site property boundary (PolyMet 2015e). It is assumed that ore processing would be responsible for all modeled air concentrations. Additional inputs such as deposition velocity, lake surface area, and water mixing zone were included for evaluation. Based on the results of the modeling, the potential deposition over the Partridge River (Colby Lake) would be 0.0045 $g/m^2/yr$ or about 4 percent of background, with a potential surface water concentration from deposition to the lake surface as 0.04 mg/L. The potential deposition and estimated potential incremental sulfate concentration for Embarrass River (Sabin Lake) would also be 0.0045 g/m^2/yr and 0.04 mg/L, respectively. Overall, the sulfur in the particulate and the potential sulfur surface water concentrations would be a small percentage of background deposition for the Embarrass River and Partridge River watersheds.

Based on the results of the additional assessment of sulfur deposition, the potential addition of sulfur from these emissions sources would be small to negligible, and therefore would not be expected to have effects on mercury methylation or fish mercury concentrations. Additional information regarding to mercury methylation is provided in Section 5.2.2.3.4. Mercury deposition and bioaccumulation in fish (PolyMet 2015e) and the assessment of the cumulative effects is provided in Section 6.2.6.4.3.

5.2.7.3 NorthMet Project No Action Alternative

Since this alternative would not involve introducing new emission sources, the NorthMet Project No Action Alternative would have no additional effects on air quality either regionally or locally. Therefore, air quality would be substantially similar to existing conditions.

5.2.7.4 Mitigation Measures

If, during permitting, it is determined that mitigation measures are necessary, the measures described in this section could be considered; however, most of the mitigation measures described are incorporated into the design. PolyMet has proposed the following mitigation measures to reduce effects on air quality associated with GHGs.

5.2.7.4.1 Greenhouse Gas Reduction Measures

<u>Review of Current Mitigation Included In the NorthMet Project Proposed Action</u>

The NorthMet Project Proposed Action incorporates both energy and production efficiency to reduce associated GHGs (Barr 2011e). The potential to minimize and reduce GHG emissions from changes in existing land cover (i.e., release of carbon tied up in terrestrial biomass, soils, or peat and the loss of carbon sequestration capacity from the environment) are also discussed (PolyMet 2015e). The following provides a summary of the reduction measures.

PolyMet proposes a hydrometallurgical process, rather than a pyrometallurgical process, which would result in reduced energy usage. The hydrometallurgical process is expected to reduce the NorthMet Project Proposed Action's energy demand by 50 percent over comparable pyrometallurgical processes. However, while energy use is reduced by one-half, GHG emissions do not decline per unit of production from what would be expected from a pyrometallurgical process, principally because of the large load of non-energy process emissions associated with hydro processing.

PolyMet also proposes to use premium efficiency motors in selected locations rather than standard motors. Motor efficiencies typically vary between 85 and 96 percent, depending upon the size and load of the motor. Gravity transport of process slurries would also be used where possible, instead of pumps. PolyMet proposes to configure the processing plant such that the overall power factor for the facility is as close to one (energy input to energy output) as practical, which would help minimize electricity use.

The primary production excavators and two of the three blast-hole drills would be electric rather than diesel powered, eliminating a direct source of GHG emissions. PolyMet would purchase new gen-set locomotives, which are more efficient and use less fuel than conventional locomotives. Space heating in the former LTVSMC processing plant is a major contributor to total direct GHG emissions and PolyMet would employ natural gas heaters. Per unit of useful energy, the combustion of natural gas results in lower CO_2e emissions than does the combustion of other fuels. Of the three feasible space heating options, electric heating, propane-fired heating, and natural gas-fired heating, natural gas-fired heating would result in aggregate in CO_2 emissions that would be about 80 percent lower than those for electric heating and 66 percent lower than those for propane-fired heaters.

PolyMet evaluated additional methods to reduce the NorthMet Project Proposed Action's GHG emissions but found the additional methods infeasible (PolyMet 2015e). The methods evaluated included electric drive mine haul trucks, electric locomotives, mill technology, flotation alternatives, and the use of waste heat from autoclaves for space heating.

Additional Mitigation

To mitigate GHG effects associated with a change in existing land cover (i.e., secondary effects), PolyMet would provide compensatory wetland mitigation (see Section 5.2.3 of this FEIS) for direct effects on wetlands as well as for indirect effects on fragmented wetlands. One of the goals of the compensatory mitigation is to restore high-quality wetland communities of the same type, quality, function, and value as those affected by the NorthMet Project Proposed Action. Given site limitations and technical feasibility, it is impracticable to replace all affected wetland types with an equivalent area of in-kind wetlands. Off-site wetland compensation of 1,631.4 acres wetland restoration and/or preservation, and 225.0 acres of upland buffer have been planned. This off-site mitigation would take place at three sites in northern Minnesota. Based upon the proposed wetland mitigation plan, the number of acres replaced would equal and/or exceed the total number of acres of all types of wetlands lost to NorthMet Project Proposed Action-related activities, other than deep marsh and the final ratios would be determined during wetland permitting. However, the excess replacement would contribute to some degree to compensation of the NorthMet Project Proposed Action's effects on deep marsh wetlands.

5.2.7.4.2 Rail Car Ore Transport Fugitive Dust Mitigation Measures

Rail cars have been designed to centralize the ore fines to the central portion of the rail car to minimize the potential for spillage during transport. Due to the natural moisture content and large size of the ore being mined, fugitive dust from rail car transport is expected to be minimal. Three additional fugitive dust control measures have been identified as part of the Mine Site Fugitive Emission Control Plan. These include the minimizing the drop distance of the ore into the railcars, reporting dusty conditions during loading and transport, and conducting one observation per train to evaluate rail car loading conditions. In addition, annual training would be conducted for all locomotive workers on methods to minimize fugitive dust during ore transport and loading.

5.2.7.4.3 Voluntary Mitigation Measures

Based upon the emissions defined in Section 5.2.7.1.3, the majority of the NO_x and SO_2 emissions are associated with mobile sources (e.g., diesel trucks, locomotives, mining equipment). Although the analysis of these pollutants showed that the NorthMet Project Proposed Action would not cause or significantly contribute to air quality exceedances, a voluntary anti-idle program could further reduce these emissions, as well as PM and GHG. Although there is no regulatory requirement for a program, PolyMet is considering the implementation of an idling reduction policy that would consider the size, fuel type, and function of each type of vehicle, as well as weather conditions and anticipated duration of vehicle stoppage. The policy would need to account for extreme weather conditions in order to avoid potential construction or production delays from the inability of vehicles to restart once turned off. In addition, vehicle owner's policies and maintenance requirements would have to be incorporated for heavy construction equipment and light vehicles that are not owned and operated by PolyMet. The results of such a policy would benefit by reducing environmental impacts, improving worker health and safety, and reducing fuel usage and engine wear.

5.2.7.5 Amphibole Mineral Fibers

5.2.7.5.1 Environmental Consequences

Background

The NorthMet Project Proposed Action would mine ore from the Duluth Complex, which may contain amphibole mineral fibers. Taconite ore mined from the Biwabik Iron Formation at the Northshore Mine and processed at the Silver Bay plant, has received public attention with regard to potential releases of amphibole mineral fibers such as those found with taconite ore on the east end of the Mesabi Iron Range in northeast Minnesota.

Regulatory Definitions and Mineralogy

Amphibole mineral fibers are a naturally occurring type of mineral fiber that can be found in two different crystalline structures: the asbestiform and non-asbestiform types. Asbestiform type amphibole fibers consist of aggregates of long, thick, flexible fibrils that separate along grain boundaries between fibrils. The effects on human health as a result of inhalation exposure to this form of amphibole mineral fiber has been well documented. These effects include an increased risk of developing lung cancer and mesothelioma. The non-asbestiform type of amphibole mineral fiber can be found as blockier cleavage fragments. These cleavage fragments can be released through the crushing or fracturing of rock containing the mineral fibers. There is ongoing debate about whether exposure to thoracic-size non-asbestiform amphibole cleavage fragments also increase the risk for certain respiratory diseases, but there is currently no consensus on the issue.

The term "asbestos" has a long history of use within industrial/commercial and regulatory contexts, but is not appropriately used as a mineralogical definition. Asbestos is the name of a group of highly fibrous minerals with separable, long, and thin fibers. Individual asbestos fibers are strong and flexible, heat resistant, and chemically inert. There are six regulated types of asbestos. The six regulated minerals and their associated mineral group are:

- Chrysotile (Serpentine),
- Crocidolite (Reibeckitte) (Amphibole),
- Amosite (Cummingtonite-grunerite) (Amphibole),

- Anthophyllite Asbestos (Amphibole),
- Tremolite Asbestos (Amphibole), and
- Actinolite Asbestos (Amphibole).

From a mineral perspective, amphibole minerals are distinguished from each other by the amount of sodium, calcium, magnesium, and iron that they contain.

A mineral fiber can be analyzed and classified using a microscope. Chrysotile is easily identified by microscopic analysis because of its distinct particle shape. For amphiboles, the distinction between asbestiform and non-asbestiform is less clear. Amphibole particles have a spectrum of shapes from blocky to prismatic to acicular. Amphiboles also break (or cleave) into smaller fragments when finely ground. Long, thin cleavage fragments resemble asbestos fibers, but may not be asbestiform. Cleavage fragments tend to be roughly twice as thick as asbestos fibers (Addison and McConnell 2008). The aspect ratio distributions (i.e., length-to-width ratio) of a population of cleavage fragments and a population of asbestos fibers can overlap. This overlap means that some fibers may be classified as either cleavage fragments or asbestos fibers (Millette 2006). An analyst can compare particle shapes to asbestos reference materials but it can be difficult to classify individual fibers as asbestiform or cleavage fragments because individual fibers do not exhibit all the characteristics of a population.

Regulatory definitions for classifying asbestos and other mineral fibers vary and often do not differentiate between asbestiform and non-asbestiform minerals. The USEPA defines the dimensions of an "asbestos fiber" as a particle 5 micrometers (μm) in length or longer with an aspect ratio of at least 20:1 (USEPA 1993). The National Institute for Occupational Safety and Health (NIOSH) defines an "occupational fiber" as a particle 5 μm in length or longer with an aspect ratio of at least 3:1 (NIOSH 1994). Minnesota agencies define a Minnesota regulated fiber (MN-fiber) as an amphibole or chrysotile mineral particle with an aspect ratio of 3:1 or greater with no limit on length (MDH Methods 851 and 852). The State of Minnesota's definition of fibers does not distinguish between asbestiform and non-asbestiform amphibole fibers, including cleavage fragments.

Health Impact

The health impacts from exposure to asbestiform members of the serpentine and amphibole mineral groups via respiration of those minerals are well known. Less certain are the health risks associated with exposure to the non-asbestiform varieties of amphibole minerals, which may be present in the air as cleavage fragments. While chemically and elementally identical to asbestos, these fibers have different physical properties. It is not certain exactly what properties of a mineral fiber affect its potency and, in turn, impact the health of an exposed population.

When an agency is evaluating reasonably foreseeable significant adverse effects on the human environment in an EIS and there is incomplete or unavailable information because the overall costs of obtaining it are exorbitant or the means to obtain it are not known, NEPA directs the agency to make it clear that such information is lacking, discuss the relevance of the lacking information, and discuss any information relevant to evaluation the future impacts. In these cases, NEPA also directs the agency to evaluate these impacts based upon theoretical approaches or research methods generally accepted in the scientific community provided that the analysis of the impacts is supported by credible scientific evidence, is not based on pure conjecture, and is within the rule of reason.

The Co-lead Agencies believe that there is currently incomplete and unavailable scientific information to characterize the health risk to the public from exposure to mineral fibers and that the means to obtain such information are not known. Because of this, it is not possible to evaluate the potential for significant adverse effects on the human environment from the release of amphibole mineral fibers associated with the NorthMet Project Proposed Action. This section provides a summary of existing credible scientific evidence that, with additional research, may one day provide guidance for future development of a human health based standard for amphibole mineral fiber. There is an ongoing effort in the environmental health community to develop the scientific tools and expertise to arrive at such a standard in the future. Since the health impacts from exposure to fibers cannot be evaluated at this point in time, the approach is to minimize the release of fibers through control and treatment technology and to conduct ambient air monitoring for fibers.

The toxicological literature review prepared for the MDNR (MDNR 2009b) discussed non-asbestiform fibers. A brief summary follows.

Palekar et al. (1979) found non-asbestiform particles to be cytotoxic (meaning toxic to cells); however, epidemiological studies have found limited potential for carcinogenesis from cleavage fragments. Gamble and Gibbs (2008) provided a review of several epidemiological studies regarding exposure to cleavage fragments including several involving taconite miners. They found that there was no statistically significant increase in either lung cancer or mesothelioma from exposure to taconite mining. Ilgren (2004) reviewed animal and human studies and came to the same conclusion. Additionally, Gylseth et al. (1981) performed a study in which non-asbestiform amphibole dust in the lungs of taconite miners was examined. Whereas Gylseth et al. (1981) concluded that exposure to the miners constituted a minor carcinogenic risk, they could not exclude exposure to taconite as a contributing factor to the lung cancer found in the miners examined. Asbestosis and mesothelioma latency periods of 15 to 50 years are not uncommon, creating uncertainties in the interpretation of studies performed to date. It should be noted that taconite is mined in the Biwabik Formation, whereas the ore proposed to be mined for the NorthMet Project Proposed Action is from the Duluth Complex, which is not in contact with the Biwabik Formation at the NorthMet Deposit.

In 1997, the Minnesota Cancer Surveillance System first identified an excess of mesothelioma cases among a cohort of males who worked in the mining industry in Northeastern Minnesota. In response to this information, the MDH conducted an epidemiologic study to investigate the exposure of these workers to commercial asbestos. This study identified exposure to commercial asbestos as a probable cause for a part of the observed increase in mesothelioma rates. The results of this study were published in the 2003 report *Exposures to Commercial Asbestos in Northeastern Minnesota Iron Miners who Developed Mesothelioma* (MDH 2003). In a February 2015 press release that provided an update on new mesothelioma cases in the cohort, the MDH stated that "based on the available evidence, the elevation in mesothelioma cases in Northeastern Minnesota is most likely an occupational health concern, and does not reflect any increased risk for the broader community" (MDH 2015b). The MDH continues surveillance for newly diagnosed cases of mesothelioma in Minnesota.

The study did not address the potential occupational or public health risks associated with exposure to non-asbetiform amphibole mineral fibers and is unable to provide any scientific evidence for or against the existence of such risks. Furthermore, the MDH considers the role of non-asbestiform amphibole fibers in the induction of health effects to be uncertain at this time but concludes that amphibole mineral fibers have the potential for an undetermined toxicity and potency.

The University of Minnesota School of Public Health conducted a research effort, known as the Minnesota Taconite Workers Health Study (University of Minnesota 2013), funded by the State of Minnesota, to better understand taconite worker health issues, including an epidemiological investigation into causes of excess rates of disease, including mesothelioma, among taconite workers. The results of this study did not rule out exposure to amphibole mineral fibers as being a potential source of health risk or having some role in the incidence of disease among taconite workers. The results also do not define what level of exposure would pose a medically significant hazard or risk to the surrounding community, but research from this and other scientific studies will be considered in developing any future health-based fiber standard.

Occurrence in the Duluth Complex

The October 2005 SDD for the NorthMet Proposed Action EIS identified that the "… EIS will provide information about the presence of fibers in the NorthMet deposit." Since February 2006 fibers-related information has been submitted to the Minnesota State Agencies (MDNR; MPCA; MDH) for their review and consideration. The report entitled *Fiber Information, NorthMet Mine and Ore Processing Facilities Project, Fibers Data Related to the Processing of NorthMet Deposit Ore* (2007l), hereafter referred to as the "2007 Mineral Fibers Report," provided the bulk of the fibers-related data and information.

The Minnesota Environmental Quality Board (MEQB) has reported that the Duluth Complex contains minor amounts of amphibole minerals, but did not identify chrysotile as a mineral of concern (MEQB 1979). The MEQB (1979) identified that the concentration of asbestiform amphibole minerals in the Duluth Complex ore is expected to be low, "…less than 0.1 ppm by weight in the mineralized areas of the Duluth Complex…." Composite samples using ore from the NorthMet Deposit collected during flotation pilot plant studies in 2000 conducted for PolyMet (SGS 2004) provided results for amphibole and serpentine minerals representative of the MEQB (1979) conclusions. Recognizing the differences between the NorthMet Deposit versus the Biwabik Iron Formation, the MPCA, MDNR, and MDH requested that PolyMet provide additional information on fiber-related data for its mining and processing operations in the NorthMet Deposit.

PolyMet conducted additional flotation pilot testing in July and August 2005. Collected samples considered to be representative of the head feed, tailings, and flotation process water associated with processing ore from the NorthMet Deposit were prepared for analysis by Transmission Electron Microscopy by additional grinding of the ore and tailings samples with mortar and pestle to produce a very fine powder. Stevenson (1978) states that the finer a material is ground, the higher the number of fibers identified by MDH counting rules (MDH Methods 851 and 852). According to the laboratory conducting this analysis, this only affects fiber counts, not the identification of asbestiform fibers since asbestiform fibers have high tensile strength and flexibility (PolyMet 2015e).

Overall, amphibole mineral fibers were found to represent a relatively small percent of the mineral fibers associated with the processing of NorthMet Deposit ore (Flotation Pilot Testing in July and August 2005); approximately 9 percent of the fibers identified from all collected samples of ore, tailings, and process water. Chrysotile mineral fibers were not identified in samples of ore, tailings, or process water collected from the flotation pilot testing. However, PolyMet's petrographic observations indicate that chrysotile minerals are about 2 percent of the minerals associated with the waste rock from the NorthMet Project Proposed Action.

It is not possible to accurately quantify the amount of fibers that might be emitted from the facility. Instead, this data was used to confirm the presence of amphibole minerals in the ore body and, thus, that the potential exists for both MN-fibers to be emitted from the facility and for the public to be exposed to these fibers.

Data provided in the 2007 Mineral Fibers Report indicates that about 95 percent of the mineral fibers identified in samples collected from the flotation pilot testing were 3 microns or smaller in size, with most being less than 2 microns in size. Therefore, $PM_{2.5}$ (fine particulate) could be used as a surrogate for all mineral fibers, including amphibole mineral fibers.

5.2.7.5.2 Evaluation Criteria

Because the exact human health risk of exposure to non-asbestiform amphibole mineral particles is unknown as well and because there is no method to quantify the potential fiber emissions, there is no accepted scientific methodology for performing a formal health risk assessment for the quantitative assessment of human health effects from the proposed operations. Thus, there is an uncertain level of potential health risk from airborne amphibole mineral fibers for the NorthMet Project Proposed Action. As such, the focus is on minimizing any potential release of airborne amphibole mineral fibers and to conduct monitoring for fibers in the ambient air.

5.2.7.5.3 NorthMet Project Proposed Action

The presence of amphibole minerals in the Duluth Complex indicates that the potential exists for the emissions of amphibole mineral fibers from the proposed operations. MN-fibers identified in samples collected from the 2005 flotation pilot testing of material representative of processing NorthMet Deposit ore (Barr 2007d) were predominately less than 2.5 µm in aerodynamic diameter (99.6 percent less than 2.5 µm), placing them in the fine fraction of particulate matter ($PM_{2.5}$). A small fraction of these fibers were identified as amphibole (approximately 9 percent). There is the potential that amphibole mineral fibers may be found in water that has come in contact with ore at the Mine Site.

The MPCA and the MDH have emphasized additional control of airborne fine particles to minimize the environmental release and potential exposure of the public to asbestiform and non-asbestiform amphibole mineral fibers These additional controls include measures to minimize fugitive dust emissions from blasting and tailings basin activities, the use of BACT-like particulate emission control technology, water treatment, and ambient air monitoring. These minimization measures are outlined in the following paragraphs.

Fugitive Dust Control

Several measures of regulatory requirements would assist in minimizing emissions of fibers. Compliance with the requirements for blasting, found in *Minnesota Rules*, chapter 6132, would minimize fugitive dust from blasting operations. A fugitive dust suppression plan for the Tailings Basin would be evaluated and approved by the MPCA as part of the air permit. In addition, the NorthMet Project Proposed Action would be required to comply with Federal Mine Safety and Health Administration's regulations for mining operations that include implementation of standards for asbestos exposure to minimize worker exposure. Such measures would also minimize release of amphibole mineral fibers.

The potential for the release of amphibole mineral fibers to the air at the Mine Site would be low because the ore would not be crushed at the Mine Site and the unpaved road surfaces would be constructed of material that is not likely to contain amphibole minerals. PolyMet's decision to use larger haul trucks at the Mine Site, as well as the incorporation of an updated mine plan into the emission calculations, has reduced the estimated fugitive particulate emissions, further reducing the potential for emissions of airborne amphibole mineral particles.

The Tailings Basin would be operated to minimize all fugitive particulate emissions by management to minimize exposed beach areas and wind erosion fugitive dust by treatment of the Tailings Basin roads and inactive beach areas. The deposition of wet tailings would keep the active work area wet and prevent wind erosion. Capillary action near the pond edge is expected to keep the fines wet and minimize the potential for entrainment of the fines into the air.

Particulate Emissions Control Technology

In order to minimize amphibole mineral fiber emissions, and since MN-fibers are predominately in the $PM_{2.5}$ size range, a $PM_{2.5}$ BACT-like analysis for the proposed PolyMet operations was performed in accordance with the USEPA's guidance. The NorthMet Project Proposed Action is not subject to PSD, so this analysis is not otherwise required. The purpose of this analysis was solely to determine the best control for $PM_{2.5}$ and thus for fibers. For this analysis, control technologies are ranked in order of effectiveness, and starting with the most stringent technology, each are evaluated until a technology cannot be ruled out on technological or economic grounds.

The vast majority of potential emissions of MN-fibers for the NorthMet Project Proposed Action would occur from the ore crushing operations at the Plant Site, with minor potential emissions from the Tailings Basin and the Mine Site (PolyMet 2015e).

As a result of the BACT-like analysis, the NorthMet Project Proposed Action would install emission controls in the crushing plant, such that the emissions of fine particulate matter from the ore crushing and associated material handling sources are controlled consistent with recent BACT determinations. The controls would include the use of fabric filters (baghouse or cartridge) designed to reduce emissions to 0.0025 gram per dry standard cubic foot at each unit (PolyMet 2015e). These controls would be applied to all emission sources within the coarse crushing operations (10 units), the drive house (2 units), the fine crushers (8 units), and the concentrator (15 units).

In addition to these controls, the NorthMet Project Proposed Action would also use high-efficiency particulate air (HEPA) filters following the fabric filters on selected units. The HEPA filters would be used when exhaust air from the fabric filters is routed back into the building to provide an added level of assurance that worker exposure to inhalable dust is minimized. In this case, the venting of exhaust air back into a building provides a benefit of reducing the heating fuel demand that offsets the additional cost and energy usage associated with re-routing of air back into a building (PolyMet 2015e). The combination of the cartridge and HEPA filters for fine particulates has a removal efficiency of 99.97 percent. Six units within the coarse crushing operations and nine units within the concentrator would utilize the HEPA filters year-round. Eight of the 10 units within the drive house and fine crusher operations would utilize the HEPA filters during heating season only (PolyMet 2015e).

The use of HEPA filters, during non-essential operations, would provide little air quality benefits for reducing exposure to fine particulates outside the facility boundary. In addition, the modeled $PM_{2.5}$ effects demonstrate that the $PM_{2.5}$ concentrations, which are in the same size range as the amphibole mineral fibers, rapidly decrease in magnitude in all directions. As such, the operational and air pollution equipment controls for the NorthMet Project Proposed Action represent the highest feasible level of fine particulate matter control and, coupled with Hoyt Lakes being 5 miles from the Plant Site, further reduce the potential for public exposure to airborne amphibole mineral fibers.

Amphibole Mineral Fibers in Water Discharges

There is the potential that amphibole mineral fibers may be found in water that has come in contact with ore at the Mine Site. There is no applicable water quality standard specific to non-asbestiform amphibole mineral fibers. The USEPA has developed drinking water standards for asbestos that drinking water utilities must comply with based upon information on the USEPA website(http://water.epa.gov/drink/contaminants/basicinformation/asbestos.cfm). This standard, an MCL, is 7 million fibers per liter. The USEPA has provided proven methods of water treatment to meet the MCL, including coagulation/filtration, direct and diatomite filtration, and corrosion control.

Water in contact with waste rock, ore, and pit walls would be treated during operations utilizing a greensand filter. No discharge would occur off site during operations. During post-closure, a greensand filter, pre-filters, and a RO system (or equivalent performing technology) would be used to treat water to meet water quality standards prior to discharge. This treated water would be discharged into the West Pit Creek, flows to the Partridge River, which then flows into Colby Lake, the only lake in the area used for drinking water. It is the source of drinking water for the City of Hoyt Lakes. Currently, the City utilizes sand filters, coagulation, and settling and has been in compliance with the USEPA asbestos standard. When the RO treatment or equivalently performing system is constructed at the Mine Site, it would operate in the same fashion as the City’s treatment system. As such, the discharge from the Mine Site is expected to be in compliance with the federal standard prior to it being treated again by the City of Hoyt Lakes.

Nearby Ambient Fiber Monitoring

Baseline ambient air monitoring for mineral fiber concentration is currently being done at Hoyt Lakes. The monitoring location was approved by the MPCA and the monitoring is being conducted according to MPCA methodology. Ambient air monitoring for mineral fibers would also be conducted following facility startup. This would allow the MPCA to compare baseline ambient fiber concentrations with fiber concentrations observed during project activities and with other proposed NorthMet Project Proposed Action emissions.

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5.2.8 Noise and Vibration

This section describes effects on humans, including effects on recreational and cultural/spiritual activity, of noise, vibration, and airblast related to the NorthMet Project Proposed Action. The effects on wildlife are described in Section 5.2.5.

Summary

Both noise and vibration dissipate with distance. The residences closest to the mine are at a distance where blasting and other NorthMet Project Proposed Action-related noise would not be heard. The NorthMet Project Proposed Action would comply with all daytime and nighttime regulatory noise limits at sensitive receptors, and the changes in total noise level from current conditions during nighttime operations would not be perceptible. Immediate access to areas around the mine would be restricted. Members of the general public who may be recreating near the NorthMet Project area and tribal members who may have a cultural and spiritual connection to archeological sites in the Superior National Forest, in areas immediately near the mine, may occasionally experience noise and/or vibration associated with the NorthMet Project Proposed Action.

5.2.8.1 Methodology and Evaluation Criteria

This section describes the methodologies and criteria used to evaluate potential noise, ground vibration, and airblast at areas of the Mine Site and Plant Site. NorthMet Project Proposed Action-related sound levels were estimated using the International Standards Organization (ISO) 9613-2 sound-propagation model. The Site Law Formula was the basis for estimating vibration effects. Airblast was estimated using the Terrock model. Each is a desktop model that estimates project effects using site-specific conditions. Estimated effects were compared to federal, state, or local regulations or to project design standards, as appropriate. For noise and vibration, the area of potential effect was defined as a 20-mile radius from the Mine Site and a 20-mile radius from the Plant Site. The area of potential effect for airblast was the distance from the source where measured effects were below the known level for human effects.

5.2.8.1.1 Noise

Noise Impact Assessment Methodology

The noise impact assessment areas for the NorthMet Project Proposed Action include the noise-sensitive receptors within a 20-mile radius of the Mine Site and a 20-mile radius of the Plant Site. The 20-mile radius was selected in order to include the southern edge of the BWCAW, which is located approximately 20 miles north of the Mine Site and Plant Site. The ISO 9613-2 sound-propagation model (*Acoustics-Attenuation of Sound during Propagation Outdoors)* is accepted worldwide and was used to determine the extent of noise effects from the NorthMet Project Proposed Action. This model is the only one that encompasses a standardized method for calculating sound propagation and is the basis for most sophisticated computer modeling programs (Ray 2010). This sound-propagation model consists of octave-band algorithms with nominal mid-band frequencies from 63 to 8,000 Hz for computing the attenuation of sound originating from a point sound source or an assembly of point sources. The source(s) may be mobile or stationary. The model predicts equivalent continuous A-weighted sound pressure levels (L_{eq}) from sources of known sound emission and accounts for the following site conditions and physical effects:

- Meteorological conditions favorable to sound propagation (i.e., downwind propagation with wind speeds between 1 and 5 meters per second when measured 3 to 11 meters above the ground). This is a conservative approach because not all receptors may be located downwind of the sources (i.e., receptors located upwind would experience less noise since noise propagates farther downwind than upwind).
- Topography and the extent of ground absorption from different surfaces.
- Noise emission of each source, as well as its location and elevation.
- Location and elevation above local ground level of all sensitive receptors.
- Screening from any enclosures, barriers, earth berms, buildings, or vegetation.
- Attenuation due to distance (geometrical divergence) and atmospheric absorption.
- Increase in noise level due to reflections from nearby facades and reflective objects.

For the noise assessment of the NorthMet Project Proposed Action, ground topography or surface effects were modeled assuming that the area around the source and the receptors would be a mixed 50 percent hard non-absorptive ground (e.g., paved surfaces, water, ice, concrete, and all other ground surfaces having a low porosity) and 50 percent soft absorptive surface (e.g., ground covered by grass, trees, and farm land, and all other ground surfaces having a high porosity). This is a conservative assumption, as almost 100 percent of the ground adjacent to the mine sound sources and closest receptors is porous with more absorptive capacity that can attenuate noise levels. Temperature and relative humidity of 20 ºC and 70 percent, respectively, were used in estimating the attenuation due to atmospheric absorption. Attenuation due to geometric divergence or spreading is mainly a function of the distance between the sound source and the receiver. A further conservative assumption is that the modeling analysis did not include any potential shielding effects from pit walls, waste rock stockpiles, berms, or vegetation.

Sound power levels for all equipment and trucks at the Mine Site and Plant Site were based on measured octave-band sound power data obtained from similar mine projects in Australia (Bassett Acoustics 2004; URS 2005). For modeling purposes, it was conservatively assumed that all equipment at the Mine Site and Plant Site would be steady noise sources (except for high-energy impulsive noise from blasting [explosives]) and would operate simultaneously and continuously for 24 hours per day. Impact assessment methodology for blasting noise (i.e., airblast overpressures) discussed in Section 5.2.8.1.2, Vibration and Airblast.

<u>Noise Impact Assessment Criteria</u>

Noise effects are commonly judged according to two general criteria: the extent to which a project would exceed federal, state, or (where applicable) local noise regulations, and the estimated degree of disturbance to people who live in or use an area.

According to the noise standards for Minnesota (*Minnesota Rules*, part 7030.0040, subpart 2), permissible noise levels are broadly classified according to land uses such as residential, commercial, or industrial. The standards distinguish between daytime and nighttime noise, with less noise permitted at night. The standards list the sound levels not to be exceeded for more than

10 and 50 percent of the time (L_{10} and L_{50}) during any 1 hour period. The applicable Minnesota Noise Standards are shown in Table 5.2.8-1. Section 4.2.8 provides additional discussion of common noise levels.

Table 5.2.8-1 Applicable Noise Standards for Different Land Uses in Minnesota

Noise Area Classification[1]	Noise Standard (dBA)			
	Daytime (7 a.m. to 10 p.m.)		Nighttime (10 p.m. to 7 a.m.)	
	L_{50}	L_{10}	L_{50}	L_{10}
1	60.0	65.0	50.0	55.0
2	65.0	70.0	65.0	70.0
3	75.0	80.0	75.0	80.0

Source: *Minnesota Rules*, part 7030.0040, subpart 2; MPCA 2008a.

Note:
[1] The land use activities associated with each Noise Area Classification (NAC) are described in Minnesota Rules, part 7030.0040, subpart 2 and MPCA 2008a.

- Land use activities under NAC 1 include household units, group quarters, residential hotels, transient lodging camp grounds, correctional institutions, mobile home parks or courts, health and educational services, religious activities, resorts, camping and picnicking areas, motion picture production, and other cultural, entertainment, and recreational activities.
- Land use activities under NAC 2 include rail, road, water, and air transportation activities (passenger), wholesale and retail trade, parks, recreational activities (except entertainment assembly and race tracts), automobile parking, personal services, business services, and other professional services (repair, legal, and contract construction services).
- Land use activities under NAC 3 include manufacturing, petroleum refining and related industries, primary metal industries, race tracks, fair grounds and amusement parks, agricultural and fishing-related activities, retail trade (eating and drinking) and transportation, communication, and utilities (except transportation services and arrangements).

As shown in Table 5.2.8-1, the most stringent standard is the nighttime (10 p.m. to 7 a.m.) standard in a NAC 1, which is 50 dBA for no more than 50 percent of the time (L_{50}). In other words, a nighttime L_{50} of 50 dBA means that from 10 p.m. to 7 a.m., noise levels may not exceed 50 dBA more than 30 minutes in an hour. Similarly, a nighttime L_{10} of 55 dBA means that during these same hours, noise levels may not exceed 55 dBA more than 6 minutes in an hour. Land use activities under NAC 1 include household units or private residences, mobile home parks, transient lodging campgrounds and picnic areas, churches, schools, hospitals, and other cultural, entertainment, and recreational activities.

There are no federal or local noise regulations that would apply to the NorthMet Project Proposed Action.

In addition to state and federal standards, the degree of disturbance becomes a key factor in the evaluation of noise effects, which, in this case, includes a focus on residents in the vicinity of the NorthMet Project Proposed Action, as well as people who frequent the area for recreation, fishing, and hunting, and tribal members who may be involved in traditional natural resource harvests on national forest lands. The concept of human disturbance is known to vary with a number of interrelated factors including: changes in noise levels; the presence of other, non-project-related noise sources in the vicinity; people’s attitudes toward the project; the number of people exposed; and the type of human activity affected (e.g., sleep or quiet conversation as compared to physical work or active recreation).

NorthMet Project Proposed Action-related noise effects have been evaluated at sensitive receptors using the state daytime and nighttime noise standards (L_{50} and L_{10}) for NAC 1. These noise standards would apply to the NorthMet Project area throughout the years that the mine is operating (years 1 to 20), when elevated sound level activities from mining, hauling, and crushing operations would occur. The same noise standards would also apply to any potential noise source during closure and post-closure (i.e., after year 20).

Area of Audibility for Boundary Waters Canoe Area Wilderness

Sound from project activities may be audible even if the sound level is lower than the background ambient level. This is because stationary (e.g., drill rigs, crushers) and mobile sources (e.g., dump trucks, graders) associated with mining and crushing activities at the Mine Site and Plant Site may be of a different quality (e.g., electric motor or diesel engine versus a bird call) than natural ambient sound.

It is assumed that noise associated with drilling, excavating, hauling, and crushing activities may be audible up to the location that sound level emitted from these project-related sources attenuates to a level that is 8 dBA below ambient A-weighted sound level. This is identified by the National Park Service at 64 FR 3969-3972 for noise emitted by aircraft that may affect Park visitors. There may be some variability when comparing sound propagation from aircraft engines as done by the National Park Service versus project-related sources (electric motors, diesel engines, etc.). However, for the purpose of this analysis, the 8 dBA method is considered adequate to estimate audible distance from noise sources at the Mine Site and Plant Site. It should be noted that the area of audibility usually applies to certain areas considered by the National Park Service to require substantial restoration of natural quiet (64 FR 3969-3972). For the NorthMet Project Proposed Action, the area of audibility or audibility impacts applies to the BWCAW only. An area of audibility could also be calculated for other non-wilderness receptor locations such as recreational sites within the vicinity of the NorthMet Project area. However, since the area of audibility is based on measured baseline levels for each receptor of concern, separate areas of audibility would be needed for each receptor type. Applying the area of audibility for the BWCAW for other receptor locations is conservative due to the expected higher baseline levels in these areas.

5.2.8.1.2 Vibration and Airblast

Ground Vibration Impact Assessment Methodology

The ground vibration impact assessment area for the NorthMet Project Proposed Action encompasses a 20-mile radius from the Mine Site. When an explosive is detonated in a blasthole, a pressure wave is generated in the surrounding rock. As this pressure wave moves from the borehole, it forms seismic waves by displacing particles in the earth (e.g., glacial till, bedrock). Ground vibration varies with distance from the blast, charge mass per hole, type of explosive, geological conditions, and blasting specifications. For similar geological conditions and blasting specifications, ground vibration varies with distance from the blast and charge mass per hole, according to the Site Law formula. This formula has been used for assessing ground vibration effects from blasting activities at multiple mine and quarry sites in Australia and has also been used in this assessment. The formula accounts for different rock types with a site constant K_g (see note in Table 5.2.8-5 for definition of K_g). Typical K_g factors for free-face hard or highly structured rock, free-face average rock, and heavily confined rock are 500, 1,140, and 5,000, respectively (Dyno Nobel 2010). This vibration assessment has been conducted using a range of these three K_g factors to allow for varying degrees of vibration transmission through different rock types.

Airblast Overpressures Impact Assessment Methodology

The impact assessment area for airblast overpressure (or blasting noise) for the NorthMet Project Proposed Action is the same area that was used to evaluate ground vibration. An airblast is an airborne shock wave that results from the detonation of explosives. The magnitude of airblast overpressure levels at a point remote from the blast is a function of many parameters including charge mass (mass of explosive per drilled hole), confinement, burden (distance between two drilled holes and perpendicular to the free face), attenuation rate, shielding direction relative to the blast, and meteorological conditions at the time of the blast. The attenuation rate for low-frequency blast vibration has been found from experience to be a 9 dBL reduction per doubling of distance (Terrock Consulting Engineers 2009).

Analysis of blasting data from mines and quarries has permitted a relationship to be established between the maximum 120 dBL distance (the distance in front of the blast that the 120 dBL contour occurs), charge mass per hole, and burden using the Terrock model. This model has been used for assessing airblast effects from blasting activities at multiple mine and quarry sites in Australia and has also been used in this assessment. The model accounts for a dimensionless empirical constant, k_a (usually 250 for quarry and mine blasting), and determines the maximum distance to the 120 dBL contour from the blast site.

Ground Vibration and Airblast Overpressure Evaluation Criteria

Humans can feel ground vibration and airblast overpressures at levels well below those that can cause damage to property. Ground vibration and airblast overpressure limits, therefore, have two aspects: an environmental or acceptable human response (annoyance) limit, and a limit to prevent structural damage (which should be considered separately).

To minimize human annoyance and prevent structural damage to properties outside mining areas, the effects of ground vibration and air overpressure from blasting operations must meet the requirements of *Minnesota Rules*, part 6132.2900, subpart 2. According to the *Minnesota Rules*, the maximum PPV from blasting should not exceed 1 in/s (25.4 mm/s) at the location of a structure located on lands not owned or controlled by the permittee. Air overpressure on lands not owned or controlled by the permittee should not exceed 130 dB, as measured on a linear peak scale (dBL) sensitive to a frequency band ranging from 6 cycles per second to 200 cycles per second.

Ground vibration and air blast (overpressure) from rock blasting are primarily related to the weight of explosive detonated at any single instant and the distance to a structure or sensitive receptor.

PolyMet would be required to construct and maintain their own facilities to withstand expected vibration levels and to meet city code requirements. Aside from the *Minnesota Rules*, there are no specific federal or local vibration regulations associated with mine blasting that would apply to the NorthMet Project Proposed Action.

5.2.8.2 NorthMet Project Proposed Action

5.2.8.2.1 Noise

The primary sources of noise from the Mine Site (3,014.5 acres) during operations would be drilling; blasting; excavation work (hydraulic excavators, front-end loaders); dump trucks hauling material along mine haul roads; material-handling activities at the Rail Transfer Hopper, Overburden Storage and Laydown Area, and waste rock stockpiles; and train horns. Noise would also be generated from auxiliary and support equipment such as tracked dozers, wheel dozers, graders, water trucks, backhoes, and fuel trucks. The sound power levels for each of these sources, based on data from operating mines, are summarized in Table 5.2.8-2.

Table 5.2.8-2 Maximum Sound Power Levels of Major Equipment and Trucks during Operations at the Mine Site and Plant Site

Noise Source	Octave Band Center Frequency (Hz)								Overall Linear-Weighted Sound Power Level (dBL)	Overall A-Weighted Sound Power Level (dBA)
Description	**63.0**	**125.0**	**250.0**	**500.0**	**1000.0**	**2000.0**	**4000.0**	**8000.0**		
Mine Site										
Rotary Drill Rig	110.0	123.0	114.0	119.0	111.0	109.0	103.0	98.0	125.0	119.0
Hydraulic Excavator (31-cy)	111.0	122.0	118.0	117.0	115.0	110.0	104.0	99.0	125.0	119.0
Hydraulic Excavator (31-cy)	111.0	122.0	118.0	117.0	115.0	110.0	104.0	99.0	125.0	119.0
Hydraulic Excavator (31-cy)	111.0	122.0	118.0	117.0	115.0	110.0	104.0	99.0	125.0	119.0
Front-end Loader (21.5-cy)	112.0	111.0	112.0	114.0	112.0	112.0	106.0	101.0	120.0	117.0
Tracked Dozer (582-hp)	118.0	118.0	104.0	100.0	104.0	102.0	97.0	92.0	121.0	109.0
Tracked Dozer (582-hp)	118.0	118.0	104.0	100.0	104.0	102.0	97.0	92.0	121.0	109.0
Wheel Dozer (450-hp)	117.0	123.0	119.0	111.0	107.0	101.0	91.0	83.0	125.0	115.0
Grader (275-hp)	111.0	117.0	113.0	105.0	101.0	95.0	85.0	77.0	119.0	109.0
Grader (275-hp)	111.0	117.0	113.0	105.0	101.0	95.0	85.0	77.0	119.0	109.0
Water Truck (937-hp)	107.0	110.0	116.0	114.0	109.0	107.0	101.0	102.0	120.0	116.0
Water Truck (937-hp)	107.0	110.0	116.0	114.0	109.0	107.0	101.0	102.0	120.0	116.0
Wheel Loader (800-hp)	112.0	111.0	112.0	114.0	112.0	112.0	106	101.0	120.0	117.0
Backhoe (110-hp)	111.0	117.0	113.0	105.0	101.0	95.0	85.0	77.0	119.0	109.0
Fuel Truck (150-hp)	111.0	117.0	113.0	105.0	101.0	95.0	85.0	77.0	119.0	109.0
Fuel Truck (150-hp)	111.0	117.0	113.0	105.0	101.0	95.0	85.0	77.0	119.0	109.0

Noise Source Description	Octave Band Center Frequency (Hz)								Overall Linear-Weighted Sound Power Level (dBL)	Overall A-Weighted Sound Power Level (dBA)
	63.0	125.0	250.0	500.0	1000.0	2000.0	4000.0	8000.0		
Mine Site										
Dump Truck (240-ton)	95.0	100.0	109.0	114.0	117.0	116.0	111.0	100.0	121.0	121.0
Dump Truck (240-ton)	95.0	100.0	109.0	114.0	117.0	116.0	111.0	100.0	121.0	121.0
Dump Truck (240-ton)	95.0	100.0	109.0	114.0	117.0	116.0	111.0	100.0	121.0	121.0
Dump Truck (240-ton)	95.0	100.0	109.0	114.0	117.0	116.0	111.0	100.0	121.0	121.0
Dump Truck (240-ton)	95.0	100.0	109.0	114.0	117.0	116.0	111.0	100.0	121.0	121.0
Dump Truck (240-ton)	95.0	100.0	109.0	114.0	117.0	116.0	111.0	100.0	121.0	121.0
Dump Truck (240-ton)	95.0	100.0	109.0	114.0	117.0	116.0	111.0	100.0	121.0	121.0
Dump Truck (240-ton)	95.0	100.0	109.0	114.0	117.0	116.0	111.0	100.0	121.0	121.0
Dump Truck (240-ton)	95.0	100.0	109.0	114.0	117.0	116.0	111.0	100.0	121.0	121.0
Total Sound Power Level from all equipment at the Mine Site	125.0	131.0	128.0	128.0	128.0	127.0	121.0	113.0	136.0	133.0
Plant Site										
Primary Crusher	123.0	123.0	121.0	111.0	106.0	105.0	100.0	94.0	127.0	116.0

Notes:
1 Assumes all mine equipment and trucks would be in continuous operation at any given time at the Mine Site.
2 Sound power levels for all equipment and trucks at the Mine Site were taken from the Noise and Vibration Assessment for the Clermont Coal Mine Project, Queensland Australia, August 2004 (Bassett Acoustics 2004). Sound power levels for backhoe and fuel trucks were not available and were assumed to be the same as for the graders due to their similar hp ratings.
3 Sound power levels for the primary crusher at the Plant Site (116 dBA) were taken from the McArthur River Mine Open Cut Project, Australia (URS 2005).
4 All mine and plant equipment were assumed to be approximately 5 meters from ground level.
5 Total sound power level from all equipment at the Mine Site was calculated by logarithmically adding all the octave-band sound power levels for each piece of equipment at the site.

To estimate potential noise effects on closest receptors, noise from proposed mine operations was modeled using the ISO 9613-2 sound-propagation model, as described in Section 5.2.8.1. The Mine Site assessment predicted effects at nine different receptor locations scattered throughout the vicinity of the site. The closest noise-sensitive areas to the Mine Site are shown on Figure 4.2.8-1; the closest of these is the City of Babbitt, located 6.5 miles north of the Mine Site. In addition to the nine identified receptors, other sensitive receptors such as trails and recreational sites (family campgrounds, camp sites, boating, fishing, swimming, and family picnic areas) within the NorthMet Project are vicinity are also shown on Figure 4.2.8-1.

All major mine equipment and trucks shown in Table 5.2.8-2 were assumed to be steady noise sources (see Section 4.2.8.1, Types of Noise) operating simultaneously and continuously for 24 hours per day. This is a conservative assumption, as most noise sources identified in Table 5.2.8-2 are mobile sources such as dump trucks, fuel trucks, dozer, graders, etc., which are non-steady sources (i.e., fluctuating or intermittent sources) that would not operate simultaneously or continuously for 24 hours per day. Tonal noise may occur as a result of the moving parts of internal combustion engines of mobile sources; however, the overestimated sound power levels resulting from the conservative assumption described above (i.e., that all mobile sources are steady sources operating simultaneously) would likely offset any noise increases associated with tonal sounds. The NorthMet Project Proposed Action would not generate highly impulsive sounds such as drop hammering, pile driving, or pavement breaking. High-energy impulsive sounds associated with the use of explosives during blasting (i.e., blasting noise or airblast overpressures) are discussed in Section 5.2.8.2.2. As indicated in Section 4.2.8.1, Types of Noise, annoyance to sounds with strong low-frequency content is virtually only an indoor problem. Because the closest residences (i.e., indoor receptors) are over 8 and 4 miles from the Mine Site and Plant Site, respectively (see Tables 5.2.8-3 and 5.2.8-4), the likelihood of low-frequency-induced annoyance at such distances is very low.

Modeled sound levels from all mine equipment and trucks experienced at the nearest receptors during daytime and nighttime mine operations (excluding baseline levels and plant sources), are shown in Table 5.2.8-3.

Table 5.2.8-3 Predicted Noise Levels at Nearest Receptors to Mining and Hauling Operations at Mine Site (excludes Baseline Levels)

	Distance to Mine Site (miles)[2]		Daytime Noise Levels at Closest Receptors to Mine Site (excludes Baseline Levels) (dBA)			Nighttime Noise Levels at Closest Receptors to Mine Site (excludes Baseline Levels) (dBA)		
Receptor	**Distance**	**Direction**	**L_{eq}**	**L_{50}**	**L_{10}**	**L_{eq}**	**L_{50}**	**L_{10}**
Private Residences (R-1)	8.4	NW	11.9	10.9	14.7	11.9	10.9	14.7
Hoyt Lakes (R-2)	10.3	SW	9.1	8.1	11.9	9.1	8.1	11.9
Boy Scout Camp (R-3)	12.3	SW	6.7	5.7	9.5	6.7	5.7	9.5
Babbitt (R-4)	6.5	N	15.2	14.2	18.0	15.2	14.2	18.0
Skibo (R-5)	9.1	S	10.8	9.8	13.6	10.8	9.8	13.6
Aurora (R-6)	13.8	SW	5.1	4.1	7.9	5.1	4.1	7.9
Ely (R-7)	20.4	N-NE	0.0	0.0	3.8	0.0	0.0	3.8
BWCA Wilderness (R-8)	21.9	N	0.0	0.0	3.8	0.0	0.0	3.8
Tower (R-9)	19.3	NW	0.3	0.0	3.8	0.3	0.0	3.8

Note:
[1] N = North, S = South, E = East, W = West, NW = Northwest, NE = Northeast, SW = Southwest

Table 5.2.8-3 indicates that the highest noise levels that would be experienced during operations at the Mine Site would occur at the closest receptors in Babbitt. Excluding baseline levels, L_{50} and L_{10} noise levels from the Mine Site are 14.2 and 18.0 dBA, respectively. Due to the low noise contribution from the Mine Site sources, total L_{50} and L_{10} noise levels at Babbitt and other receptors during daytime and nighttime, inclusive of baseline noise levels, would remain the same (i.e., no change in baseline levels when combined with Mine Site noise levels). The predicted L_{eq} at noise-sensitive receptors around the Mine Site were converted to L_{50} and L_{10} using a USEPA calculation methodology (USEPA 1974). The calculation was based on an assumed standard deviation of 3 dBA for sound level distribution.

The primary sources of noise along the Transportation and Utility Corridor would be trains and train horns used during ore transport from the Mine Site to the Plant Site. The noise from the trains and their horns is expected to have minimal effects because the railroad route between the two locations is approximately 4 to 5 miles from the nearest receptors. Up to 22 trains per day are expected to deliver ore to the Plant Site. This frequency of traffic is less than that experienced on the rail line during past mining operations.

The primary sources of noise from the Plant Site would be crushers. Noise from other sources such as pumps at the existing LTVSMC Tailings Basin is expected to be minor in comparison to noise from the crushers, and, as such, was not quantified. The sound power level for the crushers was estimated to be 116 dBA (Table 5.2.8-2). Sound-propagation modeling was performed for the crushers using the ISO 9613-2 sound-propagation model and assumptions described in Section 5.2.8.1. Modeled sound levels experienced at the nearest receptors during ore-crushing operations, plus baseline levels (excluding baseline levels and mine sources), are shown in Table 5.2.8-4.

Table 5.2.8-4 Predicted Noise Levels at Nearest Receptors to Ore-crushing Operations at Plant Site (excludes Baseline Levels)

Receptor	Distance to Mine Site (miles)[2]		Daytime Noise Levels at Closest Receptors to Plant Site (excludes Baseline Levels) (dBA)			Nighttime Noise Levels at Closest Receptors to Plant Site (excludes Baseline Levels) (dBA)		
	Distance	Direction	L_{eq}	L_{50}	L_{10}	L_{eq}	L_{50}	L_{10}
Private Residences (R-1)	4.2	N	14.5	13.5	17.3	14.5	13.5	17.3
Hoyt Lakes (R-2)	5.6	S	11.0	9.9	13.8	11.0	9.9	13.8
Boy Scout Camp (R-3)	6.5	S	9.2	8.2	12.0	9.2	8.2	12.0
Babbitt (R-4)	11.8	NE	2.1	1.1	4.9	2.1	1.1	4.9
Skibo (R-5)	10.5	SE	3.5	2.5	6.3	3.5	2.5	6.3
Aurora (R-6)	6.7	SW	9.0	7.9	11.8	9.0	7.9	11.8
Ely (R-7)	24.4	NE	0.0	0.0	3.8	0.0	0.0	3.8
BWCA Wilderness (R-8)	23.0	N	0.0	0.0	3.8	0.0	0.0	3.8
Tower (R-9)	15.4	NW	0.0	0.0	3.8	0.0	0.0	3.8

Note:
[1] N = North, S = South, NW = Northwest, NE = Northeast, SW = Southwest, SE = Southeast

Table 5.2.8-4 indicates the highest nighttime L_{50} and L_{10} levels that would be experienced at the closest receptor (private residences, 4.2 miles north of the Plant Site) due to operations at the Plant Site are 13.5 and 17.3 dBA, respectively, exclusive of baseline levels. Due to the low noise contribution from the Plant Site crushers, total L_{50} and L_{10} at the private residences and other receptors during daytime and nighttime, inclusive of baseline noise levels, would remain the same (i.e., no change in baseline levels at closest receptors when combined with Plant Site noise levels).

PolyMet plans to relocate the coal ash landfill from its current location to disposal in the hydrometallurgical residue facility. This relocation of the coal ash landfill would result in temporary noise associated with the use of tracked excavators or front-end loaders for removing fill materials, truck movements along a 2.5-mile haul road to the future Hydrometallurgical Residue Facility, and other construction equipment such as a grader, dozer, and water truck. These activities would be short-term (approximately 50 shifts with 8 hours per shift) and would occur mostly during daytime when noise increases are more tolerable. In addition, there are no noise sensitive receptors in close proximity or within a 1-mile radius of these activities. Based on the information above, noise impacts associated with the relocation of the coal ash landfill would not exceed applicable evaluation criteria.

Aside from the relocation of the landfill, PolyMet also plans to replace the existing conventional ball mills at the Plant Site with semi-autogenous mills. The sound power levels for the replacement semi-autogenous mills are expected to generate a less or equal amount of noise level when compared to the existing ball mills and, as such, are not likely to result in any noise increases. Therefore, noise impact from this change would not exceed applicable evaluation criteria.

The total combined noise effect from operations at the Mine Site, Transportation and Utility Corridor, and Plant Site plus baseline levels is discussed in Section 5.2.8.2.3, Total Noise Effects from NorthMet Project Proposed Action Operations. The area of audibility and noise effects on off-site transportation are also discussed in Section 5.2.8.2.3.

5.2.8.2.2 Ground Vibration and Airblast Overpressure

The potential for ground vibration from hauling material via dump trucks along the mine haul road is expected to be low since rubber-tired vehicles do not generate any significant amount of ground vibration. However, blasting at the Mine Site could affect surrounding (off-site) residential receptors and structures or buildings with regard to ground vibration and airblast overpressure. Blasting could also affect Mine Site infrastructure such as wooden transmission power poles, the electrical substation, water pipelines, railway lines and infrastructure, and fixed mine plant and industrial buildings. The potential effects of ground vibration and airblast overpressure are discussed below. PolyMet has committed to develop an ore and rock blasting program with industry standard methods and experiences from other area mines, including blast vibration damage prevention and monitoring.

Ground Vibration from Blasting at the Mine Site

Except at very close distances to a blast, when permanent ground displacement could occur, ground vibration is an elastic wave motion and the ground returns to its original position after the wave passes. The attenuation rate varies based on the characteristics of the rock through which the vibration travels. Characteristics such as faults and jointing planes, degree and depth of weathering, and the top soil profile contribute to a wide variation of vibration levels.

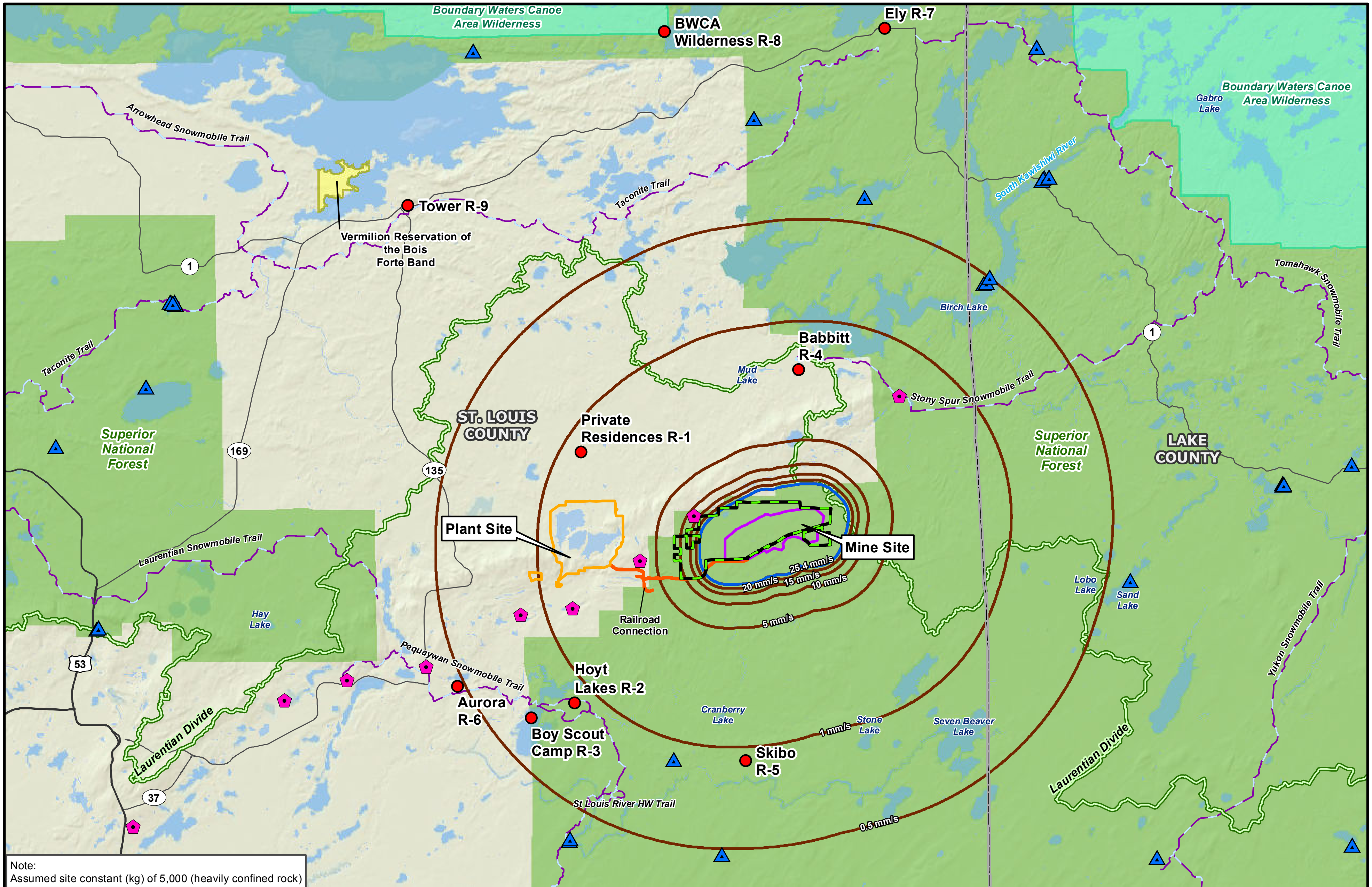
The potential effect of ground vibration from blasting at the Mine Site was assessed using the Site Law formula, as described in Section 5.2.8.1. The vibration assessment was conducted over a range of K_g factors that represent the vibration transmission through different types of ore or waste rock. Using the Site Law formula and appropriate blast parameters, the limiting distances (i.e., distances beyond which an effect would not occur using different K_g factors) for ore and waste rock blasts at incremental ground vibration levels for off-site structures and Mine Site infrastructure were calculated and are shown in Table 5.2.8-5. Ground vibration contours from blasting at the Mine Site are shown on Figure 5.2.8-1 (based on a maximum K_g factor of 5,000 for heavily confined rocks).

Table 5.2.8-5 Limiting Distances for Ore and Waste Rock Blasts at Incremental Ground Vibration Levels

Ground Vibration, PPV	**Limiting Distance from Blast, D (m)[1]**		
(mm/sec)	k_g = 500	k_g = 1,140	k_g = 5,000
25.4	375	627	1,581
20	435	728	1,835
15	521	872	2,197
10	671	1,123	2,830
5	1,035	1,733	4,365
3	1,424	2,384	6,007
1	2,830	4,738	11,936
0.5	4,365	7,306	18,407

Notes:
kg = Site specific empirical constant for predicting ground vibration levels (dimensionless). Usually determined by site calibration. Typical K_g factors for free face hard /highly structured rock, free face average rock, and heavily confined rock are 500, 1140, and 5000, respectively.

[1] Limiting distances for predicting ground vibration levels from blasting were estimated based on the charge mass per hole (3,388 kg/hole). The charge mass per hole was estimated using the blast parameters and specification for this project such as blasthole diameter (311 mm), hole length (22.6 m), burden (8.84 m), spacing (10.1 m), and explosive density (1.69 kg/m^3).



Noise Sensitive Receptor
Federal Lands
Plant Site
Mine Site
Transportation and Utility Corridor
Recreational Site
Native American Reservation
Boundary Waters Canoe Area Wilderness
National Forest
Wildlife Travel Corridor
Ground Vibration Contours
Minnesota Ground Vibration Limit (25.4 mm/s)

MNDNR
US Army Corps of Engineers St. Paul District

0 1 2 4 6 Miles

Figure 5.2.8-1
Predicted Ground Vibration Contours from Blasting at the Mine Site
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The environmental effects of blasting at non-ferrous mining operations are regulated by the MDNR to ensure that the effects of ground vibrations from production blasts would not be detrimental to human health or welfare or property outside the mining area. According to *Minnesota Rules,* part 6132.2900, subpart 2*,* the maximum PPV from blasting shall not exceed 1 in/s (25.4 mm/s) at the location of a structure located on lands not owned or controlled by the permittee. Assuming a worst-case K_g of 5,000 (heavily confined rocks) and 3,388 kg (7,471 lbs) of explosives per blast hole, the limiting distance for blasts at ground vibration levels of 25.4 mm/s (1 in/s) is 1,581 meters (0.98 mile) and the impact area for this Minnesota ground vibration limit is approximately 11,334 acres (see Table 5.2.8-5; Figure 5.2.8-1). None of the human or structural receptors (off-site) are located within this ground vibration impact area. The maximum ground vibration level for the closest human or structural receptor in the City of Babbitt, 6.5 miles north of the Mine Site, from the blast site is predicted to be on the order of 1.24 mm/s (0.05 in/s). The predicted ground vibration at all nearby human and structural receptors resulting from blasting at the Mine Site would be well below the applicable limits in Minnesota. Blasting would not occur at night.

For Mine Site infrastructure, assuming a worst-case K_g of 5,000 (heavily confined rocks) and 3,388 kg (7,471 lbs) of explosives per blast hole, the limiting distance for blasts at ground vibration levels ranging from 100 to 300 mm/s (3.93 to 11.8 in/s) are 671 and 338 meters (0.42 and 0.21 miles), respectively. Most of the Mine Site infrastructure is outside the calculated limiting distance for blasts; however, some infrastructure, such as the transmission lines and process water pipes, may be located around the mine pit edges (see Figures 3.2-5 to 3.2-8) and could be within these limiting distances if blasting were conducted at the mine pit edges. Because this is a conservative worst-case assessment, PolyMet would be required to construct and maintain their own facilities to withstand expected vibration levels and meet city code requirements. Ground vibration could be controlled at these locations (i.e., infrastructure around mine pit edges) by limiting the charge mass per hole.

Figure 5.2.8-1 shows that there are no residences, recreational sites, trails, or MPCA staff recommended wild rice waters within the Minnesota ground vibration impact area (i.e., the Minnesota ground vibration limit of 25.4 mm/s, which is the blue contour line on the figure [11,334 acres]). The closest recreational site is a family picnic area located approximately 9 miles south of the Mine Site and Plant Site (near Skibo). This family picnic area as well as other recreational sites located further away such as those near Birch Lake and South Kawishiwi River are outside the impact area. The closest wildlife corridor located northeast of the Mine Site is also outside the impact area. The Upper St. Louis River contains wild rice beds used by tribal members for traditional resource harvests. The wild rice beds are usually in close proximity to draft MPCA staff-recommended wild rice waters such as Mud Lake and Birch Lake (north of Mine Site), Lobo Lake and Sand Lake (east of Mine Site), Stone Lake and Seven Beaver Lake (southeast of Mine Site), Cranberry Lake (south of Mine Site), and Hay Lake (west of Plant Site). There are no wild rice beds or draft MPCA staff-recommended wild rice waters within the impact area.

Though not depicted on Figure 5.2.8-1 due to sensitivity regarding cultural resources and locations, three archaeological sites have been identified within the NorthMet Project area: Spring Mine Lake Sugarbush, *Mesabe Widjiu* [Laurentian Divide], and BBLV Trail Segment #1 (USFS #01-569). The Spring Mine Lake Sugarbush and the *Mesabe Widjiu* are located more than 2 miles away from the Mine Site (approximately 1 mile from the Plant Site). Since ground vibration impacts from blasting at the Mine Site would be experienced less than a mile from the blast site, both archaeological sites are expected to be outside the ground vibration impact area (11,334 acres). The Partridge River Segment of the BBLV Trail, used by the Ojibwe people for hundreds of years, remains an important cultural and spiritual connection for the Bands. The BBLV Trail Segment #1 (USFS #01-569) crosses the NorthMet Project area. Portions of the trail segment that cross the Mine Site are expected to be within the ground vibration impact area and may experience ground vibration levels close to the Minnesota standards. Details of the location and uses of the archaeological sites are discussed in Section 4.2.9, Cultural Resources.

Based on the information above, ground vibration levels from mine blasting are expected to be below the Minnesota ground vibration standards for humans and off-site structures (*Minnesota Rules,* part 6132.2900, subpart 2), including people that use the Superior National Forest for recreational activities such as family campgrounds, camp sites, fishing, boating, swimming, and family picnic areas. Immediate access to areas around the Mine Site would be restricted, but tribal members who may have a cultural and spiritual connection to archaeological sites in the Superior National Forest, in areas immediately near the mine, may occasionally experience ground vibration associated with the NorthMet Project Proposed Action. Mitigation measures for the impacted cultural resource areas are discussed in Section 5.2.9, Cultural Resources. During the closure and post-closure phases (i.e., after year 20), blasting at the Mine Site would cease, so no blast-related ground vibration would occur. Machinery, such as planters used to restore and rehabilitate the Mine Site during the closure phase, would not generate a significant amount of ground vibration. Therefore, potential ground vibration levels during the closure and post-closure phases are expected to be below the Minnesota ground vibration standards for humans and structures (*Minnesota Rules,* part 6132.2900, subpart 2).

Airblast Overpressure from Blasting at the Mine Site

The airblast overpressure (or blasting noise) effect from the Mine Site was assessed using the Terrock model, as described in Section 5.2.8.1. Using this analytical method for ore and/or waste rock blasts at the Mine Site, the 120 dBL distance for the assumed blast specifications is a maximum of 3,451 meters (2.2 miles) in front of the blast (see Table 5.2.8-6). The incremental distances for airblast overpressure levels from 100 to 130 dBL were calculated using an attenuation rate of a 9 dBL decrease per doubling of distance (Terrock Consulting Engineers 2009). Airblast contours for these overpressure levels from blasting at the Mine Site are shown on Figure 5.2.8-2.

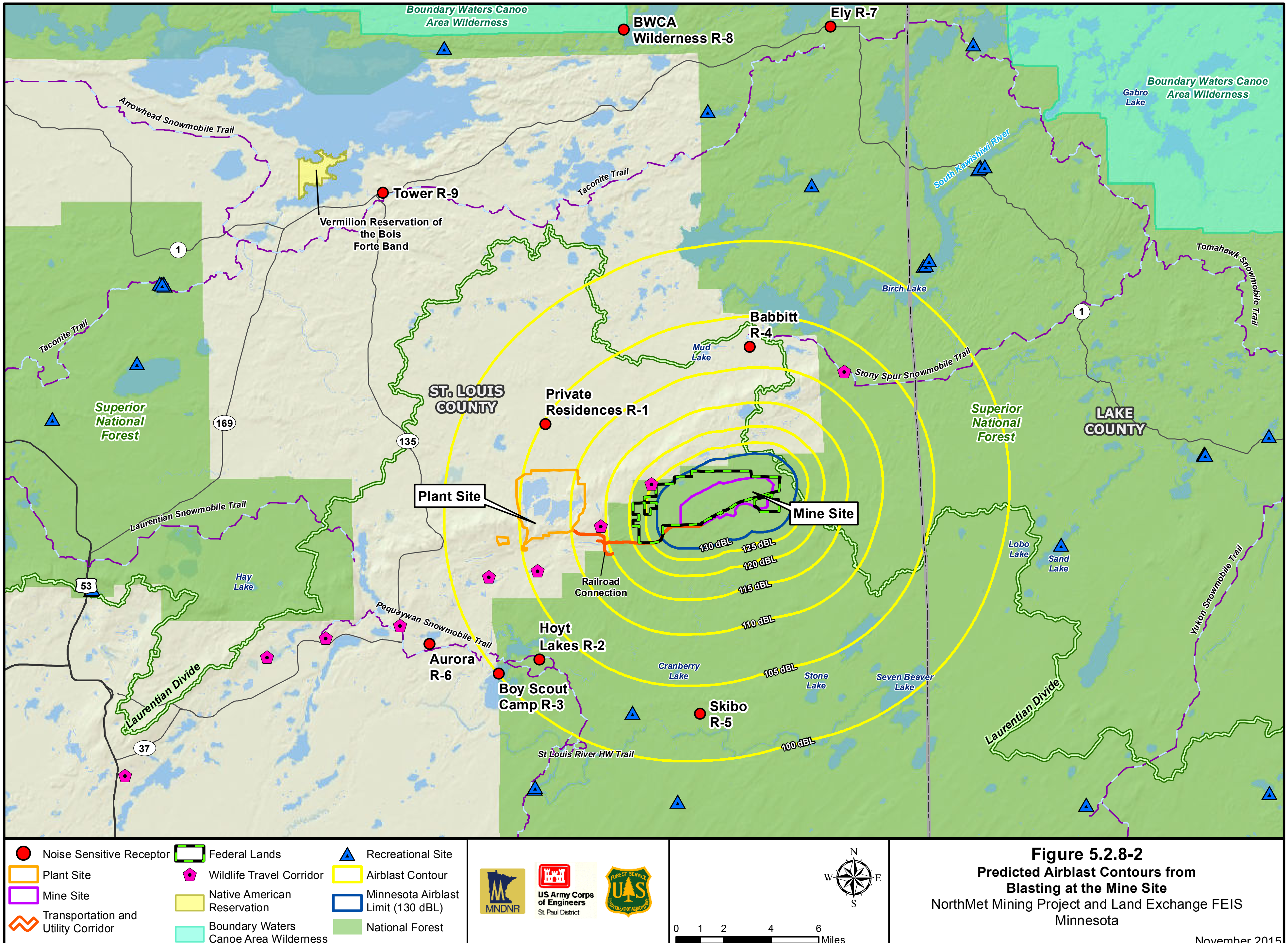

Figure 5.2.8-2
Predicted Airblast Contours from Blasting at the Mine Site
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Table 5.2.8-6 Limiting Distances for Ore and Waste Rock Blasts at Incremental Airblast Overpressure Levels

Hole Diameter, d (mm)	Burden, B (mm)	Charge Mass per Hole, M (kg/hole)	Distance to the 120 dBL Contour, D_{120} (m)	Distance to the 130 dBL Contour, D_{130} (m)	Distance to the 125 dBL Contour, D_{125} (m)	Distance to the 115 dBL Contour, D_{115} (m)	Distance to the 110 dBL Contour, D_{110} (m)	Distance to the 105 dBL Contour, D_{105} (m)	Distance to the 100 dBL Contour, D_{100} (m)
311	8,839	3,388	3,451	1,602	2,351	5,065	7,434	10,912	16,016

Note:
Based on the computed distance for the 120 dBL contours, the distances for the other airblast contour levels (130 dBL, 125 dBL, 115 dBL, 110 dBL, 105 dBL, and 100 dBL) were calculated using an attenuation rate of 9 dBL decrease per doubling of distance.

As with ground vibration, the environmental effects of airblasts are regulated by the MDNR. According to *Minnesota Rules*, part 6132.2900, subpart 2, air overpressure on lands not owned or controlled by the permittee shall not exceed 130 dBL. The distance from the Mine Site to the 130 dBL compliance level is 1,602 meters (1 mile) and the impact area for this Minnesota airblast overpressure limit is approximately 11,469 acres. None of the receptors (buildings or structures) is close enough to the Mine Site to achieve this level of exposure (Figure 5.2.8-2). The maximum airblast overpressure level for the closest receptor in the City of Babbitt is predicted to be approximately 106 dBL. The predicted airblast overpressures at all nearby receptors resulting from blasting activities at the Mine Site would be below the applicable limits in Minnesota. Blasting would not occur at night.

Figure 5.2.8-2 shows that there are no residences, recreational sites, trails, or state wild rice beds within the Minnesota airblast overpressure impact area (11,469 acres). The closest recreational site is a family picnic area located approximately 9 miles south of the Mine Site and Plant Site (near Skibo). This family picnic area as well as other recreational sites located further away such as those near Birch Lake and South Kawishiwi River are outside the impact area. The closest wildlife corridor located northeast of the Mine Site is also outside the impact area.

Though not depicted on Figure 5.2.8-2 due to sensitivity regarding cultural resources and locations, three archaeological sites have been identified within the NorthMet Project area: Spring Mine Lake Sugarbush, *Mesabe Widjiu* [Laurentian Divide], and BBLV Trail Segment #1 (USFS #01-569). The Spring Mine Lake Sugarbush and the *Mesabe Widjiu* are located more than 2 miles away from the Mine Site and (approximately 1 mile from the Plant Site). Since airblast impacts from blasting at the Mine Site would be experienced approximately 1 mile from the blast site, both archaeological sites would be outside the airblast impact area (11,469 acres). As noted previously, the BBLV Trail Segment #1 (USFS #01-569) crosses the NorthMet Project area. Portions of the trail segment that cross the Mine Site would be within the airblast impact area and may experience airblast levels close to the Minnesota standards. Details of the location and uses of the archaeological sites are discussed in Section 4.2.9, Cultural Resources.

Based on the information above, airblast overpressure levels from mine blasting would be below the Minnesota airblast standards for humans and structures (*Minnesota Rules,* part 6132.2900, subpart 2); including people that use the Superior National Forest for recreational activities such as family campgrounds, camp sites, hiking, fishing, boating, swimming, and family picnic areas. Immediate access to areas around the mine would be restricted, but tribal members who may have a cultural and spiritual connection to archaeological sites in the Superior National Forest, in areas immediately near the mine, may occasionally experience airblast overpressures associated with the NorthMet Project Proposed Action. Mitigation measures for the impacted cultural resource areas are discussed in Section 5.2.9, Cultural Resources.

During the closure and post-closure phases (i.e., after year 20), blasting at the Mine Site would cease, so no airblast overpressures would occur during the closure and post-closure phases.

Vibration and Airblast Overpressure from Rail Transport

The transport of ore via trains from the Mine Site to the Plant Site could generate ground vibration within a few ft of the rail ROW, but due to the low volume of trains, such vibration levels are expected to be below the Minnesota ground vibration standards for humans and structures (*Minnesota Rules,* part 6132.2900, subpart 2). No blasting would occur along the Transportation and Utility Corridor, so ground vibration or airblast overpressure effects are not expected in this area.

Vibration and Airblast Overpressure at Plant Site

The crushers, water pumps (near the Tailings Basin) and other large stationary equipment that would be located at the Plant Site are designed to ensure that potential ground vibration effects are minimized to acceptable levels. Therefore, during operation, vibration levels at the receptors closest to the Plant Site would be below the Minnesota vibration standards for humans and structures (*Minnesota Rules,* part 6132.2900, subpart 2). No blasting would occur at the Plant Site, so ground vibration or airblast overpressure effects are not expected.

5.2.8.2.3 Total Noise Effects from NorthMet Project Proposed Action Operations

To determine the combined noise effect of the NorthMet Project Proposed Action, the total noise generated from operations at both the Mine Site and Plant Site was logarithmically added to the existing ambient daytime and nighttime baseline levels. Noise effects from rail transport were also assessed, but qualitatively.

Operations at the Mine Site and Plant Site would occur 24 hours per day. The total noise that would be experienced at any receptor location during the daytime (7 a.m. to 10 p.m.) and nighttime (10 p.m. to 7 a.m.) would be equal to the combined noise from both the mining and hauling operations at the Mine Site and the ore-crushing operations at the Plant Site, plus baseline noise levels.

Decibels are logarithmic values, so calculating the additive effect of two separate noise sources is a logarithmic calculation rather than an algebraic addition. This means that individual sound levels cannot be added directly to get the combined sound level. This also means that the greater the distance between two sound levels, the smaller the effect the lesser dB level would have on the total sound level.

The total noise associated with NorthMet Project Proposed Action operations when mining, hauling, and ore-crushing operations occur concurrently was calculated using data from Tables 5.2.8-3 (Mine Site) and 5.2.8-4 (Plant Site), along with baseline noise levels, and is summarized in Table 5.2.8-7. The calculations for daytime and nighttime noise levels are presented for comparison with the Minnesota noise standards. Aside from comparison to absolute noise limits, the NorthMet Project Proposed Action was also evaluated based on projected noise increases above baseline levels (i.e., 3 dB threshold of perception per MPCA 2008a). In all cases, the

NorthMet Project Proposed Action, when in operation, would comply with the applicable standard. Figures 5.2.8-3, 5.2.8-4, 5.2.8-5, and 5.2.8-6 show L_{50} and L_{10} noise contours at 5 dBA intervals during the daytime and nighttime.

Table 5.2.8-7 Total Noise Associated with Concurrent Operations at the Mine Site and Plant Site (includes Baseline Levels)

Receptor	Daytime and Nighttime Baseline Noise Levels (dBA)			Daytime Noise Levels at Closest Receptors to Mine Site and Plant Site Operations (plus Baseline Levels)[1], (dBA)			Nighttime Noise Levels at Closest Receptors to Mine Site and Plant Site Operations (plus Baseline Levels), (dBA)			Minnesota Daytime and Nighttime Noise Standards for Residential Areas (dBA)		
	L_{eq}	L_{50}	L_{10}	L_{eq}	L_{50}	L_{10}	L_{eq}	L_{50}	L_{10}	L_{eq}	L_{50}	L_{10}
Private Residences (R-1)	45.0 dBA (D); 35.0 dBA (N)	44.0 dBA (D); 34.0 dBA (N)	48.8 dBA (D); 37.8 dBA (N)	45.0	44.0	48.8	35.1	34.1	37.9	NA	60.0 dBA (D); 50.0 dBA (N)	65.0 dBA (D); 55.0 dBA (N)
Hoyt Lakes (R-2)	45.0 dBA (D); 35.0 dBA (N)	44.0 dBA (D); 34.0 dBA (N)	48.8 dBA (D); 37.8 dBA (N)	45.0	44.0	48.8	35.0	34.0	37.8	NA	60.0 dBA (D); 50.0 dBA (N)	65.0 dBA (D); 55.0 dBA (N)
Boy Scout Camp (R-3)	45.0 dBA (D); 35.0 dBA (N)	44.0 dBA (D); 34.0 dBA (N)	48.8 dBA (D); 37.8 dBA (N)	45.0	44.0	48.8	35.0	34.0	37.8	NA	60.0 dBA (D); 50.0 dBA (N)	65.0 dBA (D); 55.0 dBA (N)
Babbitt (R-4)	45.0 dBA (D); 35.0 dBA (N)	44.0 dBA (D); 34.0 dBA (N)	48.8 dBA (D); 37.8 dBA (N)	45.0	44.0	48.8	35.0	34.0	37.8	NA	60.0 dBA (D); 50.0 dBA (N)	65.0 dBA (D); 55.0 dBA (N)
Skibo (R-5)	45.0 dBA (D); 35.0 dBA (N)	44.0 dBA (D); 34.0 dBA (N)	48.8 dBA (D); 37.8 dBA (N)	45.0	44.0	48.8	35.0	34.0	37.8	NA	60.0 dBA (D); 50.0 dBA (N)	65.0 dBA (D); 55.0 dBA (N)
Aurora (R-6)	45.0 dBA (D); 35.0 dBA (N)	44.0 dBA (D); 34.0 dBA (N)	48.8 dBA (D); 37.8 dBA (N)	45.0	44.0	48.8	35.0	34.0	37.8	NA	60.0 dBA (D); 50.0 dBA (N)	65.0 dBA (D); 55.0 dBA (N)
Ely (R-7)	45.0 dBA (D); 35.0 dBA (N)	44.0 dBA (D); 34.0 dBA (N)	48.8 dBA (D); 37.8 dBA (N)	45.0	44.0	48.8	35.0	34.0	37.8	NA	60.0 dBA (D); 50.0 dBA (N)	65.0 dBA (D); 55.0 dBA (N)
BWCA Wilderness (R-8)	34.0 dBA (D); 34.0 dBA (N)	23.4 dBA (D); 23.4 dBA (N)	33.2 dBA (D); 33.2 dBA (N)	34.0	23.4	33.2	34.0	23.4	33.2	NA	60.0 dBA (D); 50.0 dBA (N)	65.0 dBA (D); 55.0 dBA (N)
Tower (R-9)	45.0 dBA (D); 35.0 dBA (N)	44.0 dBA (D); 34.0 dBA (N)	48.8 dBA (D); 37.8 dBA (N)	45.0	44.0	48.8	35.0	34.0	37.8	NA	60.0 dBA (D); 50.0 dBA (N)	65.0 dBA (D); 55.0 dBA (N)

Notes:

D= Daytime; N = Nighttime; NA = Not applicable (there are no L_{eq} standards for noise under the Minnesota Noise Standards).

[1] Total noise levels during daytime and nighttime were estimated by logarithmically adding the predicted noise levels from operations at the Mine Site (Table 5.2.8-3) and Plant Site (Table 5.2.8-4) with the existing baseline noise levels (baseline levels are provided in Table 4.2.8-3).

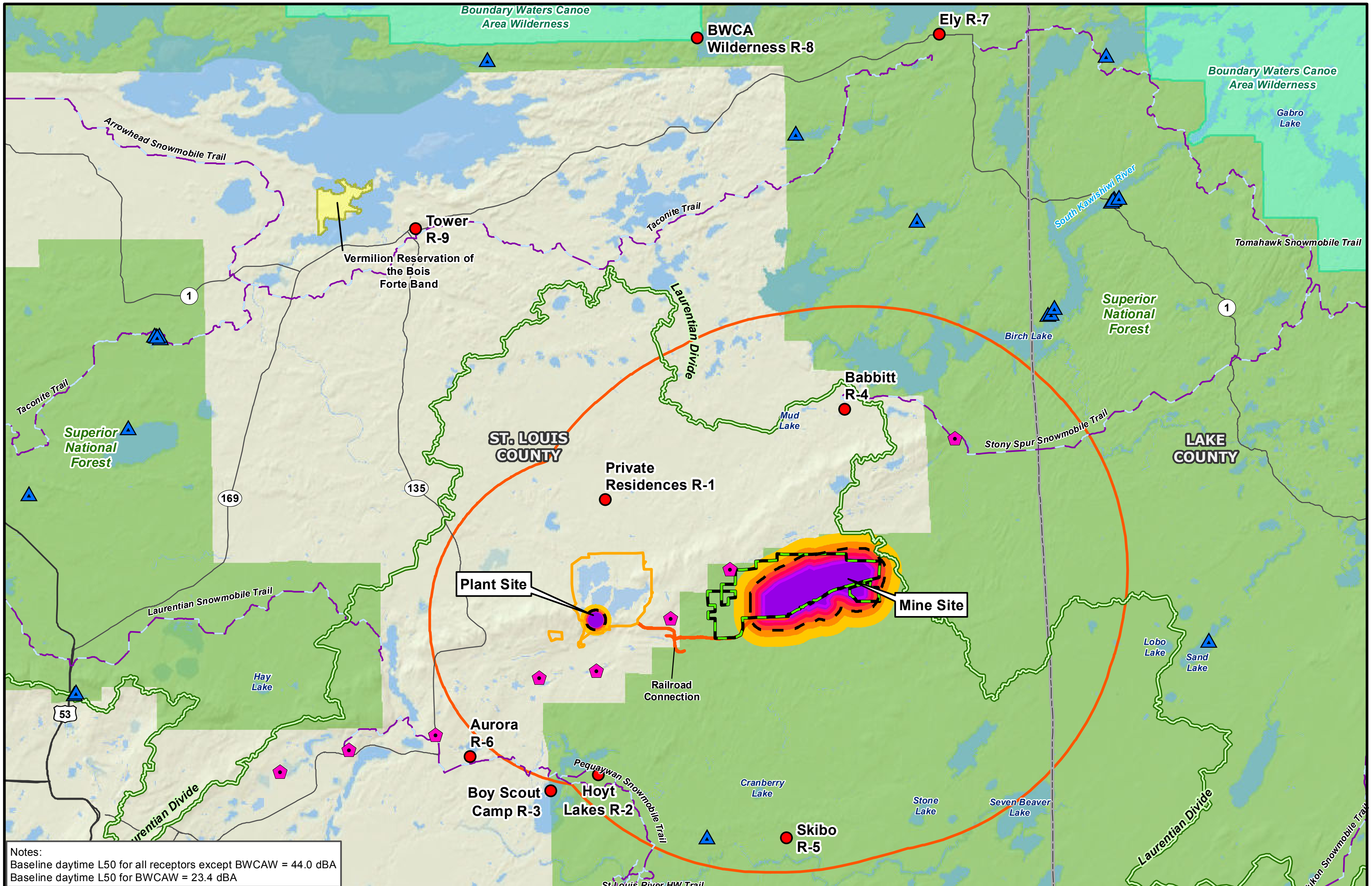

Figure 5.2.8-3

Predicted Daytime L50 Noise Contours at Closest Receptors (Includes Baseline L50 Levels)

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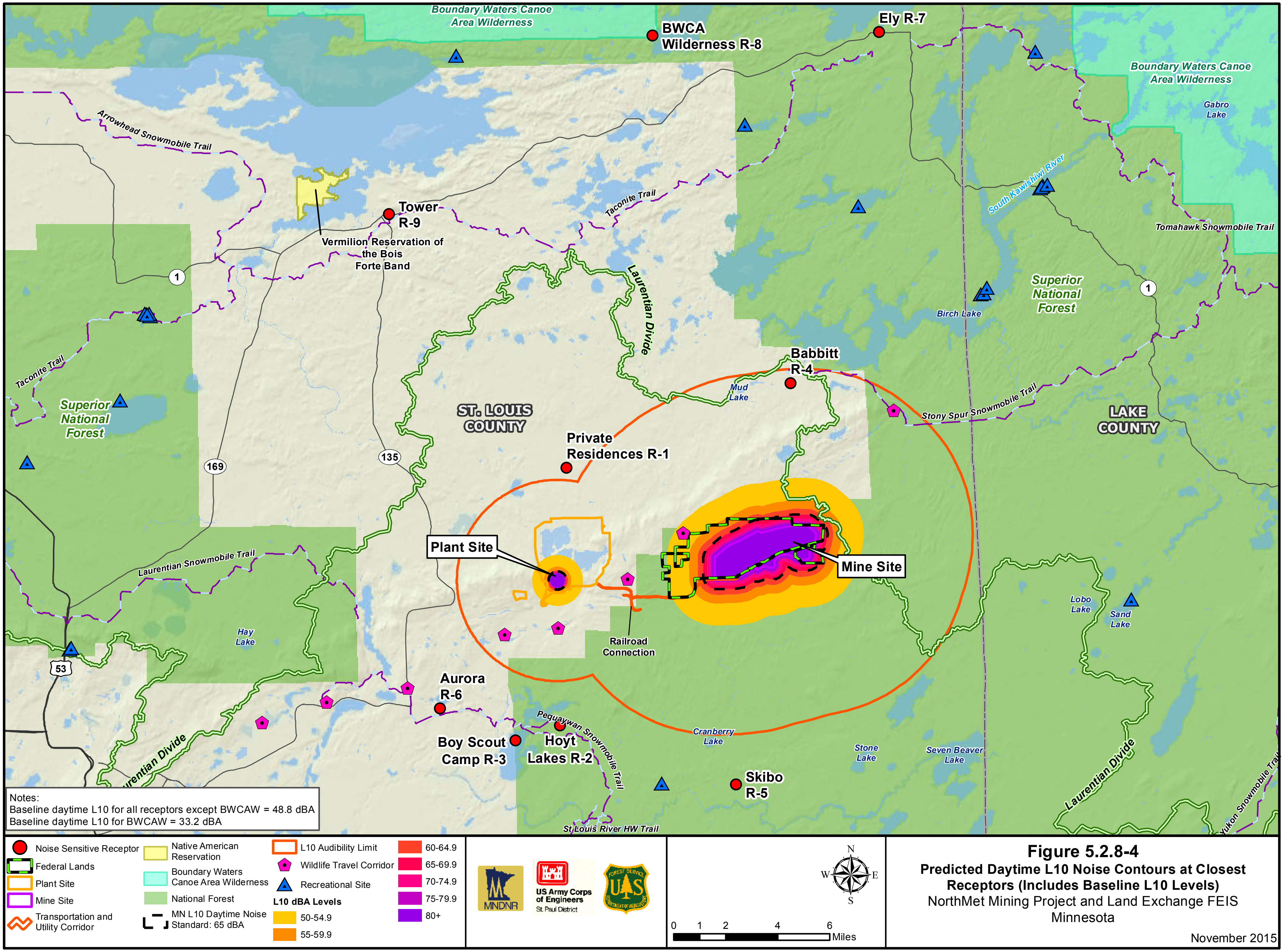

Figure 5.2.8-4
Predicted Daytime L10 Noise Contours at Closest Receptors (Includes Baseline L10 Levels)
NorthMet Mining Project and Land Exchange FEIS
Minnesota

November 2015

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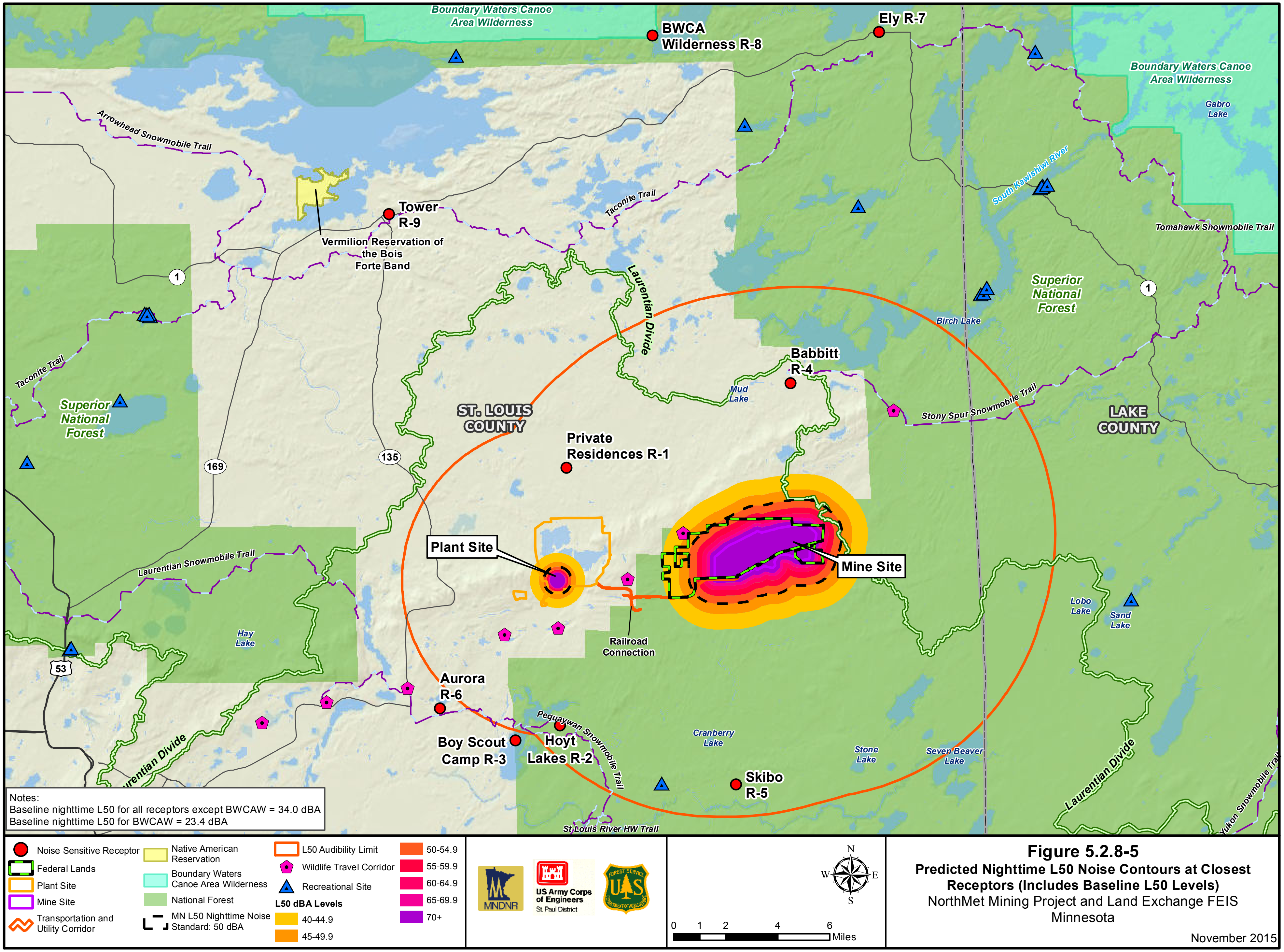

Figure 5.2.8-5

Predicted Nighttime L50 Noise Contours at Closest Receptors (Includes Baseline L50 Levels)

NorthMet Mining Project and Land Exchange FEIS

Minnesota

November 2015

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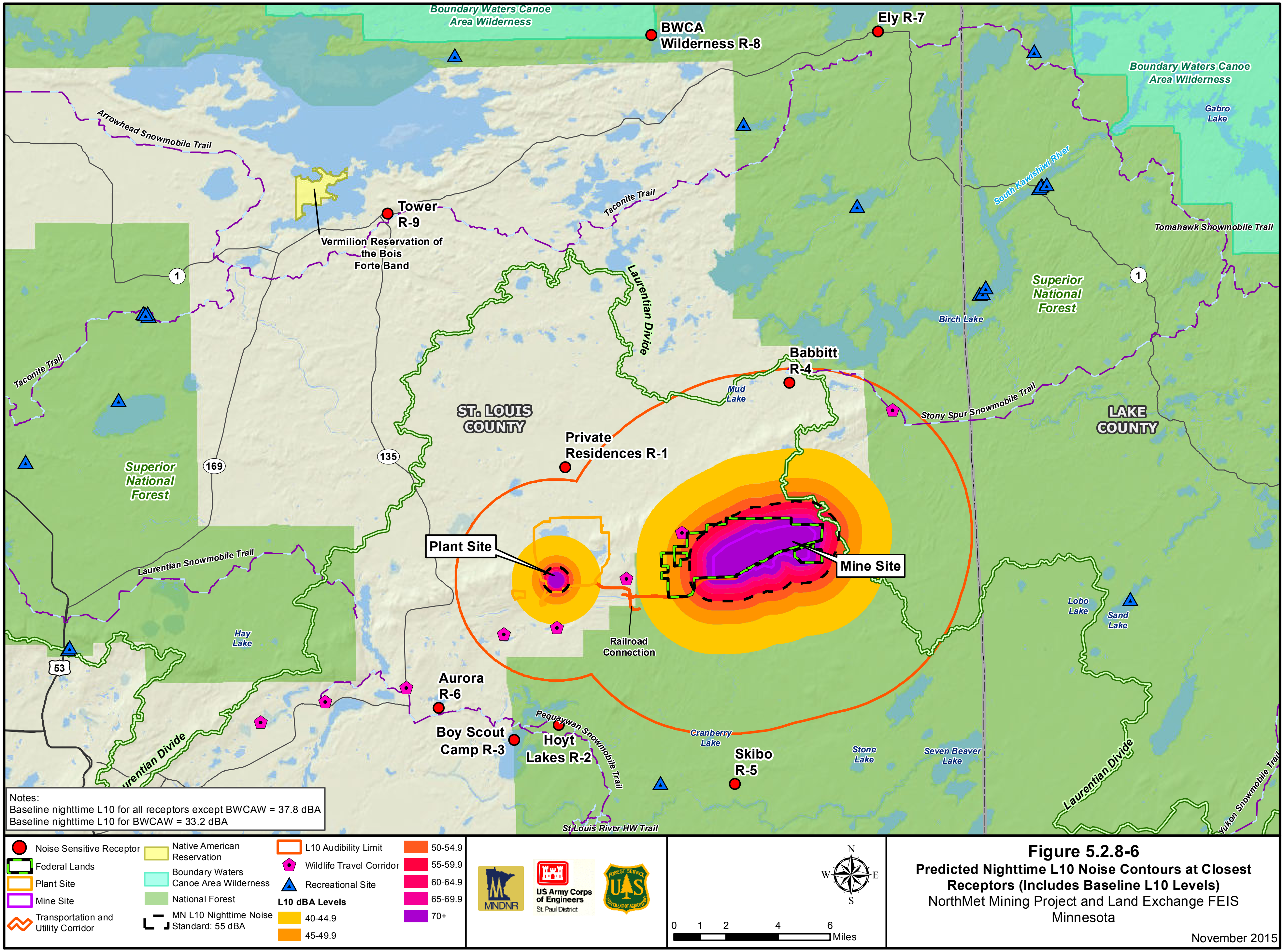

Figure 5.2.8-6

Predicted Nighttime L10 Noise Contours at Closest Receptors (Includes Baseline L10 Levels)

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Daytime Operation Impacts (7 a.m. to 10 p.m.)

Table 5.2.8-7 and Figures 5.2.8-3 and 5.2.8-4 present the total estimated daytime L_{50} and L_{10} levels that would be experienced at the closest receptors to the Mine Site and Plant Site. Noise from Mine Site and Plant Site operations, plus baseline levels, are predicted to be well below the Minnesota daytime noise standards of 60 dBA (L_{50}) and 65 dBA (L_{10}) for residential areas, trails, recreational sites (family campgrounds, campsites, boating, fishing, swimming, and family picnic areas), and draft MPCA staff-recommended wild rice waters and beds (used by tribal members for traditional resource harvests).

As an example of how the total noise level is calculated, the L_{50} daytime level of 44 dBA for private residences shown in Table 5.2.8.7 is the result of adding 10.9 dBA (daytime L_{50} levels from Mine Site operations only, excluding Plant Site operations and baseline levels), 13.5 dBA (daytime L_{50} levels from Plant Site operations only, excluding Mine Site operations and baseline levels), and 44 dBA, which is the assumed daytime L_{50} baseline level. The result of the logarithmic addition indicates that noise from the Mine Site and Plant Site has no measureable effect on the baseline conditions of the closest receptors. Figure 5.2.8-3 shows that the daytime L_{50} impact area for the closest receptors would be 6,629 and 255 acres at the Mine Site and Plant Site, respectively. Similarly, Figure 5.2.8-4 shows that the daytime L_{10} impact area for the closest receptors would be 6,266 and 242 acres at the Mine Site and Plant Site, respectively. These receptors are well outside the daytime impact areas. The closest recreational site is a family picnic area located approximately 9 miles south of the Mine Site and Plant Site (near Skibo). This family picnic area as well as other recreational sites located further away such as those near Birch Lake and South Kawishiwi River are outside the daytime impact area.

The Upper St. Louis River contains wild rice beds harvested by tribal members. The wild rice beds are usually in close proximity to draft MPCA staff-recommended wild rice waters such as Mud Lake and Birch Lake (north of Mine Site), Lobo Lake and Sand Lake (east of Mine Site), Stone Lake and Seven Beaver Lake (southeast of Mine Site), Cranberry Lake (south of Mine Site), and Hay Lake (west of Plant Site). Details of the location and uses of the cultural/tribal resource areas are discussed in Section 4.2.9, Cultural Resources.

The closest wildlife corridor located northeast of the Mine Site is also outside the daytime impact area. The highest daytime noise levels, including baseline levels, predicted for the closest NAC 1 receptor to the Mine Site (i.e., Babbitt (R-4)) were 44 dBA (L_{50}) and 48.8 dBA (L_{10}). The daytime noise effect of the Mine Site on Babbitt is an increase of 0 dBA (L_{50}) and 0 dBA (L_{10}) from baseline levels. Similarly, the highest daytime noise levels, including baseline levels, predicted for the closest NAC 1 receptor to the Plant Site (i.e., Private Residences (R-1)) were 44 dBA (L_{50}) and 48.8 dBA (L_{10}). The daytime noise effect of the Plant Site on the private residences is an increase of 0 dBA (L_{50}) and 0 dBA (L_{10}) from baseline levels. This 0 dBA increase is below the 3 dBA threshold of perception per the MCPA's *Guide to Noise Control in Minnesota* (MPCA 2008a) and would not be perceptible to residents, recreational users, or tribal members that use the draft MPCA staff-recommended wild rice waters and beds for harvesting purposes.

As discussed earlier, noise from trains and train horns during ore transportation during the day from the Mine Site to the Plant Site is expected to be minimal because the railroad route between the two is approximately 4 to 5 miles from the nearest receptors. Up to 22 trains per day are expected to deliver ore to the Plant Site. This frequency of traffic is less than that experienced on the rail line during past mining operations.

Blasting at the Mine Site is a source of impulsive or non-continuous noise. Blasting noise is not included in the noise level estimates shown in Table 5.2.8-7 because mine-blasting is typically an instantaneous event (not continuous or steady), and would occur only during daytime periods. PolyMet expects that blasting of ore and waste rock would take place approximately once every 2 or 3 days. This would usually include separate blasts of ore and waste rock benches. Rock-blasting could potentially have noise levels ranging from 111 to 115 dBA at 50 ft from the blasting site. With modern blasting techniques, the blasting would be experienced by the nearest receptors as a faint warning whistle or siren, followed by a very brief, muted clap of thunder.

Public acceptance is generally improved by scheduling blasting at the same time every day to further reduce the startle factor. The closest receptor (City of Babbitt) is located 6.5 miles from the Mine Site, so noise effects from blasting are not expected to be significant. In addition, noise effects from blasting would only occur during the early stages of mining, when blasting occurs at the surface down to a few ft below ground levels. As the depth of the pit increases over the life of the mine, noise effects from blasting would be attenuated by the pit walls.

Though not depicted on Figures 5.2.8-3 and 5.2.8-4 due to sensitivity regarding cultural resources and locations, three archaeological sites have been identified within the NorthMet Project area: Spring Mine Lake Sugarbush, *Mesabe Widjiu* [Laurentian Divide], and BBLV Trail Segment #1 (USFS #01-569). The Spring Mine Lake Sugarbush and the *Mesabe Widjiu* are located more than 2 miles away from the Mine Site and approximately 1 mile from the Plant Site (approximated 2 miles from the plant crushers). Based on these distances, both archaeological sites are expected to be outside the daytime noise impact area for the Mine Site (6,629 acres) and Plant Site (255 acres). As noted previously, the BBLV Trail Segment #1 (USFS #01-569) crosses the NorthMet Project area. Portions of the trail segment that cross the Mine Site and Plant Site are expected to be within the daytime impact area and may experience daytime noise levels close to the Minnesota standards.

Details of the location and uses of the archaeological sites are discussed in Section 4.2.9, Cultural Resources.

Nighttime Operation Impacts (10 p.m. to 7 a.m.)

Table 5.2.8-7 and Figures 5.2.8-5 and 5.2.8-6 indicate that the total estimated nighttime L_{50} and L_{10} levels that would be experienced at the receptors closest to the Mine Site and Plant Site are expected to be below the Minnesota nighttime noise standards of 50 dBA (L_{50}) and 55 dBA (L_{10}). Figure 5.2.8-5 shows that the nighttime L_{50} impact areas for the closest residential areas, trails, draft MPCA staff-recommended wild rice waters (used by tribal members for traditional resource harvests), and recreational sites would be 11,456 acres and 568 acres at the Mine Site and Plant Site, respectively.

Similarly, Figure 5.2.8-6 shows that the nighttime L_{10} impact areas for the closest residential areas, trails, draft MPCA staff-recommended wild rice waters, and recreational sites would be 10,695 acres and 503 acres at the Mine Site and Plant Site, respectively. These receptors are well outside the nighttime impact areas. As indicated above, the closest recreational site is a family picnic area located approximately 9 miles south of the Mine Site and Plant Site (near Skibo). This family picnic area as well as other recreational sites located further away such as those near Birch Lake and South Kawishiwi River are outside the nighttime impact area. There are no draft MPCA staff-recommended wild rice waters or beds within the nighttime impact area. Details of the location and use of cultural/tribal resource areas are discussed in Section 4.2.9 and 5.2.9. The closest wildlife corridor located northeast of the Mine Site is also outside the impact area. The highest nighttime L_{50} and L_{10} levels, including baseline levels, predicted for the closest receptor to the Mine Site (i.e., Babbitt (R-4)) were 34 dBA and 37.8 dBA, respectively. The nighttime noise effect of Mine Site operations on Babbitt is a net increase of 0 dBA (L_{50}) and 0 dBA (L_{10}) from baseline levels. Similarly, the highest nighttime L_{50} and L_{10} levels, including baseline levels, predicted for the closest receptor to the Plant Site (i.e., Private Residences (R-1)) were 34.1 dBA and 37.9 dBA, respectively. The nighttime noise effect of the Plant Site on the private residences is an increase of 0.1 dBA (L_{50}) and 0.1 dBA (L_{10}) from baseline levels. This increase of 0.1 dBA is below the 3 dBA threshold of perception per the MCPA's *Guide to Noise Control in Minnesota* (MPCA 2008a) and would not be perceptible to residents, recreational users, and tribal members that use draft MPCA staff-recommended wild rice waters and beds for traditional resource harvests. It should be noted that the noise model conservatively assumes that all mine equipment shown in Table 5.2.8-2 would be operating simultaneously during daytime and nighttime. Under actual conditions, the predicted noise levels would be lower because not all equipment would be operating simultaneously and some equipment would not operate at all during nighttime.

Though not depicted on Figures 5.2.8-5 and 5.2.8-6 due to sensitivity regarding cultural resources and locations, three archaeological sites have been identified within the NorthMet Project area: Spring Mine Lake Sugarbush, *Mesabe Widjiu* [Laurentian Divide], and BBLV Trail Segment #1 (USFS #01-569). The Spring Mine Lake Sugarbush and the *Mesabe Widjiu* are located more than 2 miles from the Mine Site and approximately 1 mile from the Plant Site (approximated 2 miles from the plant crushers). Based on the distances, both archaeological sites are expected to be outside the nighttime noise impact areas for the Mine Site (11,456 acres) and Plant Site (568 acres). As noted previously, the BBLV Trail Segment #1 (USFS #01-569) crosses the NorthMet Project area. Portions of the trail segment that cross the Mine Site and Plant Site are expected to be within the nighttime impact area and may experience nighttime noise levels close to the Minnesota standards. Details of the location and uses of the archaeological sites are discussed in Section 4.2.9, Cultural Resources.

Mine-blasting and ore transportation via trains along the Transportation and Utility Corridor would not occur between 10 p.m. and 7 a.m., so there would not be noise effects associated with these activities at night.

Summary of Daytime and Nighttime Operation Noise Impacts

Based on the information above, the total predicted daytime and nighttime noise (L_{50} and L_{10}) level experienced at NAC 1 areas such as the closest residential areas (the City of Babbitt north of the Mine Site, and private residences located north of the Plant Site), trails, recreational sites (including recreational sites at Birch Lake and South Kawashiwi River), and draft MPCA staff-recommended wild rice waters and beds used by tribal members for traditional resource harvests would meet the Minnesota daytime and nighttime noise standards. In addition, the projected noise increase above baseline levels would be below the 3 dBA threshold of perception. Immediate access to areas around the mine would be restricted, but tribal members who may have a cultural and spiritual connection to archaeological sites in the Superior National Forest, in areas immediately near the Mine Site or Plant Site, may occasionally experience noise associated with the NorthMet Project Proposed Action. Mitigation measures for the impacted cultural resource areas are discussed in Section 5.2.9, Cultural Resources.

During closure and post-closure (i.e., after year 20), the major noise sources and activities at the Mine Site and Plant Site (e.g., drilling, blasting, mining, excavation work, hauling, and crushing operations) would cease. Progressive reclamation would occur throughout the 20-year mine life for features such as the permanent stockpile and pit areas at the Mine Site and at the exterior slopes of the Tailings Basin at the Plant Site. This would leave a smaller portion of the Mine Site and Plant Site needing to be reclaimed at closure. During the closure phase, machinery, such as planters, used to restore and/or rehabilitate the Mine Site and Plant Site and conduct other reclamation activities (e.g., structure demolition, dike removal, etc.) would generate some noise; however, such noise would occur over a short time period and mostly during daytime periods when increased noise levels would be more tolerable. Therefore, noise levels at the Mine Site and Plant Site during the closure and post-closure phases are expected to be below the Minnesota noise standards and below the 3 dBA threshold of perception.

Area of Audibility for the Boundary Waters Canoe Area Wilderness

The L_{50} audibility area would be approximately 247,612 acres around the Mine Site and Plant Site, assuming all noise sources are operating simultaneously during daytime and nighttime (Figure 5.2.8-3 and 5.2.8-5). Similarly, the L_{10} audibility area would be approximately 131,035 acres around the Mine Site and Plant Site, assuming all noise sources are operating simultaneously during daytime and nighttime (see Figures 5.2.8-4 and 5.2.8-6). The BWCAW is outside this area of audibility. Therefore, sound from the Mine Site and Plant Site operations would not be audible at the BWCAW. While some receptors (e.g., residential areas like Babbitt and Hoyt Lakes and a family picnic area near Skibo) are within this area of audibility shown on Figures 5.2.8-3 to 5.2.8-6, it should be noted that the area of audibility was calculated based on the low measured baseline levels for BWCAW, which is a place of natural quiet (L50 of 23.4 dBA and L10 of 33.2 dBA). The baseline levels for the recreational sites and residential areas are likely higher than the BWCAW baseline levels (though actual measurements have not been taken at these areas), so actual area of audibility for these other receptors would be much smaller than that for BWCAW.

Noise Effects on Off-Site Transportation

Transportation of NorthMet Project Proposed Action consumables and products could result in some noise from increased traffic on public roads and commercial railroads. Public roads could also experience minor increase in noise levels due to additional traffic from employees and service providers, particularly along State Highway 135 and County Road 666.

Traffic noise from employee vehicles, service provider vehicles, and trucks transporting process consumables and products result in a small increase in daily traffic volumes (approximately 7 trucks per day and 149 employee and service provider vehicles per day along State Highway 135; and approximately 42 employee and service provider vehicles per day along County Road 666 [see BA provided in Appendix D]) in comparison to the existing annual average daily traffic (AADT) volumes of State Highway 135 and County Road 666. Based on AADT data that Barr Engineering Company obtained from the Minnesota Department of Transportation (Barr 2014a), the NorthMet Project offsite traffic volumes are approximately 2 to 18 percent and 5 to 30 percent of existing AADT at State Highway 135 (850 to 8300 vehicles per day) and County Road 666 (140 to 810 vehicles per day), respectively.

Similarly, railway noise from trains carrying process consumables and concentrates from the Plant Site to Virginia, Minnesota, and/or vice versa (via Canadian National Railroad) are not expected to be significant due to the small increase in monthly railway traffic volumes (approximately 100-car train once per month and a 30-car train four times per month, year round, for product shipment; and approximately 100-car train once per week, April through October, for process consumables [see BA provided in Appendix D]) in comparison to the existing monthly traffic volumes of the Canadian National Railroad. Based on existing rail traffic information that Barr Engineering Company obtained from Canadian National Railway Company (Barr, Pers. Comm., November 6, 2014) the NorthMet Project Proposed Action off-site traffic volumes are approximately 3.0 and 3.8 percent of existing rail traffic near the Plant Site (i.e., the Iron Junction to Allen Junction rail segment) during non-summer months (8 trains per day or approximately 240 trains per month) and during summer months (10 trains per day or approximately 300 trains per month), respectively.

Based on the off-site traffic information described above, noise effects on off-site transportation are not expected to be significant. In addition, all NorthMet Project Proposed Action-related off-site roadway and railway traffic would occur during daytime hours only, and the off-site trucks would not exceed 40 miles per hour and would avoid densely populated areas to the extent practicable. Any noise sensitive receptor near the Canadian National Railroad, State Highway 135, and County Road 666 would not be exposed to a new noise source since these infrastructures have been in operation for decades.

5.2.8.3 NorthMet Project No Action Alternative

Under the NorthMet Project No Action Alternative, the NorthMet Project Proposed Action would not occur and there would be no increase in noise and vibration levels in any of the areas proposed for project development Therefore, there would be no change in existing noise and vibration levels at the closest receptors.

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5.2.9 Cultural Resources

This section summarizes the environmental consequences of the NorthMet Project Proposed Action on historic properties, including the potential effects, types of avoidance, effect minimization measures, and potential mitigation measures that are relevant to these historic properties. Additionally, this section summarizes the environmental consequences of the NorthMet Project Proposed Action on 1854 Treaty resources—i.e., those species and/or habitats that are traditionally or culturally important to the Bands.

The federal Co-lead Agencies have identified several historic properties in consultation with the SHPO, Bands, and PolyMet. The federal Co-lead Agencies have also consulted with the SHPO, Bands, and PolyMet concerning NRHP eligibility of the historic properties, and have determined that the Spring Mine Lake Sugarbush; the Partridge River Section of the *Mesabe Widjiu*; the Partridge River Segment of the BBLV Trail; Erie Mining Company Railroad Mine and Plant Track, Main Line Segment, and Dunka Railroad Segment; Erie Mining Company Concentrator Building; Erie Mining Company Administration Building; Erie Mining Company Hoyt Lakes Operation Mining Landscape Historic District; and DM&IR Segment are eligible for inclusion in the NRHP. All other cultural resources identified as part of the NorthMet Project Proposed Action, as identified in Section 4.2.9.2.4, were determined to be not eligible for inclusion in the NRHP, and therefore will not receive further consideration under Section 106 during review of the NorthMet Project Proposed Action. The SHPO concurred with these determinations.

After consultation with the SHPO, Bands, and PolyMet, the federal Co-lead Agencies have determined that there would be no adverse effect on the Erie Mining Company Railroad Mine and Plant Track, Main Line Segment, and Dunka Railroad Segment; Erie Mining Company Administration Building; and DM&IR Segment. However, the federal Co-lead Agencies determined that the Partridge River Section of the *Mesabe Widjiu*, the Partridge River Segment of the BBLVTrail, Spring Mine Lake Sugarbush, Erie Mining Company Concentrator Building, and Erie Mining Company Hoyt Lakes Operation Mining Landscape Historic District would be adversely affected by the NorthMet Project Proposed Action. The SHPO agreed with these findings. The federal Co-lead Agencies submitted the adverse effects determinations to the ACHP, which chose not to participate in the resolution of adverse effects. These determinations were used to facilitate consultation with the SHPO, Bands, and PolyMet pertaining to the resolution of adverse effects. Mitigation measures to resolve adverse effects are being developed through consultation and the Co-lead Agencies have drafted an MOA for consulting party review. An MOA resolving adverse effects will be executed and the NHPA process completed prior to the Co-lead Agencies' final decisions.

The Co-lead Agencies committed to providing an appendix in the FEIS that contains the Tribal Cooperating Agencies' comments and supporting documentation representing MDOs. See Appendix C for comments and supporting documentation from the Bois Forte, Grand Portage, Fond du Lac, GLIFWC, and the 1854 Treaty Authority. These take the form of eight position papers and a Co-lead Agency Preliminary SDEIS comment disposition spreadsheet for the Tribal Cooperating Agencies.

The Tribal Cooperating Agency submittals in Appendix C are provided verbatim and in identical form as they were for the SDEIS. They were considered in the development of the FEIS. Refer to Chapter 8 for more information.

5.2.9.1 Methodology and Evaluation Criteria Overview

In consultation with the SHPO, the Bands, and PolyMet, the federal Co-lead Agencies applied the criteria of adverse effects to historic properties within the APE to evaluate the potential effect of the NorthMet Project Proposed Action on the historic properties, as codified in 36 CFR 800.5.

An adverse effect is found when an undertaking may alter, directly or indirectly, any of the characteristics of a historic property that qualify the property for inclusion in the NRHP in a manner that would diminish the integrity of the property's location, design, setting, materials, workmanship, feeling, or association. These elements of integrity are discussed at length in Section 4.2.9. Adverse effects may include reasonably foreseeable indirect effects that occur later in time, are farther removed, or are cumulative.

Direct effects caused by the undertaking occur at the same time and place. Indirect effects caused by the undertaking are later in time or further removed in distance but are still reasonably foreseeable. The federal Co-lead Agencies confer with consulting parties to determine the undertaking's effects on historic properties, to resolve adverse effects, and to develop mitigation measures as necessary. For the NorthMet Project Proposed Action, the following is a summary of potential effect types:

- Physical disturbance or damage to all or part of the property caused by ground disturbance (e.g., digging, trenching, etc.);
- Introduction of visual, atmospheric, or audible elements that could diminish the integrity of the property's significant historic features during short-term NorthMet Project Proposed Action-related construction and operation of aboveground facilities and roads, as well as long-term effects from operation;
- Change in the character of the use or of physical features within the property's setting that contribute to its significance; and
- Transfer of property out of federal ownership without adequate conditions to ensure consideration of historic properties.

Effects determinations have the following three possible outcomes:

1. Finding of no historic property affected – The undertaking does not have the potential to cause effects on historic properties that may be present.
2. Finding of no adverse effect – The historic property would be affected; however, the effects of an undertaking do not meet the criteria of adverse effect, or measures have been taken to avoid or minimize adverse effects.
3. Finding of adverse effect – The undertaking may affect the integrity, which would alter, directly or indirectly, any of the characteristics of a historic property that qualify it for inclusion in the NRHP. If an adverse effect is found, the federal Co-lead Agencies shall consult further to resolve the adverse effect.

5.2.9.1.1 Types of Potential Effects

The potential for the NorthMet Project Proposed Action to affect a historic property may depend on the project stage and the development and use of the NorthMet Project area. Potential effects that may occur during the construction and operations of the NorthMet Project Proposed Action are discussed in the following subsections.

Construction

NorthMet Project Proposed Action construction activities could affect cultural resources in a variety of ways, including the following:

- Possible direct damage to cultural resources within the construction footprint;
- Possible indirect damage to cultural resources through vibrations caused by earth-moving and heavy equipment;
- Temporary loss of community access to cultural resources, such as cultural resources of traditional significance;
- Potential permanent visual effects that alter the viewshed to or from a cultural resource as it pertains to the cultural resource's setting and feeling;
- Potential temporary visual effects on cultural resources while heavy equipment and numerous personnel are present;
- Increased dust and noise that may affect historic structures or cultural resources of traditional significance near the construction area; and
- Discovery of previously unknown cultural resources within the construction footprint.

The duration of the construction phase would affect the degree of effects on cultural resources. Potential indirect effects during construction—such as noise, dust, vibrations, heavy equipment traffic, and changes in viewshed—could be temporary and would be expected to last for the duration of construction in specific areas and for discrete periods of time.

Operations

During the operations phase of the NorthMet Project Proposed Action, only previously surveyed and assessed areas would be expected to require periodic disturbance; therefore, the potential for additional direct effects to cultural resources would be limited.

Indirect effects during operations could consist of a permanent change in viewshed to historic structures near NorthMet Project area facilities, and a periodic increase in noise, vibration, and dust created by vehicular traffic conducting operation and maintenance activities.

5.2.9.1.2 Resolution of Adverse Effects

Adverse effects on eligible properties have been determined. Mitigation measures would be taken to avoid or minimize effects on historic properties, to the extent practicable. The following are potential mitigation measures:

- Avoidance, which could be accomplished by shifting the footprint away from the resource, limiting activities in the vicinity of the resource, monitoring construction activities near the resource to inform whether additional actions are warranted, or through any combination of these techniques;

- Minimization, which would reduce the effects on the resource through avoidance measures as described above, but would not completely eliminate the effects; and
- Mitigation, which would offset that effect through some of the following means:
  - protection of a similar resource nearby;
  - detailed documentation of the resource through data recovery (e.g., excavations, in the case of archaeological sites, or Historic American Buildings Survey/Historic American Engineering Record documentation, in the case of historic structures);
  - contributions to the preservation of cultural heritage in the affected community;
  - interpretative exhibits highlighting information gained about cultural resources through the NorthMet Project Proposed Action; or
  - some combination of these strategies.

The federal Co-lead Agencies have taken into account the effects of the NorthMet Project Proposed Action on properties that are listed on, or considered eligible for listing on, the NRHP per Section 106 of the NHPA and consistent with USFS and USACE practices. Because the NorthMet Project Proposed Action would result in an adverse effect on certain eligible properties, as discussed further below, the federal Co-lead Agencies have consulted with the SHPO, the Bands, and PolyMet to identify practicable ways to avoid, minimize, or mitigate the harmful effects of the undertaking. The ACHP was notified of adverse effect by letter on May 21, 2015, but declined to participate. The federal Co-lead Agencies are currently in the process of developing an MOA, which identifies the steps the federal Co-lead Agencies would take to avoid, minimize, or mitigate the adverse effects.

5.2.9.2 Affected Cultural Resources

This section describes the effects of the NorthMet Project Proposed Action on historic properties within the APE, as well as other cultural resources. As outlined in Section 4.2.9, the federal Co-lead Agencies determined that the Erie Mining Company Railroad Mine and Plant Track, Main Line Segment, and Dunka Railroad Segment; Erie Mining Company Concentrator Building; Erie Mining Company Administration Building; Erie Mining Company Hoyt Lakes Operation Mining Landscape Historic District; DM&IR Segment, Spring Mine Lake Sugarbush, the Partridge River Section of the *Mesabe Widjiu*, and the Partridge River Segment of the BBLV Trail are eligible for inclusion in the NRHP. The federal Co-lead Agencies, in consultation with the SHPO, Bands, and PolyMet, have determined effects for the eligible properties and are currently working to resolve adverse effects. The Co-lead Agencies have drafted an MOA for consulting party review. While the MOA will recognize that, given the current stage of planning, there are no anticipated adverse effects on the Erie Mining Company Railroad Mine and Plant Track, Mina Line Segment, the DM&IR Segment, and the Erie Mining Company Administration Building, the document acknowledges the possibility of adverse effects at some point in the future and will include a stipulation to address those effects. The MOA will also have a provision to address post-review discoveries.

5.2.9.2.1 Historic Properties

Erie Mining Company Concentrator Building

The Concentrator Building reflects Erie Mining Company's decades of experimentation in production and engineering design (Zellie 2007). The Co-lead Agencies have determined the Concentrator Building eligible for inclusion in the NRHP under Criterion A in the areas of industry and engineering, and also under Criterion C in the area of engineering.

Direct effects to this property would consist of interior and exterior refurbishment and use. For example, emission controls on ore grinding equipment would be replaced with components that meet or exceed the particulate emission standard required of new sources at taconite plants. To reduce space heating requirements, the building insulation would be improved. Additionally, the concentrator building would be demolished at mine closure and decommissioning, consistent with Minnesota state mining standards. There would be minor exterior and interior alterations to the other primary plant buildings and structures. The NorthMet Project Proposed Action would include the construction of several new buildings adjacent to the Concentrator Building. Based on the above considerations, the federal Co-lead Agencies have determined that the NorthMet Project Proposed Action would adversely affect the Concentrator Building. The SHPO has agreed with this finding. The federal Co-lead Agencies, in consultation with the SHPO, Bands, and PolyMet, are currently working on an MOA to resolve adverse effects.

Erie Mining Company Railroad Mine and Plant Track, Main Line Segment, and Dunka Railroad Segment

The federal Co-lead Agencies have determined the Erie Mining Company Railroad Mine and Plant Track, Main Line Segment, and Dunka Railroad Segment (SL-HLC-015) eligible for inclusion in the NRHP under Criterion A in the areas of Commerce, Industry, and Transportation, and under Criterion C. Although the majority of the main track of railroad is outside of the NorthMet Project area, the segments of the Erie Main Line Railroad and Mine and Plant Track, and Dunka Railroad within the APE would be directly affected near the NorthMet Project area.

Direct effects to this property would consist of refurbishment and use. Refurbishment, however, is not expected to result in significant alterations. Nonetheless, the Erie Mining Company railroad would be removed at mine closure and decommission, consistent with Minnesota state mine reclamation standards. There would be no expected indirect effects, as the use of the Plant Site and mining activities would be consistent with the railroad's original use. Based on the above considerations, the federal Co-lead Agencies have determined that the NorthMet Project Proposed Action would not adversely affect the Erie Mining Company railroad. The SHPO has agreed with this finding. The federal Co-lead Agencies, in consultation with the SHPO, Bands, and PolyMet, are currently working on an MOA to resolve adverse effects.

Erie Mining Company Administration Building

The Erie Mining Company Administration Building remains a well-preserved component of the original taconite plant design. It is significant under NRHP Criterion A in the areas of Industry and Engineering and is associated with the statewide historic context, "Minnesota's Iron Ore Industry, 1880s-1945," and under Criterion C. The Administration Building is within the APE for the NorthMet Project Proposed Action; however, refurbishment is not part of the current undertaking. While the federal Co-lead Agencies have determined the Administration Building would need to be updated subsequent to mine permitting, no plans have been provided to the Co-lead Agencies for analysis of effects. The Co-lead Agencies have evaluated the potential for ambient air quality to adversely affect the structure pursuant to air modeling data analyzed during the FEIS process. The Administration Building would not be affected by isopleths (dust particulate) as modeled. The Administration Building is located in an area of the APE where air quality is not expected to exceed current background levels; therefore, no adverse effect is anticipated from changes in air quality. Therefore, the federal Co-lead Agencies have determined that the NorthMet Project Proposed Action would not adversely affect the Erie Mining Company Administration Building. The SHPO has agreed with this finding. The federal Co-lead Agencies, in consultation with the SHPO, Bands, and PolyMet, are currently working on an MOA to resolve adverse effects.

Erie Mining Company Hoyt Lakes Operation Mining Landscape Historic District

The NorthMet Project Proposed Action is contingent upon reuse of the Erie Plant Site and existing railroad infrastructure. Proposed new construction within the Erie Plant Site area includes an oxygen plant, Hydrometallurgical Plant, Hydrometallurgical Residue Facility, and WWTP. The Erie Heating and Additive Plan (SL-HLC-049), which is considered as a contributing element of the Erie Mining Company Landscape Historic District, is proposed for demolition under the NorthMet Project Proposed Action. Several non-contributing temporary structures associated with the LTVSMC period of use (from 1986 to 2001) within the footprint of the proposed WWTP would be relocated and repurposed on site. Key infrastructure at the Plant Site would be refurbished and reused under the NorthMet Project Proposed Action.

Processes at the Beneficiation Plant would include ore crushing, grinding, floatation, dewatering, storage, and shipping. Crushing and grinding would occur at the existing coarse-crusher building, fine-crusher building, and concentrator building, all of which are associated with the overall industrial processes of Erie operations during the period of significance. The Co-lead Agencies have determined that the proposed refurbishment and reuse of these facilities is compatible with the industrial processes that occurred during the period of historic significance. Ore would continue to be transported to the Plant Site by rail from an adjacent Mine Site, and the buildings would continue to function in a similar fashion as they did during the period of historic significance. Dewatering would take place at a new concentrate dewatering and storage building. This building would be constructed near the new Hydrometallurgical Plant, on the footprint of the Erie (LTVSMC) Heating and Additive Plant (SL-HLC-049), which would be demolished. The Area 1 Shop, rail car maintenance shop (Area 2 Shops), and Colby Lake pumphouse would be reused under the current proposal. The expected activities at each location would be consistent with those carried out during the period of significance. The current information suggests that refurbishment would be limited to painting and exterior rehabilitation, as needed. Refurbishment would likely include updates to building interiors; however, outside of the concentrator building, these interior renovations are not expected to diminish the integrity of those structures that contribute to the Erie Hoyt Lakes Operation Mining Landscape Historic District.

The Co-lead Agencies have considered the potential effects on both the properties determined to be individually eligible and to those properties considered as contributing elements to the larger mining landscape historic district. Given that both new construction and demolition of contributing buildings is proposed within the Plant Site boundaries, the federal Co-lead Agencies have determined that an adverse effect finding is warranted for this larger mining landscape historic district. The SHPO has agreed with this finding. The federal Co-lead Agencies, in consultation with the SHPO, Bands, and PolyMet, are currently working on an MOA to resolve adverse effects.

DM&IR Segment

The Canadian Northern Railway currently owns the DM&IR segment of track within the APE of the NorthMet Project Proposed Action. While PolyMet asserts that reuse of part of the DM&IR segment is “likely,” there are no immediate plans for reuse of this railroad as part of the current NorthMet Project Proposed Action. Although it is possible that the DM&IR segment would be reused if permitting proceeds, since there are no reasonably foreseeable proposals, there are no adverse effects to be identified in this analysis. Therefore, the federal Co-lead Agencies have determined that there would be no adverse effect. The SHPO has agreed with this finding. The federal Co-lead Agencies, in consultation with the SHPO, Bands, and PolyMet, are currently working on an MOA to resolve adverse effects.

Spring Mine Lake Sugarbush

The federal Co-lead Agencies have determined the Spring Mine Lake Sugarbush eligible for inclusion in the NRHP under Criterion A for its association with important Ojibwe spiritual and cultural practices. Under Criterion D, the site is significant for its potential to answer important questions about possible 19th century and 20th century Ojibwe maple sugaring practices.

Direct effects on this property would not result from the NorthMet Project Proposed Action. The Spring Mine Lake Sugarbush is not within the footprint of the Mine Site, the Plant Site, or any other ancillary NorthMet Project area features.

Based on an indirect visual effects analysis conducted for the NorthMet Project Proposed Action and the site visits conducted in 2010, the federal Co-lead Agencies have determined that the NorthMet Project Proposed Action would not result in a visual intrusion that would diminish the integrity of setting, feeling, or associations. The Spring Mine Lake Sugarbush is a number of miles from the Mine Site and sufficiently screened from the Plant Site and the Tailings Basin where those project features are not visible. The Plant Site and Tailings Basin are existing LTVSMC mine features. Their footprint would not be expanded to any significant extent, nor would the addition of material be visible from the Spring Mine Lake Sugarbush to a significantly greater extent than current conditions.

The analysis of possible atmospheric effects that was completed for the NorthMet Project Proposed Action indicates that the Spring Mine Lake Sugarbush is not in an area expected to be affected by dust deposition. The Spring Mine Lake Sugarbush and its grove of mature maple trees has existed throughout the past 50 years of mining, which included the use of the existing Plant Site and Tailings Basin as well as numerous mineral extraction locations (mine pits) in close proximity to the Spring Mine Lake Sugarbush in comparison to the Mine Site.

The Spring Mine Lake Sugarbush may be associated with the trail systems, such as the BBLV Trail Segment, that are known to have traversed this area. The portion of that trail corridor in proximity to the Spring Mine Lake Sugarbush has been for the most part destroyed by past mining operations. The NorthMet Project Proposed Action would not result in the loss of any additional portions of that corridor, or trails, in proximity to the Spring Mine Lake Sugarbush. For further discussion, see the discussion of effects on the BBLV Trail Segment.

Based on this analysis, the federal Co-lead Agencies made the determination that there would be no direct effects resulting from the NorthMet Project Proposed Action nor would there be any significant changes to the setting, feeling, or associations of the Spring Mine Lake Sugarbush.

After consultation with the Bands concerning effects on the Spring Mine Lake Sugarbush, the federal Co-lead Agencies acknowledged that the analysis of atmospheric effects on the Spring Mine Lake Sugarbush was an estimation based on modeling and that dust deposition is expected to occur near this property. The Co-lead Agencies, through consultation with the Bands, are also aware of concerns among the consulting parties for potential inadvertent damage to the site given the proximity of the site to key operational areas associated with the proposed Plant Site. After consideration of concerns and perceptions raised by the consulting parties, the federal Co-lead Agencies have determined that the NorthMet Project Proposed Action would adversely affect the Spring Mine Lake Sugarbush. The SHPO has agreed with this finding. The federal Co-lead Agencies, in consultation with the SHPO, Bands, and PolyMet, are currently working on an MOA to resolve adverse effects.

Partridge River Section of the Mesabe Widjiu

The federal Co-lead Agencies have determined the *Mesabe Widjiu* eligible for inclusion in the NRHP under Criterion A for its association with important Ojibwe spiritual and cultural practices, and under Criterion B. Although the federal Co-lead Agencies are assessing the effects of the NorthMet Project Proposed Action on only the portion of the *Mesabe Widjiu* within the APE, it is recognized that the property and its significance extends beyond the APE.

The Partridge River Section of the *Mesabe Widjiu* was previously disturbed both directly and indirectly by the former LTVSMC Plant Site and Tailings Basin, as well as by mining and logging activities in the Mine Site area. The Tailings Basin would be reused by PolyMet, as would buildings within the Plant Site.

Direct effects on the *Mesabe Widjiu* would occur at the Tailing Basin, which currently abuts a portion of that land form. A slight expansion of the Tailings Basin would intrude on that portion of the *Mesabe Widjiu*. Otherwise, the use of existing facilities at the Plant Site would involve minimal ground disturbance of previously undisturbed parts of the *Mesabe Widjiu*. Direct effects on the *Mesabe Widjiu* at the Mine Site would not occur as the *Mesabe Widjiu* is not considered to be within the footprint of the Mine Site.

Indirect effects to the *Mesabe Widjiu* would result from the features at the Mine Site location. Although there are existing mine features between the *Mesabe Widjiu* and the Mine Site location, the NorthMet Project Proposed Action would further diminish the integrity of setting and feeling. The large-scale alterations to the landscape resulting from mine pits, stockpiles, material handling facilities, etc., would be long-term changes that would further diminish the association of the *Mesabe Widjiu* with the natural features of the Partridge River headwaters.

Although the multiple cultural resources investigations for the NorthMet Project Proposed Action did not reveal any specific locations adjacent to the NorthMet Project area that are used by the Bands, this does not diminish the significance of effects for that portion of the *Mesabe Widjiu*. Given the nature of Ojibwe spiritual practices, which is a personal connection to the natural elements of the environment, locations of this type are very difficult to identify. The *Mesabe Widjiu* is a historic property to which the Ojibwe have had a spiritual connection for hundreds of years.

Based on the above considerations, the federal Co-lead Agencies have determined that the NorthMet Project Proposed Action would adversely affect the *Mesabe Widjiu*. The SHPO has agreed with this finding. The federal Co-lead Agencies, in consultation with the SHPO, Bands, and PolyMet, are currently working on an MOA to resolve adverse effects.

Partridge River Segment of the Beaver Bay to Lake Vermilion Trail

The federal Co-lead Agencies have determined that the Partridge River Segment of the BBLV Trail is significant for the role it played in the broad patterns of Ojibwe land use and early mineral exploration. It is eligible for inclusion in the NRHP under Criterion A.

The portion of the BBLV Trail Segment that lies within the Mine Site would be directly affected by the NorthMet Project Proposed Action, which would result in its permanent removal. Based on this, the federal Co-lead Agencies have determined that the NorthMet Project Proposed Action would adversely affect the BBLV Trail Segment. The SHPO has agreed with this finding. The federal Co-lead Agencies, in consultation with the SHPO, Bands, and PolyMet, are currently working on an MOA to resolve adverse effects.

Potential for Properties of Tribal Significance Constituting a Historic District

The federal Co-lead Agencies have consulted with the Bands regarding the possibility of the historic properties of tribal significance being considered as part of a National Register District. A District, as defined in National Register Bulletin 15 *How to Apply the National Register Criteria for Evaluation*, in addition to having integrity, "possesses a significant concentration, linkage, or continuity of sites, buildings, structures, or objects united historically or aesthetically by plan or physical development" (NPS 1995). While the BBLV Trail Segment and the Spring Mine Lake Sugarbush appear to share a similar period of significance and are related to 19th century Ojibwe land use and transportation contexts, the federal Co-lead Agencies have determined that these properties do not collectively retain integrity of setting and association nor are they arranged in such a way that they could be considered a "unified entity" *(ibid)*. In addition, prior resource extractive developments have significantly altered the landscape within and adjacent to the NorthMet Project area. These developments and landscape alterations make it difficult to ascertain the linkages that may have historically existed between these properties. The federal Co-lead Agencies do not find that the identified historic properties constitute a "significant concentration" of sites, as further defined in Bulletin 15 (*ibid*). While the federal Co-lead Agencies recognize and affirm that overland trails (and at least one reported "encampment") existed in the NorthMet Project area at the time of the initial Government Land Office surveys, the level of post-19th century development has destroyed and largely obscured the ability of the extant historic properties to convey a sense of continuity and linkage. The oral interview information that has been provided to the Co-lead Agencies does not contain details that speak specifically to these sites; however, the information provided in the oral interviews regarding the *Mesabi Widjiu* was fully considered, and played a key role in the federal Co-lead Agencies prior determination of adverse effect. That said, the federal Co-lead Agencies recognize the position of the consulting Bands regarding the connected nature of cultural resources throughout the 1854

Ceded Territory and affirm that the historical context of these properties has been a key component of resolution of adverse effects on eligible properties.

The federal Co-lead Agencies have previously commented on the consulting Bands' request (Grand Portage 2013) to consider a much larger historic district that extends down to the north shore of Lake Superior for the purposes of Section 106 review for the NorthMet Project Proposed Action. For the reasons stated in the above paragraph, the federal Co-lead Agencies, at this time, have determined that additional identification and evaluation efforts within this area would be outside of the scope of NorthMet Project Proposed Action.

5.2.9.2.2 1854 Treaty Resources

Natural resources important to Ojibwe culture can be recognized even when tribal use of a natural resource may not qualify that resource as a historic property for further consideration under Section 106. The right to hunt, fish, and gather on lands within the 1854 Ceded Territory is protected by the 1854 Treaty. Limitation or elimination of access to public lands within the 1854 Ceded Territory for these purposes may be considered an effect on 1854 Treaty rights. The loss of 1854 Treaty resources may also have an effect on the Bands' ability to exercise 1854 Treaty rights in the NorthMet Project area, but the NorthMet Project Proposed Action is not likely to have a significant impact on the overall availability of 1854 Treaty resources that are typically part of subsistence activities in the 1854 Ceded Territory.

An analysis of effects on 1854 Treaty resources, as described and discussed in Section 4.2.9, is limited by the lack of available information concerning the use of such resources. To help determine how the Bands have traditionally exercised their usufructuary rights on or near the NorthMet Project area, the Bands conducted interviews of individual members of Bois Forte, Fond du Lac, and Grand Portage, although only the results of interviews with Bois Forte were made available.

There is little specific information concerning the use of natural resources by the Bands in the NorthMet Project area, other than the Spring Mine Lake Sugarbush, which is being considered under Section 106 of the NHPA. This likely reflects limited present day or recent past subsistence gathering in the NorthMet Project area due to general inaccessibility. This lack of data also precludes the quantitative analysis of how Band members would be affected socioeconomically by effects on 1854 Treaty resources, further discussed in Section 5.2.10. The primary source of data for assessing effects from the NorthMet Project Proposed Action on 1854 Treaty resources is from the analysis of the environment discussed in detail in Section 4.2.9 of this FEIS.

As stated in Table 5.2.9-1 below, the NorthMet Project Proposed Action would affect 4,028.3 acres within the Nashwauk Uplands and Laurentian Uplands subsections, which constitutes a total of 0.3 percent of these two subsections.

Table 5.2.9-1 Acres of the Laurentian Uplands and Nashwauk Uplands Subsections Affected by the NorthMet Project Proposed Action

Land Cover	Total Acres	Acres Affected by the NorthMet Project Proposed Action	Percent of Combined Nashwauk Uplands and Laurentian Uplands Subsections Affected by the NorthMet Project Proposed Action
Aquatic Environments	396,966	581.7	0.1
Disturbed	46,174	1,242.4	2.7
Forest	885,566	1,908.6	0.2
Cropland/Grassland/ Shrubland	48,602	295.6	0.6
Total	1,377,308	4,028.3	0.3

Source: MDNR 2011f; MDNR 2011i.

The cover type most affected by the NorthMet Project Proposed Action is disturbed land, which includes reuse of the existing LTVSMC Tailings Basin. Less than 1 percent of each of the remaining cover types would be affected. Effects on the 1854 Treaty resources associated with these cover types are discussed below.

Vegetation

Vegetation that would be affected by the NorthMet Project Proposed Action is covered in the vegetation analysis in Section 5.2.4. Consequences of the NorthMet Project Proposed Action would include direct effects on land cover types.

The NorthMet Project Proposed Action would disturb 1,718.6 acres of land at the Mine Site, with the largest effects to upland conifer forest and lowland conifer forest. Consequently, the plant species or resources regulated by the 1854 Treaty Authority for gathering within these cover types would likely be most affected (see Table 5.2.9-2). The Plant Site contains 2,189.7 acres that would be disturbed, although most effects occur in areas already previously disturbed. Though the aquatic environment cover type would be heavily affected at the Plant Site, it consists mostly of tailings ponds where no regulated plant species or resources would be present. The majority of the 120.1 acres of the Transportation and Utility Corridor has also already been disturbed.

Table 5.2.9-2 Affected Cover Types of Associated Species and Resources Regulated by the 1854 Treaty Authority at the NorthMet Project Area

Cover Types	**Associated Plant Species or Resource**	**Affected Mine Site (Acres)[1]**	**Affected Transportation and Utility Corridor (Acres)[1]**	**Affected Plant Site (Acres)[1]**
Upland coniferous forest	Conifer boughs, princess pine, birch bark, firewood, other plants or forest products	741.9	2.6	52.0
Lowland coniferous forest	Conifer boughs, princess pine, firewood, other plants or forest products	437.2	0.2	20.7
Upland deciduous forest	Princess pine, ginseng, birch bark, firewood, other plants or forest products	354.7	2.7	295.1
Shrubland	Firewood, other plants or forest products	133.0	7.7	144.9
Disturbed	NA	44.0	94.4	1,104.0
Aquatic environments	Wild rice, other plants or forest products	6.0	2.7	573.0
Cropland/Grassland	NA	0.2	9.8	0.0
Upland conifer-deciduous mixed forest	Conifer boughs, princess pine, ginseng, birch bark, firewood, other plants or forest products	1.5	0.0	0.0
Lowland deciduous forest	Princess pine, birch bark, firewood, other plants or forest products	0.0	0.0	0.0
Total		**1,718.6**	**120.1**	**2,189.7**

Source: 1854 Treaty Authority 2007.

Note:
[1] Acres from Section 5.2.4.

In addition to the direct effects discussed above, there may also be indirect effects on cover types. Hydrology changes and dust from traffic and mining operations could affect plant communities near the NorthMet Project area, which could further reduce plant species or resources regulated by 1854 Treaty Authority. Mitigation measures, which would minimize these effects, are discussed in Section 5.2.4. Subsistence gathering at these locations is probably limited because of general inaccessibility.

According to the NorthMet Project Cultural Landscape Study (Zellie 2012), some of the most common species include balsam fir, speckled alder, and low-bush blueberry (see Table 4.2.9-4). These species were identified in multiple community types and are more likely to remain within the NorthMet Project area, despite the direct and indirect effects from the NorthMet Project Proposed Action. Within the combined Laurentian Uplands and Nashwauk Uplands ecological subsections, less than 0.3 percent would be affected by the NorthMet Project Proposed Action. As an estimate, the species or resources listed in Table 4.2.9-4 could likely decrease by the same margin within these Ecological Classification System (ECS) subsections.

Wildlife

Similar to the effects on SGCNs discussed in Section 5.2.5, the NorthMet Project Proposed Action would affect 1854 Treaty Authority-regulated species as a result of increased human activity and noise, potential collisions with vehicular and rail traffic, and decrease of habitat. Generally, effects on common and/or game animals (such as white-tailed deer, fox, grouse, waterfowl, etc.) would be similar to the effects on ETSC species (e.g., gray wolf, moose, etc.), which are discussed in Sections 5.2.5.2.1 and 5.2.5.2.2. Local effects are expected due to competition from migrating individuals, but these would not threaten overall populations. See Section 5.2.5 for a more thorough discussion of the types of effects on wildlife.

As there is likely limited present day or recent past subsistence gathering in the NorthMet Project area due to general inaccessibility, the NorthMet Project Proposed Action is unlikely to further diminish the exercise of 1854 Treaty rights in the area.

Increased Human Activity

The 1854 Treaty Authority-regulated species would be directly and indirectly affected through increased human activity due to mining activities. Factors such as noise, dust, light, and vehicle traffic may frighten some species and discourage their use of otherwise suitable habitat. Displaced to other habitat, individuals could face increased competition for resources. Less mobile species, such as herptiles (e.g., frogs, turtles), would likely incur relatively high mortality rates due to less ability to leave the affected area. Cliff-nesting birds could be affected by disturbance if they were to nest along the cliffs created by the pit rims.

Noise Effects

Noise associated with mining activities, including noise from vehicle and rail traffic, would likely affect wildlife, including 1854 Treaty Authority-regulated species. Section 5.2.8 provides further discussion on the noise modeling predictions for the NorthMet Project area. Though wildlife species are likely to be sensitive to changes in noise levels, there are no local, national, or international standards or limits that are applicable to the NorthMet Project Proposed Action. State standards are discussed Section 5.2.8, Noise. Wildlife species may be affected by noise in the NorthMet Project area, though adjacent habitat is available.

Vehicular and Rail Traffic Effects

Traffic effects from collisions with wildlife depend upon factors such as traffic volume, traffic speed, and the species involved. Species that utilize the small preserved forest island remnants between haul roads at the Mine Site would be most affected. Indirect effects from vehicle activities are expected locally at the Mine Site for 1854 Treaty Authority-regulated species and the overall local ecosystem. Effects at the Transportation and Utility Corridor are primarily related to vehicle and rail traffic. The 1854 Treaty Authority-regulated species may be affected by noise and light associated with vehicle and rail traffic, and by collisions with vehicles or trains. Transportation effects at the Plant Site are primarily related to vehicle traffic associated with the construction of the Tailings Basin embankments and bentonite application, primarily during the construction phase of the NorthMet Project Proposed Action. The 1854 Treaty Authority-regulated species may be affected by noise and light associated with vehicle traffic and by collisions with vehicles.

Habitat Effects

The direct effect on wildlife habitat, and thus on species regulated by the 1854 Treaty Authority, was assessed by evaluating the acres of habitat types that would be lost under the NorthMet Project Proposed Action. The changes in cover type are summarized in Table 5.2.9-3.

Table 5.2.9-3 Direct Effects on Key Habitat Types

Key Habitat Types	Total Acres[1] of Cover Type Directly Affected at the Mine Site	Total Acres[1] of Cover Type Directly Affected at the Transportation and Utility Corridor	Total Acres[1] of Cover Type Directly Affected at the Plant Site
Mature Upland Forest, Continuous Upland/Lowland Forest (MIH1-13)	1,535.3	5.5	367.8
Open Ground, Bare Soils (no MIH)	44.0	94.4	1,104.0
Grassland and Brushland, Early Successional Forest (no MIH)	133.2	17.5	144.9
Aquatic Environments (MIH 14)	6.0	2.7	573.0
Total	**1,718.6**	**120.1**	**2,189.7**

Data from Tables 5.2.4-1, 5.2.4-4, and 5.2.4-6.

Note:
[1] Total acres may be more or less than presented due to rounding.

Mature Upland/Lowland Forest

At the Mine Site, 1,535.3 acres of the mature forest would be lost as a result of the NorthMet Project Proposed Action. All 5.5 acres of mature upland/lowland forest along the Transportation and Utility Corridor would be affected. Approximately 368 acres of forest habitat at the Plant Site would be disturbed, most of which is in small or isolated patches of aspen-birch forest that are in poor to fair condition (MDNR 2013a).

The 1854 Treaty Authority-regulated species consist of several common and/or game animals. These species are largely mobile and would likely be displaced, not injured or killed, during mine construction and operation. Reclamation of the Mine Site would include revegetating nearly all disturbed ground according to *Minnesota Rules*, part 6132.2700. Reclamation and revegetation of the NorthMet Project area would improve wildlife habitat relative to conditions during mine operations; however, the quality of habitat for 1854 Treaty Authority-regulated species would remain degraded for decades after closure relative to pre-mining conditions.

Open Ground/Bare Soils

No 1854 Treaty Authority-regulated species are identified as utilizing open ground or bare soils habitat at the Mine Site, Transportation and Utility Corridor, or Plant Site. These areas were the result of past mining activity, are generally of low-quality, and are expected to decrease after mine closure as a result of reclamation.

Brush/Grassland

Approximately 133 acres of brush/grassland at the Mine Site would be directly affected by the NorthMet Project Proposed Action. Young trees (less than 4 inches dbh) make up most of this habitat type (ENSR 2005). Although all 17.5 acres of brush/grassland at the Transportation and Utility Corridor would be directly affected, activities at the Transportation and Utility Corridor would not affect grassland/brush 1854 Treaty Authority-regulated species based on the fragmented nature of this habitat. Approximately 145 acres of brush/grassland at the Plant Site would be directly affected by the activities at the Plant Site. The reclaimed Plant Site, specifically the Tailings Basin, would be revegetated with grassland vegetation species. Overall, the NorthMet Project Proposed Action would have a minimal effect on grassland/brush 1854 Treaty Authority-regulated species.

Open Water

The NorthMet Project Proposed Action would create approximately 321 acres of open water at the Mine Site by eventually flooding the West Pit, which is estimated to fill by year 52. At the Plant Site, open water habitat primarily occurs in the existing LTVSMC Tailings Basin. Existing open water habitat would be maintained during operations, though the acreage of open water would fluctuate according to processing needs. See Section 5.2.5 for further discussion of wildlife use of the open water at the NorthMet Project area.

Wetlands

Based on the site-specific wetland delineation, the NorthMet Project Proposed Action would directly impact 758.2 acres of wetlands at the Mine Site, though surrounding similar wetland habitat would likely be adequate to absorb the displaced wildlife. There are 7.2 acres of wetlands along the Transportation and Utility Corridor, all of which would be impacted by activities along the corridor. There would be 148.4 acres of wetland at the Plant Site directly impacted (see Sections 4.2.3 and 5.2.3). On-site wetland use by 1854 Treaty Authority-regulated species may be limited by the NorthMet Project Proposed Action. Wetlands at the Mine Site are considered 99 percent high quality and 1 percent moderate quality, 100 percent high quality along the Transportation and Utility Corridor, and 94 percent low quality and 6 percent moderate quality at the Plant Site.

Wetland mitigation is proposed off-site at three mitigation sites (See Section 5.2.3). Off-site wetland compensation of 1,602.7 acres could provide up to 1,513.3 wetland mitigation credits. In addition, a total of 197.1 acres of upland buffer areas are proposed to be established with native vegetation around the wetland restoration areas. In accordance with USACE guidelines, credit for the upland buffer areas would be at a 4:1 ratio, resulting in an additional 49.3 credits. The total off-site mitigation could provide up to 1,562.5 wetland mitigation credits. Compensatory ratios determined in permitting may vary from these assumptions. The determination of final mitigation credits required to offset the impacts of the proposed NorthMet Project Proposed Action would be determined during permitting.

Aquatic Species

The potential environmental effects of the NorthMet Project Proposed Action on fish and aquatic macroinvertebrate communities found in the vicinity of the NorthMet Project area are primarily discussed in Section 5.2.6. Direct and indirect effects could include changes in water quality and alteration of physical habitat.

The NorthMet Project Proposed Action would not result in physical habitat effects on the Partridge River or Embarrass River watersheds as a result of hydrologic changes. Generally, fish species regulated by the 1854 Treaty Authority (see Table 4.2.9-7) that occur in the NorthMet Project area would not experience effects from physical habitat loss or alteration.

For the 29 solutes evaluated, the GoldSim model predicted that the NorthMet Project Proposed Action would not cause any significant water quality impacts because: 1) exceedances of the P90 threshold did not occur, 2) the NorthMet Project Proposed Action concentrations were no higher than concentrations predicted for the CEC scenario, 3) the frequency or magnitude of exceedances for NorthMet Project Proposed Action conditions was within an acceptable range, or 4) the effects were not attributable to NorthMet Project Proposed Action discharges. See Section 5.2.2 for a more thorough discussion of water quality effects and 5.2.6 for a discussion of water quality effects pertaining to aquatic species.

The NorthMet Project Proposed Action is expected to result in a net decrease in mercury loadings to the Partridge River from 24.2 to 23.0 grams per year, primarily as a result of a decrease in natural runoff and a proportional increase in water discharged from the West Pit via the WWTF. It is also expected to result in a net increase in mercury loadings to the Embarrass River from 22.3 to 22.5 grams per year, primarily due to the redirection of flow associated with the construction of the East Dam as part of the Tailings Basin expansion to the Embarrass River. However, the NorthMet Project Proposed Action would also result in a 45 percent reduction in sulfate loads (P50 modeling results) at PM-13, which would reduce the potential for mercury methylation. Overall, the NorthMet Project Proposed Action is not expected to increase the mercury content in fish in the St. Louis River. See Sections 5.2.2 and 5.2.6 for a more thorough discussion of mercury bioaccumulation.

Overall Effects on 1854 Treaty Resources

As discussed above, the NorthMet Project Proposed Action would have effects on 1854 Treaty resources—i.e., those areas and species that are traditionally or culturally important to the Bands. There are two categories of effects: those relating to plant and animal species of interest to Band members, and those relating to areas where these plant and animal species are hunted, fished, or gathered. As discussed above and in other resource-specific sections of the FEIS, the NorthMet Project Proposed Action would result in direct environmental effects due to ground-disturbing activities. Band members' use of the NorthMet Project area is not well-defined, and did not emerge through interviews. A good faith effort was made on the part of the Co-lead Agencies to identify use areas in or adjacent to the NorthMet Project area; however, those efforts resulted in little specific information concerning recent-historic subsistence use and no information regarding contemporary subsistence activity at the Mine Site, Transportation and Utility Corridor, or Plant Site. In addition, as described in Section 5.2.11, the NorthMet Project area is surrounded by private land and cannot be easily accessed due to private roads. Without private landowner permission, there is minimal opportunity for the Bands to exercise usufructuary rights (hunting, fishing, and gathering) on this property.

Construction and operation of the NorthMet Project Proposed Action is not likely to significantly reduce overall availability of 1854 Treaty resources that are typically part of subsistence activities in the 1854 Ceded Territory. Some individuals and localized populations may be affected, but overall species populations are expected to remain available. Additionally, noise and other consequences of operations would affect migration or other animal species behavior.

The importance of fish as a subsistence resource in Ojibwe communities is well documented historically, and fish continue to be an important component of the day-to-day diet, while fishing itself remains an important socio-cultural and economic activity in Tribal communities across the Upper Great Lakes. The NorthMet Project Proposed Action could affect the availability of 1854

Treaty resources for some Band members because of real or perceived factors. For instance, bioaccumulation of mercury in fish could affect Band members' willingness to rely on subsistence fishing as a contribution to household economies, as well as affect continuation of traditional fishing practices, but there is no evidence that this availability would significantly affect subsistence use given the lack of information showing recent or historic fishing activity in the NorthMet Project area.

Effects on the environment, including any from increased mercury, are all expected to meet the standards and regulations set forth by the appropriate state or federal agency or program. These laws are intended to protect important natural and cultural resources and include, but are not limited to the ESA, CWA, and CAA. Effects on 1854 Treaty resources are difficult to quantify when the effects are within environmental standards, yet above current baseline conditions. As such, cultural effects on the Bands would be difficult to quantify in regards to such incremental increases below standards or effects to species where appropriate mitigation is used.

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5.2.10 Socioeconomics

This section describes the potential socioeconomic consequences of the NorthMet Project Proposed Action on communities in the study area (consisting of St. Louis, Lake, and Cook counties—see Section 4.2.10 and Figure 4.2.10-1). Socioeconomics includes demographic characteristics of the study area's population, economic characteristics (employment, income, market composition—i.e., the types of firms and employers located in the study area), public finance, housing, public services, and the economic characteristics of subsistence activities. The cultural aspects of subsistence, specifically for Native American populations, are discussed in Section 5.2.9. Individual subsistence products (e.g., wild rice, game animals, etc.) are discussed in appropriate resource-specific sections of the FEIS.

Summary

The NorthMet Project Proposed Action would generate as many as 500 direct jobs during peak construction and 360 direct jobs during operation. These direct jobs would generate additional indirect and induced employment, estimated to be 332 additional construction-phase jobs and 631 additional operations-phase jobs. While some skilled workers would be involved only temporarily and possibly relocate from outside the region, the majority of the NorthMet Project Proposed Action-related jobs are expected to be filled by those currently residing in the Arrowhead region.

Federal, state, and local taxes would total up to an estimated $80 million annually. During operations, there would be approximately $231 million per year in direct value added through wages and rents and $332 million per year in direct output related to the value of the extracted minerals. As with employment, these direct economic contributions would create indirect and induced contributions estimated at $99 million in value added and $182 million in output.

The NorthMet Project Proposed Action would create slightly increased demand for housing and public services in cities and towns near the NorthMet Project area. The resulting increase in housing demand and prices could have minor effects on the Environmental Justice (EJ) populations.

The NorthMet Project No Action Alternative would have no effects.

5.2.10.1 Methodology and Evaluation Criteria

As discussed in Section 4.2.10, the study area for socioeconomics includes Cook, Lake, and St. Louis counties. Because socioeconomic consequences are measured and felt across a broad geographic area, this section does not distinguish between the Mine Site, Transportation and Utility Corridor, and Plant Site. Rather, this section describes the socioeconomic consequences of the NorthMet Project Proposed Action across the entire three-county study area and, where appropriate, includes the study area communities listed in Section 4.2.10.

5.2.10.1.1 Evaluation Criteria

Specific criteria used to evaluate socioeconomic consequences include the following:

- Changes in local population, employment, or earnings associated with NorthMet Project Proposed Action operations.
- Changes in public sector revenues, expenditures, or the underlying fiscal conditions of local governments.
- Changes in economic activity for non-mining industries in the region, particularly the tourism industry.
- Changes in demand for temporary or permanent housing during NorthMet Project Proposed Action construction, operation, and closure periods.
- Changes in long-term demands on public services and infrastructure that reduce capacities in these systems, either triggering the need for capital expansion or resulting in a discernible reduction in the level of service provided.
- Displacement or other use of property that affects residences or businesses.
- Disproportionate effects on minority (including Native American) or low-income populations, including human health or environmental effects, and subsistence—especially if the NorthMet Project Proposed Action results in large reductions in abundance or major redistribution of subsistence resources, substantial interference with harvestable access to active subsistence sites, or major increases in non-rural resident hunting (Barnard Dunkelberg 2009).

5.2.10.1.2 Determination of Study Area

As discussed in Section 4.2.10, the socioeconomic study area for this section includes all of Cook, Lake, and St. Louis counties (the three counties that comprise the Arrowhead region of Northeastern Minnesota). This study area includes the Mine Site, Transportation and Utility Corridor, and Plant Site, as well as all of the tracts involved in the Land Exchange Proposed Action. The size of this study area also captures much of the region's recreational resources (which are important economic engines) and a substantial portion of the 1854 Ceded Territory, which is important to the Bands. Finally, the three-county study area is large enough to reflect a regional economic picture against which the NorthMet Project Proposed Action's effects can be compared.

Where possible, the analysis of effects is based on a quantitative comparison of baseline conditions (see Section 4.2.10) against predicted future conditions in the entire three-county area. In cases where such quantitative data are not available for the entire region (e.g., the IMPLAN model discussed in Section 5.2.10.1.3), the evaluation of effects is either limited to St. Louis County—the site of the NorthMet Project area—or includes the other counties but only qualitatively.

5.2.10.1.3 IMPLAN Model Methodology

Many of the socioeconomic effects of the NorthMet Project such as increased population, housing demand, and effects on public facilities and services are functions of the jobs and revenue that the NorthMet Project Proposed Action creates. To model these effects, the

University of Minnesota Duluth Labovitz Bureau of Business and Economic Research (BBER) used the IMPLAN software package. IMPLAN uses an input-output approach to model the economic effects of changes in baseline conditions (e.g., a large industrial project such as the NorthMet Project Proposed Action). IMPLAN reports direct, indirect, and induced effects (definitions of these terms are provided below) in terms of employment, output (the value of production), and value added (wages, rents, taxes, etc.).

For both the SDEIS and the FEIS, BBER used version 3.0 of IMPLAN; this version uses economic baseline data from 2009, the most recent year for which data were available to BBER at the time the model was developed (BBER 2012). (The model does assume a recovery—by the mining industry, and the overall economy—from the recession that was in place in 2009.) Due to their small populations, workforces, and their distance from the NorthMet Project area, Cook and Lake counties are not expected to experience substantial additional effects from the NorthMet Project Proposed Action. As a result, the IMPLAN model includes only St. Louis County, which acts as a proxy for the entire three-county study area.

Economic effects were modeled for two construction phases: a 15-month Phase I and a 12-month Phase II that would begin 6 months after completion of Phase I. The phases represent two distinct periods of activity in mine construction involving distinct skill sets and activities. Two operations phases were also modeled: a 6-month Startup Phase and a Typical Year (BBER 2012). The IMPLAN model did not project the number of years of operation, due to the inherent difficulty of predicting how variations in the grade of the extracted material or macroeconomic forces—such as industry cycles or metal prices (see below)—would affect mine life. The Typical Year estimate is intended to model the economic effects of standard operations, recognizing that “some years will be a little better, others a little worse” (BBER 2012). The IMPLAN model also did not include effects during the closure phase or the post-closure period, again due to the difficulty of predicting the timing and extent of those phases.

The IMPLAN model focuses on three categories of economic effects:

- Employment: calculated in terms of jobs, not full-time equivalent (FTE) positions. The model does not make a distinction between full-time, part-time, permanent, or temporary jobs. Direct employment estimates were provided by PolyMet.
- Value added: measures economic contributions to the local economy through wages, rents, interest, and profits.
- Output: the value of the goods or services (e.g., minerals and processed mineral products) produced.

Each category of effects comprises three separate components:

- Direct effects: new jobs, spending, and output resulting directly from the NorthMet Project Proposed Action (e.g., PolyMet employees, salaries, spending, and sales).
- Indirect effects: additional inter-industry spending and employment resulting from direct effects (e.g., wholesale purchase of tires by tire retailers who are NorthMet Project Proposed Action vendors).
- Induced effects: additional household expenditure resulting from the direct and indirect effects (e.g., increased patronage of local restaurants by employees of PolyMet or affiliated industries).

The findings of the IMPLAN model are presented in section 5.2.10.2.

5.2.10.1.4 Sources of Uncertainty and Variability

The anticipated socioeconomic effects of the NorthMet Project Proposed Action are based on the best available data, economic modeling, and lessons learned from the history of metal mining in the Mesabi Iron Range. As this history shows, there are numerous sources of economic uncertainty surrounding a project such as the NorthMet Project Proposed Action. The largest overarching socioeconomic concerns related to the NorthMet Project Proposed Action are listed below. Their relationship to the determination of effects is discussed, as appropriate, throughout the remainder of Section 5.2.10.

Industry Cycles

The feasibility of mining is strongly tied to the market price of the commodities being extracted. When prices are high, mining activity is high (the "boom"); when prices drop, mining activity can often slow down or cease entirely (the "bust"). Such changes in mining activity would have effects on host communities. The diverse economy of the study area could offset the degree to which the effects of a bust are experienced. Though this "boom and bust" phenomenon is often present in mining economies, IMPLAN does not model this phenomenon (or assume that it would occur) because the duration of a boom or bust and the severity relative to modeled commodity prices cannot be predicted. Table 5.2.10-1 shows the metal prices assumed in the IMPLAN model, along with recent average prices and the lowest prices experienced during the 2008-9 recession. The potential effects of major changes in commodity prices are addressed in the discussions of effects during the operations phase.

Table 5.2.10-1 Comparison of Assumed (IMPLAN) and Actual Commodity Prices

Commodity	Price Assumed in IMPLAN[1]	Average Actual Price[2]	Comparison Low Price[3]
Copper	$2.90/lb	$3.56/lb	$1.39/lb
Nickel	$12.20/lb	$9.47/lb	$4.39/lb
Cobalt	$23.50/lb	$111.69/lb	$13.56/lb
Platinum	$1,230.00/oz	$1,689.00/oz	$843.00/oz
Gold	$635.00/oz	$1,485.00/oz	$755.00/oz

Sources: BBER 2012 (commodity prices); Foth 2012 (average actual price); PolyMet, Pers. Comm., March 29, 2012 (recent low price).

Notes:
1 Prices based on PolyMet's 2008 Bankable Feasibility Study (PolyMet 2008b). This is the most detailed published information available, and PolyMet is legally bound to these data.
2 Three-year rolling average metal prices as of June 30, 2012 (Foth 2012).
3 Monthly low during 2008-2009 recession.

Changes in Industrial Productivity

Throughout the nation, "regional labor productivity [in mining and overall]…has increased dramatically" since publication of the 2009 DEIS (BBER 2012). Over the longer term (since approximately 1980), mining productivity in the Arrowhead region has also increased, due to mechanization and technological innovation (Power 2007). As a result, far fewer miners are now required per unit of extracted material than before, which therefore lessens the effects of booms and busts in mining communities. Continued technologically driven productivity increases could lead to lower employment than assumed by IMPLAN or other projections.

Local Employment

The NorthMet Project Proposed Action's socioeconomic effects may be influenced by the degree to which PolyMet hires employees who already live in the socioeconomic study area. The FEIS assumes that at least some (but not all) direct and indirect jobs would be filled by current study area residents; more specific assumptions about the construction, operations, and closure phases are discussed in subsequent portions of this section, as are the ways in which changes in "local" employment shares would affect different aspects of the study area's socioeconomic character.

Environmental Costs and Non-market Value

The FEIS contains extensive discussion of the environmental and social effects of the NorthMet Project Proposed Action (and the Land Exchange Proposed Action) in this section and other resource-specific sections. These effects could, in turn, have real and/or perceived economic costs. Non-market values refer to the importance given to characteristics of the land that have personal or community value, but that are not typically expressed in monetary value. Beauty, quiet, and the ability to view nature are examples of non-market values.

Neither NEPA nor CEQ requires the cost and benefits of a proposed action to be quantified in dollars or any other common metric; however, this FEIS acknowledges that economic costs and loss of non-market value may result from environmental and social effects. Also acknowledged is that the agreement on the value (i.e., the "cost") of environmental effects is often difficult to achieve. Therefore, the approach of this FEIS is to evaluate environmental and social effects directly, in the appropriate resource-specific section (e.g., the impacts on wildlife are discussed in the Wildlife section, and impacts on water quality are discussed in the Water Resources section).

5.2.10.2 NorthMet Project Proposed Action

This section evaluates the NorthMet Project Proposed Action's effects on socioeconomics in the three-county study area.

5.2.10.2.1 Population and Population Trends

This section discusses the changes in the study area's population resulting from the NorthMet Project Proposed Action. These population changes would be driven primarily by NorthMet Project Proposed Action-related changes in employment.

Construction

IMPLAN modeling estimates that construction activities would create an average of 500 direct and 128 indirect construction jobs over the 18-month Phase I period (the most labor-intensive portion of the construction phase). The 204 induced jobs during this phase are likely to be existing residents hired to accommodate the additional demand from direct and indirect jobs.

Typical mine construction involves fluctuating work flows and specialized crews that may be employed for short duration tasks within the construction time frame. Very few construction phase employees would work within the NorthMet Project area for the entire 30-month construction period (including Phase I, the 6-month gap, and Phase II).

Given the NorthMet Project area, most construction employees would likely be from Minnesota, and many would already live in the study area. Many direct and indirect employees are likely to reside outside of the communities in the immediate vicinity of the NorthMet Project area (e.g., Hoyt Lakes, Babbitt, Biwabik, Aurora). However, mine workers in the Arrowhead region and beyond "are willing to commute considerable distance to…well-paid jobs…to protect investment in their homes" (Power 2007). This finding is generally true of mine construction workers as well. As a result, most employees (regardless of project phase) would not need to relocate.

Due to the proximity of the NorthMet Project area to population centers such as Duluth (80 miles), Hibbing (50 miles), and Virginia (25 miles), the FEIS assumes that 80 percent of direct and indirect construction labor (approximately 500 employees during Phase I of construction, which requires more workers than Phase II) would commute to the NorthMet Project Proposed Action construction site on a regular basis (PolyMet 2012d). The FEIS assumes that another 5 to 10 percent of direct and indirect workers (approximately 25 to 50 employees) would temporarily reside in the study area, at local hotels or in designated mobile home facilities, but would not relocate their families to the region.

The remaining 10 to 15 percent of the direct and indirect workforce (as many as approximately 100 employees) would relocate to the study area for portions (or all) of the construction process (PolyMet 2012d). An influx of 100 workers would equate to as many as 225 total new residents (including family members—see the average population per housing unit in Table 4.2.10-14) who would seek long-term (e.g., more than a few months) residences in nearby communities. This represents an increase of less than one quarter of 1 percent over the 2010 population of the study area (approximately 216,000 residents—see Table 4.2.10-1), and slightly more than a 2 percent increase in the population of nearby cities (Aurora, Babbitt, Biwabik, Hoyt Lakes, Tower, and Virginia). Such a small increase would not meaningfully change the demographic composition of the study area; thus, construction of the NorthMet Project Proposed Action would have negligible effects on population.

Operations

During typical operations, the NorthMet Project Proposed Action would generate 360 direct and 330 indirect jobs. Direct and indirect employees are likely to work at the Mine Site, Plant Site, and in the study area for a substantial period of time (perhaps as long as the 20-year projected life of the mine). Direct and indirect employees who do not already live within commuting distance of the Mine Site and Plant Site (i.e., in the study area) are likely to relocate to the study area. It is not known how many direct employees would be current study area residents. PolyMet estimates that as many as 338 of the 360 new direct operations-phase positions (94 percent of these positions) could be filled by study area residents (PolyMet 2012c).

For purposes of this analysis, the FEIS assumes that approximately 75 percent of direct and indirect operations phase employees would be local residents who would not need to relocate as a result of employment. The FEIS also assumes that the vast majority of the 301 induced jobs created during operations would be filled by existing residents or the spouses and children of new NorthMet Project Proposed Action employees.

The remaining 25 percent of operations-phase workers (approximately 175 employees) would relocate to the study area with their families, causing a total increase of approximately 400 new residents (see the average population per housing unit in Table 4.2.10-14). This is less than one quarter of one percent of the study area population (approximately 216,000 residents).

These workers are likely to be younger, on average, than the existing populations of the study area communities, and may have higher overall incomes. Other demographic characteristics (race, level of education) cannot be determined. The effect of such a shift on housing and public services is discussed below.

Increases in worker productivity spurred by technological change could reduce the anticipated number of direct, indirect, and induced employees. The effect of such reductions would be to reduce the overall new population of the study area. This in turn would diminish the NorthMet Project Proposed Action's demographic effects.

Reclamation and Closure

During the closure of the NorthMet Project Proposed Action, PolyMet estimates that a reduced number of employees and contractors would remain employed for approximately 3 to 4 years for building demolition, but other closure activities would likely be followed by several years of reclamation activities (e.g., surface water quality monitoring). PolyMet is in the process of preparing reclamation designs and estimates. Current estimates are based on experience at closure of the former LTVSMC processing plant and include 30 to 50 FTEs for the first 7 years, which includes demolition, remediation, reclamation, construction, and monitoring, and 5 to 10 FTEs for the following 30 years, which includes a period of monitoring, reporting, and active water treatment. During closure, direct, indirect, and induced employment associated with the project would decline. All other factors being equal, by the end of the seven-year closure period, the demographic characteristics of the study area would likely revert to levels that could be expected under the NorthMet Project No Action Alternative.

5.2.10.2.2 Employment and Income

Table 5.2.10-2 shows the anticipated economic contributions of the NorthMet Project Proposed Action, as modeled using IMPLAN. Detailed estimates of jobs by type are provided in the IMPLAN Report (BBER 2012). The IMPLAN model includes assumptions about the portion of employment, value added, and output that accrues to the study area (in the case of the IMPLAN model, this is limited to St. Louis County), as opposed to the amount that "leaks" to locations outside of St. Louis County (BBER 2012). While the data in Table 5.2.10-2 depict the economic effects of the project specifically on St. Louis County alone, they capture the vast majority of the NorthMet Project Proposed Action's effects in the entire three-county study area. By comparison, the total value added to the Minnesota economy in 2009 (from all sources) was $268 billion (USFS, Pers. Comm., July 26, 2013).

Table 5.2.10-2 Summary of IMPLAN Model Results

Phase[1]	Direct Effect	Indirect Effect	Induced Effect	Total
Construction Phase I				
Value Added[2]	$143,637,243	$41,774,260	$61,120,854	**$246,532,357**
Output[3]	$312,000,009	$75,343,964	$101,199,927	**$488,543,900**
Employment	500	128	204	**832**
Construction Phase II				
Value Added	$75,501,628	$21,958,266	$32,127,628	**$129,587,122**
Output	$164,000,005	$39,603,897	$53,194,833	**$256,798,717**
Employment	264	68	107	**439**
Operations Phase – Startup				
Value Added	$44,619,571	$12,117,664	$6,865,833	**$63,603,068**
Output	$64,122,003	$23,821,174	$11,367,855	**$99,311,032**
Employment	300	275	251	**826**
Operations Phase – Typical Year				
Value Added	$231,315,193	$62,819,962	$35,593,610	**$329,728,765**
Output	$332,418,993	$123,492,880	$58,932,833	**$514,844,706**
Employment	360	330	301	**991**

Source: BBER 2012.

Notes:
1 The IMPLAN model did not include effects during the closure phase or post-closure period.
2 Defined in BBER 2012 as “a measure of the affecting industry’s contribution to the local community; it includes wages, rents, interest and profits.”
3 Defined in BBER 2012 as “the value of local production required to sustain activities.”

Construction

Construction of the NorthMet Project would create as many as 832 jobs during the peak of Phase I, of which 500 would be mine construction jobs. Indirect and induced employment would be spread across a variety of industries, such as engineering, restaurants, medical providers, and hospitals (see Table 10 in BBER 2012). The NorthMet Project Proposed Action-related construction employment would increase overall study area employment by less than one percent at its peak (less during Phase II).

As discussed in Section 5.2.10.2.1, the FEIS assumes that a substantial share of direct construction jobs would be filled by study area residents—particularly those with construction experience—while other study area residents would obtain indirect and induced jobs. Construction is therefore expected to at least marginally reduce the unemployment rate in the study area.

It is not known how much of the estimated $376 million in total value added during the two parts of the construction phase would be dedicated to employee salaries, although employee pay is assumed to be a substantial share. The value added from the NorthMet Project Proposed Action is likely to be substantial compared to other non-ferrous (e.g., copper, nickel, lead, zinc) mining activity.

While employment related to the construction phase of the NorthMet Project Proposed Action would have minimal effects, the earnings from construction employees would be positive, albeit relatively short-lived (e.g., for no more than the 36-month overall construction phase).

Operations

Overall Effects

During typical year operations, the NorthMet Project Proposed Action would generate nearly 1,000 total direct, indirect, and induced jobs. This would increase study area employment by approximately one percent. One-third of new employment (360 jobs) would be direct mine-related jobs. The remainder would be spread among a variety of industries, such computer programming, restaurants, engineering, and health care (BBER 2012).

As discussed in Section 5.2.10.2.1, the FEIS assumes that a substantial share of direct operations jobs would be filled by study area residents, particularly those with mining experience. In 2009, there were approximately 3,000 mining jobs in the study area (U.S. Census Bureau 2009). This figure does not include residents who have skills appropriate for the mining sector but who are not currently employed in mining. Other local residents are likely to obtain indirect and induced jobs. Operation of the NorthMet Project Proposed Action could reduce unemployment in the study area by nearly one percent (991 new jobs out of 111,090 members of the workforce, see Table 4.2.10-9).

It is not known how much of the estimated $330 million in total value added during typical operations would be dedicated to employee salaries, although employee pay is assumed to be a substantial share. The NorthMet Project Proposed Action's estimated value added (and thus earnings) is substantial compared to the 2007 estimate of $250 million in annual statewide value added economic effects from non-ferrous mining (BBER 2009).

Earnings and all economic contributions of the NorthMet Project are influenced by external market factors, such as those discussed in Section 5.2.10.1.4. Significant decreases in metal prices and/or competition from other regions or countries can lead to reduced production. PolyMet states that, due to its structure as a "low-cost producer," the NorthMet Project Proposed Action would be unlikely to completely cease operations during a recession (PolyMet, Pers. Comm., March 29, 2012). That statement notwithstanding, complete suspension of mining activity is not an uncommon response to recession or significant drops in commodity prices. This "bust" aspect of the cyclical economy is familiar to mining regions in Minnesota and beyond (Power 2007; Freudenberg and Wilson 2002). Increases in productivity may not affect the output of the NorthMet Project Proposed Action (i.e., the sales price of the extracted and processed materials), but could reduce employment and value added.

To account for some of these concerns, commodity prices in the IMPLAN model are generally conservative, compared to price trends. In particular, copper, gold, and platinum prices used in the IMPLAN model are significantly below recent average prices. Nickel and cobalt, which are expected to comprise a small share of the total volume extracted by PolyMet, are significantly above current average prices, but were also conservative compared to contemporary prices that formed the basis of PolyMet's 2008 Bankable Feasibility Study (see notes in Table 5.2.10-1) (PolyMet 2008b). Section 5.2.10.1.4 provides more information about sources of uncertainty and variability.

Effects on Regional Tourism

Effects on species (game animals, fish, and vegetation) and resources (water quality, air quality, and noise) that contribute to the tourism industry are discussed in appropriate sections of Chapter 5. Housing is also an important component of the tourism industry—the Arrowhead region is often regarded as a location for long vacations, rather than short day-trips—and is discussed in Section 5.2.10.2.4. To the degree that the NorthMet Project Proposed Action adversely affects those resources, then it also has the potential to affect the tourism industry. However, the presence of the NorthMet Project Proposed Action would not significantly affect regional recreation or visual resources (see Section 5.2.11.2.1), nor would it affect air or water quality or increase noise levels in popular regional recreation resources such as BWCAW (see Section 5.2.12). Consequently, there is also insufficient evidence to suggest that the presence of the NorthMet Project Proposed Action would affect the tourism industry as a whole.

As discussed in 5.2.10.2.1, the NorthMet Project Proposed Action would retain a small workforce, generating a corresponding small number of indirect and induced jobs, to perform post-mining activities such as demolition and reclamation as well as to maintain a very small post-closure staff. Using the IMPLAN model's construction-phase employment multipliers (BBER 2012) a 50-person closure staff (direct employment) could equate to as many as 30 indirect and induced jobs (a decline, compared to the 1,000 operations-phase jobs generated by the NorthMet Project Proposed Action). Because no minerals or other commodities would be extracted, the value added from the closure phase would be limited to employee salaries, rents, and other contributions.

Closure

Overall, the employment, output, and value added from the closure phase would be small compared to the study area's overall economy. More important, at mine closure, workers who held operations-phase direct, indirect, and induced jobs would be expected to secure alternative local employment, retire, or relocate out of area. There would likely be a spike in unemployment and a resulting decline in income during the transition between the operations and closure phases. The 991 operations-phase jobs (including direct, indirect, and induced jobs) collectively account for less than one percent of the overall study area workforce (111,090 individuals—see Table 4.2.10-9). Any increase in study area unemployment during and after closure—resulting from individuals who remain in the study area workforce but who cannot find jobs—would be minimal. As former employees moved, found new work in the area, or retired, unemployment and income would normalize to levels predicted for the NorthMet Project No Action Alternative (holding all other economic variables constant).

5.2.10.2.3 Public Finance

The IMPLAN model estimates the value of several federal and state taxes, including personal income taxes (i.e., taxes paid by employees on their salaries), indirect business taxes, and other taxes paid as a result of the NorthMet Project Proposed Action for the duration of the project (BBER 2012). PolyMet provided the tax estimates for taxes that would be paid directly by the company (PolyMet, Pers. Comm., March 29, 2012). The remainder of this section discusses those tax estimates.

Construction

Construction of the NorthMet Project Proposed Action would generate approximately $51 million in federal tax revenue, and $24 million in state tax revenue (combined, both construction phases) (BBER 2012). A portion of these tax contributions would be returned to the study area through various federal programs (e.g., grants to school systems and state governments) and through distributions from the state's general fund. However, such effects on local public finances are indirect and difficult to quantify. Other construction-phase revenues could include sales and use tax on some materials used for NorthMet Project Proposed Action construction, although most such materials and supplies are exempt from the tax (MDR 2011).

Operations

The majority of economic benefits to the local community through taxes would be realized during the operations period. IMPLAN modeling estimates that, during a typical year of operation, the federal government would receive approximately $30 million, and the state and local governments would receive approximately $39 million in taxes from the operation of the NorthMet Project Proposed Action.

PolyMet estimates that, if the NorthMet Project Proposed Action was currently in operation, its direct federal and state tax payments would have ranged from approximately $37 to $80 million per year during the previous 5-year period (PolyMet, Pers. Comm., March 29, 2012). Table 5.2.10-3 details how these direct tax payments would be divided among different state and federal taxes (as described in Section 4.2.10.1.3), if the NorthMet Project Proposed Action would have been in full operation in 2011. A substantial portion of state taxes would be returned to study area school systems, local governments, and local general funds.

Table 5.2.10-3 Estimated Annual NorthMet Project Proposed Action Taxes Paid, 2011 Dollars (millions)

	Minnesota Taxes[1]	Federal Taxes[1]
Net Proceeds Tax	$5.9	NA
Occupation Tax	$7.1	NA
Sales and Use Tax	$2.4	NA
Withholding Tax on Royalty Payments[2]	Undetermined	Undetermined
Ad Valorem Tax	$0.2	NA
Total	**$15.6**	**$64**

Source: PolyMet, Pers. Comm., March 29, 2012.

Notes:
[1] Assumes full operation at 2011 metal prices.
[2] Royalty payments would be subject to a 6.25% withholding tax. The value of this tax cannot be calculated or estimated at this time.

The magnitude of tax contributions is strongly linked to commodity prices. A significant drop in commodity prices would likely result in a significant reduction in tax revenue generated by the NorthMet Project Proposed Action. Even under such circumstances, operation of the NorthMet Project Proposed Action would benefit the local economy.

Reclamation and Closure

Closure activities would last approximately 20 years after cessation of operations. The first seven years of this period would be the most active, and would include reclamation, demolition, and restoration of the site. Years 7 to 20 of closure would include low-intensity monitoring, maintenance, and water treatment activities, followed by covering of the Tailings Basin at the end of this period. Low-intensity post-closure activities (such as long-term monitoring and maintenance) would extend indefinitely beyond year 20 of closure.

During closure and post-closure, the NorthMet Project Proposed Action would generate a small amount of tax revenue from the above activities, primarily from income taxes and business taxes. Other revenue sources, such as net proceeds taxes, and local ad valorem taxes would no longer apply. By the end of the closure phase, contributions to public finances would return to levels that would be expected for the NorthMet Project No Action Alternative. Relative to existing conditions, closure of the NorthMet Project Proposed Action would generate a negligible benefit for public finances in the study area.

5.2.10.2.4 Housing

Housing effects are tied to both employment and earnings; increases in both of these factors can cause increased demand for housing. There are more than 24,000 vacant housing units in the study area, of which approximately 7,000 are "permanent" (not seasonal) vacant units (see Table 4.2.10-14). Of that total, approximately 4,000 non-seasonal vacant units are located in the individual study area communities listed in Section 4.2.10 (the remainder are scattered throughout St. Louis, Lake, and Cook counties). All of these communities are within a reasonable commuting distance of the NorthMet Project area (Power 2007).

Construction

As described in Section 5.2.10.2.1, 75 percent of the construction-phase employees are expected to commute to their jobs from existing residences in or near the study area. Relatively few construction-phase employees (approximately 100) are expected to permanently relocate to the study area, due to the short-term and transient nature of mine construction. Given the existing vacant housing stock (and including seasonal units, which could be converted to permanent units at the owners' discretion), this added demand in permanent housing in the study area would be largely imperceptible.

Approximately 25 to 50 employees may choose to procure temporary housing. This could consist of short-term rentals of available housing units (seasonal or otherwise), and use of mobile home parks or hotels/motels. Lodging and mobile home facilities close to the NorthMet Project area, such as those in Aurora, Hoyt Lakes and Babbitt, could be more heavily occupied throughout both phases of the construction period, affecting both availability and pricing for the region's tourist demand. However, there are approximately 5,400 hotel rooms and more than 1,400 mobile home berths (as well as park facilities that permit mobile homes) in the study area (Northland Connection 2012). Construction-phase demand for these accommodations would not substantially limit availability.

Operations

Demand for permanent housing is likely to increase during the operations phase. As discussed in Section 5.2.10.2.1, approximately 175 workers would choose to relocate to the study area. The actual number of housing units required to accommodate this demand may be lower (less than 380), due to the presence of two-worker in-migrating households (e.g., the spouse of a direct employee may obtain an indirect or induced job). Even if there are no multiple-worker in-migrating households (an unlikely scenario), the study area has approximately 7,000 vacant non-seasonal housing units. Thus, the study area has adequate housing to accommodate the influx of workers associated with the NorthMet Project Proposed Action.

Individual communities close to the NorthMet Project area may experience more competition for available housing units. While it is unlikely that any single community would achieve 100 percent non-seasonal occupancy, such competition could drive up housing prices and could also encourage the renovation of existing housing units and/or construction of new housing units (either on vacant land or as replacements of older housing units). Given the small number of new residents, such effects would be minor.

As with other economic effects of the NorthMet Project Proposed Action, effects on housing are tied to market fluctuations and workforce productivity. Major changes in levels of production (caused by major changes in commodity prices) could cause effects on housing demand and value. However, the total estimated new housing demand associated with the NorthMet Project Proposed Action is relatively small compared to the region's existing housing supply. Even a market "bust" (a drop in commodity prices so severe that it causes shutdown of the NorthMet Project Proposed Action) should not dramatically alter the housing market in any single community, let alone the study area as a whole.

There are concerns that the presence of the NorthMet Project Proposed Action could reduce housing demand (and thus housing value) in the study area, because of the conflict between the NorthMet Project Proposed Action's heavy industrial character and the high-quality natural environment that supports the region's tourism economy and thus the housing market. As described in Section 5.2.11, the NorthMet Project Proposed Action's effects on recreation and visual resources would be very limited.

Given the coexistence of mining and tourism in the Arrowhead region, the NorthMet Project Proposed Action's effects on the study area's housing values would be minimal. The most likely result of the operation of the NorthMet Project Proposed Action is a minor increase in housing demand and prices in study area communities, with moderate effects in individual communities closest to the NorthMet Project area. Increased housing prices may or may not be a negative effect; average housing values in the communities closest to the NorthMet Project area are relatively low compared to other study area communities. Minor to moderate increases in housing value would likely be seen as a benefit by homeowners, and the opportunity to add newer housing stock (either through rehabilitation of existing units or the construction of new units) to the study area would generally improve property values, thus improving local property tax revenues in those communities.

Reclamation and Closure

During and following reclamation and closure of the NorthMet Project Proposed Action, it is likely that the demand for housing would drop as workers migrate from the area. Housing characteristics (vacancy rates and values) would likely revert to levels that would be expected for the NorthMet Project No Action Alternative. However, increases in housing demand spurred by the strength of the tourism industry and the increasing popularity of the study area for retirement could obscure any such declines.

5.2.10.2.5 Public Services and Facilities

The NorthMet Project Proposed Action would affect public services and facilities in the study area both directly and indirectly. Direct effects would include services provided to the NorthMet Project Proposed Action itself, and would largely be limited to demand for emergency response in the case of an accident. Indirect effects would include increased demand for public services such as potable water, sewer, emergency services, and schools in communities where direct, indirect, and induced employees and their families live.

Most public water and sewer infrastructure in the study area was designed to accommodate larger populations than currently exist; therefore, the NorthMet Project Proposed Action would generally have no effect on these services (see Table 4.2.10-15). As Section 4.2.10.1.5 shows, emergency and medical services are equipped to handle existing demand, and most have mutual aid agreements in place with nearby cities to cooperatively respond to major emergencies.

The public schools in the study area were constructed to accommodate larger populations than currently exist in the study area (e.g., the larger populations that were associated with the iron and taconite mining industry in the 1960s and 1970s). Collectively, public schools in the study area have capacity for nearly 22,000 students, with existing enrollment of nearly 16,000 students. Thus, these schools are able to support new students without building new facilities. To address concerns about maintenance of older buildings, several school facilities in the region have already established renovation programs, and some schools in Duluth plan to downsize (see Section 4.2.10.1.5). These plans predate the NorthMet Project Proposed Action, and would not be accelerated or changed by new population associated with any phase of the NorthMet Project Proposed Action.

The five technical and community colleges and two four-year colleges located throughout the study area provide a variety of degree programs. These schools would continue to provide educational opportunities to new and existing study area residents seeking further education, including high school graduates and existing employees seeking to enhance their job skills. Several community colleges and universities in the study area offer, or are developing, educational curriculum related to jobs in the mining industry.

Construction

Direct demands from construction of the NorthMet Project Proposed Action would primarily fall on local emergency service providers who would respond to any emergencies at the NorthMet Project area.

A small number of construction-phase employees and their families (approximately 225 total new residents, as described in Section 5.2.10.2.1) are expected to permanently relocate to the study area, while another 150 employees would stay in the study area for moderate periods of time (from several weeks to several months), in hotels or mobile homes. All of these employees would generate indirect demand for drinking water, wastewater capacity, and emergency services; the relocated residents would also generate demand for space in public schools.

Public schools in the study area generally have sufficient capacity to accommodate new students. As described in Section 4.2.10.1.5, several school facilities in the region are in need of renovation. This need predates the NorthMet Project Proposed Action, and would not be exacerbated by the relatively small number of new students added by NorthMet Project Proposed Action construction.

Operations

Direct demands from operation of the NorthMet Project Proposed Action would primarily fall on local emergency service providers who would respond to any emergencies within the NorthMet Project area. Approximately 400 operation-phase employees and family members are expected to relocate to the study area (see Section 5.2.10.2.1). All of these employees and their families would generate demand for drinking water, wastewater capacity, emergency services, and school capacity.

Additional police, fire, and ambulance staff may be required to service increased populations in study area cities, particularly in smaller cities. However, these expansions are likely to consist of one to two employees per service (e.g., one new police officer, two new firefighters), per city, as well as upgrades of existing equipment, rather than wholesale expansions of police and fire departments. Increased tax revenues from the NorthMet Project Proposed Action would be expected to cover the costs of these expansions.

Reclamation and Closure

During reclamation and closure of the NorthMet Project Proposed Action, direct and indirect demands for public service would decrease to baseline levels (those present at the start of the NorthMet Project Proposed Action) due to the anticipated decrease in population and activity at the Mine Site and Plant Site. Any cap upgrades to public services and facilities constructed to accommodate operations-phase demands, such as newer police and fire vehicles, would be available to the remaining residents of the study area during closure and post-closure activities.

5.2.10.2.6 Environmental Justice and Subsistence

Evaluation of EJ effects—the degree to which the potential effects of the NorthMet Project Proposed Action or any alternative are felt disproportionately across a community, considering ethnicity, age, and income—follows criteria set forth in the following federal EOs:

- EO 12898, (*Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations,* 1994), directs federal agencies to incorporate EJ into their mission and activities. Federal agencies are to accomplish this by conducting programs, policies, and activities that substantially affect human health or the environment in a manner that does not exclude communities from participation in, deny communities the benefits of, or subject communities to discrimination under such actions, because of their race, color, or national origin.

- EO 13045, (*Protection of Children from Environmental Health Risks and Safety Risks,* 1997), requires each federal agency give high priority to the identification and assessment of environmental health and safety risks to children.

In particular, this EJ analysis focuses on the degree to which the NorthMet Project Proposed Action could disproportionately affect the populations described above and includes residents of the study area, as well as Band members who use the study area for subsistence, regardless of where they live.

Minority (non-white) populations comprise less than 5 percent of the study area, and less than 5 percent of the individual communities listed in Table 4.2.10-3 (except for the three reservations). By comparison, the minority population of Minnesota was approximately 15 percent. The following groups in the study area meet the criteria described above:

- Approximately 13.5 percent of the study area population is below the federal poverty level, compared to 10 percent for the state.
- Native Americans comprise 2.3 percent of the study area, compared to 1.1 percent of the state population.
- Children (individuals under 18 years of age) comprise nearly 29 percent of the study area population, compared to 24 percent for the state.

Native American tribes exercise usufructuary rights to hunt, fish, and gather plants within the 1854 Ceded Territory, which includes the study area. This section discusses the degree to which the NorthMet Project Proposed Action would disproportionately affect these subsistence practices, with the understanding that these practices have both socioeconomic and cultural value for the Native American tribes. Section 5.2.9 discusses the cultural aspects of subsistence in greater detail.

Construction

As described in Section 5.2.10.2.2, the economic effects of construction of the NorthMet Project Proposed Action would be largely positive. Construction would provide new jobs, substantial new earnings, and indirect contributions to public finances. Potential negative socioeconomic effects of construction of the NorthMet Project Proposed Action include increased demand for short-term housing (hotels and mobile home facilities)—although this is a benefit for the owners of those facilities—and increased demand for public services (especially emergency services). These negative effects are generally minor.

Increased public service demands would not disproportionately affect EJ populations. Increased prices would negatively affect the study area's poorest residents who did not receive a commensurate direct or indirect economic benefit from the NorthMet Project Proposed Action. Approximately 150 workers are expected to relocate to or occupy short-term housing in the study area during construction. This number of new and temporary residents, and therefore demand for public services, is small compared to available vacant housing, although poor residents closer to the NorthMet Project area may experience higher prices and demand than in the study area as a whole.

The NorthMet Project area is within the 1854 Ceded Territory. Section 4.2.10.1.6 and Table 4.2.9-1 in Section 4.2.9 summarize available information about subsistence patterns and resources within the 1854 Ceded Territory. Construction of the NorthMet Proposed Action would make the Mine Site unavailable for subsistence use. The degree to which construction of the NorthMet Project Proposed Action would affect individual subsistence resources (i.e., fish, game, and plant species) outside of the Mine Site, Transportation and Utility Corridor, and Plant Site is discussed in Section 5.2.9 (Cultural Resources).

Operations

As described in Section 5.2.10.2.2, the economic effects of operation of the NorthMet Project Proposed Action would be largely positive. Operations would provide new jobs, substantial new earnings, and substantial direct and indirect contributions to public finances.

Potential negative socioeconomic effects of operation of the NorthMet Project Proposed Action include increased demand for housing (which could negatively affect the study area's poorest residents who did not receive a direct or indirect commensurate economic benefit from the NorthMet Project Proposed Action) and increased demand for public services and facilities.

Increased public service demands would not disproportionately affect minority and low income populations. The influx of direct, indirect, and induced NorthMet Project Proposed Action employees could cause demand for as many as 175 housing units across the study area. While this number is small compared to available vacant housing in the study area, some marginal increase in housing demand and cost, as well as demand for public services, is possible, particularly in communities closer to the NorthMet Project area. Increased housing competition would likely affect the study area’s poorest residents, particularly renters (whose housing costs are more volatile), and particularly those living closer to the NorthMet Project area.

Operation of the NorthMet Project Proposed Action would make the Mine Site unavailable for subsistence use; noise and other consequences of operations could affect migration or other animal species behavior in the vicinity of the Mine Site and Plant Site (see Section 5.2.5, Wildlife).

Operations could affect individuals who consume fish harvested from nearby waterbodies. The NorthMet Project Proposed Action would increase mercury concentrations in the Embarrass River Watershed, as well as some nearby lakes, although it would decrease mercury concentrations in the Partridge River watershed (see Section 5.2.2.3.4). As described in Section 4.2.10.1.6, subsistence fishing and consumption is a common activity for Native American bands in the 1854 Ceded Territory. Members of the Grand Portage and Fond du Lac bands are known to consume substantially more fish than the assumed statewide average. As a result, increased mercury concentrations, and potential increases in mercury bioaccumulation in fish tissue could therefore constitute an EJ impact for Band members and other subsistence consumers of fish. However, the AERA assessed health effects for recreational and tribal fishermen and their families consuming fish that could potentially contain elevated bioaccumulated levels of methylmercury. A potential small change in fish mercury concentration was estimated based on modeled emissions and deposition. The potential change in methylmercury concentration is not statistically measureable given variability in background concentrations and current laboratory analytical methods (Barr 2013j). Therefore, there is no expected change in fish mercury concentrations, and no subsequent change in human health risks related to fish consumption (see Section 5.2.7.2.5). This information is summarized in Section 7.3.4.4.3 of the FEIS.

Reclamation and Closure

During reclamation and closure, socioeconomic characteristics of the study area would revert to conditions that would be expected for the NorthMet Project No Action Alternative. Employment, earnings, and contributions to public finances generated by the NorthMet Project Proposed Action would end (potentially with a phase-out period); housing demand and prices would ease as would demands for public services and facilities. Poorer residents of the study area would have more difficulty coping with this transition if they hold lower-paying, less secure "induced" jobs (as opposed to direct or indirect jobs), as they may have more difficulty moving out of the study area to secure new jobs (particularly if housing values drop). However, given the relatively small number of jobs generated by the NorthMet Project Proposed Action (compared to the total number of jobs held by study area residents), these difficulties would not be substantially higher than existing conditions.

As during other phases, land access to the NorthMet Project area would remain closed to the public during and following the closure phase. Deposition of mercury from the NorthMet Project Proposed Action would cease at closure. Per the AERA assessment, there is no expected change in mercury concentrations in fish, and no subsequent change in human health risks related to fish consumption (see Section 5.2.7.2.5).

5.2.10.3 NorthMet Project No Action Alternative

Under the NorthMet Project No Action Alternative, the NorthMet Project Proposed Action would not be developed. There would be no NorthMet Project Proposed Action-related change to the study area. Externally existing demographic trends such as population growth or decline, and shifts in employment patterns would continue. The study area would not accrue the economic benefits of the NorthMet Project Proposed Action, nor would it experience any of the negative effects identified in this FEIS. As described in Section 5.2.10.2, the presence of the NorthMet Project Proposed Action would not hamper growth of the Arrowhead region's tourism industry; the NorthMet Project No Action Alternative would not hasten this growth, either. Overall, the NorthMet Project No Action Alternative would have no effect on socioeconomics in the study area.

5.2.11 Recreation and Visual Resources

This section describes the potential environmental effects of the NorthMet Project Proposed Action on recreational facilities and activities that typically take place in the NorthMet Project area, as well as the surrounding Arrowhead region. Recreation in this region is strongly tied to the aesthetic condition of the landscape so this section also describes the effects of anticipated project activities on visual resources in the NorthMet Project area and surrounding land.

Summary

Most of the Mine Site, a part of the Superior National Forest, is currently public land. However, the Mine Site is surrounded by private land that lacks public roads or trails and is therefore not publicly accessible by land. The Transportation and Utility Corridor and Plant Site are privately owned lands and are not open to the public for recreation. Direct effects on recreation in this area from the NorthMet Project Proposed Action would be limited. With the exception of the Skibo Vista Scenic Outlook, views of project activities would be limited by topography and distance. The NorthMet Project could reduce recreational use of nearby lands, including portions of the Superior National Forest, but would not affect recreational patterns and facilities in the Arrowhead region as a whole. The BWCAW and Voyageurs National Park (recreational resources that are discussed in greater detail in Section 5.2.12) are each more than 19 miles from the NorthMet Project Area. An analysis of potential air quality effects demonstrated that there are no expected effects on visibility in these areas when compared to pristine conditions.

5.2.11.1 Methodology and Evaluation Criteria

5.2.11.1.1 Recreation

The primary issues related to recreational facilities and activities on and near the proposed project facilities include the following:

- Direct effects due to construction, operation, and closure of the NorthMet Project Proposed Action resulting in the reduction of the number and/or acreage of recreational facilities (parks, lakes, trails, etc.) potentially available for public use;
- Indirect effects of the NorthMet Project Proposed Action, including reduction in the use of recreational facilities in areas surrounding the proposed project facilities due to noise, dust, and other disturbances; and
- The net effect of local (i.e., the area surrounding the Mine Site and Plant Site) and regional recreation during post closure.

Evaluation of the NorthMet Project Proposed Action against these criteria was based on comparison to the USFS ROS for land that is controlled by USFS. The USFS uses the ROS to inventory recreational settings and characteristics (see Section 4.2.11.1 for further explanation of the ROS).

Effects on the region's overall recreation resources (e.g., lands not necessarily controlled by USFS) are based on qualitative analysis of NorthMet Project Proposed Action activities, as they relate to the region's recreational opportunities (as summarized in Section 4.2.11). Specific considerations include distance (both direct and via road or trail) between the NorthMet Project and various recreation resources, and the likelihood that the NorthMet Project Proposed Action would change the noise or visual environment, or the character of water, flora, and fauna present in these resources. These evaluations are based on extensive touring of the region and review of available mapping and descriptive material about the region's recreation resources.

5.2.11.1.2 Visual Resources

The primary issues related to visual resources on and near the Mine Site and Plant Site include the following:

- The nature and severity of effects of the NorthMet Project Proposed Action on sensitive viewpoints, including nearby homes, businesses, and vistas;
- Changes to the extent or scale of visible mining disturbances; and
- The ultimate appearance of the NorthMet Project Proposed Action after reclamation is completed versus current and interim stages of active mining.

Evaluation of the NorthMet Project Proposed Action against these criteria was based on comparison to the USFS Scenery Management System classes for land that is or would be controlled by the USFS. The USFS uses the Scenery Management System to identify desired visual conditions, as expressed by SIOs (see Section 4.2.11.1 for further explanation of SIOs).

Effects on the region's overall visual environment (e.g., lands not necessarily controlled by USFS) are based on qualitative analysis of the NorthMet Project's activities (particularly structures, stockpiles, and other visible activities), as they relate to what observers are likely to see in the region. This understanding is based on extensive touring and photo-documentation of views and visual conditions in the region. In addition, GIS, printed maps, and aerial photography were used to identify potential sensitive viewpoints, for which visual simulations of future mine facilities were developed.

5.2.11.2 NorthMet Project Proposed Action

5.2.11.2.1 Recreation

Surface rights to most of the Mine Site are held by the USFS, as part of the Superior National Forest. As described in Section 4.2.11, the ROS classes for the portion of the Mine Site located on federal lands are Semi-Primitive Motorized and Roaded Natural. The setting and characteristics of the portion of the Mine Site located on private lands is similar to the Roaded Natural class. However, there is no officially established public access (e.g., roads or trails) to the Mine Site (see Section 4.2.11.1), and thus limited opportunity for recreational activity. No access (or recreational opportunities) would be allowed during construction, operation, or closure of the NorthMet Project Proposed Action. Accordingly, the NorthMet Project Proposed Action would have no effect on recreation within the Mine Site.

Construction and operation of the NorthMet Project Proposed Action would be entirely contained within the NorthMet Project area (i.e., the Mine Site, Transportation and Utility Corridor, and Plant Site). Thus, the NorthMet Project Proposed Action would not directly affect access to or use of regional recreational facilities such as other portions of the Superior National Forest, nearby parks and other public lands, or the BWCAW.

The public's enjoyment of recreational activities in the region—such as hunting, fishing, boating, hiking, and winter sports—is tied in part to visual resources, as discussed below, and also to a wide variety of factors evaluated in other sections of Chapter 5.0. Such factors include, but are not limited to, recreation access including roads, trail access, boat access, and parking areas; the availability and quality of fish and other aquatic species; vegetation; wildlife (particularly game species); noise; air quality; water quality; and wetlands. Effects on these resources are presented in the corresponding sections in Chapter 5.0.

The mine facilities such as mine pits, stockpiles, and associated facilities would be set back from most publicly accessible land, including portions of the Superior National Forest south of the Transportation and Utility Corridor. In addition, the lack of designated trails in these portions of the Superior National Forest means that the number of recreational users who would approach the Mine Site would be limited. Nonetheless, the presence of the NorthMet Project Proposed Action would likely make recreational activities in the immediate vicinity of to the Mine Site, Transportation and Utility Corridor, and Plant Site less enjoyable (and therefore less likely) for some observers. In particular, three potential effects of the NorthMet Project Proposed Action could reduce recreational activity: noise, effects on fish populations (related to recreational fishing), and effects on wildlife populations (related to recreational hunting).

The presence of noise could discourage use of the portions of the Superior National Forest closest to the Mine Site and Plant Site (e.g., immediately south of the Transportation and Utility Corridor). Noise levels, including operational noise, ground vibration, and airblast overpressure, that exceed the most stringent category of state noise standards generally would not extend more than 0.9 mile from the Mine Site during the day and 2.3 miles at night (see Figures 5.2.8-1 through 5.2.8-4).

The ROS classes for those portions of the Superior National Forest within 2.3 miles of the Mine Site are Semi-Primitive Motorized and Non-Motorized. NorthMet Project Proposed Action-related noise would affect up to 6,450 acres of the Superior National Forest within this 2.3 mile area. In these areas, project-related noise could limit full realization of the intended ROS classifications. Outside of the 2.3 mile area, NorthMet Project Proposed Action-related noise would not be inconsistent with ROS classes.

NorthMet Project Proposed Action-related noise, air emissions, and water discharges could potentially influence wildlife behavior in portions of the Superior National Forest closest to the Mine Site and Plant Site, as discussed in the wildlife Section 5.2.5. To the degree that game species are disturbed by NorthMet Project Proposed Action-related noise, they could choose to avoid this portion of the Superior National Forest, leading to reduced hunting opportunities in these areas. However, the area affected by noise comprises approximately 0.2 percent of the more than 3 million acres of the Superior National Forest. Species displaced by noise are likely to remain in surrounding areas of the Superior National Forest; overall opportunities for hunting and wildlife viewing on public lands in the region are not expected to change substantially.

Excluding effects related to noise, fisheries, air quality, and other effects described elsewhere in Chapter 5.0, and given the proximity of active and past mining and industrial activity to high-quality recreational activity in the Arrowhead region (such as the BWCAW), there is no evidence that the presence of the NorthMet Project Proposed Action in and of itself would affect the public's ability to hunt, fish, and conduct other recreational activities, or that it would affect the overall recreational experience (apart from specific activities) in the Arrowhead region as a whole.

After closure, PolyMet would retain ownership of the Mine Site and the federal lands, and public access would likely remain restricted.

The Plant Site is located at the former LTVSMC processing plant. It is owned by PolyMet, and it is not open to the public. Entry roads are gated and/or guarded. No recreational activity is permitted at this site, nor would it be permitted during construction, operation, and closure of the NorthMet Project Proposed Action.

5.2.11.2.2 Visual Resources

At the Mine Site, the maximum height of the waste rock stockpiles would range from approximately 1,840 ft amsl (Category 1 Stockpile and Category 4 Stockpile) to 1,770 ft amsl (Category 2/3 Stockpile), or a maximum stockpile elevation of 180 to 240 ft above ground surface (PolyMet 2015a). The Giants Range rises sharply to the north of the Mine Site, blocking views of the mine, stockpiles, and safety lights (used when the stockpiles are active) from receptors to the north and west, including the BWCAW.

The Mine Site would be in operation 24 hours per day; therefore, nighttime safety lighting of the active stockpiles would potentially contribute to a localized “glow” effect that could be visible in the night sky. Light sources at the Mine Site would be similar to light levels at other mining projects across the Iron Range. For example, most of the lighting at the Mine Site would be directed downward, such as at the digging area in the case of the shovels and loaders, at the driving surface in the case of the haul trucks and locomotives, and at the dumping area at the stockpiles and the rail transfer hopper. The area around the blasthole drills would be illuminated so the drill can maneuver around the pattern. PolyMet does not propose any further specific mitigation measures with respect to light effects (PolyMet, Pers. Comm., July 25, 2012).

The upland forest surrounding the Mine Site to the east, south, and west would shield ground-level views of the Mine Site (including mine, stockpiles, and associated facilities) in those areas. These forest stands are a mix of coniferous and deciduous forests upwards of 60 ft in height and would provide year-round screening within several miles of the Mine Site (except, perhaps, from portions of the Superior National Forest that are very close to the southern boundary of the Transportation and Utility Corridor).

Viewers at elevated vistas to the south would have clearer views of the Mine Site. Figure 5.2.11-1 simulates the profile of the maximum extent of stockpiles (the largest visible component of the Mine Site) from the Skibo Vista Overlook on the Superior National Forest Scenic Byway, approximately 12 miles south-southwest of the Mine Site. Given the 180- to 240-ft height of the stockpiles, a portion of these would be visible above the treeline. The stockpiles would not project above Giants Range or alter the silhouette of the skyline.

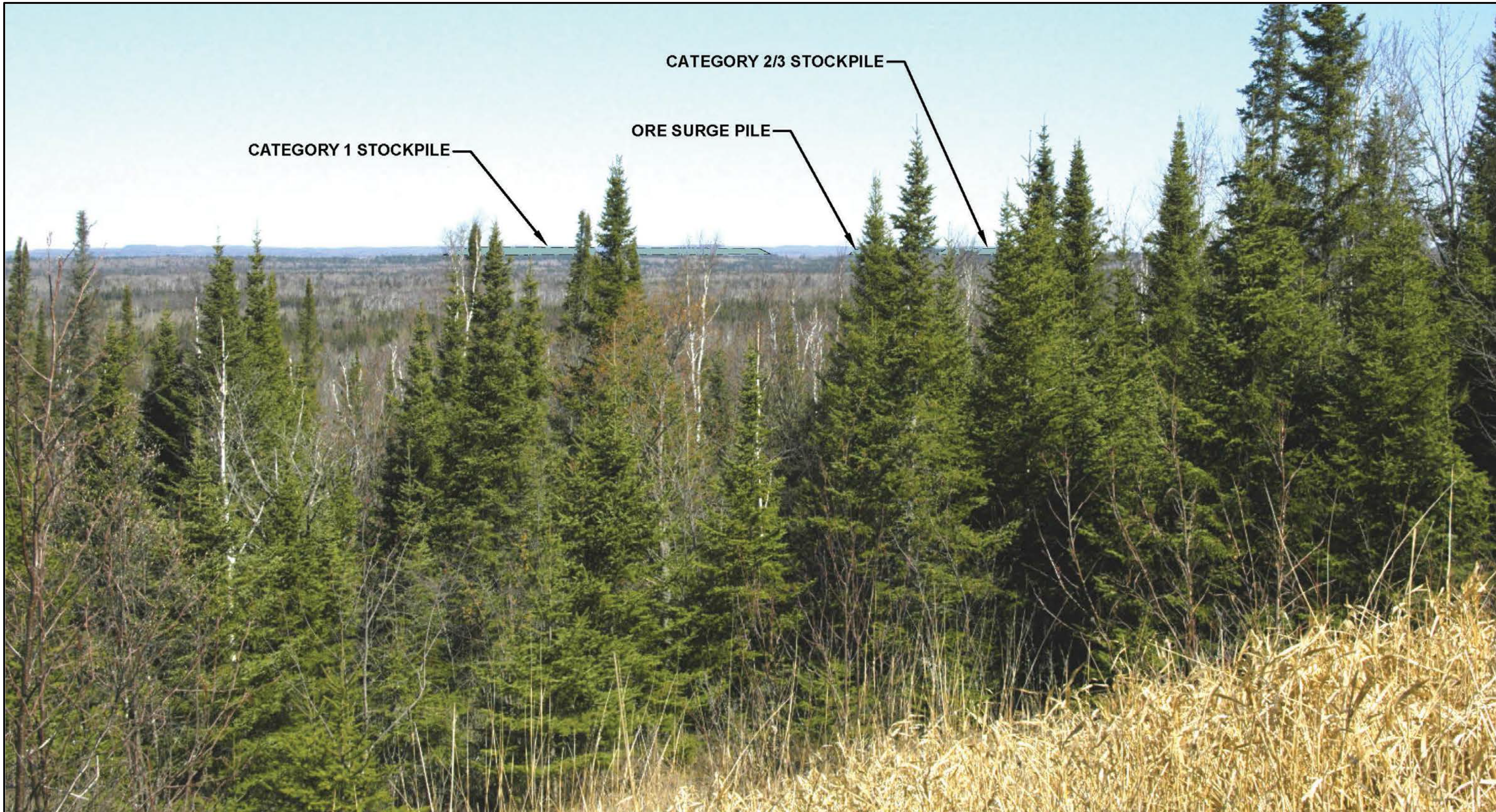

Figure 5.2.11-1
Photo Simulation - View of Mine Site from Skibo Overlook
NorthMet Mining Project and Land Exchange FEIS
Minnesota

MNDNR
US Army Corps of Engineers
St. Paul District

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Visual conditions would vary throughout the course of the mine's life. Initially, stockpiles would be less visible until heights exceed the surrounding treeline. The Category 2/3 Stockpile and Category 4 Stockpile would reach their maximum heights in year 11, after which they would be relocated into the East Pit. The Category 1 Stockpile would reach its maximum and permanent height in year 12 (excluding the cover material placed over the stockpile at mine closure). The height, shape, and coloring of the stockpiles would vary throughout the life of the mine; however, the coloring of the stockpiles would likely differ from the surrounding landscape, and would likely be more visible during winter months when screening from deciduous trees is at a minimum (although snow cover could tend to make the stockpiles look more like natural landforms). Viewers on elevated terrain to the east, north, or west of the Mine Site would generally have more limited views of the mine and stockpiles, although there could be sporadic direct views of the Mine Site, depending on exact location and vegetative screening

Mining and associated industrial activities are long-established aspects of the Mesabi Iron Range landscape. The NorthMet Project Proposed Action would introduce visual elements to the landscape that are similar to other active mines in the region, such as the adjacent Northshore Mine. However, these visual disturbances would occur in an area that, as shown in Figure 5.2.11-1, is currently vegetated.

In addition to the new visible components of the Mine Site and Plant Site (see below), mine construction, operations, and closure would likely generate some visible diesel exhaust and fugitive dust emissions from mine vehicles. Construction and closure emissions would likely be difficult to discern from the Skibo Vista Overlook and other distant viewpoints (see Section 5.2.7 for more details on anticipated emissions). As with the mine facilities themselves, construction emissions would generally be difficult to see from closer viewpoints due to the screening effect of terrain and vegetation.

Evaluations of visual conditions are subjective, and are based in part on individual preferences. Many viewers consider any substantial disturbance of the existing landscape to be undesirable, but some viewers find industrial sites visually compelling. While much of northeast Minnesota's recreation and tourist economy is based on high-quality wildlife, wilderness, and vegetation, there are distinct mine-related tourism resources. The Low SIO of the federal lands associated with the Mine Site indicates that the Mine Site is an area where the USFS has determined that evidence of management activities may dominate the view.

Following the completion of the mining activities, the PolyMet reclamation plan would remove all buildings and facilities at the Mine Site, and would revegetate disturbed areas with an approved vegetation mix. The Category 1 Stockpile would remain in place, and would also be vegetated, to the degree possible. This structure would be noticeable above the treeline, especially in winter, as shown in Figure 5.2.11-1. However, other similar stockpiles are found throughout the region. Over time, this feature would take on the appearance of a vegetated hill, and would blend in with the overall landscape.

No substantial changes are anticipated to the visual character of the Plant Site during NorthMet Project Proposed Action operations. The NorthMet Project Proposed Action would use, update, and expand existing infrastructure at the former LTVSMC processing plant, including an expanded Tailings Basin, additional hydrometallurgical processing facilities, and refurbished mill buildings. Figure 5.2.11-2 shows the current view of the Plant Site from Skibo Overlook. New structures constructed as a result of the NorthMet Project Proposed Action would not be visible from the overlook. During operations, steam plumes from the Plant Site would be visible under certain conditions, particularly from distant viewpoints such as Skibo Vista. To the degree that existing processing buildings are refurbished or removed (as appropriate), the NorthMet Project area would create the appearance of an active, maintained industrial site, rather than the current dilapidated appearance.

The Tailings Basin is visible to rural residences on County Road 358, located approximately 1 mile to the north of the Plant Site. The NorthMet Project Proposed Action would raise the elevation of Cells 1E and 2E to approximately the same elevation as the existing Cell 2W. The hydrometallurgical residue cells would raise the elevation on the southern portion of Cell 2W by about 40 ft. These changes would not be out of character with the existing Tailings Basin, although the low silhouette of the Tailings Basin on the southern horizon would be noticeably expanded.

Through the closure process, all buildings and facilities at the Plant Site would be removed. At-grade (or below-grade) slabs and foundations would remain and would be covered with surface overburden. Most structures would be removed within three years of the start of closure, except for water treatment facilities necessary to maintain post-closure water quality standards. The Plant Site would be revegetated and seeded to promote a self-sustaining community of regionally-appropriate vegetation. As a result, the visual appearance of the Plant Site during and following closure would evolve rapidly from the operations-phase industrial character to a vegetated area that progressively becomes indistinguishable from adjacent vegetated areas.

5.2.11.3 NorthMet Project No Action Alternative

5.2.11.3.1 Recreation

Under the NorthMet Project No Action Alternative, the NorthMet Project Proposed Action would not be developed. The Mine Site would remain unchanged, and the USFS would continue to retain surface rights to the federal lands that comprise portions of the Mine Site. Given other private ownership (e.g., the Transportation and Utility Corridor), the federal lands would remain generally inaccessible to the public. There would be no direct or indirect effects on recreational activities at the Mine Site or the region's surrounding recreational resources. Under the NorthMet Project No Action Alternative, the NorthMet Project Proposed Action would not be developed, and the Plant Site would remain off-limits to the public for recreation or other uses.

5.2.11.3.2 Visual Resources

Under the NorthMet Project No Action Alternative, the NorthMet Project Proposed Action would not be developed, and would retain the Low SIO assigned by USFS. The Mine Site would remain unchanged, and there would be no effects on visual resources at the Mine Site. Under the NorthMet Project No Action Alternative, the NorthMet Project Proposed Action would not be developed. The former LTVSMC process facility would be reclaimed, including building removal, in accordance with a separate closure plan. Reclamation activities could create a short-term disruption of the visual landscape, while long-term effects would be to reduce the developed nature of the site sooner than under the NorthMet Project Proposed Action.

Figure 5.2.11-2
Photo Simulation - View of Plant Site from Skibo Overlook
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5.2.12 Wilderness and Other Special Designation Areas

Designations such as Wilderness or RNAs emphasize higher restrictions on human activity and access, while other designations, such as historic landmarks or scenic byways, emphasize management that seeks to enhance public enjoyment of certain spaces. Evaluation of the effects on each type of designation considered how each set of characteristics or management objectives would be changed by the NorthMet Project Proposed Action or the project alternatives. Potential effects could occur due to mining activity or due to changes in other human activity resulting from mining activity. No specific issues related to wilderness or special designation areas were identified during public scoping. As discussed in Section 4.2.12, for the purposes of this analysis, the term "wilderness" is defined by the Wilderness Act of 1964 (Public Law 88-577) (16 USC § 1131-1136). In its planning, management, and monitoring, the USFS identifies four characteristics of wilderness, as defined in the Wilderness Act: Untrammeled, Undeveloped, Natural, and Solitude or a Primitive and Unconfined Type of Recreation.

Summary

The NorthMet Project Proposed Action would have no direct effects on wilderness or special designation areas. Air quality and water quality in these areas would be virtually unchanged from existing conditions; distance from activities associated with the NorthMet Project Proposed Action would leave ambient noise levels also unchanged. The absence of these direct effects means that there would be no indirect effects on wildlife, vegetation, or aquatic species. There could be a minimal visual effect on the Skibo Vista Scenic Overlook along the Superior National Forest Scenic Byway, and therefore an associated indirect effect on recreation.

5.2.12.1 Methodology and Evaluation Criteria

This section uses data presented in Section 4.2.12 for all wilderness or special designation areas (including state parks) within a 25-mile radius of the NorthMet Project area. While no direct effects on wilderness character or special designation areas are anticipated due to changes in air quality, water quality or noise, recreation opportunities could be indirectly affected because of a small change in visual character.

For land that is or would be controlled by the USFS, the recreation evaluation criteria of the ROS system were used to determine indirect project effects (see Section 5.2.11.1.1).

5.2.12.2 NorthMet Project Proposed Action

5.2.12.2.1 Federally Managed Areas

Table 5.2.12-1 lists the federally managed wilderness and other special designation areas within or adjacent to the NorthMet Project area and indicates significant features that would have the most bearing on the potential effects of the NorthMet Project Proposed Action. Isle Royale National Park is outside of the study area for evaluation of Wilderness and Other Special Designation; however, the visibility analyses in Section 5.2.7.2.2 do include Isle Royale National Park.

Table 5.2.12-1 Federally Managed Wilderness and Other Special Designation Areas located within or Adjacent to the NorthMet Project Area

Special Designation Area	Distance (miles) to the NorthMet Project Area	Significant Feature
Boundary Waters Canoe Area Wilderness	25	Laurentian Divide
Voyageurs National Park	50	Laurentian Divide
Research Natural Areas		
Big Lake-Seven Beavers cRNA	12	Watershed, topography, vegetation
Keeley Creek RNA	25	Watershed, topography, vegetation
Dragon Lake cRNA	25	Watershed, topography, vegetation
Unique Biological Areas		
Little Isabella River UBA	25	Watershed, topography, vegetation
Harris Lake National Natural Landmark	20	Watershed, topography, vegetation
National Historic Landmark		
Soudan Iron Mine	18	Topography, vegetation
National Recreation Trail		
Taconite State Trail	15-17	Topography, vegetation

The table shows that all of the federally managed areas would be well-removed from activities related to the NorthMet Project Proposed Action, and generally would be screened by intervening topography and vegetation.

Effects from the NorthMet Project Proposed Action associated with Class I Increment, visibility, and sulfur dioxide effects on flora and fauna would be all well below their respective significance levels in all Class I areas, including the BWCAW and Voyageurs National Park. In addition, all sulfur dioxide and sulfur deposition relating to terrestrial and aquatic settings would be well below "green light" significance levels in these areas. Total nitrogen deposition effects approach their significance levels at the BWCAW (see Section 5.2.7.2.2).

Due to the presence of the Laurentian Divide, there would be no direct effects on waters of the BWCAW or Voyageurs National Park. The NorthMet Project area is in the Lake Superior Basin, while these two Class I areas are to the northeast of the Laurentian Divide where streams and rivers flow to the Hudson Bay Basin.

As described in Section 5.2.8, daytime noise standards for sensitive receptors would not be reached beyond 0.8 mile from the Mine Site and 0.5 mile from the Plant Site. The nighttime noise standards would not be exceeded beyond 2.3 miles from the Mine Site and 1.5 miles from the Plant Site. The BWCAW and Voyageurs National Park, as well as the rest of the specially designated areas within 25 miles of the NorthMet Project area are all located at distances much greater than these ranges and so would not be expected to be directly affected by NorthMet Project Proposed Action-related noise. Nighttime views from the BWCAW toward the NorthMet Project area and nearby towns are such that light from the NorthMet Project Proposed Action would be indistinguishable from other sources of illumination.

The RNAs, cRNAs, and UBAs are also in watersheds not affected by the NorthMet Project Proposed Action so there would be no direct or indirect effects on surface water or groundwater in these areas. Topography and vegetation again screen these areas from view of the NorthMet Project Proposed Action-related activities so there are no direct effects on visual resources or indirect effects on recreation.

By virtue of distance, as well as topography and vegetation, the Taconite State Trail would experience neither direct nor indirect effects from the NorthMet Project Proposed Action.

By virtue of distance, topography, watershed, or vegetation, none of the four characteristics of Wilderness defined above (Untrammeled, Undeveloped, Natural, and Solitude or a Primitive and Unconfined Type of Recreation) would be affected by the NorthMet Project Proposed Action.

5.2.12.2.2 State-Managed Areas

Table 5.2.12-2 shows that all of the state-managed wilderness and other special designation areas would be well-removed from activities related to the NorthMet Project Proposed Action and generally would be screened by intervening topography and vegetation.

Table 5.2.12-2 State-Managed Wilderness and Other Special Designation Areas located within or Adjacent to the NorthMet Project Area

Special Designation Area	Distance (miles) to the NorthMet Project Area	Significant Feature
Boundary Waters Canoe Area Wilderness	25	Laurentian Divide
State Parks		
Soudan Underground Mine State Park	18	Watershed, topography, vegetation
Lake Vermilion State Park	16	Watershed, topography, vegetation
Iron Range Off-Highway State Park	11	Watershed, topography, vegetation
Bear Head Lake State Park	17	Watershed, topography, vegetation
National Historic Landmark		
Soudan Iron Mine	18	Topography, vegetation
National Scenic Byway		
Superior National Forest Scenic Byway	9	Topography, vegetation

All of the state parks have been shown to be in areas where predicted concentrations would be below secondary air standards that are designed to protect public welfare, including decreased visibility and damage to animals, crops, and vegetation. None of the state parks are within watersheds potentially affected by the NorthMet Project Proposed Action, so there would be neither direct effects on water quality nor indirect effects on aquatic species or wetlands.

Topography and vegetation screen the parks from view of the activities within NorthMet Project area, so there would be no direct effects on visual resources and no indirect effects on recreation.

The Superior National Forest Scenic Byway is at a distance where it would be unaffected by NorthMet Project Proposed Action-related noise. Similar to other specially designated resources, there would be no direct or indirect effects due to air quality or water quality (i.e., visibility of waters potentially affected by the NorthMet Project Proposed Action). Most of the Byway is screened from view of the NorthMet Project Proposed Action by topography and vegetation. However, from Skibo Vista Scenic Overlook, which is approximately 12 miles south-southwest of the Mine Site, a portion of the stockpiles would be visible above the treeline. This direct effect would also mean a potentially small indirect effect on recreation.

By virtue of distance, topography, watershed, or vegetation, none of the four characteristics of Wilderness defined above (Untrammeled, Undeveloped, Natural, and Solitude or a Primitive and Unconfined Type of Recreation) would be affected by the NorthMet Project Proposed Action.

5.2.12.3 NorthMet Project No Action Alternative

Under the NorthMet Project No Action Alternative, the NorthMet Project Proposed Action would not be developed. The NorthMet Project No Action Alternative presents no anticipated effect on the BWCAW, Voyageurs National Park, established and candidate RNAs, UBAs, National Historic Landmarks, the Superior National Forest Scenic Byway, and a National Recreation Trail, as the Mine Site and portions of the federal lands would continue to be managed in the same way they have been.

5.2.13 Hazardous Materials

Issues relating to the presence of hazardous materials or waste may include the accidental release of these materials during transportation, storage, handling, and/or use at the NorthMet Project area and any resulting potential effects on the environment. Environmental resources that could potentially be affected by hazardous materials and hazardous waste if they are accidentally released include: air, water, soil, and ecological resources. The APE therefore corresponds to the areas defined for each specific resource.

The NorthMet Project Proposed Action would use, or generate as waste, the following hazardous materials (Barr 2007d; PolyMet, Pers. Comm., November 17, 2011; PolyMet, Pers. Comm., May 11, 2012):

- Fuels, equipment maintenance products, and solvents – diesel fuel, gasoline, oils, grease, lubricants, anti-freeze, solvents, and lead-acid batteries used for equipment operation and maintenance;
- Plant reagents – sodium hydrosulfide, sodium hydroxide, acids, flocculants, and antiscalants used in processing plant applications;
- Mine Site WWTF chemicals – calcium hydroxide (hydrated lime), sodium metasilicate, ferric chloride, sodium hydroxide, polymer flocculent, carbon dioxide liquid, citric acid, and sodium hypochlorite;
- Plant Site WWTP chemicals – potassium permanganate, antiscalant, carbon dioxide liquid, and calcium hydroxide (hydrated lime);
- Blasting agents – ANFO, emulsions, emulsion blends (a blend of ANFO and emulsion), blasting caps, initiators and fuses, and other high explosives used in blasting; and
- Other materials – assay chemicals, and other by-products characterized as hazardous waste.

The MPCA has determined that the hydrometallurgical residue is not hazardous by legal definition under RCRA. PolyMet has provided supporting calculations that have determined the hydrometallurgical residue is not lethal per MN01 definition (PolyMet 2015t). Mishandling of hazardous materials or wastes could result in spills, accidental release, or discharge into the environment, which could cause effects on workers, waters of the state, or the general public. Mitigation measures to prevent releases in transportation, storage, and handling or use of these materials are described in several hazardous material management plans necessary to comply with various regulatory requirements for the NorthMet Project Proposed Action. The following sections present the methodology and evaluation criteria used to estimate the risks to the public and environment from the use of hazardous materials and the generation of hazardous waste during the construction, operation, and closure phases of the NorthMet Project Proposed Action. The presentation is broken down into the major activities of transportation, storage, and handling and use.

Summary

Materials defined as hazardous are a routine part of mining and ore processing. Their handling, storage, and disposal are regulated by a number of state and federal laws. Adherence to these would limit the potential for off-site effects on only the transport of large quantities of hazardous materials. Transport routes have been defined that limit the potential for effects on population centers and sensitive resources. Given overall Project design and operational commitments, there would be no significant adverse effects from the proposed use or generation of hazardous wastes by the NorthMet Project Proposed Action.

5.2.13.1 Evaluation Criteria

Several criteria are generally used in federal and State of Minnesota regulations and statutes to define the effects from an accidental spill, release, or discharge of contaminants or hazardous material or waste to the environment. The basic principle of these criteria is the protection of people and the environment. Based on this principle, the NorthMet Project Proposed Action would have an environmental effect if the following were to occur:

- A spill, release, or discharge of any hazardous material or hazardous waste during transportation that, if not recovered in a timely manner, could cause pollution of waters of the state, or other harm to the environment or to the public;
- A spill, release, or discharge of any hazardous material or hazardous waste during handling or use, which could cause pollution of waters of the state, or other harm to the environment or to the public;
- Hazardous emissions from handling of any hazardous materials or hazardous waste that have the potential to cause harm to the public or the environment; and
- A spill, release, or discharge from on-site storage facilities exceeding the volumes of the primary and secondary containment structures, and which could not be recovered in a timely manner, and thus pollute waters of the state or cause other harm to the environment or to the public.

5.2.13.2 NorthMet Project Proposed Action

Federal and State of Minnesota regulations establish management and reporting requirements for hazardous materials. Based on current design, applicable administrative rules and statutes include the following:

- *Minnesota Statute* 115.061 – Duty to Notify and Avoid Water Pollution (*Minnesota Statues*, chapter 115, Water Pollution Control; Sanitary Districts);
- USEPA 40 CFR 302 – Designation, Reportable Quantities, and Notification, Section 6 – Notification Requirements (USEPA 40 CFR 300–399, Superfund; Emergency Planning; Community Right-to-Know Programs);
- USEPA 40 CFR 355 – Emergency Planning and Notification, Subpart C – Emergency Release Notification (USEPA 40 CFR 300–399, Superfund; Emergency Planning; Community Right-to-Know Programs);
- USEPA 40 CFR 355–372 – EPCRA (USEPA 40 CFR 300–399, Superfund; Emergency Planning; Community Right-to-Know Programs);
- USEPA 40 CFR 112 – Oil Pollution Prevention (USEPA 40 CFR 100–149, Water Programs);

- USEPA 40 CFR 68 – Chemical Accident Prevention Provisions (USEPA 40 CFR 70–99, Air Programs II);
- USEPA Clean Air Act, Section 112(b) – Hazardous Air Pollutants (42 USC chapter 85, Air Pollution Prevention and Control);
- OSHA 29 CFR 1910.120 – Hazardous Waste Operations and Emergency Response (OSHA 29 CFR 1900–1910);
- DOT 49 CFR 100–180 – Hazardous Materials Transportation (Hazardous Materials Transportation 49 CFR 100–180, Chapter I, Pipeline and Hazardous Materials Safety Administration, DOT);
- MSHA Rule 30 CFR Part 47 Hazard Communication (Mine Safety Administration 30 CFR 1–199);
- *Minnesota Statutes*, chapters 115 and 115A–115E – Water Pollution Control, through Oil and Hazardous Substance Discharge Preparedness (*Minnesota Statues*, chapter 115, Water Pollution Control; Sanitary Districts);
- *Minnesota Rules*, chapter 7151 – Aboveground Storage of Liquid Substances (*Minnesota Rules*, MPCA, chapter 7151);
- *Minnesota Rules*, chapters 7045–7048 – Hazardous Waste (*Minnesota Rules*, MPCA, chapter 7045–7048);
- *Minnesota Rules*, chapters 7507 and 7513 – Hazardous Materials (*Minnesota Rules*, MPCA, chapter 7507–7513);
- *Minnesota Rules*, chapter 7035 – Solid Waste (*Minnesota Rules*, MPCA, chapter 7035); and
- *Minnesota Rules*, chapter 6132 – Nonferrous Metallic Mineral Mining (*Minnesota Rules*, Department of Natural Resources, chapter 6132).

A list of the larger quantity hazardous materials transported, stored, handled, recycled, or disposed, and their classifications, that would be associated with the NorthMet Project Proposed Action construction, operation, and closure is provided in Table 5.2.13-1. The estimated delivery frequency, volumes, and annual use of these materials are also listed in Table 5.2.13-1.

The MPCA reviewed hydrometallurgical residue pilot-testing and analysis data provided by PolyMet and has established the following statements (MPCA, Pers. Comm., October 24, 2014):

1. TCLP testing results of pilot test residues in 2005 and 2009 did not meet the thresholds to be regulated as a RCRA hazardous waste.
2. Elimination of the bulk hydrometallurgical mode from the NorthMet Project Proposed Action since the DEIS would not materially affect the chemical composition of residue stored in the Hydrometallurgical Residue Facility, and 2005 and 2009 testing results will be representative of the residue stored in the Hydrometallurgical Residue Facility if the current Project is approved.
3. New residue resulting from future hydrometallurgical pilot-testing and/or Phase 2 of the NorthMet Project Proposed Action should be tested to verify that the residue remains under RCRA hazardous waste thresholds.

Table 5.2.13-1 Hazardous Materials used during Construction, Operation, and Closure Phases of the NorthMet Project Proposed Action

				Deliveries (Estimated Frequency)		
Material	**Classifications & Precautions****	**Environmental Concern**	**Storage Capacity**	**Means**	**Approximate Rate**	**Annual Use (Est.)**
ANFO	Explosive 1.1D or 1.5D: Irritant to skin and eyes. May cause nausea if ingested and irritation to nose and throat if ingested.	Harmful to aquatic life at low concentrations.	No on-site storage. Vendor provided on a daily basis.	Vendor/truck	883,333 lbs/month	10,600,000 lbs/year
Booster (solid - cord sensitive)	Explosive 1.1D: Eye irritant. Skin irritant. Inhalation of dust may cause irritation, sneezing or coughing.	May cause elevated nitrate levels in water and could affect aquatic animals.	No on-site storage. Vendor provided on a daily basis.	Vendor/truck	1,555/month	18,650/year
Emulsion	Explosive 1.5D: Eye irritant. May be harmful if ingested. Inhalation may cause dizziness, nausea, or intestinal upset.	May cause elevated nitrate levels in water and could affect aquatic animals.	No on-site storage. Vendor provided on a daily basis.	Vendor/truck	387,500 lbs/month	4,650,000 lbs/year
Diesel fuel	Flammable: Continued exposure to vapors can irritate eyes and lungs. Potentially fatal if ingested.	Any spill or release may cause adsorption to sediment and soil and may cause a visible sheen or deposit of a sludge or emulsion if released to surface waters creating a hazard for plants and animals.	<u>Mine:</u> 3 - 12,000 gal or 2 - 20,000 gal <u>Locomotives:</u> 15,000 gal <u>Plant:</u> 12,000 gal	Tanker truck (volume/ tanker truck = 5,500-9,000 gal)	74 tanker truck loads/month	<u>Mine:</u> 5,910,000 gal/year <u>Plant:</u> Uncertain, but relatively minor <u>Locomotives:</u> 473,040 gal/year
Grease (385 lbs/55-gallon drum)	Mild skin irritant, ingestion may cause discomfort.	Spill or release may cause adsorption to sediment and soil and may cause a visible sheen or deposit of a sludge or emulsion if released to surface waters creating a hazard for plants and animals.	Existing bulk storage at Area 1 and Area 2 Shops.	55-gal drums	<1 truck/month	<u>Mine:</u> Unknown <u>Plant:</u> Uncertain, but relatively minor <u>Locomotives:</u> 16 lb/year – each locomotive

Material	Classifications & Precautions**	Environmental Concern	Storage Capacity	Deliveries (Estimated Frequency) Means	Deliveries (Estimated Frequency) Approximate Rate	Annual Use (Est.)
Lubricating oil	Minimal health hazards.	Spill or release may cause adsorption to sediment and soil and may cause a visible sheen or deposit of a sludge or emulsion if released to surface waters creating a hazard for plants and animals.	Mine: 2,000 gal Plant: 2 – 7,000 gal 2 – 12,000 gal 1 – 12,338 gal	Tanker truck (typically <3,000 gal/tanker truck)	2 tanker truck loads/month	Mine: 47,000 gal/year Plant: Uncertain, but relatively minor Locomotives: 200 gal/year – each locomotive
Transmission oil	Minimal health hazards.	Spill or release may cause adsorption to sediment and soil and may cause a visible sheen or deposit of a sludge or emulsion if released to surface waters creating a hazard for plants and animals.	Mine: 1,500 gal	Tanker truck (typically <3,000 gal/tanker truck)	< 2 loads/month	Mine: 33,000 gal/year
Hydraulic oil	Minimal health hazards.	Spill or release may cause adsorption to sediment and soil and may cause a visible sheen or deposit of a sludge or emulsion if released to surface waters creating a hazard for plants and animals. Bio-accumulation is unlikely due to the very low water solubility; bio-availability to aquatic organisms is minimal.	Mine: 2,000 gal Plant: 2 - 2,500 gal	Tanker truck (typically <3,000 gal/tanker truck)	< 1 load/month	Mine: 13,000 gal/year Plant: Uncertain, but relatively minor
Coolant (ethylene glycol mix)	Harmful or fatal if swallowed; eye, skin, and respiratory irritant.	Practically non-toxic to aquatic organisms on an acute basis.	Mine: 600 gal Plant: 6,000 gal	55-gal drums and tanker truck (typically <3,000 gal/tanker truck)	1 delivery/month	Mine: 12,000 gal/year Plant: Uncertain, but relatively minor

Material	Classifications & Precautions**	Environmental Concern	Storage Capacity	Deliveries (Estimated Frequency) Means	Deliveries (Estimated Frequency) Approximate Rate	Annual Use (Est.)
Gasoline (light vehicles)	Flammable; harmful or fatal if swallowed; eye, skin, and respiratory irritant.	Spill or release may cause adsorption to sediment and soil and may cause a visible sheen or deposit of a sludge or emulsion if released to surface waters creating a hazard for plants and animals.	Plant: 2 - 6,000 gal	Tanker truck (typically <3,000 gal/tanker truck)	2 deliveries/month	Plant: 500 gal/day or 178,000 gal/year
Degreaser	Skin and eye irritant, potential inhalation hazard.	Spill or release may cause adsorption to sediment and soil and may cause a visible sheen or deposit of a sludge or emulsion if released to surface waters creating a hazard for plants and animals. Should not be released undiluted into the environment.	Plant: 1 - 400 gal 1 - 2,500 gal	55-gal drums and/or tanker truck (typically <3,000 gal/tanker truck)	As needed to keep full; < 1 delivery/month	Uncertain, likely less than 15,000 gal/year
Used oil	Minimal health hazards.	Spill or release may cause adsorption to sediment and soil and may cause a visible sheen or deposit of a sludge or emulsion if released to surface waters creating a hazard for plants and animals.	55-gal drums or storage tank	Not Applicable	Removed from site as needed typically by vendor with bulk tank truck; approximately 2 times/month	Mine: 47,000 gal/year Plant: Uncertain, but relatively minor Locomotives: 200 gal/year – each locomotive
Caustic (NaOH) (assume 10.7 lbs/gal)	Skin and eye irritant, corrosive.	No known environmental effects.	1,100-gal storage tank	Tanker truck (typically <3,000 gal/tanker truck)	1 load/month	64 t/year
Flocculant (MagnaFloc 10)	Inhalation irritant.	No known environmental effects.	1,875-lb bulk bags	Freight truck	1 truck/2 months	16.5 t/year
Flocculant (MagnaFloc 342)	Low overall toxicity.	Toxic to some species of fish if released into waters.	1,875-lb bulk bags of powder	Freight truck	< 1 truck/month	26 t/year

Material	Classifications & Precautions**	Environmental Concern	Storage Capacity	Deliveries (Estimated Frequency) Means	Deliveries (Estimated Frequency) Approximate Rate	Annual Use (Est.)
Flocculant (MagnaFloc 351)	Low overall toxicity.	No known environmental effects.	1,875-lb bulk bags of powder	Freight truck	<1 truck/month	179 t/year
Sulfuric acid (assume 15 lbs/gal)	Skin and eye irritant, corrosive.	Toxic to some species of fish if released into waters.	78,700-gal storage tank with secondary containment	Bulk rail tank car (13,000-gal or 98-t capacity)	2 tank cars/year	138 t/year
Hydrochloric acid (assume 10 lbs/gal)	Skin and eye irritant, corrosive.	If released into the soil, this material is not expected to bio-degrade and may leach into groundwater.	59,500-gal storage tank with secondary containment	Bulk rail tank car (13,000-gal or 65-t capacity)	2 tank cars/month	1,485 t/year
Liquid sulfur dioxide	Extremely corrosive to exposed tissues, DOT poison gas, corrosive.	Toxic to some plants and animals if released into waters.	30,000-gal pressurized storage tank with secondary containment	Bulk rail tank car (15-55 t/car)	2 tank cars/month	1,254 t/year
Sodium hydrosulfide (assume 11 lbs/gal)	Extremely corrosive to exposed tissues. Contact with acid releases toxic gas. DOT corrosive.	Toxic to aquatic organisms if released into waters.	52,600-gal storage tank	Tanker truck (volume/tanker truck = 5,500-9,000 gal;	< 1 tanker/month	334 t/year
Potassium amyl xanthate (PAX)	DOT spontaneously combustible. Mild irritant. Heating and moisture produces H_2S, a toxic gas.	Toxic to animals in large quantities. Contact with water liberates extremely flammable gases, which can cause rapid burning and release of toxins into the air.	~30,000-gal storage tank	1,650-lb bulk bags, 25 bags/truck load	~5 trucks/month	1,075 t/year
Methyl isobutyl carbinol (assume 6.72 lbs/gal)	Flammable liquid.	This material is readily bio-degradable and practically not bio-accumulable and is slightly adsorptive in soils and sediments. Practically non-toxic to aquatic animals if released into waters.	~10,000-gal storage tank	Tanker truck (volume/tanker truck = 5,500-9,000 gal)	~ 6 trucks/month	1,124 t/year
Limestone	Harmful if swallowed; eye, skin, and respiratory irritant.	Airborne particulates may cause some harm to environment dependent on concentrations.	Bulk - stockpiled on-site	Bulk rail car (70-110 t/rail car)	Up to 100 rail cars/week from April to October	87,341 t/year

Material	Classifications & Precautions**	Environmental Concern	Storage Capacity	Deliveries (Estimated Frequency) Means	Deliveries (Estimated Frequency) Approximate Rate	Annual Use (Est.)
Lime	Eye and skin irritant; harmful if swallowed. Avoid breathing vapor or dust.	Possibly hazardous in the short term. Degradation products are not likely; however, long-term degradation products may arise.	Bulk - lime silo	Freight truck (20 – 25 t/truck)	15 loads/month	5,181 t/year
Magnesium hydroxide	Harmful if swallowed; eye, skin, and respiratory irritant.	Possibly hazardous in the short term. Degradation products are not likely; however, long-term degradation products may arise.	Storage tank	Bulk rail car (65 – 104 t/rail car)	3 tank cars/month	3,674 t/year
Grinding metals (metal alloy grinding rods and balls)	Harmful if swallowed; eye and respiratory irritant, if fine particles.	Airborne particulates may cause some harm to environment dependent on concentrations.	None required	Bulk rail car (100 t/rail car)	13 rail cars/month	15,600 t/year
Flotation activators (copper sulfate)	Harmful if swallowed; eye and respiratory irritant.	Toxic to fish and plants if released into waters.	9,200-gal activator storage tank	Reuse from Oxidation Autoclave	Not applicable	650 t/year
Ferric chloride (35%)	Very hazardous if ingested; corrosive to eyes and skin; respiratory irritant.	Mutagen; harmful to fish and invertebrates; reproductive effects, low potential for bio-accumulation; no information regarding environmental fate or toxicity.	6,000- and 1,000-gal storage tank	Tanker truck (typically <3,000 gal/tanker truck)	1,200 gal/month	14,400 gal/year
Potassium permanganate	Eye and skin irritant; respiratory irritant.	Mutagen; ecological information not available.	Bulk (dry)	Freight truck	1,300 lbs/month	16,000 lbs/year
Liquid carbon dioxide	Gas is an asphyxiant; prolonged skin or eye contact to gas, liquid or solid (crystals) may cause severe frostbite.	No adverse effects; carbon dioxide does not contain Class I or II ozone depleting chemicals.	Bulk (liquefied gas)	Tanker (cylinder) truck	105 t/month	1250 t/year

Notes:

t = short tons; equal to 2,000 lbs.

Notes:
The United Nations hazard classification system for classifying explosive materials and explosive components is recognized internationally and is used universally by the United States Department of Defense, United States Department of Energy (USDOE) contractors, and the DOT. UN numbers however, are different from the hazard class and division designations used by the DOT.

Hazard Classification 1.1D and 1.5D: 1.1 is a Hazard Class division for Class 1 (Explosives) and is defined as a Mass Detonation Hazard. It is expected that if one item in a container or pallet inadvertently detonates, the explosion will sympathetically detonate the surrounding items. The explosion could propagate to all or the majority of the items stored together, causing a mass detonation. There will also be fragments from the item's casing and/or structures in the blast area. Hazard Class division 1.5 is an Explosive substance, very insensitive (with a mass explosion hazard).

The "D" is the Class 1 Compatibility Group defined as the secondary detonating explosive substance or black powder or article containing a secondary detonating explosive substance, in each case without means of initiation and without a propelling charge, or article containing a primary explosive substance and containing two or more effective protective features (UNO 2012).

**Precautions are described as indicated by NIOSH (2007), or those described in chemical-specific Material Safety Data Sheets (MSDSs) (Montana Refining Company 2011), (Dow 2009), (EDS 2009a), (CSCC 2005), (EDS 2009b), (Praxair Technology 2009b), (Flottec 2009), (Martin Marietta Materials 2007), (Western Lime Corporation 2009), (AluChem 2010), (Old Bridge Chemicals 1999), (H-Valley Chemical 2006), (ClearTech Industries 2010), and (Praxair Technology 2009a).

Material, Storage Capacity, Delivery Means, Delivery Approximate Rate, and Annual Use Estimate (PolyMet, Pers. Comm., November 17, 2011; PolyMet, Pers. Comm., May 11, 2012).

5.2.13.2.1 Transportation

All hazardous materials would be transported by commercial carriers in accordance with state and federal hazardous material shipping requirements. Such carriers would be licensed and inspected by the Minnesota DOT. Tanker trucks would possess a Certificate of Compliance issued by the Minnesota Motor Vehicle Division. These permits, licenses, and certificates would be the responsibility of the carrier. Federal regulations (49 CFR) require that all shipments of hazardous materials be properly identified and placarded. Shipping documents must be accessible and include MSDSs that describe the hazardous material, immediate health hazards, fire and explosion risks, immediate precautions, fire-fighting information, procedures for handling leaks or spills, first aid measures, and emergency response telephone numbers.

Hazardous waste would also be transported from the Mine Site and Plant Site for proper disposal. Transportation of these wastes would require compliance with state and federal regulations that include requirements for hazardous waste manifests with the shipments, labeling, and/or use of placards, and emergency information. PolyMet employees would be trained to manage all wastes in accordance with their specific job duties. Transportation of hazardous waste would be conducted by vendors also licensed and trained to manage hazardous waste.

As identified in Table 5.2.13-1, trucks would be used to transport a variety of hazardous materials to the Mine Site and Plant Site. Shipments of hazardous materials would originate from a number of locations. The risk of accidental truck spills was evaluated using two representative hazardous materials, diesel fuel and PAX, due to the relatively large number of deliveries and health risks associated with these materials (Rhyne 1994). Approximately 74 tanker truck loads of diesel fuel and 5 truckloads of PAX would be delivered monthly. These quantities would amount to approximately 17,800 and 1,200 shipments of diesel fuel and PAX, respectively, based on 20 years of estimated mine life.

For this evaluation, materials were assumed to be shipped from Duluth. These materials would be transported approximately 60 miles along State Highway 53 (four-lane divided highway) from Duluth to Eveleth, and then approximately 20 miles along State Highways 37 and 135 (two-lane highways) from Eveleth to the North Gate access road to the site. This route would take the materials through the towns of Duluth, Twig, Independence, Canyon, Cotton, Central Lakes, Eveleth, Gilbert, Biwabik, and Pineville and across the Cloquet, Whiteface, St Louis, and Embarrass rivers and Paleface Creek. These state highways already provide transportation routes for freight that includes hazardous materials and waste. St. Louis County Emergency Services are available for response to incidents associated with hazardous materials due to the current transport of these materials from existing businesses that use hazardous materials or generate hazardous waste within their operations. Emergency response services vary from medical rescue and ambulance services to fire-fighting and local HazMat-trained response teams stationed in various cities or districts along the defined transportation route. The locations of emergency response services are identified in multiple sectors within the county as defined by the St. Louis County Hazard Mitigation Plan prepared by the St. Louis County Emergency Management division of the St Louis County Sheriff's Office (St. Louis County 2013). The County HazMat Response Team is stationed in Duluth.

The effect of an accidental release would depend on the location in relation to population, local activities, the quantity released, environmental factors, and the nature of the released material. The probability of an accidental release of the representative hazardous materials described above during transportation was calculated using the Federal Highway Administration truck accident statistics model (Rhyne 1994) as presented in Table 5.2.13-2. The definition of hazardous materials, per the Minnesota Hazardous Materials and Uniform HazMat Registration Program is, “a substance or material capable of posing unreasonable risk to health, safety, and property when transported in commerce, as determined by the US Secretary of Transportation.” According to these statistics, the average rate of truck accidents for transport along a rural interstate highway, such as State Highway 53, is 0.64 per million miles traveled. For rural two-lane highways, such as State Highways 37 and 135, the average truck accident rate is 2.19 accidents per million miles traveled.

Table 5.2.13-2 Release Probability of Representative Materials Transported during Construction, Operation, and Closure Phases of the NorthMet Project Proposed Action

	Rural State/Interstate Highway (four lane)						Rural State Highway (two lane)						
Material Transported	**No. of Truck Deliveries**	**Haul Distance (Miles)**	**Accident Rate Per Million Miles Traveled**	**Calculated Number of Accidents**	**Probability of Release Given an Accident (%)**	**Calculated Number of Spills**	**No. of Truck Deliveries**	**Haul Distance (Miles)**	**Accident Rate Per Million Miles Traveled**	**Calculated Number of Accidents**	**Probability of Release Given an Accident (%)**	**Calculated Number of Spills**	**Combined Total Estimated Release (Freeway and Rural Two- Lane)**
Diesel Fuel	17,800.0	60.0	0.64	0.68352	18.8	0.12850	17,800.0	20.0	2.19	0.77964	18.8	0.14657	0.27
PAX	1,200.0	60.0	0.64	0.04608	18.8	0.00866	1,200.0	20.0	2.19	0.05256	18.8	0.00988	0.018

Source: Federal Highway Administration truck accident statistics model (Rhyne 1994).

The probability of a release or spill was based on accident statistics for liquid tankers carrying hazardous materials. The Federal Highway Administration statistics indicate that on average, 18.8 percent of the total accidents involving liquid tankers carrying hazardous materials resulted in a spill or release.

Using the accident and liquid tanker spill statistics, the evaluation indicates that the probability for an accidental release of liquids under truck transport during the life of the NorthMet Project Proposed Action is less than one spill accident for each of the representative materials considered. The release probability indicates there is a 1.8 percent probability of an accident resulting in a release of PAX, and a 27 percent probability of an accident resulting in a release of diesel fuel that could occur over the entire 20-year life of the NorthMet Project Proposed Action. The higher probability of a diesel fuel accident is due to the greater expected number of diesel fuel deliveries to the site.

The odds of a potential release of hazardous materials during a transportation accident would incrementally increase if the other shipments listed in Table 5.2.13-1 were included. An accidental release could range from a minor oil spill at the Mine Site and Plant Site, where cleanup equipment would be readily available, to a severe spill during transport involving a large release of diesel fuel or other hazardous material, where emergency cleanup equipment would not be readily available. Some of the chemicals could have immediate adverse effects on water quality and aquatic resources if a spill were to enter a surface water body. Considering the overall risk of an accident involving a spill, and the anticipated transport routes, the probability of a spill into a waterway would be moderate. An alternative transportation route, shorter by about 17 miles, was evaluated but rejected because of its close proximity to water bodies such as Wild Rice and Island lakes. The transportation route selected for this evaluation is longer, but is farther away from waterbodies, so in the event that an accidental spill or release of materials occurs, it could be managed in a more timely manner to reduce the likelihood of environmental harm. A shorter route could be used, but the probability of effect on a water body would be greater due to the proximity of the waterbodies.

A large-scale release of hazardous liquids delivered to the site by tanker truck (9,000-gallon capacity) or rail car (up to 13,000-gallon capacity)—such as diesel fuel, acid, or other hazardous materials—could have implications for public health and safety. The location of the release would again be the primary factor in determining potential effects. As indicated in Table 5.2.13-2, the probability of a release anywhere along a proposed transportation route was calculated to be low. Review of the Hazmat Intelligence Portal of the U.S. DOT indicates that the likelihood of a bulk rail incident is 40 percent less than that of a highway incident (PHMSA 2012b). The likelihood of a rail incident, when all incidents are included, is 82 percent less than that of a highway incident (PHMSA 2012a).

In addition to location, the potential harm presented by the material released is a factor in determining the effect of a release. A qualitative evaluation of the materials to be shipped indicates that the probability of causing harm is low for most materials. For example, though ANFO is an explosive, it will only detonate under specific conditions, such as when ignited with detonators, heat, or a sudden shock wave in a confined space. Caustic soda is corrosive and can be fatal if ingested or has prolonged contact with the skin; however, in a spill situation, emergency response would be undertaken to prevent or minimize exposure, such as restricting site access and immediate containment and removal. In the event of a release during transport, the commercial transportation company would be responsible for first response and cleanup.

Local and regional law enforcement, fire protection, and emergency planning agencies would also mobilize to secure the site and protect public safety.

In the event of an accident involving the release of hazardous material, 49 CFR requires that the carrier notify local emergency response personnel, the National Response Center (for discharge of reportable quantities of hazardous materials) (Hazardous Materials Transportation 49 CFR 100–180, Chapter I, Pipeline And Hazardous Materials Safety Administration, DOT). Minnesota Statutes require notification of the Minnesota State Duty Officer (Minnesota Statues, chapter 115, Water Pollution Control). PolyMet and its hazardous material handlers and/or DOT-regulated contractors would be required to comply with these and similar regulatory requirements, which also stipulate emergency planning and response actions.

5.2.13.2.2 Storage

The approximate capacities of hazardous material storage tanks that would be at the NorthMet Project area are listed in Table 5.2.13-1. Mobile tanker trucks may be used on site to fuel and maintain haul trucks, mobile equipment, and locomotives. The number of these trucks and their capacities would be based on NorthMet Project Proposed Action specifications. Tanks and vessels would be positioned on approved secondary containment with interior sumps to route spilled products or process solutions to lined collection areas. In addition, hazardous materials would be unloaded on an approved containment surface with sumps to route spills to lined collection areas. Some of the hazardous material storage tanks at the Mine Site would be double-walled for provision of secondary containment. Mine Site hazardous material storage tanks without double-walls and Plant Site hazardous material storage tanks would be designed to have secondary containment sufficient to hold at least 110 percent of the volume of the largest tank in the containment area. Waste materials such as used motor oil, hazardous waste, and spent hazardous materials would be managed by PolyMet employees while on-site, and shipped off-site for recycling or disposal using a DOT-licensed transporter. In addition, fire assay wastes—including cupels, crucibles, and slag—would be managed by PolyMet employees while on site and shipped off site for recycling or disposal at a licensed facility using a DOT-licensed transporter. Certain materials may be stored on-site for a period before shipment. These materials would be stored in compliance with safety storage requirements as dictated by state and federal requirements. The storage period would also comply with Minnesota and federal storage timeline stipulations. All stored wastes would be appropriately labeled and dated for timeline inspection purposes.

5.2.13.2.3 Handling and Use

Over the life of the NorthMet Project Proposed Action, the probability of minor spills of oils and lubricants would be relatively high. Releases could occur during operations because of a poor connection of an oil or hydraulic line, or as the result of equipment failure. Effects of such minor spills could include contamination of surface water and soil; however, spills of this nature would likely be small, localized, and contained.

Some of these spills may be reportable. In Minnesota, spills or discharges of more than 5 gallons of petroleum products or any quantity of chemicals or materials, whether accidental or otherwise, are required by law to be reported to the Minnesota State Duty Officer at the MPCA, by the person with control of the spill, which, if not recovered, may cause pollution of waters of the state. The responsible NorthMet Project Proposed Action person is required to recover as rapidly and thoroughly as possible such spilled material, and take immediate action as reasonably possible to minimize or abate pollution of waters of the state (*Minnesota Statutes*, section 115.061, Duty to Notify and Avoid Water Pollution).

Emergency release notification requirements under EPCRA (USEPA 40 CFR, chapter 355) exist in addition to the release notification requirements of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) (USEPA 40 CFR, chapter 302). If the NorthMet Project Proposed Action had a release of a CERCLA hazardous substance, it would be required to comply with the notification requirements of EPCRA, and the release notification requirements of CERCLA. If the reportable quantity of a substance were released within a 24-hour period at the NorthMet Project area, and the substance was on the list of extremely hazardous substances under EPCRA or the list of CERCLA hazardous substances (USEPA 40 CFR, chapter 302.4), then PolyMet would be subject to reporting requirements described in 40 CFR 355.60, 40 CFR 302, and the Emergency Notification Procedures in Minnesota as required by Title III of the Superfund Amendments and Reauthorization Act (USEPA 40 CFR, chapters 300 to 399).

The requirements for storage of oils and lubricants, including the requirement for spill prevention, control, and countermeasure (SPCC) planning are found in the Oil Pollution Prevention Act (USEPA 40 CFR, chapter 112) and MN § 115E (Minnesota Statues, chapter 115, Water Pollution Control; Sanitary Districts). Applicable Minnesota Statutes include: Prevention and Response Plans (Section 115E.04), Response Plans for Tank Facilities (Section 115E.045, Subdivision 2), and Responses to Releases (Section 115C.03). A list of hazardous material management and response plans is presented in Table 5.2.13-3.

Table 5.2.13-3 Hazardous Material Management Plans

Plans	Applicable Statute/Regulation	Materials/Applications
SPCC Plan	USEPA 40 CFR chapter 112	Oil/petroleum spills
Toxic Pollution Prevention Plan (TPPP)	Minnesota Statutes, chapter 115D Subdivision 1(a) USEPA 40 CFR 260 - 279 DOT 49 CFR	Waste minimization, handling, storage, disposal, recycling of hazardous substances, chemicals, fluids, and other wastes. Transportation of hazardous materials.
Hazard Communications Standards	MSHA Rule 30 CFR Part 47	Evaluation of the hazards of chemicals mines produce or use and the provision of information to miners.
Emergency Response Plan	OSHA 29 CFR 1910.120 USEPA 40 CFR 68	Hazardous material release response guidance.
Spill Prevention/Response Plan	29 CFR 1910.120/CAA Section 112 Minnesota Statutes, chapter 115E (may also be applicable to trucking vendors)	General guidance Minnesota state guideline for responding to spills and releases.
Risk Management Program	USEPA 40 CFR 68	Hazard assessment, accident history, prevention program and training, and emergency response program.

The threshold quantity, as defined in 40 CFR 112, for triggering the requirement for development of a SPCC plan is 1,320 gallons of petroleum products in bulk container storage greater than 55 gallons. Since the NorthMet Project area would have more than 1,320 but less than 1,000,000 gallons of oil storage, an SPCC plan would be required under 40 CFR 112. The primary goal of an SPCC plan is to develop strategies to prevent oil spills from reaching Minnesota and United States waters. An SPCC plan is thus specific to each facility, providing persons responsible for planning emergency response site-specific information such as a description of facilities, storage information, preventative measures, response action, equipment, and contact information. An SPCC plan must also provide information for routine facility inspections.

To reduce the likelihood of incidental spills of petroleum products, a preliminary SPCC plan has been prepared for the NorthMet Project Proposed Action. The plan identifies potential emergencies that may arise during operations or an activity within the NorthMet Project area. The plan establishes a framework to respond effectively to the identified potential emergencies.

The final SPCC plan would include procedures, methods, equipment, and other requirements to prevent discharges of oil from facilities, and to contain such discharges, should they occur. The SPCC plan would also contain a detailed, facility-specific description of how the operations comply with the requirements of the Oil Pollution Prevention regulation (USEPA 40 CFR, Part 112). The SPCC plan would address measures such as secondary containment, facility drainage, dikes and barriers, sump and collection systems, retention ponds, curbing, tank corrosion protection systems, liquid level devices, and emergency shut-off or release alarms. The final SPCC plan must be certified by a Professional Engineer that in their professional judgment the following are true:

- The SPCC plan is adequate for the facility;
- Technical standards have been considered;
- Inspections and tests are adequate for the facility; and
- The SPCC plan has been prepared in accordance with good engineering practices, including consideration of applicable industry practice.

A final SPCC plan is not possible for the NorthMet Project Proposed Action until construction has been completed. However, PolyMet has prepared a preliminary SPCC plan that is compliant with 40 CFR 112 requirements.

The policies and procedures set forth in the SPCC plan, inclusive of PolyMet’s Standard Operating Procedure for Storage Tank Management, would be prepared to comply with *Minnesota Rules*, chapter 7151, Aboveground Storage of Liquid Materials.

The preliminary SPCC plan would be finalized and certified by a Professional Engineer, as required, after petroleum storage and handling facilities have been constructed. Based on current planning information, the final SPCC plan would need to address at least the following areas or activities involving petroleum and other oils:

- A truck fueling station;
- Remote fueling activities (i.e., at the equipment operating location);
- ASTs;

- Large-quantity oil-filled equipment;
- Locomotive fueling (at Area 2); and
- A gasoline fueling station (at the main gate).

The fueling station would consist of an enclosed building for fueling, including floor drain sumps and holding tanks for collection of spills. The holding tanks would be cleaned out, as needed, by a contractor with appropriate certification or license, and the waste would be transported to a recycling, treatment, or disposal facility. One fueling station would typically be provided to fuel all mobile equipment with rubber tires (trucks, dumps, front end loaders, dozers, etc.). This equipment also may be fueled in place by remote fuel tankers. Remote fueling typically would be conducted for equipment located within the mine pits and at material stockpiles (e.g., excavators, dozers, and other tracked equipment). Portable spill clean-up kits would be available at the fueling stations and on the fuel tankers. Standard operating procedures, including spill response plans, would be prepared and associated training would be conducted for fueling operations. Equipment would be attended during fueling operations. When possible, remote fueling would not be performed near sensitive areas, where, if a release were to occur, surface water could be affected. At final design stage, an updated or final version of the current SPCC plan would be prepared for the NorthMet Project Proposed Action facilities, to address specific spill response, cleanup, release notifications, etc. For oil-filled equipment, an appropriate containment system would be constructed so that discharge from a primary containment system would not escape the containment system before cleanup occurs. Alternatively, facility procedures and a contingency plan would be established that define inspections and/or a monitoring program to detect equipment requiring service or failure, and/or discharge. ASTs would be located at the truck fueling station where fuel storage would meet secondary containment standards. The tanks would have a containment dike with membrane, or a concrete enclosure to contain leaks or spills. As previously indicated, double-walled ASTs would not require secondary containment.

The SPCC documents, along with manufacturer MSDSs, would be available in all areas where hazardous materials were expected to be used or produced, and at all areas of fuel and lube-oil storage.

5.2.13.2.4 Emergency Planning and Community Right-to-Know

Management of hazardous materials at the NorthMet Project area would be governed by a number of interrelated federal, state, and local regulations, as listed in the first part of this Hazardous Materials Section. The following discusses federal and Minnesota state actions under EPCRA, including its emergency response-planning activities, Hazardous Chemical Inventory Reporting (Tier II) requirements, and Toxics Release Inventory (TRI) reporting requirements. Minnesota's hazardous materials regulations are codified in the *Minnesota Rules*, chapters 7507 and 7513, and in *Minnesota Statutes*, chapter 299K.

As required by EPCRA, Minnesota has established the Minnesota Emergency Response Commission (ERC), an agency within the Minnesota Department of Public Safety, Division of Homeland Security and Emergency Management. The Minnesota ERC coordinates information specific to hazardous materials at facilities around the state so that local emergency officials are able to prepare for emergencies. The Minnesota ERC serves as the repository for the EPCRA hazardous chemical inventory reports (Tier II reports). Along with the listing of hazardous materials identified on Table 5.2.13-1, PolyMet would prepare and submit Tier II Emergency and Hazardous Chemical Inventory Report Forms for sodium hydroxide, hydrochloric acid, sodium hydroxide, sulfuric acid, and SO_2, and would be subject to reporting additional hazardous materials or chemicals maintained on-site in quantities greater than the Tier II reporting thresholds.

The Minnesota ERC also collects data from facilities reporting under the federal TRI report program mandated by SARA Title III, Section 313. The NorthMet Project Proposed Action would be subject to TRI reporting based on the quantities of sulfuric acid and SO_2 to be maintained at the NorthMet Project area and could include others depending on actual quantities.

Under the federal Pollution Prevention Act of 1990, facilities subject to TRI reporting must also provide information on the pollution prevention and recycling activities associated with the reported toxic chemicals. The NorthMet Project Proposed Action would be subject to Minnesota's Toxic Pollution Prevention Act (Minnesota Statutes, section 115D.07), and PolyMet would have to prepare a TPPP. The TPPP would describe the facility's processes and operations, and set objectives for the handling, storage, and disposal or recycling of hazardous materials and toxic chemicals to eliminate or reduce at the source, the use, generation, or release of toxic pollutants, hazardous substances, materials, and hazardous wastes.

Under the federal CAA Amendments of 1990 Section 112(r), the NorthMet Project Proposed Action would be subject to the Accidental Release Prevention/Risk Management Plan rule, based on the projected use of hydrochloric acid and other flammable and toxic substances (42 USC, chapter 85, Air Pollution Prevention and Control). PolyMet would be required to develop a Risk Management Program that would include:

- Hazard assessment and potential effects of an accidental release, accident history, and evaluation of worst-case and accidental release scenarios;
- Prevention program including safety precautions, maintenance, monitoring, and training measures; and
- Emergency response program detailing emergency health care, training, and procedures for informing the public and response agencies should an accident occur.

The hazardous material management plans include procedures for evacuating personnel, maintaining safety, cleanup, neutralization activities, emergency contacts, internal and external notifications to regulatory authorities, and incident documentation. Proper implementation of the SPCC plan, TPPP, Hazard Communications, Emergency Response Plan, Spill Response Plans, and the Risk Management Program would minimize the incidents and effects associated with potential releases of hazardous materials.

If present, other hazardous or potentially hazardous materials or wastes would be characterized and managed per the hazardous materials management plans described in Table 5.2.13-3 above, and, if applicable, would adhere to the requirements defined in *Minnesota Rules*, chapter 7045, Hazardous Waste.

5.2.13.3 Potential Mitigation Measures

Mitigation of a hazardous material release would follow the principle of prevention, minimization, and treatment. Prevention would be achieved when any hazardous material was avoided, where possible, by replacing it with a substitute material that was not hazardous. To the extent possible, this has been done; where not possible, precautions to be defined in the TPPP would be taken to properly manage hazardous materials or substances, and keep the potential risk of exposure to a minimum. Accidentally released hazardous material would be treated quickly in accordance with the described plans.

In addition, mitigation processes or procedure definitions would be included in the following:

- Hazardous communication materials, through communications and training programs;
- Overfill protection procedures;
- Provision for secondary containment;
- Establishment of leak detection systems;
- Preventative inspection and maintenance procedures; and
- Emergency response plan.

These measures would be designed to ensure that accidental releases were prevented or minimized, and when they did occur, were responded to quickly and properly.

Monitoring activities proposed for prevention of incidental releases, mitigation, or quick removal of the effects, if hazardous materials were released, include the following:

- Regular inspection and testing of storage containers and facilities;
- Inspection of vessels for leaks, drips, or loss content of containers;
- Verification of locks, emergency valves, and other safety devices, protective equipment, and floors;
- Regular checks on the operability of emergency systems;
- Periodic awareness training for employees;
- Maintaining MSDSs at visible locations for easy access at all times; and
- Regular monitoring of surface water and groundwater quality.

Monitoring and inspection would be an integral part of the hazardous material management processes at the NorthMet Project area.

Given current Project design and operational commitments, this analysis did not identify significant adverse effects from proposed hazardous materials use or hazardous waste generation by the NorthMet Project Proposed Action. Therefore, no additional mitigation measures are proposed.

5.2.13.4 NorthMet Project No Action Alternative

The NorthMet Project No Action Alternative has no risk of environmental effect since no hazardous materials would be used, and no hazardous waste would be generated under this alternative.

5.2.14 Geotechnical Stability

The geotechnical stability of the proposed large-scale material storage facilities for the NorthMet Project Proposed Action is addressed in this section. These facilities are the waste rock stockpiles that would be created at the Mine Site; the Tailings Basin, which would be constructed on top of the existing LTVSMC Tailings Basin; and the Hydrometallurgical Residue Facility, which would be constructed at the existing LTVSMC Emergency Basin.

This section provides a summary of the required design criteria and the methodology and results of the iterative modeling and design process, as well as an overview of the proposed monitoring and mitigation plans.

Summary

Preliminary designs of the waste rock stockpiles, Tailings Basin, and Hydrometallurgical Residue Facility have been developed and shown by PolyMet, through an iterative design and modeling process, to meet the minimum Factors of Safety and water quality evaluation criteria (see Section 5.2.2) acceptable to the Co-lead Agencies. The slope stability and liner integrity of these facilities would be monitored throughout operations and long-term closure. This approach would allow for identification of a need to implement adaptive mitigation measures as a contingency to improve performance should the facilities perform differently from their design.

5.2.14.1 Methodology and Evaluation Criteria

The direct environmental consequences of the proposed large-scale waste material storage facilities, including the disturbance footprint and impacts to water, are discussed under the respective environmental factors in Chapter 5.0. This section addresses the slope stability and liner integrity of the proposed facilities.

If incorrectly designed, constructed, and/or managed, or from other unforeseen circumstances, waste material storage facilities have the potential to increase hydrologic and/or water quality effects and may become unstable, potentially leading to slope or dam failure (and/or other environmental impacts to downstream areas).

The large-scale waste material storage facilities proposed for the NorthMet Project Proposed Action would require compliance with MDNR nonferrous mining and dam safety rules, as well as the MPCA NPDES/SDS Permit. The Dam Safety permit requires that design and safety criteria be met to reduce the risk of potential failure.

The design of geotechnical structures is typically developed using an iterative design and modeling approach where the design is amended until modeling results meet the required minimum design criteria, including Factors of Safety and other requirements for permitting. Factor of Safety is used to describe the ratio of resisting forces to driving forces along a potential failure surface, whereby a Factor of Safety of 1.0 represents equilibrium between the estimated resisting shear strength and the applied shearing load along a specific plane of potential movement. Systems are often designed to a Factor of Safety above 1.0 to allow for unexpected loading conditions, unexpected operating conditions, and variations in estimated material properties.

The specific design and minimum required Factor of Safety criteria for the proposed large-scale waste materials storage facilities and the methodology applied to develop the designs of the proposed facilities in order to meet these criteria are discussed for each facility in the respective sections below. Technical analysis was performed by PolyMet and reviewed by the Co-lead Agencies.

The potential effects of hypothetical failure scenarios have not been assessed in this FEIS, as the risk of failure is mitigated through application of design and safety requirements including adaptive management procedures.

5.2.14.2 NorthMet Project Proposed Action

5.2.14.2.1 Waste Rock Stockpiles

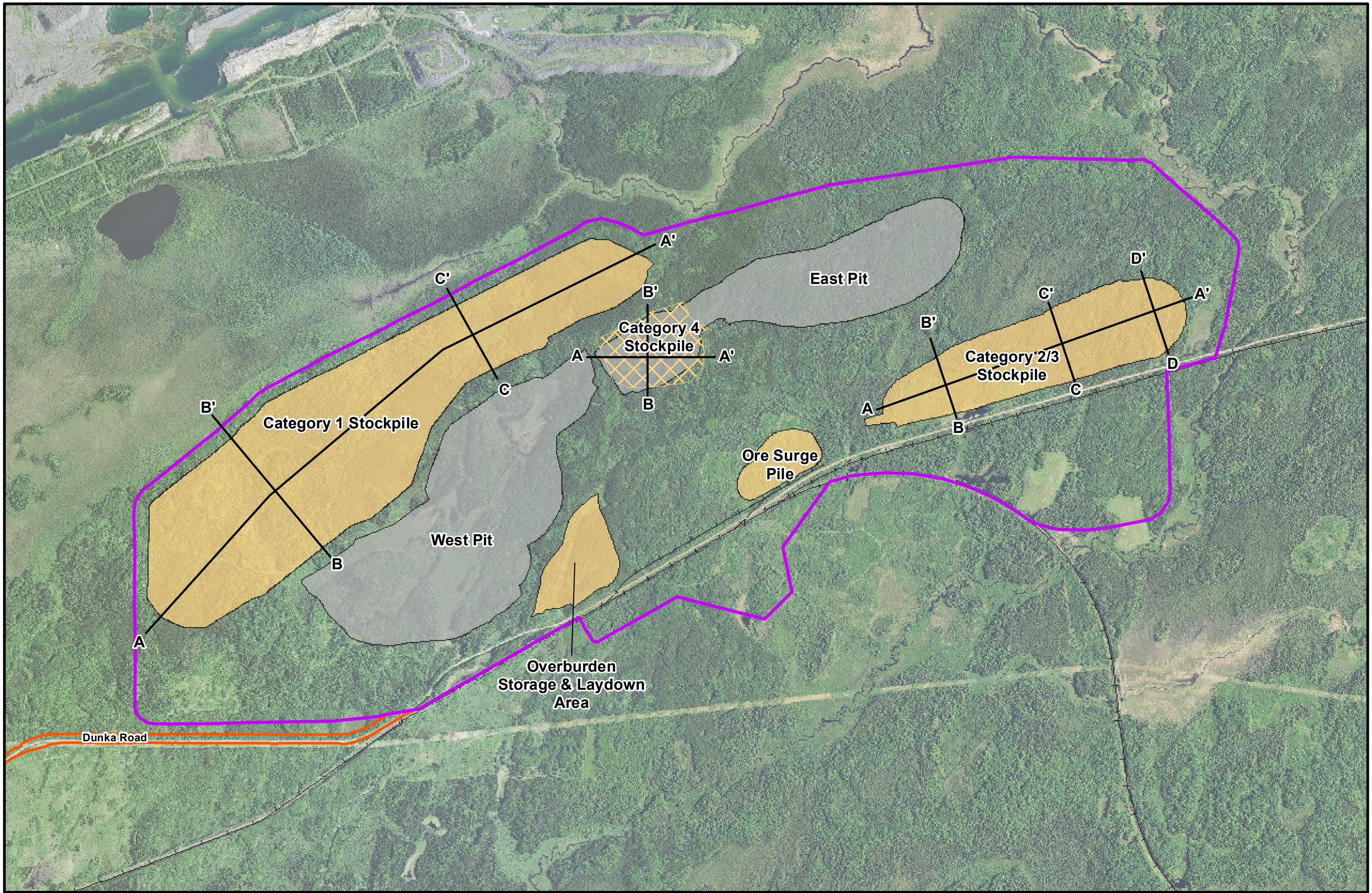
The proposed large scale waste material storage facilities at the Mine Site are:

- A permanent waste rock stockpile for Category 1 waste rock encompassed by a surface water and groundwater containment system and with an engineered geomembrane cover system at closure, and
- Temporary, lined stockpiles for Category 4 waste rock, combined Category 2/3 waste rock, and an Ore Surge Pile.

In addition to the stockpiles above, PolyMet would also prepare an Overburden Storage and Laydown Area that would be used for temporarily stockpiling overburden prior to its use.

PolyMet expects that the NorthMet Project Proposed Action would produce approximately 308 million tons of waste rock over the life of mine. Waste rock would be categorized and managed based on its potential to oxidize. The least reactive, Category 1, waste rock would be placed into a permanent stockpile, while Category 2/3 waste rock and Category 4 waste rock would be stored in temporary stockpiles before being placed as backfill into the East Pit after year 11 of operations. The location of the stockpiles is shown in Figure 5.2.14-1. The total weight of waste rock stored in a permanent stockpile (Category 1 Stockpile) would be approximately 168 million tons (see Section 3.2.2.1.7).

The data inputs, evaluation methodology, results, and design and operating requirements for the stockpiles were reported in Geotechnical Data Package Volume 3 (PolyMet 2014p) and Rock and Overburden Management Plan (PolyMet 2015h) and reviewed by the Co-lead Agencies. Additional geotechnical investigations are required to gain a better understanding of the liner interface frictional values (for the composite liners that would be used at the proposed facility), as well as the geotechnical material properties of the foundation soils in the wetland areas and stockpile geotechnical material properties prior to construction of the stockpiles. PolyMet has committed to undertake further investigations as necessary.



Mine Site
Active Stockpile
Category 4 Stockpile
Mine Pit
Stockpile Cross-Section
Transportation and Utility Corridor
Existing Railroad

0 500 1,000 2,000 3,000 Feet

Figure 5.2.14-1
Mine Site Plan - Year 11
NorthMet Mining Project and Land Exchange FEIS
Minnesota

November 2015

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Design Criteria

Waste rock stockpiles must be designed to comply with *Minnesota Rules*, parts 6132.2200 and 6132.2400 (stockpile slopes are required to meet *Minnesota Rules*, part 6132.2400, subpart 2B and stockpile foundations are required to meet *Minnesota Rules*, part 6132.2400, subpart 2A(1)). These are design requirements that have been established to attain acceptable slope stability Factors of Safety for global stability and acceptable foundation deformations, the latter of which relates to the capability of the composite geomembrane liner system to withstand the strain anticipated due to differential settlement that may occur in the stockpile foundation materials.

The NorthMet Geotechnical Modeling Work Plan (PolyMet 2015l, Attachment A) requires PolyMet to perform stockpile subgrade settlement analysis to predict magnitude of deformation and resulting strain in the stockpile geomembrane liners for comparison to allowable strain in the proposed liner system. Allowable strains are material-specific and would be determined from manufacturers specifications for the materials selected for the stockpile liners.

Methodology

In order to demonstrate that the design of the stockpiles would meet the geotechnical requirements, PolyMet completed the following:

- Collected existing conditions data needed to support foundation design (refer to Section 4.2.14);
- Configured stockpile slopes to meet or exceed the minimum dimensional requirements established by *Minnesota Rules*, part 6132.2400;
- Conducted a stockpile subgrade settlement analysis to predict the magnitude of deformation and resulting strain in the stockpile liners for comparison to allowable strain in the liner system;
- Completed slope stability analyses using RocScience's limit equilibrium program SLIDE; and
- Developed the stockpile design and operating requirements necessary to maintain required slope stability Factors of Safety and liner performance.

Design

The design of the stockpiles would need to conform to *Minnesota Rules*, parts 6132.2200 and 6132.2400. Various design specifications have been established and used for the stockpile analysis (PolyMet 2014p). The following is a summary of the design characteristics applied and considered in geotechnical evaluation.

Preconstruction Design Considerations for Stability and Water Management

Additional geotechnical investigation such as soil borings, test trenches, and geotechnical laboratory tests of on-site materials are required at the locations of the proposed stockpiles to verify the geotechnical information currently available. Examples of information that the additional investigation would yield include: confirmation of the classification of native soils, identification of depths to bedrock and groundwater, identification and delineation of on-site borrow sources, and procurement of additional material samples of waste rock and overburden soils for laboratory testing. Information would be used to modify stockpile and foundation design and confirm the design assumptions and earthwork balance computations. The additional investigations would take place before stockpile construction but cannot be undertaken until the land exchange has been completed, appropriate permitting has been received, and dewatering of the wetland areas has been performed. As noted above, before construction, the sites would be dewatered and stockpile foundations would be established on soils identified through permitting, that the MDNR agrees to be suitable for structural support; unsuitable soils on the stockpile's perimeter would be removed and replaced with structural fill for stability purposes.

The Category 1 Stockpile would be a permanent, unlined facility. A drainage system would be progressively installed around the stockpile, prior to waste rock placement, to capture ground and surface water flows that may seep from the stockpile.

The temporary Category 2/3 and 4 Stockpiles would include a composite geomembrane liner systems comprised of, from the bottom up, a foundation underdrain system, an impermeable composite liner barrier, and an overliner drainage layer. The composite liner systems are designed to perform on a level commensurate with the level of environmental risk expected by the waste rock classification type. The composite liner system for each temporary stockpile consists of a minimum of one foot of compacted soil overlain by an 80-millimeter thick Linear Low Density Polyethylene (LLDPE) geomembrane liner and a minimum of two ft of granular drainage material. The liners would utilize gravity drainage to a series of collection sumps, and an overliner drainage layer would be constructed to reduce the potential for leaks due to puncturing of the geomembrane by the waste rock. For angular overliner materials, a geomembrane liner load integrity test would be conducted during the additional investigation work mentioned above to support specification of the acceptable geomembrane thickness and polymer type.

Additional information on water containment and management is provided in Section 3.2.2.1.8.

Stockpile Design and Construction

- Stockpile design geometry used for analysis is as follows: minimum width at the top of stockpile: approximately 150 ft or as controlled by the minimum safe turning radius for operating mine haulage trucks
- Perimeter access road for light truck traffic (plus allowance for berms): 20 ft
- Nominal angle of repose slopes: 1.4H:1V (horizontal:vertical) (assumed)
- Maximum slope for stockpile foundation excavation: 2H:1V
- Grading considerations at closure:
  - For the Category 1 Stockpile: 3.75H:1V regraded interbench slopes for the geomembrane cover
  - Regrading is not necessary for Categories 2/3 and 4 stockpiles or the Ore Surge Pile as these are temporary stockpiles
- Height of first lift (over geomembrane, where located): 15 ft
- Height of second lift (over geomembrane, where located): 25 ft
- Nominal lift height (after initial two lifts over geomembrane and where no geomembrane is located): 40 ft

- Maximum stockpile heights and interbench slope configurations considered for stability analyses are:
  - 160 ft at interbench slope angles of 1.4H:1V and 2.5H:1V
  - 200 ft at interbench slope angle of 3H:1V
  - 240 ft at interbench slope angle of 3.7H:1V

Stockpile liner systems and foundation designs used for analysis are as follows:

- Number of development phases: to be determined in permitting
- Minimum grade for foundation underdrains: 0.5 percent
- Minimum grade for drainage collection overliner: 0.5 percent
- Liner system design, including piping and underliner and overliner collection points
- Liner system geomembrane: 80-millimeter linear low density polyethylene (LLDPE)

Cross sections of the proposed stockpiles are shown in Figure 5.2.14-2 and Figure 5.2.14-3.

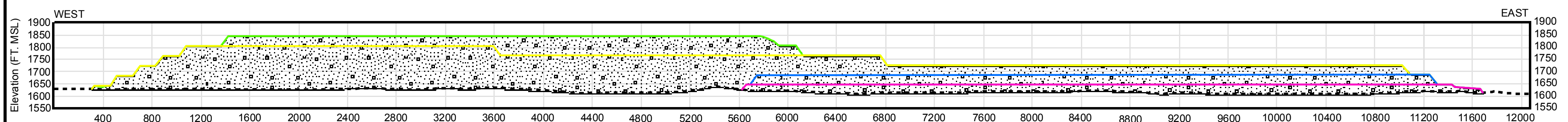
The stability model (SLIDE) assumed a geomembrane liner interface friction angle (i.e., the strength that the geomembrane possesses for resisting sliding against the adjacent earthen material) of 19 degrees, meeting the criteria of 15.7 degrees or greater. Further geotechnical investigation and laboratory testing is required to verify the liner interface shear strength values as placed against potential borrow materials comprising the underliner material, as well as the shear strength parameters for the foundation and stockpile materials prior to construction. To mitigate associated uncertainty, PolyMet has committed to removing all unsuitable foundation soils from beneath lined stockpiles and replace them (where required) with structural fill to meet strength and grade requirements (PolyMet 2015h). PolyMet has also committed to undertaking further geotechnical investigations prior to the construction of the stockpiles to define the foundation management needs.

Temporary stockpiles at the Overburden Storage and Laydown Area have not been included in stability analysis given their temporary nature and relatively small size.

Closure of the Stockpiles

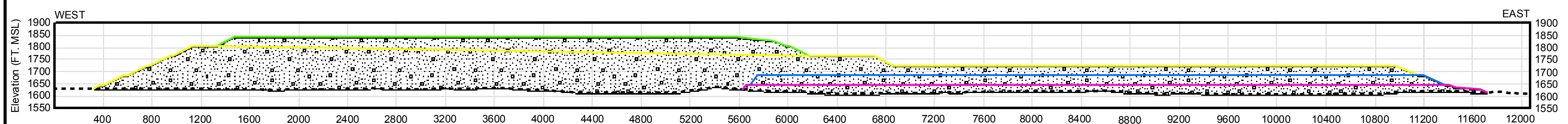
The Category 1 Stockpile would be a permanent feature that would be progressively reclaimed, starting in mine year 14, with an engineered geomembrane cover system. Reclaimed configurations are described in the section above and in the stability modeling results below. The cover would include an engineered geomembrane system that would be vegetated to meet the requirements of *Minnesota Rules*, part 6132.2200, subpart 2, item B. A subgrade layer would be placed over the Category 1 Stockpile to provide a uniform layer upon which to construct the cover system. The cover would be designed to promote runoff with reduced erosion potential. To provide an adequate base for sloping of cover materials, Category 1 Stockpile side slopes would be re-shaped to no steeper than a horizontal-to-vertical ratio of 3.75H:1V, with the cover system placed on top of the re-shaped waste rock. The outermost layer would consist of local till soils (also known as "overburden" per *Minnesota Rules*, part 6132.0100, subpart 32) adequate for native vegetation growth. To provide further erosion control, catch benches at least 30 ft in width would remain on the stockpile. Long-term maintenance of the Category 1 Stockpile would include repairing erosion and removal of woody species and trees from the stockpile cover system to mitigate against the potential for deep root systems puncturing the underlying geomembrane. Additional information on reclamation is provided in Section 3.2.2.1.10 and an overview of monitoring and maintenance actions for stability is provided below.

The Category 2/3 and 4 stockpiles and Ore Surge Pile would be temporary and would be backfilled into the East Pit following year 11. The footprint of the temporary stockpiles would be reclaimed to wetlands or other native habitats where practical.



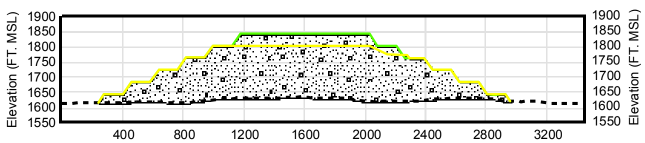
A: Operational Configuration Section

0 400 800
Horizontal Scale in Feet
2X Vertical Exaggeration



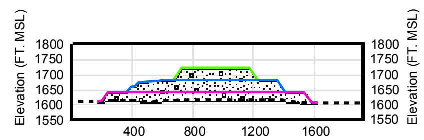
A: Reclamation Configuration Section - Interbench Slopes 3.75H:1V

0 400 800
Horizontal Scale in Feet
2X Vertical Exaggeration



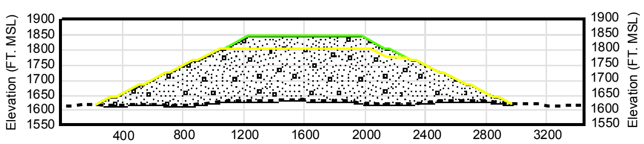
B: Operational Configuration - West Section

0 400 800
Horizontal Scale in Feet
2X Vertical Exaggeration



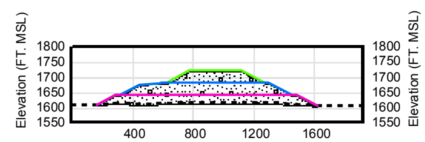
B: Operational Configuration - East Section

0 400 800
Horizontal Scale in Feet
2X Vertical Exaggeration



B: Reclamation Configuration - West Section, Interbench Slopes 3.75H:1V

0 400 800
Horizontal Scale in Feet
2X Vertical Exaggeration



B: Reclamation Configuration - East Section, Interbench Slopes 3.75H:1V

0 400 800
Horizontal Scale in Feet
2X Vertical Exaggeration

Year 1 — Ultimate Extent
Year 2 — Existing Ground Surface
Year 11

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Figure 5.2.14-2
Cross Sections of the Proposed Category 1 Stockpile
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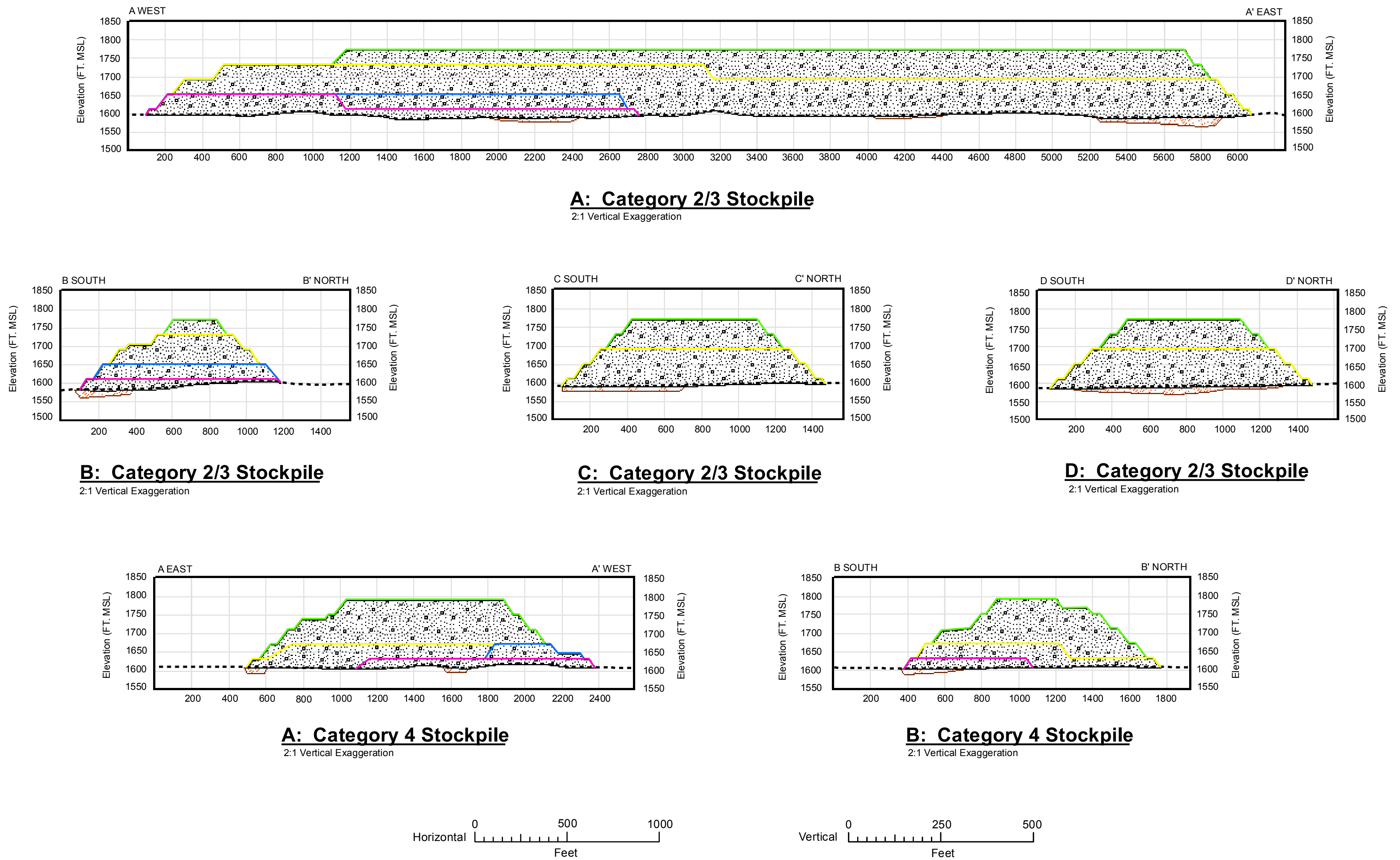

Year 1 — Ultimate Extent
Year 2 — Existing Ground Surface
Year 11 — Unsuitable Soil Excavation Surface

Figure 5.2.14-3

Cross Sections of the Proposed Category 2/3 and 4 Stockpiles at Maximum Extent

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Modeling Results

The results reported in Geotechnical Data Package Volume 3 indicate that the proposed design of the stockpiles would meet the required Factors of Safety (PolyMet 2014p). The geotechnical evaluation is summarized below.

Stability

PolyMet undertook a stability analysis of the design cross sections developed to represent the following typical conditions at different phases of stockpile development:

- Temporary Category 2/3 Stockpile, Category 4 Stockpile, and Ore Surge Pile
  1. Initial operational configuration (single lift of waste rock placed in two stages).
  2. Operational configuration at proposed final buildout (excludes the Ore Surge Pile, which would fluctuate).
- Permanent Category 1 Stockpile
  1. Initial operational configuration (a single lift of waste rock with a maximum height of 40 ft placed at the angle of repose).
  2. Operational configuration at proposed final buildout prior to reclamation (assume four lifts of waste rock).
  3. Reclaimed configuration, interbench slopes regraded to 2.5H:1V.
  4. Reclaimed configuration, interbench slopes regraded to 3H:1V.
  5. Reclaimed configuration, interbench slopes regraded to 3.75H:1V.
  6. Assuming a liner interface (i.e., overliner material/LLDPE geomembrane liner/soil liner) friction angle of 19 degrees.

Results indicated that all sections analyzed met the minimum required Factors of Safety.

Estimated liner strains resulting from foundation settlement are less than 1 percent; well below the 30 percent maximum strain allowed in the LLDPE geomembrane proposed for the geomembrane barrier layer component of the basal liner system for the Category 2/3 Stockpile, Category 4 Stockpile, and the Ore Surge Pile.

Proposed Monitoring, Maintenance, and Mitigation

A Construction Quality Assurance Plan would be developed by PolyMet for the stockpile construction prior to permitting. The objective of the plan would be to assure that the construction of the soil and geosynthetic components would be in compliance with the project specifications and to demonstrate that the regulatory requirements for the construction would be achieved. The plan also would provide the means for resolution of problems that may occur during construction. The Construction Quality Assurance Plan would be independent of the quality control programs to be followed by the manufacturers, installers, and the contractor.

A Rock and Overburden Management Plan (PolyMet 2015h) has been prepared by PolyMet that includes a description of the operating plans, monitoring procedures, and adaptive management approaches for the stockpiles.

The stockpile quantities would be monitored throughout the life of the mine and the stockpile heights and footprints would be monitored to verify that they are constructed as designed. Monitoring and maintenance of the Category 1 Stockpile would also continue through the post-closure period until the MDNR determines that the cover is stable. An annual compliance report would be developed each year for submittal to the MDNR to comply with the Permit to Mine requirements.

Information gained through ongoing monitoring would also be used to advise adaptive waste management requirements should the capacity of the Category 2/3 Stockpile, the Category 4 Stockpile, and/or the East Pit be insufficient for the mined volume of Category 2/3 and Category 4 waste rock generated by mining. Adaptive waste rock management could include expansion of the waste rock stockpiles. While moving all of the Category 1 waste rock into the West Pit as backfill was eliminated as a potential alternative (refer to Section 3.2.3.4.2), it may be possible to dispose of some excess waste rock or saturated overburden in the West Pit in areas where mining has ceased, if necessary as an adaptive measure.

Each year, an operating plan and annual report would be completed, as required for the Permit to Mine, to keep the Rock and Overburden Management Plan (PolyMet 2015h) current and to track changes in the mine plan, rock type schedule, and characterization of the material. Modifications to the Rock and Overburden Management Plan based on changes to the material characterization would be completed, as necessary.

5.2.14.2.2 Tailings Basin

Tailings from the beneficiation process would be disposed of in a Tailings Basin, constructed on top of Cell 1E and Cell 2E of the existing LTVSMC Tailings Basin. Figure 5.2.14-4 depicts the Tailings Basin at its proposed final elevation (year 20).

The data inputs, modeling methodology, results, and design and operating requirements for the Tailings Basin were reported in Geotechnical Data Package Volume 1 (PolyMet 2015l) and Flotation Tailings Management Plan (PolyMet 2015n), which were reviewed by the Co-lead Agencies. The information provided in the data package informs the permitting process and is summarized below.

Design Criteria

In Minnesota, dams must be constructed in accordance with applicable requirements of *Minnesota Rules*, parts 6115.0300–6115.0520. In addition, under the NorthMet Geotechnical Modeling Work Plan (PolyMet 2015l, Attachment A), the Co-lead Agencies require that the critical cross section of the Tailings Basin is demonstrated to meet or exceed the following minimum Factors of Safety as required for various loading scenarios:

- Factor of Safety greater than or equal to 1.5 for effective stress conditions using parameters that reflect long-term, drained strength conditions.
- Factor of Safety greater than or equal to 1.3 for short-term, undrained strength conditions for soils that are not prone to static liquefaction using undrained strength conditions.
- Liquefaction analysis of potentially liquefiable materials in undrained strength conditions including:
  - Liquefaction triggering analysis Factor of Safety greater than or equal to 1.1;

- Seismic liquefaction triggering analysis (i.e., induced by design earthquake event) Factor of Safety greater than or equal to 1.2 (or, the Co-lead Agencies may accept a Factor of Safety between 1.2 and 1.0 if the results of deformation modeling are also deemed acceptable by the Co-lead Agencies); and
- Liquefied scenario (assumes all saturated contractive materials have liquefied) Factor of Safety greater than or equal to 1.10.

These minimum Factors of Safety were selected with consideration for:

- The proposed construction of the Tailings Basin on top of the existing LTVSMC Tailings Basin and the known geotechnical conditions and material characteristics of the existing facility;
- The expected characteristics of the NorthMet Project tailings and construction materials and methods, including long-term wet closure; and
- Similar industry standards and other large tailings dams in Minnesota.

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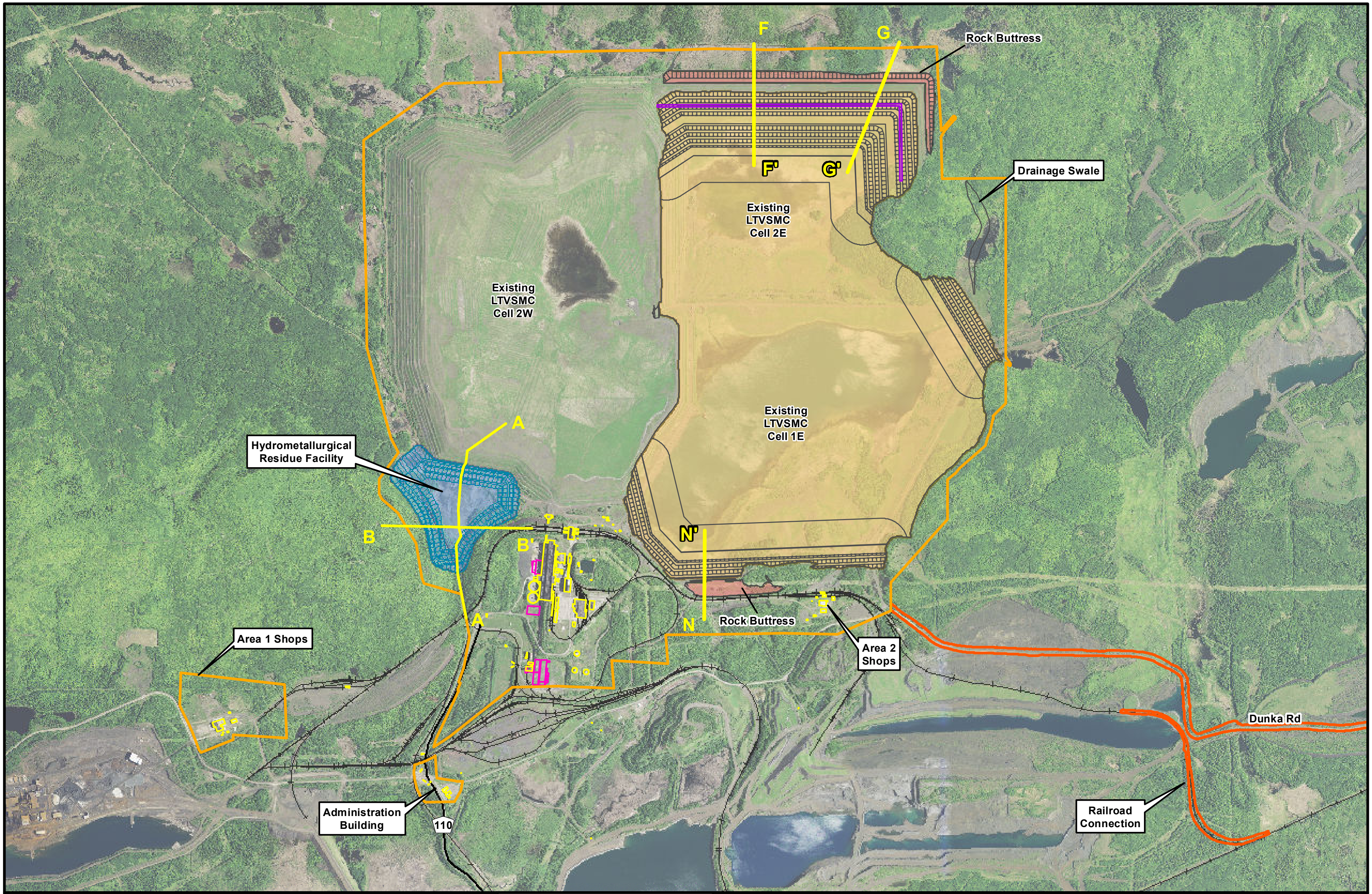

Plant Site
Tailings Basin
Proposed Buildings
Existing Building
Hydrometallurgical Residue Facility
Rock Buttress
Transportation and Utility Corridor
Cross-Section
Proposed Cement Deep Soil Mix
Existing Railroad

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N W E S

0 1,000 2,000 4,000 Feet

Figure 5.2.14-4
Proposed Plant Site Layout
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Methodology

In order to demonstrate that the design of the Tailings Basin would meet the respective geotechnical requirements, PolyMet, in accordance with the NorthMet Geotechnical Modeling Work Plan (PolyMet 2015l, Attachment A) took the following steps:

1. Gathered existing conditions data (i.e., existing basin topography, stratigraphy, soil and tailings strength and hydraulic characteristics [see Section 4.2.14], characteristics of NorthMet tailings based on material produced during the pilot-plant processing, and other data as needed to support geotechnical modeling and Tailings Basin design).
2. Developed Tailings Basin cross sections (i.e., geometry and stratigraphy for existing and planned conditions) for the Tailings Basin for seepage and stability modeling.
3. Developed seepage and stability models using Geo-Slope International, Inc. modeling software (i.e., SLOPE/W, SEEP/W and SIGMA/W as necessary) for various construction and loading scenarios (such as various dam crest and pond surface elevations during construction and closure).
4. Established the geotechnical design data for model input including identification of hydraulic and strength parameters and the triggering potential for static and seismic events of the various tailings material types.
5. Performed modeling and results interpretation.
6. Refined the design and operating requirements necessary until modeling showed that the required slope stability Factors of Safety are achieved for the critical slope cross section.

Design

Various design specifications have been established and used for Tailings Basin geotechnical analysis (PolyMet 2015l). The following is a summary of the design characteristics applied and considered in modeling.

Preconstruction Design Considerations for Stability and Water Management

Before placement of NorthMet tailings, coarse tailings sourced from the existing LTVSMC Tailings Basin would be used to construct a drainage layer to maintain a lowered phreatic surface within the new dam. A lower phreatic surface would help to prevent saturation of the dam embankments. Additional modeling would be conducted to ascertain if this drainage layer needs to be continuous along the length of the dam, or if narrow segments of foundation material would prove to be sufficiently effective.

Rock buttresses would be placed at the northern toe of the existing Cell 2E starter dam, and at the south end of Cell 1E near the railroad fill to provide resistance to the driving forces created by the dam raises. The location of the proposed rock buttress is shown in Figure 5.2.14-4. Peat would be removed from below the rock buttress footprint before placement, so that the rock can be founded on the firmer till and bedrock. Buttress material would likely consist of waste rock sourced from the LTVSMC Area 5 Stockpile (assumed to have the same geochemical properties as Category 1 waste rock for water impact modeling purposes).

Installation of CDSM columns would also be used along the northern and northeastern sides of Cell 2E to enhance the shear strength of the existing LTVSMC fine tailings, slimes, and peat layers by mixing in situ soil with cement or other suitable stabilizing agent. The location of one proposed CDSM option is shown in plan view on Figure 5.2.14-4, and cross section view on Figures 5.2.14-6 and 5.2.14-7. A potential arrangement of CDSM that may be applied at the Tailings Basin is shown in Figure 5.2.14-5.

As described in Section 3.2.2.3.10, the Tailings Basin design includes a containment system and a storm water management system that would encompass the northern, western and eastern sides of the Tailings Basin. Storm water runoff is not expected to cause significant erosion to the dams. However, if erosion were to occur, more robust erosion control measures would be implemented. A drainage swale would be added to redirect runoff storm waters falling outside of the dams. These design features would not affect the stability of the dams (PolyMet 2015l). Precipitation that falls within the Tailings Basin would be contained by a freeboard that has been designed based on the predicted bounce from a PMP event (PolyMet 2015n). Overflow would be prevented by pumping excess pond water to the WWTP. In the rare event that freeboard within the Tailings Basin, and pumping of excess water to the WWTP, is not sufficient to contain all storm water, water would be directed to an emergency overflow spillway.

A seismic hazard assessment and subsequent liquefaction analysis were undertaken for the Tailings Basin. Results indicated that a significant earthquake is unlikely in Minnesota, and a seismic design event with a peak ground acceleration of 0.024g (2,475 year return period) is not likely to trigger liquefaction in the Tailings Basin materials. Seismic deformation was also considered and the effect of settlement resulting from a design earthquake event would not affect the stability or pond containment of the Tailings Basin.

NorthMet Tailings Basin Design and Construction

The Tailings Basin would be constructed using the upstream method, whereby NorthMet dam embankments would be constructed using preferentially borrowed LTVSMC tailings on top of the existing LTVSMC tailings embankment and on the spigotted tailings adjacent to the perimeter embankment. NorthMet bulk tailings would be discharged into the new basin by perimeter spigots and a pond barge pump. New dam embankments (using LTVSMC Bulk tailings) would be raised in stages on top of the existing LTVSMC tailings impoundment, and the new tailings deposited upstream of the dam into the basin from spigots at the dam's edge. Tailings would also be discharged subaqueously in the basin via a barge.

The Tailings Basin incorporates construction of new dam embankments over the existing LTVSMC Tailings Basin Cells 1E and 2E. The design process is an iterative approach whereby various combinations of stabilization factors including slope angle, lift heights, intermediate slope bench width, drainage layers beneath the proposed NorthMet tailings, CDSM, and supporting rock buttresses were modeled to identify a design that would achieve the following:

- Provide safe permanent storage of tailings generated over the proposed 20-year operating life of the NorthMet Project Proposed Action and maintain stability post-closure;
- Efficiently and effectively recover process water from the surface of the Tailings Basin during operation, and contain groundwater and surface water seepage during operation and over the long term (refer to Section 5.2.2 for more information on water management);
- Accommodate the planned wet cover system at closure; and
- Meet project regulatory requirements (including Factors of Safety).

As shown in Figure 5.2.14-6, Figure 5.2.14-7, and Figure 5.2.14-8 the proposed design consists of eight lifts with a proposed final crest elevation (selected on the basis of tailings storage capacity requirements) modeled as 1,732 ft amsl. This would be an additional 150 ft on top of the existing LTVSMC Tailings Basin Cell 2E. This proposed elevation is similar to the elevation of the existing north dam of Cell 2W, which is at a designed final elevation of 1,735 ft amsl. A schematic cross section of the Tailings Basin is shown in Section 3.2.2.3.5.

The proposed dams would be constructed from mechanically placed and compacted "bulk tailings" taken from the existing LTVSMC Tailings Basin as needed to produce the desired dam lift height and geometry. LTVSMC "bulk tailings" are currently defined as a mixture of tailings from the existing LTVSMC Tailings Basin. The exterior face of the dams would be augmented with a bentonite layer to limit oxygen and rain water infiltration into the Tailings Basin.

The individual lifts would have a slope of 4.5H:1V, which, including setbacks, would provide for an overall slope of approximately 8.6H:1V. Each lift would be 20 ft high, with the exception of the final lift, Lift 8, which would be 10 ft in height. There is a 60-ft bench on top of each lift, with an additional 200-ft setback on top of Lift 4, and a 625-ft beach extending from the interior crest of dam to the edge of the Tailings Basin pond.

Closure of the Tailings Basin

As dams are constructed, exterior slopes would be covered with bentonite and vegetated. Upon reaching the final proposed dam elevation (after 20 years of operation), the Tailings Basin would be closed in accordance with *Minnesota Rules*, part 6132.3200 and would also include the following:

- Bentonite augmentation of the pond area bottom to reduce infiltration to a sufficient degree to maintain desired pond water elevations at closure;
- Slight slope grading of the interior portions for effective storm water routing into the pond area;
- Bentonite augmentation of the exposed embankments and beach areas; and
- Mulching and planting/seeding of native vegetation of upland areas (plants would be selected and monitored to limit root growth from penetrating bentonite).

Monitoring and maintenance measures that would be applied post closure are further addressed below and additional details on closure are provided in Section 3.2.2.3.12.

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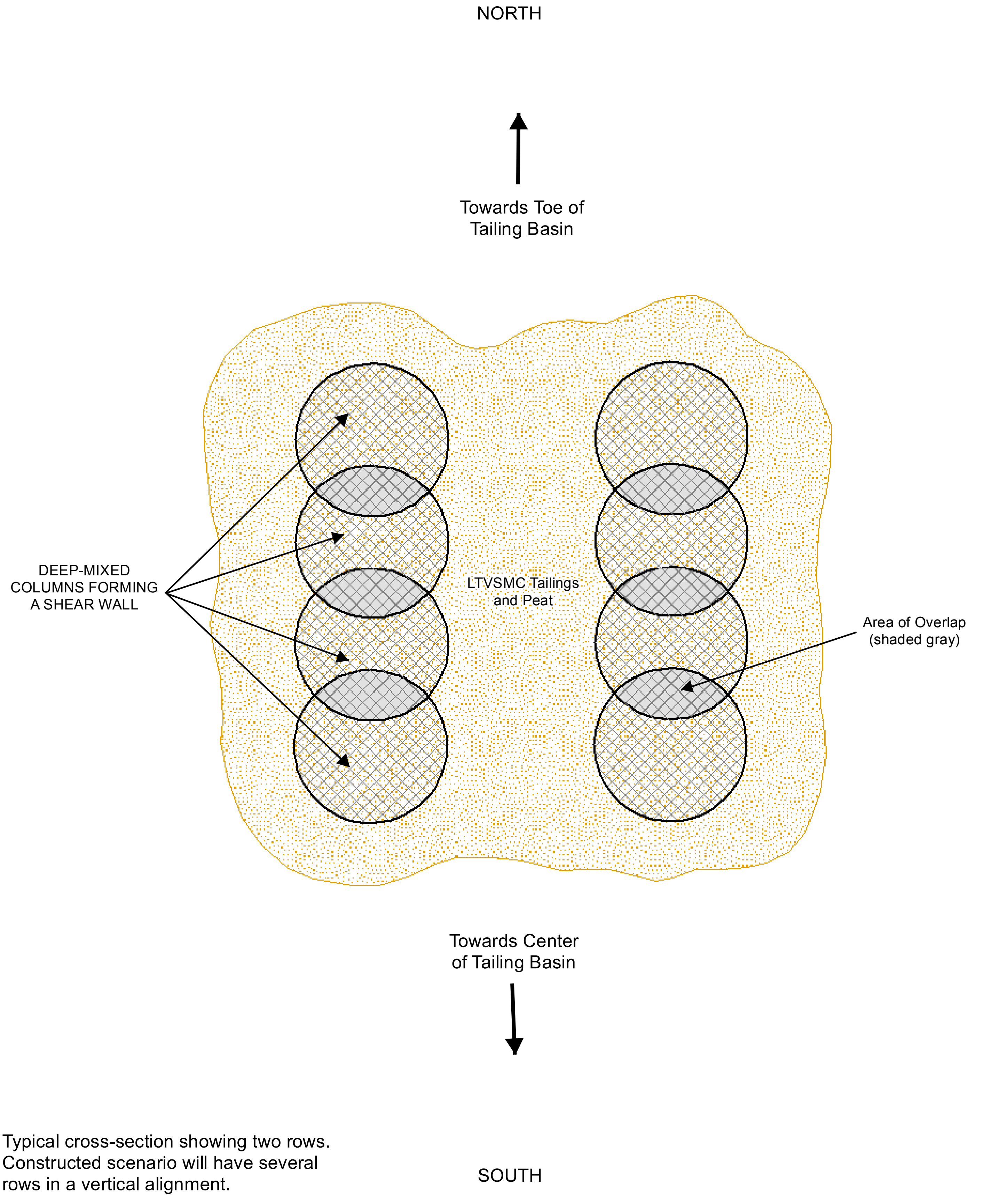

Typical cross-section showing two rows. Constructed scenario will have several rows in a vertical alignment.

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Figure 5.2.14-5
Potential Cross-section of Cement Deep Soil Mixed Columns Forming a Shear Wall
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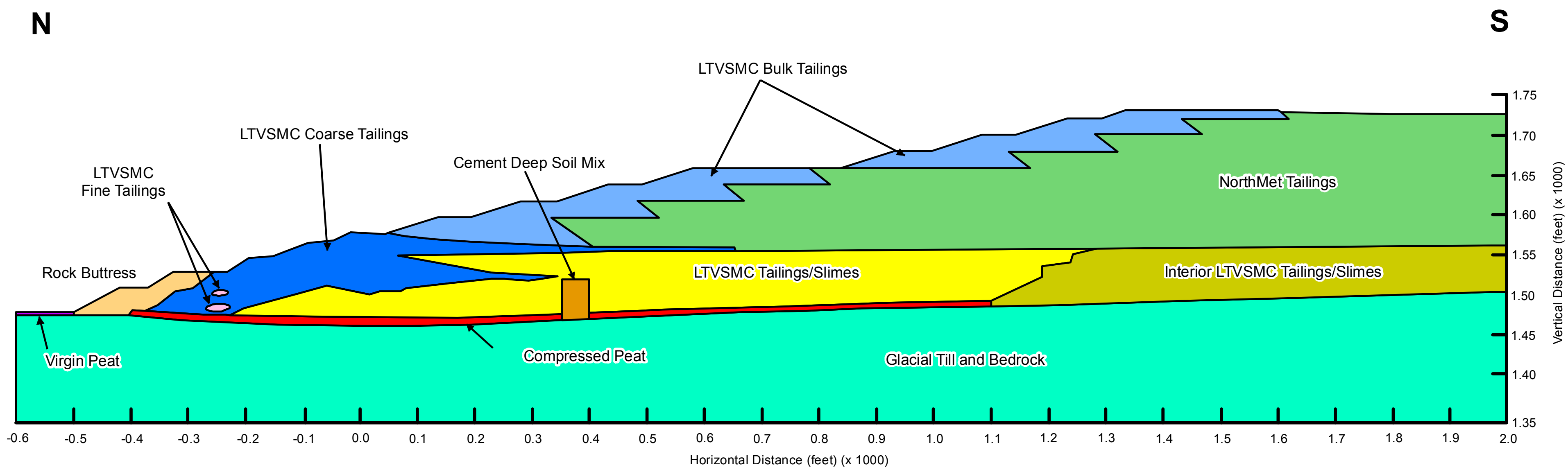

- Compressed Peat
- Interior LTVSMC Tailings/Slimes
- NorthMet Tailings
- LTVSMC Bulk Tailings
- LTVSMC Coarse Tailings
- LTVSMC Tailings/Slimes
- LTVSMC Fine Tailings
- Rock Buttress
- Cement Deep Soil Mix
- Virgin Peat
- Glacial Till and Bedrock

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Figure 5.2.14-6
Cross Section F of the Tailings Basin at Maximum Extent
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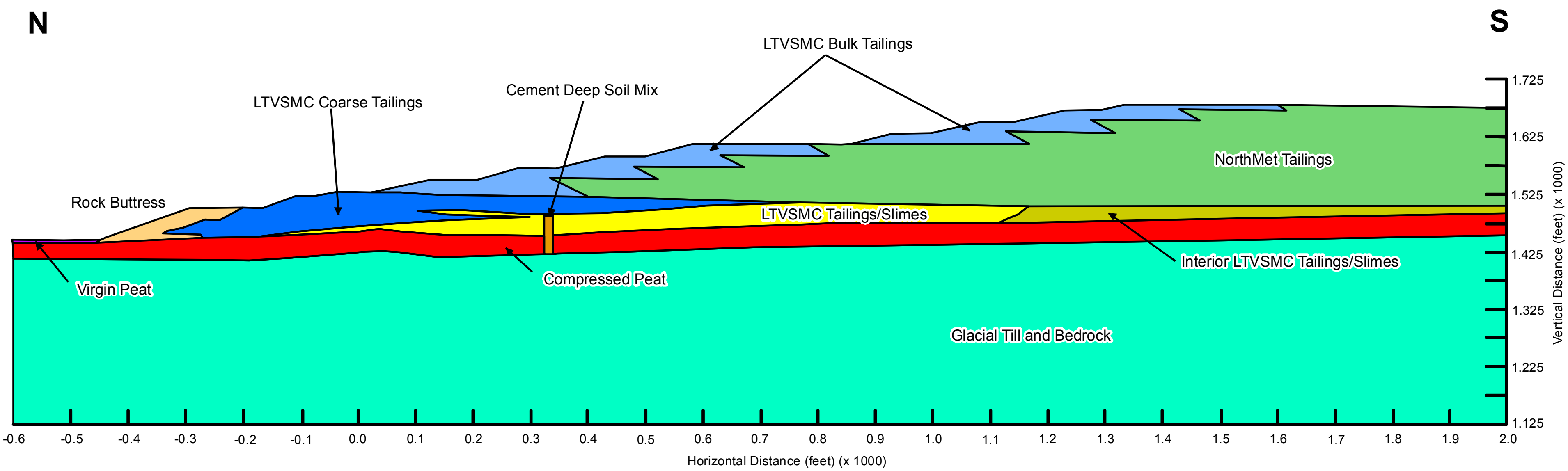

- Compressed Peat
- Interior LTVSMC Tailings/Slimes
- NorthMet Tailings
- LTVSMC Bulk Tailings
- LTVSMC Coarse Tailings
- LTVSMC Tailings/Slimes
- Rock Buttress
- Cement Deep Soil Mix
- Virgin Peat
- Glacial Till and Bedrock

Figure 5.2.14-7
Cross Section G of the Tailings Basin at Maximum Extent
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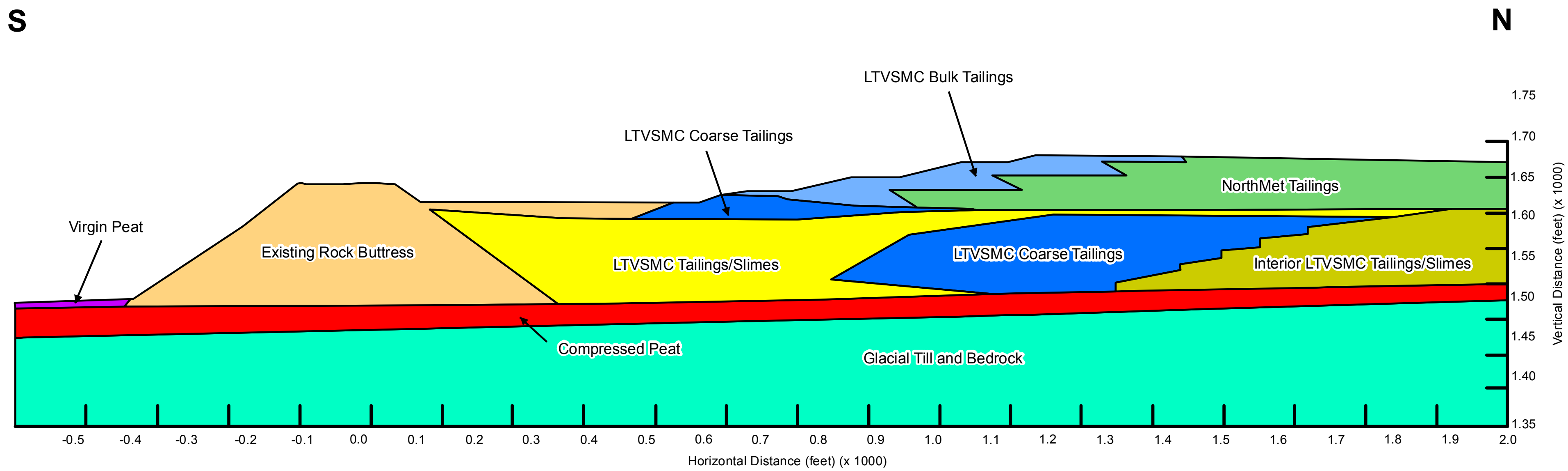

Compressed Peat
Interior LTVSMC Tailings/Slimes
NorthMet Tailings
LTVSMC Bulk Tailings
LTVSMC Coarse Tailings
LTVSMC Tailings/Slimes
Existing Rock Buttress
Cement Deep Soil Mix
Virgin Peat
Glacial Till and Bedrock

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Figure 5.2.14-8
Cross Section N of the Tailings Basin at Maximum Extent
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Identification of the Critical Cross Section

Geotechnical conditions along the length of existing LTVSMC Tailings Basin dams have varying layers of coarse tailings, fine tailings, and slimes. Cross Section F, which intersects the northern dam of Cell 2E, as shown in Figure 5.2.14-4, was selected to represent the critical cross section for stability analysis purposes as it is the maximum section based on height as measured from the downstream toe to the proposed final crest, some layers of the weaker fine tailings and slimes extend close to the dam, and the original starter dam is underlain by peat. Material types identified from borings in the existing LTVSMC Tailings Basin along Cross Section F are shown in Figure 4.2.14-3. Figure 5.2.14-6 shows the proposed design of the NorthMet Project Proposed Action Tailings Basin along Cross Section F at its full extent.

Cross Section F was analyzed in a sequential manner consisting of the development of the dam cross section stratigraphy for analyses, application of the material strength and permeability characteristics, and modeling of seepage conditions at the dam cross section, followed by stability analyses.

Cross Section F also was evaluated with the Tailings Basin at the proposed final crest height to determine whether liquefaction would be triggered in the contractive materials, based on certain triggers prescribed in the NorthMet Geotechnical Modeling Work Plan (PolyMet 2015l, Attachment A).

In addition to Cross Section F, Cross Section G and N were selected to represent separate, non-critical sections of the Tailings Basin. These cross sections are shown in plan view on Figure 5.2.14-4. Figures 5.2.14-7 and 5.2.14-8 show the proposed design of the NorthMet Project Proposed Action Tailings Basin along Cross Sections G and N at their full extent respectively. Stability modeling was also performed for these cross sections as described below.

Modeling Results

The results reported in Geotechnical Data Package Volume 1 indicate that the proposed design of the Tailings Basin would meet all respective Factors of Safety as required (PolyMet 2015l). The modeling undertaken and results obtained are summarized below. Subsequent to Geotechnical Data Package Volume 1, PolyMet evaluated the effect that the Tailings Basin groundwater containment system would have on stability. Results indicated that the groundwater containment system would not impact the stability of the Tailings Basin or the Factor of Safety results for Cross Sections F, G, and N determined in Geotechnical Data Package Volume 1 and provided below (PolyMet 2015l). All minimum Factors of Safety correspond to Cross-Section F, confirming that it is the critical cross-section given the analyses performed.

Technical documents have been reviewed by the Co-lead Agencies and these results would be further verified before the completion of permitting.

Slope Stability

The predicted Factor of Safety values for Cross Sections F, G and N at various stages of development of the Tailings Basin are summarized in Table 5.2.14-1. The geometry and physical changes to the embankments (such as CDSM) were incorporated into the design so that all computed slope stability Factors of Safety met or exceeded the Factors of Safety required by the NorthMet Geotechnical Modeling Work Plan (PolyMet 2015l, Attachment A).

Table 5.2.14-1 Summary of Stability Modeling Results

Cross-Section Location	Cross-Section F			Cross- Section G			Cross-Section N		
Case	USSA yield	ESSA	USSA liq	USSA liq	ESSA	USSA liq	USSA yield	ESSA	USSA liq
Target Factor of Safety	1.3	1.5	1.1	1.3	1.5	1.1	1.3	1.5	1.1
Design Scenarios – Steady State Seepage									
Existing Conditions	-	1.83	-	-	2.21	-	-	3.11	-
Interim Lift 2	1.89	3.12	-	2.28	3.43	-	-	-	-
Interim Lift 4	1.74	3.18	-	2.09	3.42	-	-	-	-
Interim Lift 6	1.88	3.18	-	1.93	3.43	-	1.88	4.43	-
Interim Lift 8 – Normal Pool	1.69	3.17	-	1.86	3.44	-	2.00	4.58	-
Interim Lift 8 – PMP Event	1.77	3.18	-	1.85	3.46	-	1.91	4.34	-
Long-Term Stability – Steady State Seepage									
End of Operations	-	3.07	-	-	-	-	-	-	-
20 Years after Closure	-	3.09	-	-	-	-	-	-	-
200 Years after Closure	-	3.21	-	-	-	-	-	-	-
2,000 Years after Closure	-	3.15	-	-	-	-	-	-	-
Cross-Section F Liquefaction Triggering Analysis									
Baseline	2.06	-	-	-	-	-	-	-	-
Plugged Drain	2.06	-	-	-	-	-	-	-	-
Lift 1 Rapid Loading	-	-	1.78	-	-	-	-	-	-
Erosion	1.99	-	-	-	-	-	-	-	-
Plugged Drain	1.91	-	-	-	-	-	-	-	-
Fully Liquefied with Unknown Trigger									
Operations	-	-	1.10	-	-	1.25	-	-	1.16
20 Years after Closure	-	-	1.35	-	-	-	-	-	-
200 Years after Closure	-	-	1.45	-	-	-	-	-	-
2,000 Years after Closure	-	-	1.53	-	-	-	-	-	-

Source: PolyMet 2015l

Notes:
USSA = Undrained Strength Stability Analysis
ESSA = Effective Strength Stability Analysis
Liq = Liquefied conditions
Yield = point of elastic deformation

Liquefaction

The potential for liquefaction, where a triggering event changes the stress state of the material such that it loses a significant amount of its strength, was assessed under different scenarios, including rapid loading and construction, ineffective underdrain resulting in increased saturation, and erosion events. Results shown in Table 5.2.14-1 indicate that the design under these conditions meets the minimum Factor of Safety for Cross Sections F, G, and N.

A scenario for potential liquefaction was evaluated whereby all contractive, saturated soils were modeled with their liquefied shear strengths. Table 5.2.14-1 shows that if the contractive, saturated soils were to liquefy at the end of operations, or 20, 200, or 2,000 years after operations, the design would meet the minimum Factors of Safety deemed acceptable by the Co-lead Agencies.

Potential for seismic activity was also analyzed and assessed. Results indicated that there is a very low likelihood of liquefaction as a result of seismic events.

Long-Term Closure Stability Conditions

While it is normally preferable from a stability perspective to allow tailings facilities to drain following closure, the NorthMet Project Proposed Action involves maintaining a pond on top of the Tailings Basin for water quality management purposes.

The Tailings Basin would be covered with a bentonite-amended surface on the exterior face of the NorthMet Project dam lifts (amended during construction). After the Tailings Basin has been filled to its maximum height, the dam would be prepared for reclamation by amending the 625-ft beach of tailings and the bottom of the pond with bentonite. A closure overflow channel would be constructed to drain excess water from the Tailings Basin pond in order to maintain appropriate freeboard and beach lengths.

Modeling was undertaken to predict the long-term stability of the Tailings Basin. As shown in Table 5.2.14-1, the long-term closure slope stability Factors of Safety are above the minimum value required under the Work Plan.

Proposed Monitoring

Geotechnical investigations would be performed on the Tailings Basin during construction and operations to confirm that the construction and performance of the dam meet design criteria. Results may inform adaptive design changes to ensure stability criteria would be met as construction progresses. This approach is typical for large earthen structures that are developed incrementally over long periods of time.

A Flotation Tailings Management Plan (PolyMet 2015n) has been prepared by PolyMet that includes a description of the operating plans, monitoring procedures, and adaptive management approaches for the Tailings Basin. Monitoring activities include construction material sampling, geotechnical instrumentation, geotechnical investigations, and systematic dam safety inspections.

Existing and proposed geotechnical instrumentation would measure actual tailings dam performance by monitoring stability, seepage, and deformation. Monitoring instrumentation relevant to geotechnical stability would include:

- **Piezometers** to facilitate monitoring of the pore water pressure within the Tailings Basin and perimeter dams (the phreatic surface has a significant effect on slope stability), which would be compared to modeled phreatic surface.
- **Inclinometers** to facilitate monitoring of the movement of the Tailings Basin dams.
- **Survey monitoring points** to facilitate the monitoring of horizontal and vertical deformation (including settlement) of the Tailings Basin dams.

Geotechnical investigations and systematic dam safety inspections would include:

- Staff observation of the condition of the dam and the reporting of any conditions that indicate a departure from the design specifications.
- Weekly/daily routine dam inspections by staff to observe the conditions and performance of the Tailings Basin dams and associated facilities so that any changes to dam conditions could be identified and promptly addressed. These would supplement more detailed Dam Safety Inspections (below).

- Regulator Dam Safety Inspections to evaluate, on a regular basis, the current and past performance of the Tailings Basin dams and to observe potential deficiencies in their condition, performance, and/or operation.
- Semi-annual Dam Safety Inspections undertaken by an independent Minnesota-registered consulting engineer retained specifically for dam safety expertise.
- Inspection after unusual events to monitor and report observations.
- Routine Dam Safety Reviews every 5 years by a qualified geotechnical engineer registered in the State of Minnesota. The review would ascertain that the dam has an adequate margin of safety, based on the current Dam Safety Permit, current engineering practice, and updated operations and design input data. A Dam Safety Review may also be carried out to address a specific problem.

Annual reports on the conditions of the Tailings Basin are required under the MDNR Dam Safety Permit and Permit to Mine. Monitoring and maintenance would continue post closure in accordance with permit requirements.

Proposed Maintenance and Mitigation

Typical maintenance of the facility would include repairing eroded surfaces and repair and/or replacement of damaged monitoring and operational infrastructure. The majority of the non-mechanical maintenance work at the Tailings Basin would be carried out on an as-required basis, rather than on a scheduled basis because it is driven by weather events rather than hours of operation.

Where monitoring or model updates indicate that the Factor of Safety for the Tailings Basin may no longer meet design criteria, appropriate modifications to the Tailings Basin would be considered, modeled, and, if necessary, undertaken. Modifications could include but are not limited to: modification of bench widths between lifts of the dam, modification of lift heights, and modification of slope angles. Other modifications could include increasing the size of the rock buttress, improving the performance of underdrains, and increasing mid-slope setbacks.

A Contingency Action Plan has been prepared as part of the Flotation Tailings Management Plan (PolyMet 2015n). The plan provides guidance to on-site personnel and emergency responders in the case of unplanned occurrences at the Tailings Basin. The plan defines three levels of hazardous and emergency conditions response:

1. Level 1 is defined as unusual conditions that do not warrant an emergency response but require prompt investigation and resolution.
2. Level 2 is defined as conditions that represent a potential emergency, if sustained or allowed to progress, but no emergency situation is imminent. The first action in the event of a Level 2 emergency condition is to discuss and define a response plan.
3. Level 3 is defined by either imminent failure of the Tailings Basin or a significant component thereof. The first actions in the event of any Level 3 condition are to check all persons who could potentially be affected are safe, initiate the appropriate chain of communications, and immediately undertake appropriate response actions.

Long-term maintenance tasks at the Tailings Basin would include:

- Annual inspection of vegetation on the exterior dam faces and interior beaches, with erosion repaired and vegetation reseeded in accordance with requirements of plans as needed until released from these activities by the MDNR;
- Snow removal from the dam crest to allow access during winter months;
- Reconstruction of eroded dam crest, slope or toe;
- Mulching for fugitive dust control in accordance with requirements of plans; and
- Repair and/or replacement of damaged instrumentation and monitoring.

5.2.14.2.3 Hydrometallurgical Residue Facility

As shown in Figure 5.2.14-4, hydrometallurgical residue would be disposed of in a new Hydrometallurgical Residue Facility that would be located at the site of the existing LTVSMC Emergency Basin, adjacent to the southern extent of existing LTVSMC Tailings Basin Cell 2W.

The data inputs, modeling methodology, results, and design and operating requirements for the Hydrometallurgical Residue Facility were reported in Geotechnical Data Package Volume 2 (PolyMet 2014c) and reviewed by the Co-lead Agencies. The information provided in the data package informs the permitting process and is summarized below.

Design Criteria

The design of the Hydrometallurgical Residue Facility must meet the applicable requirements of *Minnesota Rules*, parts 6115.0300–6115.0520 and the requirements of the NorthMet Geotechnical Modeling Work Plan (PolyMet 2015l, Attachment A), which include the following:

- The ability of the most sensitive slope cross section to meet a global slope stability Factor of Safety of 1.5;
- The ability of the composite liner system to comply with infinite slope stability Factor of Safety of 1.5, and
- The capability of the composite liner system to withstand the longitudinal strain anticipated due to differential settlement that may occur in the facility foundation materials.

Methodology

PolyMet took the steps listed below in order to demonstrate that the design of the Hydrometallurgical Residue Facility would meet the respective geotechnical requirements and would be in accordance with the NorthMet Geotechnical Modeling Work Plan (PolyMet 2015l, Attachment A):

1. Gathered existing conditions data (i.e., facility foundation material stratigraphy and strength data, hydrogeological data, characteristics of NorthMet Project Proposed Action residues based on those produced during the pilot-plant processing, and other data as needed to support geotechnical modeling of the Hydrometallurgical Residue Facility) (see Section 4.2.14).

2. Developed residue facility layout and cross sections (i.e., geometry and stratigraphy for existing and planned conditions) for proposed residue facility stability and deformation modeling.
3. Developed seepage and stability models using Geo-Slope International, Inc. modeling software (i.e., SLOPE/W, SEEP/W and SIGMA/W as necessary) for maximum facility dam height with minimum and maximum pond elevation, and post-closure – cover effective with minimum pond elevation.
4. Established the geotechnical design data for model input including identification of strength parameters and the triggering potential for static and seismic events.
5. Ran the models to determine Factors of Safety, and the potential for slope failure and deformation of the foundation and liner.
6. Refined the design and operating requirements necessary to maintain required slope stability Factors of Safety and deformation requirements for the critical slope cross section.

Design

Various design specifications have been established and used for the Hydrometallurgical Residue Facility geotechnical analysis (PolyMet 2014c). The following is a summary of the design characteristics applied and considered in modeling.

Preconstruction Design Considerations for Stability and Water Management

The proposed Hydrometallurgical Residue Facility would be located on top of the existing LTVSMC Emergency Basin, and would include a double liner and leakage collection system. To prevent stress deformation and strain on the liner system, the emergency tailings would be consolidated by applying a preload fill material on top of the emergency tailings to achieve the required consolidated conditions prior to construction of the Hydrometallurgical Residue Facility.

To achieve this, PolyMet would perform the following tasks:

1. Install a granular drainage layer at the existing LTVSMC Emergency Basin, as needed to facilitate wick drain installation and operation;
2. Install wick drains (if required); and
3. Place, monitor, and remove a preload fill in the existing LTVSMC Emergency Basin to pre-consolidate existing material, thereby reducing future anticipated settlements to mitigate the potential future strains.

In addition to consolidation of the existing LTVSMC emergency tailings, a railroad grade would also be abandoned and removed to facilitate construction.

Seeps have been observed along the southern edge of the LTVSMC Tailings Basin Cell 2W. These seeps have diminished since the termination of the LTVSMC operations and are expected to remain minimal as Cell 2W is not proposed for use as part of the NorthMet Project Proposed Action. The design of the Hydrometallurgical Residue Facility includes a collection drain that would collect water from the seep below the proposed constructed embankment and liner systems to transmit the collected seep to the exterior of the facility. This seepage collection system would consist of a layer of free draining soil which would reduce the potential for phreatic build-up below the liner.

The double liner and collection system would be installed with the following components, listed in order from top to bottom:

1. Upper geomembrane;
2. Geocomposite (geonet) (for leakage collection and recovery);
3. Lower geomembrane; and
4. Geosynthetic clay liner.

PolyMet initiated laboratory testing to consider the chemical compatibility of the potential geosynthetic liner to be used with leakage from residue (PolyMet 2014r). Results indicated that a polymer-treated geosynthetic liner should be used that is manufactured specifically in anticipation of the chemical characteristics of the liquid and the pore water that would be contained within the facility. The hydraulic conductivity of the leakage collection system is not expected to degrade over time. Typical liner performance assumes a 500 year service life of the geomembrane, therefore, hydraulic conductivity of the liner is not expected to degrade over that time. Specific attributes would be determined during the geosynthetic clay layer development to achieve the desired performance before final installation.

As noted in Section 4.2.14.3.4, the Minnesota Geological Survey has inferred but not confirmed the presence of a north-south trending fault that would underlie the proposed Hydrometallurgical Residue Facility. The potential presence of faults within the footprint of the Hydrometallurgical Residue Facility is not anticipated to have a negative impact on the storage of residue within the double lined facility. A probabilistic seismic hazard analysis was done for the Hydrometallurgical Residue Facility. Results indicated that a severe earthquake is highly unlikely in Minnesota, and any seismically induced forces would not likely affect the stability of the Hydrometallurgical Residue Facility.

Hydrometallurgical Residue Facility Design and Construction

The Hydrometallurgical Residue Facility has been designed as a single cell structure with a design capacity of 6,400,000 cubic yards. The perimeter would have an irregular shape consisting of the north dam (a portion of the existing southern LTVSMC Tailings Basin Cell 2W dam), natural high ground, and new dams (see Figure 5.2.14-4). New dams would be located beyond the extent of the LTVSMC Emergency Basin and founded on existing silty sand, gravel glacial till, and Giants Range granite.

The maximum height of the proposed dams is approximately 85 ft, with a crest elevation of 1,650 ft amsl and an additional 3-ft minimum freeboard (14-ft maximum freeboard at a residue surface slope of 0.5 percent). The exterior, downstream face of the dam would be constructed at a slope of 4H:1V) The interior of the Hydrometallurgical Residue Facility would be sloped at 4H:1V and 30-ft horizontal benches would be placed at elevations of 1,600 and 1,630 ft amsl.

The dams would be constructed using downstream construction methods that involve constructing a smaller starter dam first and then raising the dam upward and outward over the downstream shell of the dam as additional capacity is needed. Construction material would be sourced from natural soil and quarried bedrock between the high ground and south dam. Some

LTVSMC coarse tailings may also be utilized for dam construction. While the material is placed, it would be compacted to the design density.

Materials placed in thin, well-compacted lifts, such as those proposed for the Hydrometallurgical Residue Facility embankment fill, are understood to be sufficiently dense so that liquefaction is not anticipated under the various loading conditions, including the design earthquake event with a peak ground acceleration of 0.024g (2,475 year return period). Although liquefaction of the hydrometallurgical residue (within the basin) may occur, the embankment dam is sufficiently designed so that containment would not be lost. Therefore, the integrity of the facility would not be impacted by the loss of strength associated with potential residue liquefaction.

Closure of the Hydrometallurgical Residue Facility

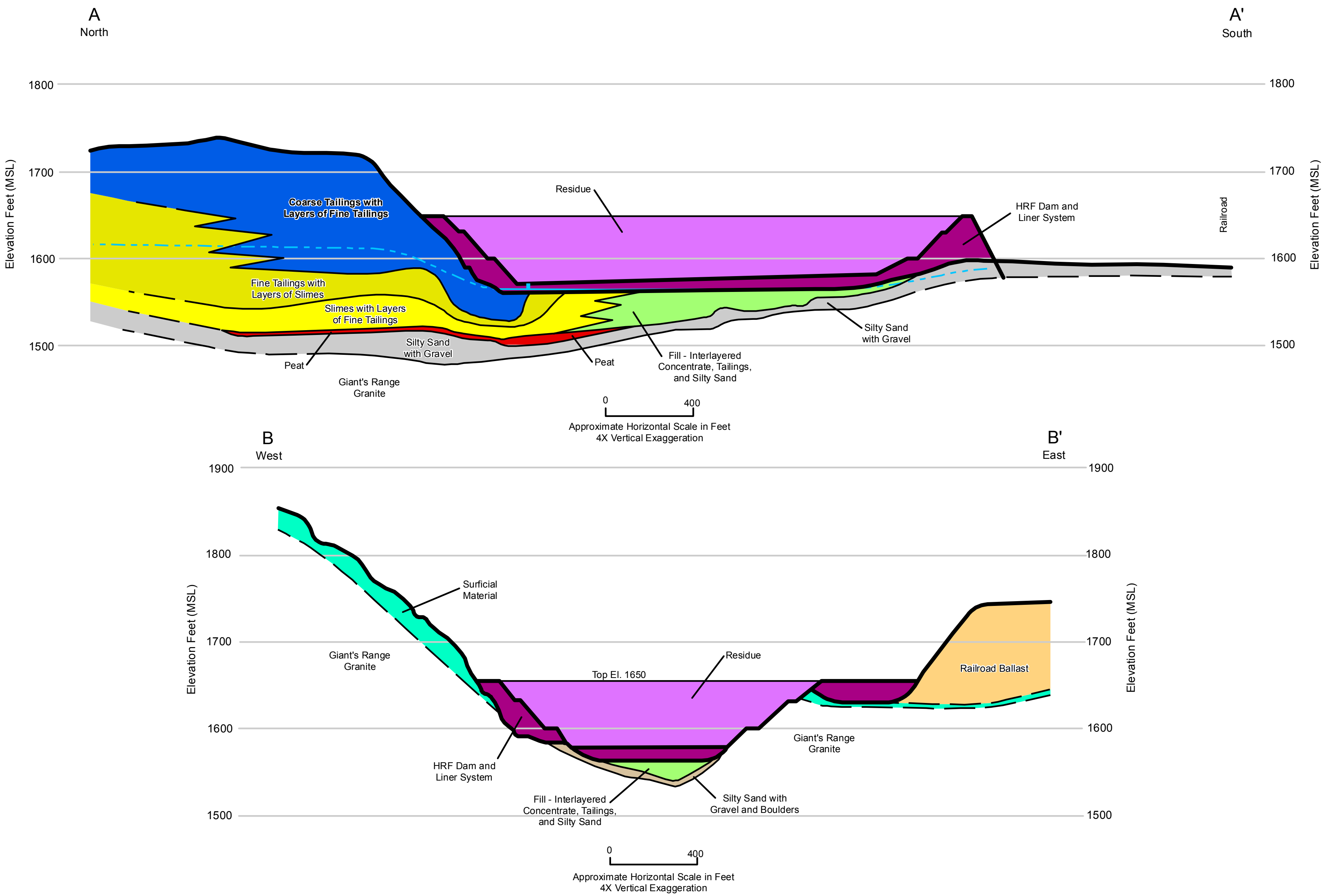
Reclamation of the Hydrometallurgical Residue Facility would include removal of ponded water, removal of pore water from the residue, construction of the cover system, and establishment of vegetation and surface water runoff controls.

Turf and final cover would be inspected and maintained by mowing once per year or as needed, fertilizing when visual inspection indicates poor vegetation growth, and implementing repairs. Additional information relating to closure of the Hydrometallurgical Residue Facility is provided in Section 3.2.2.3.12.

Identification of the Design Cross Section

Cross Section A, depicted in Figure 5.2.14-4, has been identified as the design cross section. It approximates the base of a former ravine, beginning south of the future south dam and terminating near the crest of the Hydrometallurgical Residue Facility north dam. It is considered as the design cross section, as it incorporates the thickest sections of LTVSMC slimes. Fine tailings and slimes in the Emergency Basin are the thickest at approximately 50 ft located 280 ft away from the toe of the south dam of Cell 2W. A cross section of the Hydrometallurgical Residue Facility at its maximum extent along cross sections A and B is shown in Figure 5.2.14-9.

The global slope stability discussed below was assessed along Cross Section A.



- Coarse Tailings with Layers of Fine Tailings
- Fill - Interlayered Concentrate, Tailings, and Silty Sand
- Fine Tailings with Layers of Slimes
- Slimes with Layers of Fine Tailings
- Peat
- Railroad Ballast
- Residue
- Silty Sand with Gravel
- Silty Sand with Gravel and Boulders
- HRF Dam and Liner System
- Surficial Material

MNDNR
US Army Corps of Engineers St. Paul District

Figure 5.2.14-9

Cross Sections A and B of the Hydrometallurgical Residue Facility at Year 20

NorthMet Mining Project and Land Exchange FEIS
Minnesota

November 2015

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Modeling Results

The results reported in Geotechnical Data Package Volume 2 indicate that the proposed design of the Hydrometallurgical Residue Facility would meet all respective Factors of Safety as required (PolyMet 2014c). The modeling undertaken and results are summarized below.

Stress Deformation and Strain in the Liner System

A preload would be placed on the existing LTVSMC Emergency Basin to consolidate the foundation materials before construction of the Hydrometallurgical Residue Facility. Wick drains may be used to help accelerate the consolidation time by increasing the effective hydraulic conductivity of the tailings due to decrease in flowpath length. Some portion of this load would be removed before construction, and the remaining material would be graded to provide sufficient drainage slope and provide a suitable foundation material for the facility. The material would rebound a small amount after the preload is removed. The aggregate settlement at a representative location within the Emergency Basin, considering the maximum anticipated tailings thickness in the foundation, is computed to be 3.9 ft. The material at this location is modeled to consolidate an additional 1.4 ft by the end of operations of the Hydrometallurgical Residue Facility.

Residue consolidation within the basin is modeled as beginning after the cessation of residue discharge to the Hydrometallurgical Residue Facility. Over time, the rate of consolidation would decrease with the greatest amount of consolidation occurring before pore-water pressure reaches hydrostatic equilibrium (approximately 10 years following closure). Total settlement in areas with the greatest depth of residue is estimated to be on the order of 9.6 ft. As the depth of residue decreases near the edge of the Hydrometallurgical Residue Facility, less settlement would occur. The resulting deformed surface of the Hydrometallurgical Residue Facility would be concave with the greatest deformation in areas of greatest residue thickness.

Strain in the Hydrometallurgical Residue Facility liner system would result from differential settlement in the facility foundation between points along the liner. The maximum strain in the liner system is estimated to be 0.20 percent. This value is well within acceptable limits of most geosynthetics, which range from 1 to 19 percent.

Global Slope Stability

Analysis of the new dams (i.e., those not supported by the existing LTVSMC Tailings Basin or natural topography) at their greatest height (at year 20) resulted in a computed Factor of Safety for the ESSA of 2.32, which is greater than the required minimum of 1.5. Because the friction angle for the dam fill material (approximately 30 degrees) is greater than the proposed dam downstream slope angle (18 degrees), significant surficial slope failures are not expected.

Liquefaction analysis was not applicable and not performed because the material proposed in the constructed dams would be well-compacted and the Hydrometallurgical Residue Facility liner system would limit leakage through the dams. Therefore, the embankment is not anticipated to be saturated during and after operations.

Infinite Slope Stability

The components of the double liner system are designed to act as hydraulic barriers to leakage; not as structural members of the dam system. Therefore, the liner layers must not be allowed to slide relative to one another. Evaluation of this potential for sliding was performed using infinite slope stability analyses. The minimum infinite slope stability Factor of Safety for all Hydrometallurgical Residue Facility liner system components is 1.5.

The interior slope angle for the Hydrometallurgical Residue Facility and the geosynthetic materials of the liner that would directly contact the underlying soils used for dam construction must be selected to produce a stable liner system—a system that would not slide down-slope during operations. In addition, each successive layer of the liner system must have an adequate interface-friction angle with the adjacent layer to prevent down-slope movement of any layer of the liner system. Infinite slope stability for the liner system layer interface configurations currently expected is shown in Table 5.2.14-2. Computed Factors of Safety shown in Table 5.2.14-2 are based on commonly reported interface friction angles between the materials anticipated to be used for the Hydrometallurgical Residue Facility liner. Any variation from the anticipated material types warrants project-specific interface shear testing to confirm that the friction angles are equal to or greater than those used in this analysis.

Shear failure in the geosynthetic clay/geomembrane liner systems would occur at the interface with the lowest peak shear strength. On the basis of the interface friction angles used in the analysis, the design proposed for the Hydrometallurgical Residue Facility achieves a computed Factor of Safety of 2.94.

Table 5.2.14-2 Infinite Slope Stability Analysis Results for the Hydrometallurgical Residue Facility

Interface Number	Material Types	Slope Angle, (deg)	Predicted friction Angle, (deg)	Minimum required Factor of Safety	Predicted Factor of Safety
4	Textured Geomembrane above Geocomposite Drainage Net	15.95	28	1.5	1.86
3	Geocomposite Drainage Net above Textured Geomembrane	15.95	28	1.5	1.86
2	Textured Geomembrane above Geosynthetic Clay Liner	15.95	28	1.5	1.86
1	Geosynthetic Clay Liner above Granular Soil	15.95	24	1.5	1.56

Proposed Monitoring, Maintenance, and Mitigation

A Hydrometallurgical Residue Management Plan (PolyMet 2014r) prepared by PolyMet includes a description of the operating plans, monitoring procedures, and adaptive management approaches for the Hydrometallurgical Residue Facility.

Monitoring and maintenance for the Hydrometallurgical Residue Facility would be similar to that discussed for the Tailings Basin at the end of Section 5.2.14.2.2 above.

Construction quality control and assurance would occur throughout construction of the Hydrometallurgical Residue Facility, beginning with regulatory agency review and approval of the construction quality control and assurance plan. A Construction Quality Assurance Manual template for the installation of the soil and geosynthetic components of liner and cover systems has been drafted to addresses QA/QC procedures for earthwork, geomembrane and geosynthetic clay liner installation, and piping components of the HRF double liner and leakage collection system, drainage collection system, and cover system (PolyMet 2014r). Upon completion of construction, a construction documentation report would be prepared to document that construction of the Hydrometallurgical Residue Facility was completed in conformance with regulatory agency permit requirements.

A Contingency Action Plan has been prepared as part of the Residue Management Plan (PolyMet 2014r). The plan provides guidance to on-site personnel and emergency responders in the case of unplanned occurrences at the Hydrometallurgical Residue Facility.

5.2.14.3 NorthMet Project No Action Alternative

Under the No Action Alternative, no waste rock stockpiles, or expanded Tailings Basin, or Hydrometallurgical Residue Facility would be created. The existing geotechnical conditions are discussed in Section 4.2.14. The existing LTVSMC Tailings Basin as discussed in Section 4.2.14 would remain at the site and monitoring and inspection would continue under the LTVSMC site closure plan and the MDNR Dam Safety regulations.

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5.3 LAND EXCHANGE

5.3.1 Land Use

The Land Exchange Proposed Action represents a transfer of surface rights of 6,495.4 acres from the Superior National Forest to PolyMet to eliminate the conflict between federal surface and private mineral estate. This action would remove those acres from Superior National Forest management and public use. The Land Exchange Proposed Action would remove these acres, which are part of the 1854 Ceded Territory, from lands available to the Bands to exercise reserved 1854 Treaty rights. Given the existing lack of overland public access and the current and historic use of the federal lands for mineral exploration (see Section 4.2.9), the Land Exchange Proposed Action represents little to no change in the actual level of recent or current use of the federal lands. At the same time, the Land Exchange Proposed Action brings as many as 7,075.0 acres of private land into the public domain, making it available for the Bands to exercise 1854 Treaty rights (see Section 4.3.9).

When compared with the Land Exchange No Action Alternative, the Land Exchange Proposed Action and the Land Exchange Alternative B would provide a slight improvement in key indicators described in Section 5.3.1.1. The Land Exchange Proposed Action provides for more of an improvement in overall indicators than under the Land Exchange Alternative B. The Land Exchange Proposed Action and the Land Exchange Alternative B are both compatible with adjacent zoning and management area designations.

There is no current legacy contamination on the non-federal parcels. Past legacy contamination concerns are discussed in Section 4.3.1.

5.3.1.1 Methodology and Evaluation Criteria

The area of analysis for land use effects from the Land Exchange Proposed Action included the federal and non-federal tracts, as well as properties abutting the tracts, which provide the basis for determining compatibility of land uses on the federal and non-federal parcels. The temporal analysis is based on the time of change in ownership. Management areas and subsequent land uses would be established at the time of the ownership change.

The analysis of the land use resources affected by the Land Exchange Proposed Action was guided by evaluation criteria that were developed by the USFS and the other Co-lead Agencies. The following impact indicators identify anticipated outcomes of the Land Exchange Proposed Action alternatives being considered for the NorthMet Project Proposed Action:

- Net change in the number of acres controlled by the USFS on the Superior National Forest;
- Net change in the length of the boundary around USFS-controlled land in the Superior National Forest (including internal boundaries around private in-holdings) to be managed under each of the proposed alternatives;
- Net change in the level of land fragmentation, expressed as a ratio of linear boundary-to-area (linear miles per acre) of the USFS-controlled portions of the Superior National Forest under each of the proposed alternatives;

- The degree of access to lands owned by the USFS in the Superior National Forest, as determined through the identification of public access points via road or trail;
- Degree of compatibility between USFS management areas and zoning or land use designations (in the absence of zoning) of adjacent areas;
- Potential for mineral development within the parcels, assessed by the USFS based on mineral ownership, the type of mineral, and the precedent/history for exploitation of this mineral within Minnesota; and
- Quality of title within each of the parcels being considered. Quality was evaluated by the USFS according to outstanding encumbrances on the parcels considered for each of the Land Exchange Proposed Action alternatives, including mineral ownership and development potential.

Quantitative criteria, such as boundary length and land area, were calculated using GIS. Evaluations of mineral development potential were conducted by third party professional geologists (Barr 2011c). The risk of conflict between mineral interests and USFS surface management and quality of title were assessed by a USFS Forest Realty Specialist.

5.3.1.2 Land Exchange Proposed Action

5.3.1.2.1 Forest Available for Public Access and Use

Through the Land Exchange Proposed Action, 6,495.4 acres of federal lands in the Superior National Forest would be transferred to PolyMet in exchange for up to approximately 7,075.0 acres of non-federal lands presently in private ownership. This would result in a net increase of up to 579.6 acres for the Superior National Forest.

All of the non-federal lands are within the 1854 Ceded Territory and would thus be subject to Treaty rights reserved by the Bands as a result of the Land Exchange Proposed Action. This would result in a net increase of up to 579.6 acres of publicly owned land in the 1854 Ceded Territory. Table 5.3.1-1 shows the Management Area designations that the USFS would apply to the non-federal lands under the Land Exchange.

Table 5.3.1-1 Management Area Allocations under the Land Exchange Proposed Action

	Acreage by Management Area[1]				
Tract	**General Forest**	**General Forest-Longer Rotation**	**Riparian Emphasis Areas**	**cRNA[5]**	**Total[6]**
Federal Lands[2]	355.3	6,140.1	0.0	0.0	6,495.4
Non-federal Lands[3]					
Tract 1	4,619.3	0.0	0.0	306.9	4,926.2
Tract 2	0.0	161.0	220.9	0.0	381.9
Tract 3	1,450.0	125.8	0.0	0.0	1,575.8
Tract 4	0.0	160.2	0.0	0.0	160.2
Tract 5	0.0	30.8	0.0	0.0	30.8
Subtotal, Non-federal Lands	6,069.3	477.8	220.9	306.9	7,075.0
Net Increase/(Decrease)[4]	5,714.0	(5,662.3)	220.9	306.9	579.6

Notes:
[1] See definitions of USFS Management Areas in Section 4.2.3.
[2] Source: USFS 2011a.
[3] Source: USFS 2011b.
[4] Calculated as (non-federal) minus (federal).
[5] Candidate Research Natural Area (see Section 4.2.3).
[6] Totals may not match overall NorthMet Project area acreages due to rounding.

The 6,495.4 acres of federal lands are not accessible for public use via land (see Section 4.2.11), while substantial portions of the non-federal lands do have public access via public roads or hiking trails. This distinction is a factor in evaluating land use effects, because public access defines the degree to which the lands in question can actually be used—either by the public for recreational purposes, by forestry interests for economic purposes, or for research and conservation purposes (in the case of Riparian Emphasis and cRNA management areas, defined in Section 4.3.1). Tract 1 has direct public access via existing county roads (see Figure 5.3.1-1), and Tract 4 has public access via other roads (see Figure 5.3.1-2). Tracts 2 and 3 have no direct public access (see Figure 5.3.1-1). When considered collectively, public access to, and therefore use of the Superior National Forest, would be increased under the Land Exchange Proposed Action.

Table 5.3.1-2 shows the effect of the Land Exchange Proposed Action on the total acreage within the Superior National Forest that is controlled by the USFS, the boundary of the USFS-controlled land (see Section 5.3.1.2.2), and the fragmentation ratio (see Section 5.3.1.2.3). The Land Exchange Proposed Action would increase the federal estate by adding a net of 385.1 acres to the 2,171,603.9 acres of USFS-controlled land within the Superior National Forest.

Table 5.3.1-2 Superior National Forest Boundary, Acreage, and Fragmentation under the Land Exchange Proposed Action

	Baseline / Land Exchange No Action Alternative	Land Exchange Proposed Action	
		Predicted Value	Net Increase/ (Decrease)[1]
Acreage in Superior National Forest controlled by USFS	2,171,603.9	2,171,989.0	385.1
Boundary length (linear miles)	10,054.8	10,021.6	(33.2)
Fragmentation (linear miles per acre)	0.005	0.005	0.00

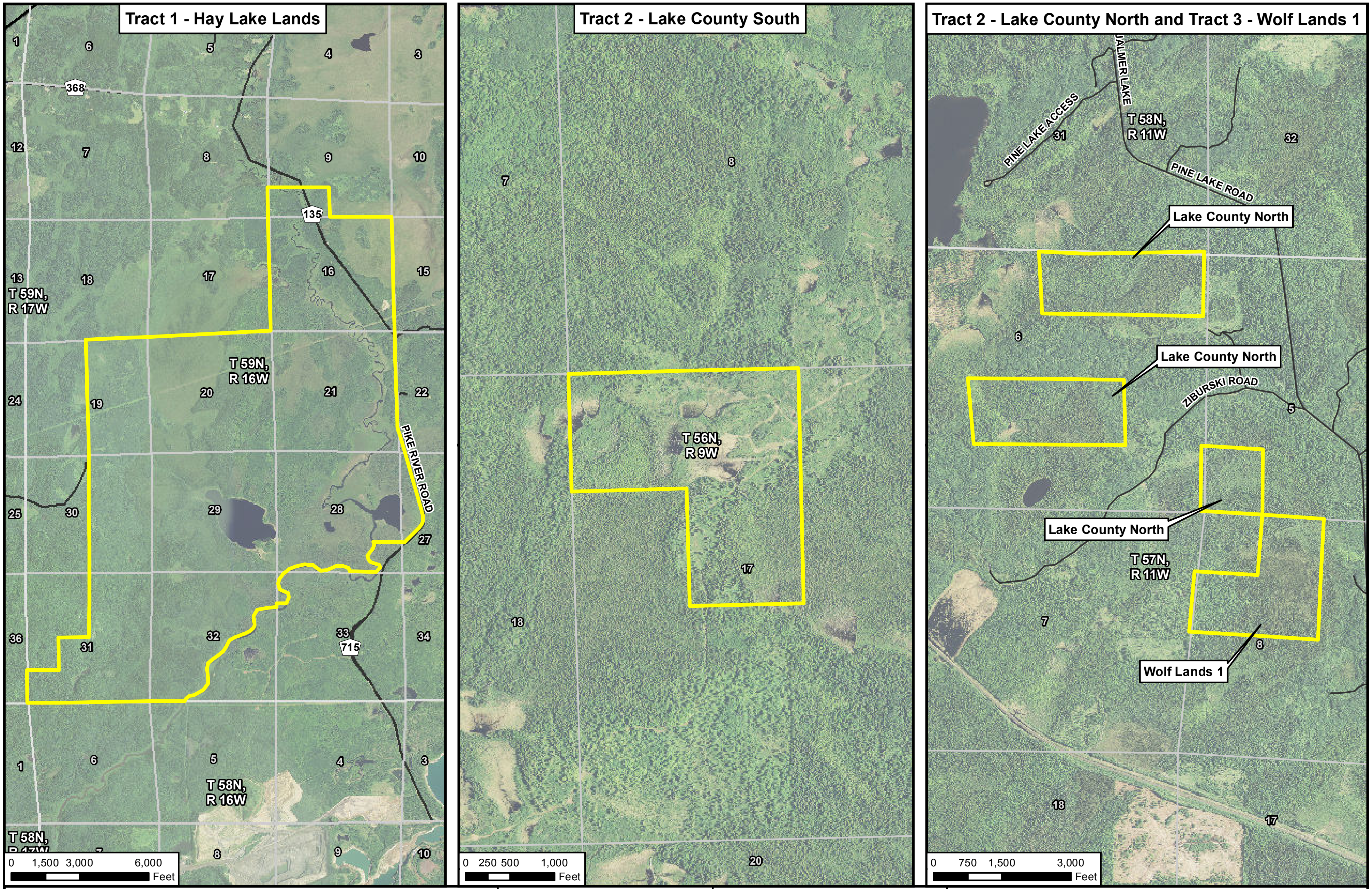
Note:
1 Totals differ from acreage reported in Section 5.3.1.2.1 (579.6 acres) due to inconsistencies in GIS data and because Mud Lake (30.5 acres) would continue to be managed by the MDNR.

5.3.1.2.2 Boundary Managed

A reduced boundary length is more desirable for the USFS, because it reduces the difficulty of accessing and managing the forest. The Land Exchange Proposed Action would result in a 33.2-linear mile net reduction of the perimeter around the USFS-controlled portions of the Superior National Forest (see Table 5.3.1-2).

5.3.1.2.3 Forest Fragmentation

The underlying assumption regarding land fragmentation of USFS-controlled portions of the Superior National Forest is that a lower ratio of boundary to area is more desirable, because it reduces the difficulty of accessing and managing the forest in addition to increasing the forest's overall quality and function. All of the non-federal parcels are contiguous with National Forest System lands, thus decreasing the ratio of boundary to area. This reduction would be marginal in magnitude, and the Land Exchange Proposed Action would not alter the existing ratio of fragmentation in the Superior National Forest of approximately 0.005 linear mile of boundary per acre of USFS-controlled Superior National Forest land (see Table 5.3.1-2).



Non-federal Lands
Section Boundary
Section Label
Road

MNDNR
US Army Corps of Engineers St. Paul District

Figure 5.3.1-1
Tracts 1, 2, and 3 Roads
NorthMet Mining Project and Land Exchange FEIS
Minnesota

November 2015

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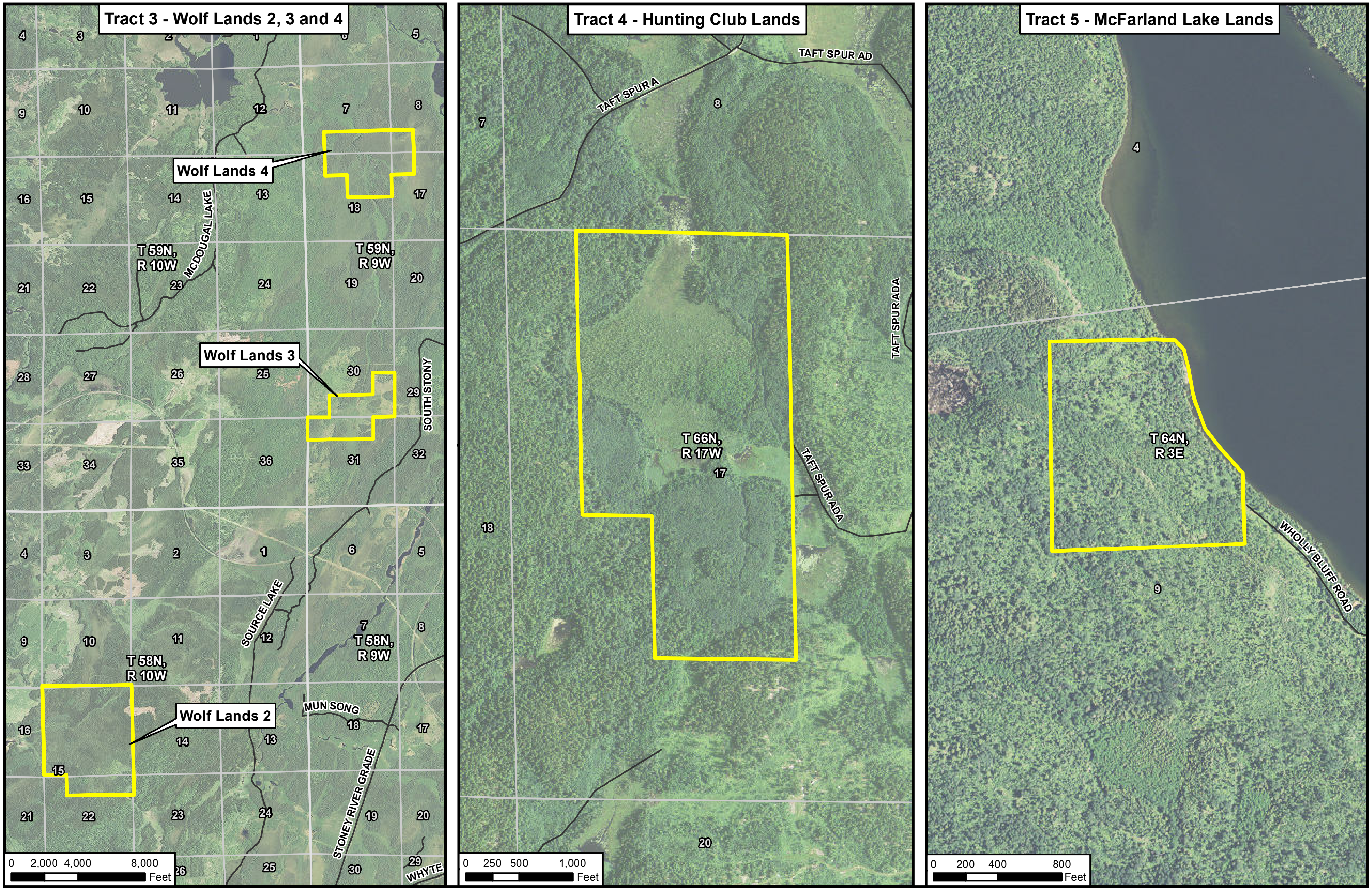

Non-federal Lands

Section Boundary

1 Section Label

Road

MNDNR

US Army Corps of Engineers St. Paul District

N E S W

Figure 5.3.1-2

Tracts 3, 4, and 5 Roads

NorthMet Mining Project and Land Exchange FEIS

Minnesota

November 2015

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5.3.1.2.4 Zoning Compatibility

Management area designations establish USFS policy for public use of National Forest System lands (e.g., recreation, scenic resources, and facilities). Section 4.3.1 provides definitions of the intended uses of the management area designations that apply to the federal and non-federal tracts, as well as surrounding areas within the Superior National Forest.

Zoning in areas adjacent to the non-federal lands outside of the Superior National Forest and compatibility with the management area designations of non-federal lands are summarized below:

- Zoning on privately owned ("non-forest") lands adjacent to Tract 1 is split among multiple zoning districts that collectively provide for residential development, wild rice production, timber, and hunting (St. Louis County 2011). With the exception of residential development and timber, these uses are generally compatible with the proposed General Forest Management Area designation of Tract 1. Recreational uses such as personal-use riding and hunting would be consistent with the cRNA designation. Non-forest lands to the east and south of Tract 1 are in the Multiple-Use Non-Shoreland (MUNS-4) district (St. Louis County 2011), which is generally compatible with the General Forest and cRNA management areas.
- Non-forest lands adjacent to Tracts 2 and 3 are in the Forest-Recreation district, as defined by the Lake County Zoning Ordinance (ERM, Pers. Comm., October 10, 2011). This is compatible with the proposed General Forest, General Forest – Longer Rotation, and Riparian Emphasis Area Management Area designations.
- Non-forest lands adjacent to Tract 4 to the west and southeast are within the St. Louis County FAM-1 zoning district, which emphasizes forestry, agricultural, and recreational uses (St. Louis County 2011). These uses are generally compatible with the proposed General Forest – Longer Rotation Management Area designation.
- Privately owned lands adjacent to Tract 5 to the north and southeast are within Cook County's Recreational Development zoning district (Cook County 2011), which is generally compatible with the proposed General Forest – Longer Rotation Management Area.

Overall, the management area designations of the non-federal lands are compatible with surrounding zoning. The Land Exchange Proposed Action would be compatible with the USFS Management Areas and zoning/land use designations of adjacent lands.

5.3.1.2.5 Mineral Development Potential and Quality of Title

The Land Exchange Proposed Action would remove from the Superior National Forest 6,495.4 acres of land with privately held, minable mineral development potential and USFS-held surface rights, in exchange for up to 7,075.0 acres of non-federal land with a low mineral development potential. As described in Section 3.3, the Land Exchange would eliminate conflict between mineral estate and surface rights on the federal lands by transferring the federal surface to the holder of the private mineral rights, fulfilling the USFS's purpose and need.

Table 5.3.1-3 summarizes the risk of conflict between mineral potential and the USFS surface management objectives on each of the non-federal parcels, as well as the overall quality of title to the land.

Table 5.3.1-3 Mineral Interests and Quality of Title for Non-Federal Lands

Tract/Parcel	Risk of Conflict Between Mineral Interests and USFS Surface Management[1]	Quality of Title[2,3]
1: Hay Lake	Moderate	Moderate
2: Lake County North	Low	Moderate
2: Lake County South	Low	Moderate
3: Wolf Lands 1	Low	Moderate
3: Wolf Lands 2	Low	Moderate
3: Wolf Lands 3	Low	Moderate
3: Wolf Lands 4	Low	Moderate
4: Hunting Club	Low	High
5: McFarland Lake	Low	Moderate

Source: USFS 2011c.

Notes:
1 Low is the best and high is the worst, as defined in USFS 2011c and Barr 2011c.
2 Condition of title represents review as of December 21, 2011 -- may be revised per specialist investigation or advice of USDA, Office of General Counsel.
3 High is the best and poor is the worst, as defined in USFS 2011c.

The risk of conflict determination in Table 5.3.1-3 expresses the degree to which "split estate" conditions could complicate achievement of USFS management goals and objectives. Split estate refers to situations where private ownership of mineral rights would occur on land whose surface is owned by the Superior National Forest after the Land Exchange Proposed Action. This concern notwithstanding, the USFS allows exploration, development, and production of mineral resources on National Forest System lands under conditions where the activities "are conducted in an environmentally sound manner so that they may contribute to economic growth and national defense" (USFS 2004b).

The "moderate" risk of conflict on Tract 1 reflects the presence of potential surficial aggregate resources in the far northeastern corner of the tract. There are also some potential surficial aggregate resources near Greenwood Lake in Tract 3, but development of these resources is constrained due to the presence of wetlands, which may limit or prohibit access (Barr 2011c). For all other tracts, the risk of conflict is low due to the low potential for mineral development.

The quality of title determination assesses existing uncertainties in surface ownership, title insurance, or other encumbrances that may be transferred to the USFS in the event of the Land Exchange moving forward, as well as the risk of conflict defined above. Details of the quality of title determination are presented below by tract (USFS 2011c):

- Tract 1: Moderate, due to the presence of surficial aggregate resources in the northeastern portion of the site and certain title encumbrances that may be cured by endorsements in the final title insurance policy.
- Tract 2: Moderate, due to the presence of privately held mineral exploitation rights. This potential is constrained by the low potential presence of subsurface mineral resources and the absence of surficial deposits.
- Tract 3: Moderate, due to the presence of privately held mineral exploitation rights on portions of all Tract 3 parcels and the presence of private timber rights for one parcel. Mining potential is constrained by the low potential presence of subsurface mineral resources, the

absence of surficial deposits, and the presence of wetlands that may make mineral exploitation difficult.

- Tract 4: High, because the mineral estate was never severed from this parcel.
- Tract 5: Moderate, due to the potential for privately held mineral exploitation rights. This potential is constrained by the low potential presence of subsurface mineral resources and the absence of surficial deposits.

By comparison, the risk of conflict between mineral and surface rights on the federal lands is high due to the presence of privately owned mineral rights and economically developable minerals and USFS surface ownership. The Land Exchange Proposed Action would reduce this risk by exchanging the high-risk federal lands for predominantly low-risk non-federal lands. The risk of conflict on the non-federal lands may be reduced and title quality further improved through subsequent arrangements with holders of mineral rights on the non-federal lands or affirmative title insurance coverage. Thus, the overall effect of the Land Exchange Proposed Action improves the quality of title and reduces the complexity of title to the federal and non-federal lands.

5.3.1.3 Land Exchange Alternative B

5.3.1.3.1 Forest Available for Public Access and Use

Under the Land Exchange Alternative B, 4,752.6 acres of federal lands would be transferred to private ownership in exchange for up to approximately 4,926.3 acres of land (Tract 1 only), as determined by appraisals. This land is currently in private ownership, resulting in a net increase of approximately 173.6 acres for the Superior National Forest. The federal lands transferred out of the Superior National Forest in this scenario have poor public access (see Section 4.3.11). The smaller federal parcel would leave an isolated island of federal lands to the west of the Mine Site. These federal lands would be difficult to access because the railroad and road are private property. Access points managed by the USFS to the isolated area are limited. The non-federal tract has relatively good public access. Land Exchange Alternative B would result in a net increase of up to 173.6 acres for the Superior National Forest. All of Tract 1 is within the 1854 Ceded Territory and would thus be available for exercise of 1854 Treaty rights reserved by the Bands. Table 5.3.1-4 shows the Management Area designations that the USFS would apply to Tract 1 under Land Exchange Alternative B.

Table 5.3.1-4 Management Area Allocations under Land Exchange Alternative B

	Acreage by Management Area[1]				
Tract	**General Forest**	**General Forest-Longer Rotation**	**Riparian Emphasis Areas**	**cRNA[5]**	**Total[6]**
Federal lands[2]	355.3	4,397.3	0.0	0.0	4,752.6
Non-federal lands[3]					
Tract 1	4,619.3	0.0	0.0	306.9	4,926.2
Net Increase/(Decrease)[4]	4,264.0	(4,397.3)	0.0	306.9	173.6

Notes:
1 See definitions of USFS Management Areas in Section 4.2.3.
2 Source: USFS 2011a.
3 Source: USFS 2011b.
4 Calculated as (non-federal) minus (federal).
5 Candidate Research Natural Area (see Section 4.2.3).
6 Totals may not match overall project area acreages due to rounding.

Table 5.3.1-5 shows the effect of the Land Exchange Alternative B on the total acreage within the Superior National Forest that is controlled by the USFS, the boundary of the USFS-controlled land (see Section 5.3.1.4.2), and the fragmentation ratio (see Section 5.3.1.4.3). The Land Exchange Alternative B would increase the federal estate by a net of 38.7 acres to the 2,171,603.9 acres of USFS-controlled land within the Superior National Forest.

Table 5.3.1-5 Superior National Forest Boundary, Acreage, and Fragmentation for Land Exchange Alternative B

	Baseline/ Land Exchange No Action Alternative	**Land Exchange Alternative B**	
		Predicted Value	**Net Increase/(Decrease)[1]**
Acreage in Superior National Forest controlled by USFS	2,171,603.9	2,171,642.6	38.7
Boundary length (linear miles)	10,054.8	10,046.2	(8.6)
Fragmentation (linear miles per acre)	0.005	0.005	0.00

Note:
1 Totals differ from acreage reported in Table 5.3.1-4 (173.6 acres) due to inconsistencies in GIS data and because Mud Lake (30.5 acres) would continue to be managed by the MDNR.

5.3.1.3.2 Boundary Managed

The Land Exchange Alternative B would result in an 8.6-mile net reduction of the perimeter around the USFS-controlled portions of the Superior National Forest (see Table 5.3.1-5).

5.3.1.3.3 Forest Fragmentation

The Land Exchange Alternative B would not change the fragmentation ratio in USFS-controlled portions of the Superior National Forest (see Table 5.3.1-5).

5.3.1.3.4 Zoning Compatibility

Under the Land Exchange Alternative B, the forest lands that would become isolated under this alternative to the west of the smaller federal parcel would remain within the Superior National

Forest, and would retain their General Forest – Longer Rotation Management Area designation. This management area is compatible with nearby mining activity. There is no existing public access to this portion of the Superior National Forest, and it is reasonable to expect that permission of the private landowner to access the land would be restricted, for health and safety reasons, for the anticipated life of the mine.

The proposed management area designation for Tract 1 under the Land Exchange Alternative B would be the same as in the Land Exchange Proposed Action (see Section 5.3.1.2.4). The Land Exchange Alternative B would be compatible with the USFS management areas and zoning/land use designations of adjacent lands.

5.3.1.3.5 Mineral Development Potential and Quality of Title

The Land Exchange Alternative B would remove 4,752.6 acres of forest lands with proven mineral development potential from the Superior National Forest, in return for up to 4,926.3 acres with moderate mineral development potential, except for potential surficial aggregate resources in the far northeastern corner of Tract 1 (Barr 2011c). The risk of conflict and quality of title for the Land Exchange Alternative B is the same as for Tract 1 in the Land Exchange Proposed Action (see Table 5.3.1-3).

As with the Land Exchange Proposed Action, the Land Exchange Alternative B would result in a reduced risk of conflict and improved quality of title. The Land Exchange Alternative B would result in relinquishing the federal parcel with severed, private mineral rights and known, economically developable minerals and acquiring parcels with low to moderate risk of conflict and moderate to high title quality. The risk of conflict and title quality may be further improved through subsequent arrangements with holders of mineral rights on the non-federal lands or affirmative title insurance coverage. Thus, the Land Exchange Alternative B would also benefit efforts to manage the Superior National Forest, although to a lesser degree than the Land Exchange Proposed Action.

Mineral rights to the Mine Site are held by PolyMet, while surface rights are held by USFS, creating a conflict between surface and mineral rights. As described in Section 3.3, the USFS's Purpose and Need is to resolve the conflict between surface and mineral rights (see Section 5.3.1).

The Land Exchange Alternative B would be consistent with this Purpose and Need, as well as existing land use designations surrounding the Mine Site. Therefore, the Land Exchange Alternative B would have no adverse effect on land use at the Mine Site. Effects on recreational and natural resource use at the Mine Site are addressed in other sections of this chapter.

5.3.1.4 Land Exchange No Action Alternative

The Land Exchange No Action Alternative represents no change to current land use on the federal and non-federal lands. There would be no change in the amount of forest boundary managed, level of forest fragmentation, or acres available for public access and use.

Under the Land Exchange No Action Alternative, interest in development of mineral potential on the federal lands could continue, and would be compatible with relevant local zoning ordinances and planning designations. The Land Exchange No Action Alternative is also compatible with the General Forest and General Forest – Longer Rotation Management Area classifications.

However, the mineral rights would remain severed from federal ownership. The potential conflict between mineral interests and USFS surface management of the federal parcel would remain.

The presence of a privately owned road (Dunka Road) and rail on the southern border of the federal lands would continue to limit public access to and use of the federal lands, as envisioned by the management area designations.

5.3.2 Water Resources

This section describes the potential effects and compares the resource value of the Land Exchange Proposed Action on water resources of the federal and non-federal lands to be exchanged, as well as for Land Exchange Alternative B and the Land Exchange No Action Alternative. The effects on the federal and non-federal lands are discussed together to facilitate comparison between the water resources of the lands exchanged. The total yield and quality of surface and groundwater currently leaving the non-federal tracts and flowing into the federal estate would not be altered by any of the Land Exchange alternatives. Under the Land Exchange Proposed Action and alternatives, the Superior National Forest would retain its ongoing responsibility for managing water resources on USFS lands in accordance with the Forest Plan. Table 5.3.2-1 shows the effects of the Land Exchange Proposed Action and Land Exchange alternatives on acreage of surface water and wild rice beds.

Under the Land Exchange Proposed Action, a net increase of 95.2 acres of MDNR-designated public water lakes (2.1 miles of shoreline) and 4.6 miles of public water streams would be added to the federal estate. By comparison, under Land Exchange Alternative B, a net increase of 116.8 acres of public water lakes (2.6 miles of shoreline) and 3.6 miles of public water streams would be added to the federal estate. One difference is that, under the Land Exchange Proposed Action, all of Mud Lake (30.5 acres) would be exchanged for the private lands, while under Land Exchange Alternative B only about 8.9 acres of Mud Lake would be included in the land exchange.

Both the Land Exchange Proposed Action and Land Exchange Alternative B would result in a net increase of wild rice beds to the federal estate. The federal lands do not contain any known wild rice beds, but Hay Lake Lands (Tract 1) contain known wild rice beds (approximately 126 acres). No wild rice beds would be affected as a result of the Land Exchange Proposed Action or Land Exchange Alternative B as no activities are proposed on the non-federal lands and the proposed mining activities would not affect these lands. Furthermore, though the Land Exchange Proposed Action would result in an increase in wild rice stands within the federal estate boundaries, there would be no change to the wild rice harvest opportunities for the public due to the Land Exchange Proposed Action or the Land Exchange Alternative B.

Table 5.3.2-1 Net Change in Surface Water and Wild Rice Beds to the Federal Estate under the Land Exchange Proposed Action and Alternatives

	Net Increase/(Decrease) of Water Resources			
Alternative	**Public Water Lakes (acres)**	**Public Water Lakes (miles of shoreline)**	**Public Water Streams (miles)**	**Wild Rice Beds (acres)[1]**
Land Exchange Proposed Action	95.2	2.1	4.6	>125.7[(2)]
Land Exchange Alternative B	116.8	2.6	3.6	>125.7[(2)]
Land Exchange No Action Alternative	0	0	0	0

Notes:
1 Wild rice beds within the Land Exchange Proposed Action and the Land Exchange Alternative B boundaries are currently, and would continue to be, located in MDNR-designated public waters.
2 Excludes area of wild rice beds in Pike River. Presence of wild rice in the Pike River, which runs through Rice Lake, was noted in Barr's surveys (2011a; 2012a; 2013l), but the area of rice was not calculated.

There is limited groundwater or surface water quality data available for the non-federal tracts, with the exception of sulfate data for the Hay Lake Lands. There are, however, no known reasons to suspect surface water or groundwater contamination of any of the tracts from human activities. In general, water quality is expected to reflect natural conditions as similar to that found from MPCA regional studies (see Section 4.3.2.2.3).

5.3.2.1 Methodology and Evaluation Criteria

The area of analysis for water resource effects of the Land Exchange alternatives included the federal and non-federal tracts proposed for the exchange.

Since the Land Exchange Proposed Action would not actually result in any direct effects, as there are no construction or other activities proposed that would affect water resources, this assessment focuses on a comparison of the net change in the quantity and quality of water resources between the federal and non-federal tracts involved in the exchange.

5.3.2.1.1 Groundwater Evaluation Criteria

Groundwater resource evaluation criteria for the Land Exchange Proposed Action include a qualitative assessment of potential for groundwater contamination of the non-federal properties using MDNR and MPCA groundwater quality data.

5.3.2.1.2 Surface Water and Wild Rice Evaluation Criteria

Surface water evaluation criteria for the Land Exchange Proposed Action include a comparison of the length of public water streams/rivers, public water lake acreage, and shoreline length between the federal and non-federal lands. This was used to determine the net change in quantity of waterbodies. In addition, a qualitative assessment of surface water quality was conducted taking into consideration available water quality data, aerial photographs, and GIS information.

Wild rice evaluation criteria include a comparison in the amount of known or potential wild rice beds between federal and non-federal lands. This was used to determine the potential change in acres of wild rice on the federal estate. Information that was used in the analysis of wild rice beds included available field data, aerial photographs, and GIS layers.

5.3.2.2 Land Exchange Proposed Action

The Land Exchange Proposed Action would involve the transfer of 6,495.4 acres of federal lands from public to private ownership, and up to 7,075.0 acres of private land to public ownership (see Figure 3.3-1).

5.3.2.2.1 Groundwater

The Land Exchange Proposed Action would not directly result in a change in groundwater quantity or quality presently at the non-federal tracts. Evaluation of existing hydrogeologic data did not suggest the potential for groundwater contamination from human activity from any of the tracts. Therefore, there does not appear to be any substantive difference in the quality of groundwater resources between the federal and non-federal tracts.

5.3.2.2.2 Surface Water and Wild Rice

The Land Exchange Proposed Action would not directly result in a change in surface water quantity or quality at the non-federal tracts. There would be a net increase to the federal estate of 4.6 miles of public water streams and 95.2 acres of public water lakes (including 2.1 miles of additional shoreline).

No wild rice stands are known to occur on the federal lands, and suitable habitat is limited. The non-federal lands that contain wild rice beds would not be affected as a result of the Land Exchange Proposed Action or Land Exchange Alternative B, because no activities are proposed on these lands and the proposed mining activities would not affect these lands. As noted in the FEIS, the Land Exchange Proposed Action would result in a net increase of 125.7 acres of wild rice beds to the federal estate. FEIS Sections 5.3.2 and 5.3.4 clarify that, although the Land Exchange would result in an increase in wild rice stands within the federal estate boundaries, there would be no change to the existing public access to Tract 1 wild rice stands via the Pike River. Consequently, there would be no increase in wild rice harvest opportunities for the public.

Table 5.3.2-2 summarizes the federal and non-federal surface water resources and shows the net changes in these resources to the federal estate that would result from the Land Exchange Proposed Action. The Hay Lake lands (Tract 1) account for the majority of the net gain in surface water and wild rice beds to the federal estate from all the non-federal lands.

Table 5.3.2-2 Net Change in Surface Water and Wild Rice Beds to the Federal Estate under the Land Exchange Proposed Action

	Surface Water Resource			
	Public Water Lakes (acres)	**Public Water Lakes (miles of shoreline)**	**Public Water Streams (miles)**	**Wild Rice Beds (acres)[1]**
		Lands Conveyed		
Federal Lands	30.5	0.9	4.5	0.0
		Lands Acquired		
Tract 1 – Hay Lake	125.7	2.8	8.1	>125.7[(2)]
Tract 2 – Lake County	0.0	0.0	0.0	0.0
Tract 3 – Wolf Lands	0.0	0.0	1.0	0.0
Tract 4 – Hunting Club	0.0	0.0	0.0	0.0
Tract 5 – McFarland Lake	0.0	0.2	0.0	0.0
Subtotal: Non-federal Lands	125.7	3.0	9.1	>125.7[(2)]
Net Increase/(Decrease)	**95.2**	**2.1**	**4.6**	**>125.7[(2)]**

Notes:
1 Wild rice beds within the Land Exchange Proposed Action boundaries are currently, and would continue to be, in MDNR-designated public waters.
2 Excludes area of wild rice beds in Pike River.

5.3.2.3 Land Exchange Alternative B

Under the Land Exchange Alternative B, 4,752.6 acres of federal lands would be transferred from public to private ownership, and 4,926.3 acres of land from private to public ownership, for a net increase in 173.7 acres in the federal estate (see Figure 3.3-2).

5.3.2.3.1 Groundwater

The Land Exchange Alternative B would not directly result in a change in groundwater quantity or quality at the non-federal tracts. Evaluation of existing hydrogeologic data did not suggest the potential for groundwater contamination from human activity from any of the tracts. Therefore, there does not appear to be any substantive difference in the quality of groundwater resources between the federal and non-federal tracts.

5.3.2.3.2 Surface Water and Wild Rice

The Land Exchange Alternative B would not directly result in a change in surface water quantity or quality at the non-federal tracts. There would be a net increase to the federal estate of about 3.6 miles of public water streams, under Land Exchange Alternative B. There would also be a net increase of about 116.8 acres of public water lake area (including 2.6 miles of shoreline) and at least 125.7 acres of wild rice beds contained within the federal estate under the Land Exchange Alternative B.

No wild rice stands are known to occur on the smaller federal parcel, and suitable habitat is limited. The non-federal lands that contain wild rice beds would not be affected as a result of the Land Exchange Proposed Action or Land Exchange Alternative B, because no activities are proposed on these lands and the proposed mining activities would not affect these lands. As noted in the FEIS, the Land Exchange Alternative B would result in a net increase of 125.7 acres of wild rice beds to the federal estate. FEIS Sections 5.3.2 and 5.3.4 clarify that, although the Land Exchange would result in an increase in wild rice stands within the federal estate boundaries, there would be no change to the existing public access to Tract 1 wild rice stands via the Pike River. Consequently, there would be no increase in wild rice harvest opportunities for the public.

Table 5.3.2-3 summarizes the federal and non-federal surface water resources and shows the net changes in these resources to the federal estate that would result from the Land Exchange Alternative B.

Table 5.3.2-3 Net Change in Surface Water and Wild Rice Beds to the Federal Estate under Land Exchange Alternative B

	Surface Water Resource			
	Public Water Lakes (acres)	**Public Water Lakes (miles of shoreline)**	**Public Water Streams (miles)**	**Wild Rice Beds (acres)[1]**
	Lands Conveyed			
Federal Lands	8.9	0.2	4.5	0.0
	Lands Acquired			
Tract 1	125.7	2.8	8.1	>125.7[(2)]
Net Increase/(Decrease)	**116.8**	**2.6**	**3.6**	**>125.7[(2)]**

Notes:
[1] Wild rice beds within the Land Exchange Alternative B boundaries are currently, and would continue to be, in MDNR-designated public waters.
[2] Excludes area of wild rice beds in Pike River.

5.3.2.4 Land Exchange No Action Alternative

Under the Land Exchange No Action Alternative, the Land Exchange Proposed Action would not take place and would result in no changes in existing water resources under federal ownership. The Superior National Forest would have an ongoing responsibility for managing water resources on the federal lands in accordance with the Forest Plan. The Land Exchange No Action Alternative would not change the USFS responsibility for managing water resources.

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5.3.3 Wetlands

This section describes the potential environmental consequences of the Land Exchange Proposed Action on wetland resources that occur on the federal and non-federal lands. In this section, effects on the federal and non-federal lands are discussed together, to facilitate calculation of net changes to wetland resources. Under the Land Exchange Proposed Action and alternatives, the Superior National Forest would retain its ongoing responsibility for managing wetland resources on Forest Service lands in accordance with the Forest Plan.

Overall, the Land Exchange Proposed Action would result in an increase to the federal estate of wetland acreage by up to 505.5 acres through the acquisition of up to 7,075.0 acres of non-federal lands in exchange for 6,495.4 acres of federal land, and thus would be in conformity with EO 11990 (see Table 5.3.3-1). The Land Exchange Proposed Action would result in a net increase to the federal estate of 376.2 acres of mapped floodplain area, but would result in a decrease of 1,602.2 acres of unmapped floodplain area, for a net decrease of 1,226.0 acres of overall floodplain area (see Table 5.3.3-1). There would be no decrease in the amount of mapped floodplain or increase in the flood damage potential associated with the Land Exchange Proposed Action. The effects on the ecological function of the floodplain wetlands would be mitigated through the Section 404 Permit and the proposed mitigation described in Section 5.2.3. The Land Exchange Proposed Action would also increase the wetlands within the federal estate. The Land Exchange Proposed Action would be in conformance with EO 11988 (USFS 2004d [FSH 5409.13 § 33.43c]). The Land Exchange Proposed Action would result in an increase of coniferous swamp, hardwood swamp, open water, shallow marsh, and shrub swamp wetland resources to the federal estate, but would result in a decrease of coniferous bog, open bog, and sedge/wet meadows wetland resources to the federal estate (see Table 5.3.3-2). In addition, the Land Exchange Proposed Action would result in an increase in waterway acreage and frontage to the federal estate (see Table 5.3.3-3).

Due to the reduced land area involved, Land Exchange Alternative B would result in a lesser degree of wetlands, floodplains, and other water resources exchanged to the federal estate as compared to the proposed Land Exchange Proposed Action. Overall, Land Exchange Alternative B would increase wetland areas to the federal estate by 69.9 acres (see Table 5.3.3-1) through the acquisition of up to 4,926.3 acres of the non-federal lands in exchange for 4,752.6 acres of federal land, and would thus be in conformity with EO 11990. The Land Exchange Alternative B would result in a net increase to the federal estate of 376.2 acres of mapped floodplain area, but would result in a decrease of 1,237.9 acres of unmapped floodplain area, for a net decrease of 861.7 acres of overall floodplain area (see Table 5.3.3-1). There would be no decrease in the amount of mapped floodplain or increase in the flood damage potential associated with the Land Exchange Alternative B. The effects on the ecological function of the floodplain wetlands would be mitigated through the Section 404 Permit and the proposed mitigation described in Section 4.2.3. The Land Exchange Alternative B would also increase the wetlands within the federal estate. The Land Exchange Alternative B would be in conformance with EO 11988 (USFS 2004d [FSH 5409.13 § 33.43c]). Land Exchange Alternative B would result in an increase of coniferous swamp, open water, shallow marsh, and shrub swamp wetland resources to the federal estate but would result in a decrease to coniferous bog, hardwood swamp, open bog, and sedge/wet meadows wetland resources to the federal estate (see Table 5.3.3-2). In addition, Land

Exchange Alternative B would result in an increase of waterway acreage and frontage to the federal estate (see Table 5.3.3-3).

Table 5.3.3-1 Net Increase or Decrease of Wetland and Floodplain Acres on the Federal Estate from the Land Exchange Proposed Action and Alternatives

	Increase (or Decrease) of Wetland and Floodplain Acres	
Alternative	**Wetlands (Acres)**	**Floodplains[1,2] (Acres)**
Land Exchange Proposed Action	505.5	(1,226.0)
Land Exchange Alternative B	69.9	(861.7)

Notes:
1 The federal floodplain area is a 500-year (0.2%) probability floodplain.
2 Includes an increase of 376.2 acres of mapped floodplains to the federal estate.

Table 5.3.3-2 Net Increase or Decrease of Wetland Resource Types on the Federal Estate from the Land Exchange Proposed Action and Alternatives

	Increase (or Decrease) of Wetland Resource Types (Acres)								
Alternative	**Coniferous Bog**	**Coniferous Swamp[1]**	**Deep Marsh**	**Hardwood Swamp[2]**	**Open Bog**	**Open Water (includes shallow, open water, and lakes)**	**Sedge/Wet Meadow**	**Shallow Marsh[3]**	**Shrub Swamp (includes alder thicket and shrub-carr)**
Land Exchange Proposed Action	(1,961.4)	1,954.6	0.0	36.9	(202.4)	151.7	(35.7)	20.5	541.3
Land Exchange Alternative B	(1,677.0)	1,477.8	0.0	(5.7)	(172.9)	168.0	(34.9)	3.2	311.4

Notes:
1 Coniferous bogs on the non-federal lands were grouped with coniferous swamps during field data collection.
2 Hardwood swamps on the non-federal lands may contain coniferous tree species.
3 Shallow marsh areas on the non-federal lands may contain deep marshes.

Table 5.3.3-3 Net Increase or Decrease of Frontage of Waterways on the Federal Estate from the Land Exchange Proposed Action and Alternatives

	Increase (or Decrease) of Frontage of Waterways					
	Lake			River/Stream/Creek		
Alternative	**Acres**	**Frontage (ft)**	**Length of Lake Frontage/Acre**	**Miles**	**Frontage (linear ft)**	**Length of River Frontage/Acre**
Land Exchange Proposed Action	99.1	12,864.0	129.8	3.8	27,456.0	34.0
Land Exchange Alternative B	120.7	15,224.0	126.1	2.8	16,896.0	3.5

Source: Data from Section 4.3.3.

Based on a qualitative assessment, the Land Exchange Proposed Action and Land Exchange Alternative B would appear to result in an increase to the federal estate of wetlands rated as high for vegetation diversity/integrity, wetland water quality, fish habitat, and amphibian habitat.

Land Exchange Alternative B would also appear to result in an increase to the federal estate of wetlands rated as high for hydrology and wildlife habitat. The Land Exchange Proposed Action would result in an increase to the federal estate of moderate and low rated wetlands for amphibian habitat, as where Land Exchange Alternative B would also result in an increase to the federal estate of wetlands rated low for amphibian habitat. The Land Exchange Proposed Action would have similarly rated hydrology, flood attenuation, downstream water quality, wildlife habitat, and aesthetics/education/cultural functions. Land Exchange Alternative B would result in a decrease to the federal estate of wetlands rated high and moderate for flood attenuation and downstream water quality and would not result in a change to aesthetics/education/cultural functions.

5.3.3.1 Methodology and Evaluation Criteria

The potential effect that the Land Exchange Proposed Action and alternatives would have on wetland resources was evaluated using two types of criteria: 1) criteria assessing conformity to EOs 11990 and 11988, which requires a wetland acre-for-acre analysis and a floodplain acre-for-acre analysis of the federal estate; and 2) criteria used in an analysis of wetlands and floodplain habitat, as well as other water resource indicators.

As previously discussed, to satisfy the requirements of EOs 11990 and 11988, the USFS policy is to use the following three conditions (USFS 2004d [FSH 5409.13 § 33.43c]): 1) the value of the wetlands or floodplains for properties received and conveyed is equal (balancing test) and the land exchange is in the public interest, 2) reservations or restrictions are retained on the unbalanced portion of the wetlands and floodplains on the federal lands when the land exchange is in the public interest but does not meet the balancing test, and 3) the federal property is removed from the exchange proposal when the conditions described in the preceding paragraphs 1 or 2 cannot be met.

In addition to evaluating wetlands in accordance with the two EOs, analysis of the Land Exchange included information on wetland community types as well as ecological floodplains.

To evaluate conformity to the EOs, the following evaluation criteria were used:

- Comparative difference in acres of wetland between the federal and non-federal parcels; and
- Comparative difference in acres of floodplain between the federal and non-federal parcels.

Other wetland resources indicators that were used are the following:

- Comparative difference in acres of wetland types between the federal and non-federal parcels;
- A MnRAM assessment of wetland function and value;
- Change in flood damage potential on the parcels and to the surrounding parcels;
- A MnRAM assessment of floodplain assets; and
- Comparative difference of length of streams, rivers, and lake frontage between the federal and non-federal parcels.

The spatial area of analysis for wetland resource effects from the Land Exchange Proposed Action and alternatives included the federal and non-federal tracts proposed for the exchange, while the temporal area of analysis assessed was the point in time at which the change in ownership would occur.

The analysis of the wetland resources affected by the Land Exchange Proposed Action and alternatives was guided by evaluation criteria that were developed by the USFS and other Co-lead Agencies, which included a comparison of wetland resource acreages, wetland resources types, wetland function and values, floodplain acreages, and other water resources acreages. GIS data and field observations were used and then compared over an area of analysis that included the federal and non-federal lands.

5.3.3.1.1 Wetlands

The federal lands contain 4,164.4 acres of wetlands (see Table 5.3.3-4). By comparison, the five non-federal land tracts contain 4,669.9 acres of wetlands. The Land Exchange Proposed Action would result in a net increase of up to 505.5 acres of wetlands to the federal estate if all five tracts are exchanged (see Table 5.3.3-4). The Land Exchange Proposed Action would increase wetland acreage to the federal estate by up to 505.5 acres through the acquisition of up to 7,075.0 acres of non-federal lands in exchange for 6,495.4 acres of federal land, and thus would be in conformity with EO 11990.

Table 5.3.3-4 Wetland and Floodplain Acres for the Land Exchange Proposed Action

Parcel		Acres of Wetlands	Acres of Floodplains
Lands Conveyed			
Federal Lands		4,164.4	1,889.4[(1)]
Lands Acquired			
Tract 1		2,930.8	551.2
Tract 2	Lake County North	209.3	0.0
	Lake County South	73.6	0.0
Tract 3	Wolf Lands 1	90.4	0.0
	Wolf Lands 2	706.2	0.0
	Wolf Lands 3	233.2	32.8
	Wolf Lands 4	362.8	79.4
Tract 4		63.6	0.0
Tract 5		0.0	0.0
Subtotal: Non-federal lands		4,669.9	633.4
Net Change			
Net Increase/(Decrease)		505.5	(1,226.0)[(2)]

Notes:
1 The federal floodplain area is a 500-year (0.2%) probability floodplain.
2 Includes an increase of 376.2 acres of mapped floodplains to the federal estate.

As part of the increase in total wetland acreage, the Land Exchange Proposed Action would result in a net increase to the federal estate of the following wetland resource types (see Table 5.3.3-5): coniferous swamp (1,954.6 acres), hardwood swamp (36.9 acres), open water (151.7 acres), shallow marsh (20.5 acres), and shrub swamp (541.3 acres). However, the Land Exchange Proposed Action would result in a net decrease to the federal estate of the following wetland resource types: coniferous bog (1,961.4 acres), open bog (202.4 acres), and sedge/wet meadow (35.7 acres).

Table 5.3.3-5 Wetland Resource Types for the Land Exchange Proposed Action

Parcel		Acres of Wetland Resource Types								
		Coniferous Bog	Coniferous Swamp[1]	Deep Marsh	Hardwood Swamp[2]	Open Bog	Open Water (includes shallow, open water, and lakes)	Sedge/Wet Meadow	Shallow Marsh[3]	Shrub Swamp (includes alder thicket and shrub-carr)
Lands Conveyed										
Federal Lands		1,961.4	1,287.8	0.0	21.1	209.5	30.8	35.7	97.0	521.1
Lands Acquired										
Tract 1		0.0	1,953.9	0.0	8.0	2.1	176.6	0.0	84.1	706.1
Tract 2	Lake County North	0.0	135.0	0.0	34.7	1.8	0.2	0.0	2.5	35.1
	Lake County South	0.0	32.4	0.0	9.9	0.0	2.5	0.0	12.3	16.5
Tract 3	Wolf Lands 1	0.0	75.4	0.0	0.0	3.0	0.0	0.0	0.0	12.0
	Wolf Lands 2	0.0	627.4	0.0	5.0	0.0	0.4	0.0	0.4	73.0
	Wolf Lands 3	0.0	82.6	0.0	0.0	0.0	0.0	0.0	5.2	145.4
	Wolf Lands 4	0.0	320.3	0.0	0.0	0.2	0.0	0.0	0.0	42.3
Tract 4		0.0	15.4	0.0	0.4	0.0	2.8	0.0	13.0	32.0
Tract 5		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Subtotal: Non-federal lands		0.0	3,242.4	0.0	58.0	7.1	182.5	0.0	117.5	1,062.4
Net Change										
Net Increase/(Decrease)		(1,961.4)	1,954.6	0.0	36.9	(202.4)	151.7	(35.7)	20.5	541.3

Notes:
1 Coniferous bogs on the non-federal lands were grouped with coniferous swamps during field data collection.
2 Hardwood swamps on the non-federal lands may contain coniferous tree species.
3 Shallow marsh areas on the non-federal lands may contain deep marshes.

5.3.3.1.2 Wetland Functional Assessment

Based on a qualitative assessment, the Land Exchange Proposed Action would appear to result in an increase to the federal estate of the following high rated wetland functions: vegetation diversity/integrity, wetland water quality, fish habitat, and amphibian habitat. The Land Exchange Proposed Action would result in an increase to the federal estate of moderate- and low-rated wetlands for amphibian habitat. The Land Exchange Proposed Action would have similarly rated hydrology, flood attenuation, downstream water quality, wildlife habitat, and aesthetics/education/cultural functions. It is recognized that the federal land contains a large contiguous wetland complex with an intact upland. Such a complex offers additional value beyond simply the accounting of the number of acres. This is reflected in the MnRAM analysis as the setting is considered. However, it should also be noted that although there are a number of separate non-federal lands proposed in the exchange, they are also part of larger ecological complexes that are intact and offer similar benefits. Conversion of these lands into federal ownership and management will provide additional protection of the values associated with larger wetland complexes.

5.3.3.1.3 Floodplains

There are no mapped floodplains within the federal lands as described in Section 4.3.3. The Land Exchange Proposed Action would result in a net increase to the federal estate of 376.2 acres of mapped floodplain area, but would result in a decrease of 1,602.2 acres of unmapped floodplain area, for a net decrease of 1,226.0 acres of overall floodplain area (see Table 5.3.3-4). There would be no decrease in the amount of mapped floodplain or increase in the flood damage potential associated with the Land Exchange Proposed Action. The effects on the ecological function of the floodplain wetlands would be mitigated through the Section 404 Permit and the proposed mitigation described in Section 4.2.3. The Land Exchange Proposed Action would also increase the wetlands within the federal estate. The Land Exchange Proposed Action would be in conformance with EO 11988 (USFS 2004d [FSH 5409.13 § 33.43c]).

5.3.3.1.4 Frontage of Waterways

The Land Exchange Proposed Action would result in a net increase of other water resources to the federal estate (see Table 5.3.3-6). A net increase of 99.1 acres of lake and 3.8 miles of rivers would be added to the federal estate from the Land Exchange Proposed Action. These increases would result in additional frontage of lakes and rivers to the federal estate.

Table 5.3.3-6 Frontage of Waterways for the Land Exchange Proposed Action

		Lake			Rivers/Creeks/Streams		
Parcel		**Acres**	**Frontage (ft)**	**Length of Lake Frontage/ Acre**	**Miles**	**Frontage (linear ft)**	**Length of River Frontage/ Acre**
Lands Conveyed							
Federal Lands		30.5	4,550.0	0.7	5.3	55,968.0	8.6
Lands Acquired							
Tract 1		129.6	16,424.0	3.5	8.1	72,864.0	15.3
Tract 2		0.0	0.0	0.0	0.0	0.0	0.0
Tract 3	Wolf Lands 1	0.0	0.0	0.0	0.0	0.0	0.0
	Wolf Lands 2	0.0	0.0	0.0	0.0	0.0	0.0
	Wolf Lands 3	0.0	0.0	0.0	0.1	1,056.0	3.8
	Wolf Lands 4	0.0	0.0	0.0	0.9	9,504.0	23.5
Tract 4		0.0	0.0	0.0	0.0	0.0	0.0
Tract 5		0.0	990.0	32.1	0.0	0.0	0.0
Subtotal: Non-federal lands		129.6	17,414.0	35.6	9.1	83,424.0	42.6
Net Change							
Net Increase/(Decrease)		99.1	12,864.0	34.9	3.8	27,456.0	34.0

Source: Data from Section 4.3.3.

5.3.3.2 Land Exchange Alternative B

5.3.3.2.1 Wetlands

The smaller federal parcel contains 2,860.9 acres of wetlands (see Table 5.3.3-7). By comparison, the non-federal lands contain 2,930.8 acres of wetlands. The Land Exchange Alternative B would result in a net increase of 69.9 acres of wetlands to the federal estate. The Land Exchange Alternative B would increase wetland areas to the federal estate by 69.9 acres through the acquisition of up to 4,926.3 acres of the non-federal lands in exchange for 4,752.6 acres of federal land, and would thus be in conformity with EO 11990.

Table 5.3.3-7 Wetland and Floodplain Acres for Land Exchange Alternative B

	Acres of Wetlands	**Acres of Floodplains**
Lands Conveyed		
Smaller Federal Parcel	2,860.9	1,412.9[1]
Lands Acquired		
Tract 1	2,930.8	551.2
Net Change		
Net Increase/(Decrease)	69.9	(861.7)[2]

Notes:
1 The federal floodplain area is a 500-year (0.2%) probability floodplain.
2 Includes an increase of 376.2 acres of mapped floodplains to the federal estate.

As part of the increase in wetland acreage, Land Exchange Alternative B would result in a net increase to the federal estate of the following wetland resource types (see Table 5.3.3-8): coniferous swamp (1,477.8 acres), open water (168.0 acres), shallow marsh (3.2), and shrub swamp (311.4 acres). However, the Land Exchange Alternative B would result in a net decrease to the federal estate of the following wetland resource types: coniferous bog (1,677.0 acres), hardwood swamp (5.7 acres), open bog (172.9 acres), and sedge/wet meadow (34.9 acres).

Table 5.3.3-8 Wetland Resource Types for Land Exchange Alternative B

	Acres of Wetland Resource Types								
Parcel	**Coniferous Bog**	**Coniferous Swamp[1]**	**Deep Marsh**	**Hardwood Swamp[2]**	**Open Bog**	**Open Water (includes shallow, open water, and lakes)**	**Sedge/Wet Meadow**	**Shallow Marsh[3]**	**Shrub Swamp (includes alder thicket and shrub-carr)**
Lands Conveyed									
Smaller Federal Parcel	1,677.0	476.1	0.0	13.7	175.0	8.6	34.9	80.9	394.7
Lands Acquired									
Tract 1	0.0	1,953.9	0.0	8.0	2.1	176.6	0.0	84.1	706.1
Net Change									
Net Increase/(Decrease)	(1,677.0)	1,477.8	0.0	(5.7)	(172.9)	168.0	(34.9)	3.2	311.4

Notes:
1 Coniferous bogs on the non-federal lands were grouped with coniferous swamps during field data collection.
2 Hardwood swamps on the non-federal lands may contain coniferous tree species.
3 Shallow marsh areas on the non-federal lands may contain deep marshes.

5.3.3.2.2 Wetland Functional Assessment

The Land Exchange Alternative B would result in an increase to the federal estate of wetlands rated as high for vegetation diversity/integrity, hydrology, wetland water quality, wildlife habitat, fish habitat, and amphibian habitat. There would be a decrease to the federal estate of wetlands rated high and moderate for flood attenuation and downstream water quality. The Land Exchange Alternative B would also result in an increase to the federal estate of wetlands rated low for amphibian habitat. The Land Exchange Alternative B would not result in a change to aesthetics/education/cultural functions to the federal estate.

5.3.3.2.3 Floodplains

There are no mapped floodplains within the federal lands as described in Section 4.3.3. The Land Exchange Alternative B would result in a net increase to the federal estate of 376.2 acres of mapped floodplain area and 1,237.9 acres of unmapped floodplain area, for a net decrease of 861.7 acres of overall floodplain area (see Table 5.3.3-7). There would be no decrease in the amount of mapped floodplain or increase in the flood damage potential associated with the Land Exchange Alternative B. The effects on the ecological function of the floodplain wetlands would be mitigated through the Section 404 Permit and the proposed mitigation described in Section 4.2.3. The Land Exchange Alternative B would also increase the wetlands within the federal estate. The Land Exchange Alternative B would be in conformance with EO 11988 (USFS 2004d [FSH 5409.13 § 33.43c]).

5.3.3.2.4 Frontage of Waterways

The Land Exchange Alternative B would result in a net increase of other water resources to the federal estate (see Table 5.3.3-9). A net increase of 120.7 acres of lake and 2.8 miles of rivers would be added to the federal estate from the Land Exchange Alternative B. These increases would result in additional frontage of lakes and rivers to the federal estate.

Table 5.3.3-9 Frontage of Waterways for Land Exchange Alternative B

	Lake			Rivers/Creeks/Streams		
Parcel	**Acres**	**Frontage (ft)**	**Length of Lake Frontage/Acre**	**Miles**	**Frontage (linear ft)**	**Length of River Frontage/Acre**
Lands Conveyed						
Smaller Federal Parcel	8.9	1,200.0	0.3	5.3	55,968.0	11.8
Lands Acquired						
Tract 1	129.6	16,424.0	3.5	8.1	72,864.0	15.3
Net Change						
Net Increase/(Decrease)	120.7	15,224.0	3.2	2.8	16,896.0	3.5

Source: Data from Section 4.3.3.

5.3.3.3 Land Exchange No Action Alternative

Under the Land Exchange No Action Alternative, the Superior National Forest would have an ongoing responsibility for managing wetland resources, floodplains, and surface waters on the federal lands in accordance with the Forest Plan. The Land Exchange No Action Alternative would not change USFS's responsibility for managing wetland resources, floodplains, and surface waters and would result in no further effects on these resources.

5.3.4 Vegetation

This section provides an evaluation of the effects of the Land Exchange Proposed Action on vegetation, including comparisons of MDNR GAP land cover types, native plant community types, MBS Sites of Biodiversity Significance, MIH types, age classes, threatened and endangered plant species, and biodiversity between the federal and non-federal lands. Table 5.3.4-1 provides a summary of these data on a net increase or decrease basis to the federal estate.

When comparing the total acres of the federal and non-federal lands, the federal estate would have an increase of 579.6 acres of MDNR GAP land cover types (see Table 5.3.4-1) as a result of the Land Exchange Proposed Action. The shrublands (1,199.4 acres) would increase the most and the upland conifer forests (919.5 acres) would decrease the most (see Table 5.3.4-2). There would be an acreage increase of upland forest (MIH 1) with lesser amounts of lowland black spruce-tamarack forest (MIH 9) and aquatic habitat (MIH 14), but a decrease of upland conifer forest (MIH 5) to the federal estate (see Table 5.3.4-1). There would be an increase to the federal estate of immature forest stands with lesser amounts of young stands, but a decrease in mature forest stands.

There would be a decrease to the federal estate of up to approximately 6,025.8 acres of MBS Sites of High Biodiversity Significance and an increase of up to 767.9 acres of MBS Sites of Moderate Biodiversity Significance under the Land Exchange Proposed Action (see Table 5.3.4-1). There would be a decrease to the federal estate of three native plant communities that are “imperiled,” “imperiled-vulnerable,” or “vulnerable,” as well as others that are ranked as “apparently secure” or “widespread and secure,” in exchange for one native plant community that is ranked as “vulnerable” and two that are ranked as “apparently secure.” There would be a decrease to the federal estate of up to 2,016.6 acres in the Jack Pine-Black Spruce landscape ecosystem, and an increase of up to 994.7 acres in the Lowland Conifer landscape ecosystem and 558.7 acres in the Mesic Red and White Pine landscape ecosystem. Additionally, the USFS would increase representation in the Dry-Mesic Red and White Pine, Mesic Birch-Aspen-Spruce-Fir, Lowland Hardwood, and Sugar Maple landscape ecosystems. Overall, there would be an increase to the federal estate of 625.2 acres of landscape ecosystems as a result of the Land Exchange Proposed Action.

There would be a decrease to the federal estate of 12 populations of 10 state-listed ETSC plant species on the federal lands in exchange for three populations of three known state-listed ETSC plant species on the non-federal lands. Though the 10 state-listed plant species on the federal lands are not known to occur on the non-federal lands, the Land Exchange Proposed Action would result in an increase to the federal estate of most habitats important to them. Drawing from the MIH exchange, RFSS plants associated with upland forest (MIH 1), lowland black spruce-tamarack forest (MIH 9), and aquatic habitat (MIH 14) could potentially exist on or spread to the habitats on the non-federal parcels. There would also be a gain of Rove Formation cliff microhabitats to the federal estate, which are important for a variety of RFSS plants in the Superior National Forest.

Rulemaking was conducted with the intent to update the list of ETSC species (*Minnesota Rules*, parts 6134.0100 to 6134.0400), with new listings becoming effective on August 19, 2013 (MDNR 2013h). This FEIS considers any new listings, or changes in the previous listings, associated with the updated list. The FEIS also considers any federal listing changes.

A Biological Evaluation has been prepared that contains further information about RFSS. The Biological Evaluation is included in Appendix D. The organization of the methodologies and discussion in the Biological Evaluation may be different from the FEIS. The document also contains determinations of effect for the species discussed.

Table 5.3.4-1 Vegetation and Cover Type Increase or Decrease to the Federal Estate Due to Land Exchange Proposed Action and Alternatives

Category		Net Increase/(Decrease)		
		Land Exchange Proposed Action	**Land Exchange Alternative B**	**Land Exchange No Action Alternative**
Habitat Types (acres)	MDNR GAP Land Cover Types	579.6	173.6	0.0
	MIH 1 (Upland Forest)	1,364.5	1,411.8	0.0
	MIH 5 (Upland Conifer Forest)	(1,172.5)	(1,084.6)	0.0
	MIH 9 (Lowland Black Spruce-tamarack Forest)	248.3	(261.1)	0.0
	MIH 14 (Aquatic Habitat)	226.7	206.2	0.0
	Lowland Shrub	(160.1)	(272.1)	0.0
	Lowland Emergent	200.2	249.6	0.0
	Upland Grass	43.3	0.0	0.0
	Young Forest Stands	507.1	262.7	0.0
	Immature Forest Stands	2,000.5	1,933.9	0.0
	Mature Forest Stands	(2,029.6)	(2,114.5)	0.0
MBS Sites (acres)	High Biodiversity Sites	(6,025.8)	(4,573.1)	0.0
	Moderate Biodiversity Sites	767.9	(0.3)	0.0
Native Plant Communities	Imperiled (S2)	(1.0)	0.0	0.0
	Imperiled/Vulnerable (S2-3)	(1.0)	(1.0)	0.0
	Vulnerable (S3)	(1) and +1 other	(1.0)	0.0
	Apparently Secure (S4)	(6) and +2 others	(2.0)	0.0
	Widespread and Secure (S5)	(6.0)	(4.0)	0.0
Landscape Ecosystems (acres)	Dry-Mesic Red and White Pine	683.0	589.2	0.0
	Jack Pine-black Spruce	(2,016.6)	(1,411.6)	0.0
	Lowland Conifer	994.7	486.2	0.0
	Lowland Hardwood	66.5	0.0	0.0
	Mesic Birch-aspen-spruce-fir	302.2	0.9	0.0
	Mesic Red and White Pine	558.7	528.0	0.0
	Sugar Maple	36.7	0.0	0.0
ETSC Species (number of species)	State-listed Plant Species	(10) species +3 different species	(10) species +1 different species	0.0
Management Area (acres)	General Forest	5,714.1	4,264.0	0.0
	General Forest – Longer Rotation	(5,658.0)	(4,397.3)	0.0
	cRNA	306.9	306.9	0.0
	Riparian Emphasis Area	220.9	0.0	0.0

5.3.4.1 Methodology and Evaluation Criteria

The vegetation assessment area for the Land Exchange Proposed Action would involve 6,495.4 acres of federal lands transferred from public to private ownership, and up to 7,075.0 acres of land transferred from private to public ownership. The spatial and temporal area of analysis for vegetation as part of the Land Exchange Proposed Action included direct and indirect effects resulting from the change in ownership of the federal and non-federal lands, including the extent of landscape ecosystems as defined in the Forest Plan or the extent of similar landscape ecosystems on the abutting forest lands.

An evaluation was conducted to determine the potential effect that the Land Exchange Proposed Action would have on the following vegetation resources:

- The quality and quantity of forest resources/lands (change in forest types and age classes);
- Change in state-listed ETSC plant species and RFSS plants (individuals, habitat, and/or populations);
- Change in biodiversity or overall vegetation and habitat; and
- The introduction and spread of invasive non-native species.

The analysis of the vegetation resources affected by the Land Exchange Proposed Action was guided by evaluation criteria that were developed by the USFS and other Co-lead Agencies, which included a comparison of the MDNR GAP land cover types, native plant communities, MBS Sites of Biodiversity Significance, MIH types (MIH 1, 5, 9, and 14, as well as lowland shrublands, lowland emergent wetlands, and upland grass), age classes (young, immature, and mature), large mature forest patches, landscape ecosystems, management areas, threatened and endangered plant species, RFSS plants, and invasive non-native plant species. GIS data for these categories were gathered to the extent possible, and then compared over an area of analysis that included the federal and non-federal lands, and also the surrounding landscape ecosystems of the Superior National Forest or ecological subsections. MIH types and age classes have also been compared within the context of landscape ecosystems to reveal how many acres of each MIH and age class would be increased or decreased on the federal estate by the Land Exchange Proposed Action within each landscape ecosystem. MIH type and age class data for the non-federal lands were interpreted from field survey maps, aerial maps, surrounding federal MIH data, topographic maps, and USFS review. These were then compared to the federal lands MIH data to determine MIH type and age class increases or decreases of acreage to the federal estate. Additionally, all of the data types mentioned have been compared to summarize the vegetative biodiversity of the federal and non-federal lands.

5.3.4.2 Land Exchange Proposed Action

5.3.4.2.1 Cover Types

Cover types consist of several categories of classification, including MDNR GAP land cover types, USFS management areas, USFS ELTs, and USFS MIH types.

Habitat Types

The Land Exchange Proposed Action would result in an increase to the federal estate of up to 579.6 acres of MDNR GAP land cover designations, with the greatest increase in shrubland acreage of 1,199.4 acres and the greatest decrease in upland conifer forest of 919.5 acres (see Table 5.3.4-2). The decrease of upland conifer forest is contrary to a goal of the 2004 Forest Plan. The Forest Plan calls for an increase in the acreage of red, white, and jack pine habitats (and a decrease in the acreage of aspen vegetation communities). In addition, the Land Exchange Proposed Action would support other Forest Plan goals to maintain acreage of lowland deciduous habitats and non-forested wetlands. The Land Exchange Proposed Action would result in a small increase to the federal estate of lowland deciduous forests, an increase in aquatic habitats, and a large increase of shrublands.

Table 5.3.4-2 Net Increase or Decrease to the Federal Estate of MDNR GAP Land Cover Types under the Land Exchange Proposed Action

Cover Types	Federal Land Acres	Non-federal Land Acres	Net Increase/ (Decrease) Acres
Shrubland	645.6	1,845.0	1,199.4
Aquatic environments	60.1	266.6	206.5
Upland deciduous forest	1,091.8	1,232.9	141.1
Upland conifer-deciduous mixed forest	20.9	50.4	29.5
Cropland/grassland	6.2	31.7	25.5
Lowland deciduous forest	9.5	28.6	19.1
Lowland coniferous forest	2,978.6	2,920.5	(58.1)
Disturbed	63.8	0.0	(63.8)
Upland coniferous forest	1,618.9	699.4	(919.5)
Total [1]	6,495.4	7,075.0	579.6

Source: MDNR 2006b.

Note:
[1] Total acres may be more or less than presented due to rounding.

Culturally Important Plants

The Land Exchange Proposed Action would result in additional wild rice beds on the federal estate by the acquisition of Tract 1. Tract 1 contains Little Rice Lake, which supports a continuous population of wild rice. Wild rice also grows along the Pike River south of Little Rice Lake and in isolated populations on Hay Lake. Section 4.3.4.2.5 provides further discussion of wild rice on Tract 1. Wild rice does not currently grow within the proposed federal land boundaries. Though the Land Exchange would result in an increase in wild rice beds within the federal estate boundaries, there is existing public access to Tract 1 wild rice beds via the Pike River. Consequently, there would be no change in wild rice harvest opportunities for the public. A carry-down boat launching access point is located on Tract 1, which may provide private access for wild rice harvesting on the Tract 1 lands.

Natural resources culturally important to the Bands are discussed in Section 4.2.9.3.3.

Minnesota Biological Survey

The Land Exchange Proposed Action would result in a decrease to the federal estate of 6,142.7 acres of MBS Sites of High Biodiversity Significance in the Laurentian Uplands subsection, and an increase of 116.9 acres of MBS Sites of High Biodiversity Significance in the North Shore Highlands subsection. Furthermore, the Land Exchange Proposed Action would result in an increase to the federal estate of 767.6 acres of MBS Sites of Moderate Biodiversity Significance in the Laurentian Uplands subsection.

Native plant community rankings are largely unavailable for the non-federal lands, with the exception of Lake County South, which has one site ranked as "vulnerable" and others ranked as "apparently secure." Section 4.3.4.2.6 provides further discussion of native plant community types on the Lake County South parcel. The Land Exchange Proposed Action would result in a decrease to the federal estate of three native plant communities on the federal lands that are ranked as "imperiled" to "vulnerable" in the state. A native plant community increase or decrease comparison cannot be accurately made since rankings are unavailable for much of the non-federal lands.

Management Areas

In conjunction with landscape ecosystem objectives, the USFS has developed desired future conditions and objectives, based on management areas, which describe what is desired socially and economically (USFS 2004b). The majority of the non-federal lands (86 percent) would be allocated to the General Forest Management Area upon completion of the Land Exchange Proposed Action. This management area provides a wide variety of goods, uses, and services, including wood products, scenic quality, recreation opportunities, and habitat types (USFS 2004b). The remaining non-federal lands would be allocated to the General Forest – Longer Rotation Management Area (7 percent), Potential/cRNA (4 percent), and Riparian Areas Management Area (3 percent). Section 5.3.1 provides a discussion of management area allocations on the non-federal lands for the Land Exchange Proposed Action.

Through the acquisition of Tract 1, the Land Exchange Proposed Action would result in a gain of a large contiguous block of land and lakeshore/river frontage. The majority of this tract (94 percent) would be allocated to the General Forest Management Area, with the balance allocated as a cRNA (6 percent). Two cRNA lands abut Tract 1 (USFS 2011b) and, upon completion of the Land Exchange Proposed Action, these two cRNA lands would be extended onto the parcel. The Pike Mountain cRNA is located at the southwestern corner of Tract 1. Approximately 135 acres of Tract 1 are proposed to be added to the Pike Mountain cRNA because it is an extension of the northern hardwood uplands with a high sugar maple component. The Loka Lake cRNA is located at the northeastern corner of Tract 1. Approximately 172 acres of the parcel are proposed to be added to the Loka Lake cRNA because it is an extension of the high-quality lowland black spruce and tamarack swamp.

The Land Exchange Proposed Action would result in Tract 2 being allocated as Riparian Areas (83 percent) and General Forest – Longer Rotation Management Area (17 percent) (USFS 2011b). The Riparian Emphasis Area Management Area provides protection to diverse age classes, but generally for older-growth forest stands along sensitive riparian areas.

The majority of Tract 3 would be allocated to the General Forest Management Area (92 percent), with the remaining 8 percent allocated to the General Forest – Longer Rotation Management Area (USFS 2011b).

All of Tracts 4 and 5 would be allocated to the General Forest – Longer Rotation Management Area (USFS 2011b). Obtaining Tract 5 would result in a gain of lakeshore property.

Overall, there would be a large increase to the federal estate in the General Forest Management Area (5,714.1 acres) and smaller increases in the cRNA (306.9 acres) and Riparian Areas (220.9

acres) Management Areas as a result of the Land Exchange Proposed Action (see Table 5.3.4-3). There would be a decrease to the federal estate of 5,662.3 acres of the General Forest – Longer Rotation Management Area. The lands to be acquired as part of the Land Exchange Proposed Action would be managed in accordance with Forest Plan standards and guidelines. Section 5.3.1 describes the management areas in detail.

Table 5.3.4-3 Net Increase or Decrease to the Federal Estate of Management Areas under the Land Exchange Proposed Action

	Federal Lands		Non-federal Lands		Net Increase/ (Decrease)
Category	**Acres**	**%**	**Acres**	**%**	**Acres**
General Forest	355.3	5	6,069.4	86	5,714.1
General Forest – Longer Rotation	6,140.2	95	477.8	7	(5,662.3)
Potential/cRNAs	0.0	0	306.9	4	306.9
Riparian Areas	0.0	0	220.9	3	220.9

Source: USFS 2011j.

Ecological Land Types

The Land Exchange Proposed Action would result in an increase to the federal estate of seven ELTs, including ELT 3, 4, 10, 11, 14, 17, and 18. Five of these ELTs are upland soils and two are lowland soils. The USFS would not lose representation of any ELTs currently on the federal lands, based on available data.

Management Indicator Habitats

The Land Exchange Proposed Action would result in an increase to the federal estate of upland forest (MIH 1; 1,364.5 acres), lowland black spruce-tamarack forest (MIH 9; 248.3 acres), and aquatic habitat (MIH 14; 226.7 acres), and a decrease of upland conifer forest (MIH 5; 1,172.5 acres) (see Table 5.3.4-4). The Land Exchange Proposed Action would also result in a decrease to the federal estate of lowland shrub habitat (160.1 acres), but an increase in lowland emergent (200.2 acres) and upland grass (43.3 acres) habitat types. While not considered MIH types, these are important habitats for several wildlife species. The fact that aquatic habitat (MIH 14) is not mapped on the federal lands results in an apparent increase to the federal estate in these categories, even though this habitat type does occur on the federal lands.

The Land Exchange Proposed Action would result in an increase to the federal estate of 2,507.6 acres of young and immature forest stands. However, it would result in a decrease to the federal estate of 2,029.6 acres of mature forest types. The Land Exchange Proposed Action would not result in a change to the federal estate of large patches (stands over 300 acres) of mature upland forests (MIH 13), as none exist on the federal lands (USFS 2012c) and the patches of mature forest on the non-federal lands are not part of the USFS Patch layer.

Table 5.3.4-4 Net Increase or Decrease to the Federal Estate of MIH Types and Age Classes under the Land Exchange Proposed Action

Category	Federal Land Acres [2]	Non-federal Land Acres [1,2]	Net Increase/ (Decrease) Acres
MIH Types			
MIH 1 (Upland Forest)	1,330.0	2,694.5	1,364.5
MIH 5 (Upland Conifer Forest)	1,252.4	79.9	(1,172.5)
MIH 9 (Lowland Black Spruce-tamarack Forest)	3,060.2	3,308.5	248.3
MIH 14 (Aquatic Habitat)	0.0	226.7	226.7
Lowland Shrub	492.3	332.2	(160.1)
Lowland Emergent	185.5	385.7	200.2
Upland Grass	0.0	43.3	43.3
Age Classes			
Young	271.1	778.2	507.1
Immature	1,539.2	3,539.7	2,000.5
Mature	3,854.2	1,824.6	(2,029.6)

Source: USFS 2010b.

Notes:
[1] According to non-federal lands cover type table (see Table 4.3.4-3).
[2] Total acres may be more or less than presented due to rounding.

Landscape Ecosystems

The Land Exchange Proposed Action would result in a decrease to the federal estate of 2,016.6 acres of the Jack Pine-Black Spruce landscape ecosystem (0.65 percent decrease), but there would be an increase of 994.7 acres in the Lowland Conifer landscape ecosystem (0.08 percent increase) and 558.7 acres of the Mesic Red and White Pine landscape ecosystem (0.73 percent increase). The Superior National Forest, as part of the Land Exchange Proposed Action, would have increased representation in the Dry-Mesic Red and White Pine landscape ecosystem (682.9 acres; 0.11 percent increase), Mesic Birch-Aspen-Spruce-Fir landscape ecosystem (302.2 acres; 0.04 percent increase), Lowland Hardwood landscape ecosystem (66.5 acres; 0.01 percent increase), and the Sugar Maple landscape ecosystem (36.7 acres; 0.04 percent increase), and there would be an overall increase to the federal estate of 625.1 acres.

Within the Superior National Forest, the USFS tracks acreage of MIH types and age classes within each landscape ecosystem to better manage them within the broader ecological context. As a result of the Land Exchange Proposed Action, there would be an increase to the federal estate in acreage of MIH types and age classes within some landscape ecosystems and a decrease in others (see Table 5.3.4-5). The greatest percentage increase to the federal estate in MIH acreage within a landscape ecosystem is lowland black spruce-tamarack forest (MIH 9) in the Mesic Birch-Aspen-Spruce-Fir landscape ecosystem, while the greatest decrease is upland conifer forest (MIH 5) in the Jack Pine-Black Spruce landscape ecosystem. The greatest percentage increase to the federal estate in age class acreage within a landscape ecosystem is the immature age class in the Lowland Conifer landscape ecosystem, while the greatest decrease is the immature and mature age classes in the Jack Pine-Black Spruce landscape ecosystem. Overall, the Lowland Conifer landscape ecosystem would have the highest acreage increase to the federal estate in MIH types and age classes, while the Jack Pine-Black Spruce landscape ecosystem would have the highest acreage decrease in MIH types and age classes.

Table 5.3.4-5 Net Increase or Decrease to the Federal Estate of MIH Types and Age Classes within Landscape Ecosystems in the Superior National Forest under the Land Exchange Proposed Action

Landscape Ecosystem Name			Dry-Mesic Red and White Pine	Jack Pine-Black Spruce	Lowland Conifer	Lowland Hardwood	Mesic Birch-Aspen-Spruce-Fir	Mesic Red and White Pine	Sugar Maple
Category			**Net Increase/(Decrease)**						
MIH Types	MIH 1	Acres [1]	517.0	(1,374.7)	289.0	10.1	140.8	527.1	1.1
		% [2]	2	(4)	2	2	0	1	1
	MIH 5	Acres [1]	15.5	(1,089.3)	(121.2)	3.2	7.6	11.6	0.0
		% [2]	0	(8)	(2)	2	0	0	0
	MIH 9	Acres [1]	26.2	(390.7)	928.9	17.1	134.7	13.8	7.8
		% [2]	1	(7)	2	1	4	0	0
	MIH 14	Acres [1]	115.5	2.2	97.8	9.1	0.3	0.8	0.9
		% [2,3]	NA	NA	NA	NA	NA	NA	NA
Lowland Shrub		Acres [1]	3.0	(95.0)	(113.0)	24.0	19.0	0.0	0.0
		% [2]	0	(4)	(1)	4	1	0	0
Lowland Emergent		Acres [1]	6.0	(62.3)	348.1	3.2	0.0	2.4	3.1
		% [2]	1	(7)	5	1	0	0	0
Upland Grass		Acres [1]	0.0	(0.2)	15.4	0.0	0.0	0.0	23.6
		% [2]	0	0	5	0	0	0	0
Age Classes	Young	Acres [1]	250.8	(21.5)	188.0	5.6	51.1	9.3	23.6
		% [2]	15	(1)	18	7	2	0	0
	Immature	Acres [1]	178.7	(700.3)	2,170.2	2.3	50.4	298.9	0.0
		% [2]	1	(4)	28	1	0	1	0
	Mature	Acres [1]	129.2	(1,079.0)	(1,559.6)	22.5	181.6	247.1	8.9
		% [2]	1	(4)	(2)	1	1	1	6

Source: USFS 2010b; USFS 2011g.

Notes:
[1] Total acres may be more or less than presented due to rounding.
[2] Percentage of acres increased or decreased on the federal estate within the entire landscape ecosystem.
[3] MIH 14 is not tracked on the federal lands; thus, percentage is NA (not applicable).

5.3.4.2.2 Invasive Non-native Plants

The Land Exchange Proposed Action would result in a reduction of occurrences of invasive non-native species on the federal lands, but an increase to the federal estate of similar occurrences of invasive non-native species on Tracts 1, 2, and 3, including common tansy, orange hawkweed, ox-eye daisy, and thistles. Tracts 4 and 5 would not have an increase of any occurrences of invasive non-native species.

5.3.4.2.3 Threatened and Endangered Plant Species

Endangered, Threatened, and Special Concern Plant Species

There are fewer occurrences of state-listed ETSC plant species on the non-federal lands (one species on Tract 1 and two species on Tract 5) than on the federal lands (10 species), so the USFS would have fewer populations as a result of the Land Exchange Proposed Action (see Table 5.3.4-6). The three species gained in the exchange are *Carex ormostachya, Woodsia scopulina,* and *Saxifraga paniculata*. Sections 4.3.4.2.5 and 4.3.4.2.9 provide a discussion of these species. There are no federally listed plant species in St. Louis, Lake, or Cook counties (USFWS 2012). Rulemaking was conducted with the intent to update the list of ETSC species (*Minnesota Rules*, parts 6134.0100 to 6134.0400), with new listings becoming effective on August 19, 2013 (MDNR 2013h). This FEIS considers any new listings, or changes in the previous listings, associated with the updated list.

Though the 10 known state-listed ETSC plant species on the federal lands are not known to occur on the non-federal lands, the Land Exchange Proposed Action would result in an increase to the federal estate of most habitats important to them. The Land Exchange Proposed Action would result in additional grassland habitat, which *Botrychium campestre* and *Botrychium pallidum* occupy. The Land Exchange Proposed Action would also result in an increase to the federal estate of upland deciduous and mixed forest habitats, used by *Botrychium pallidum*, *Botrychium rugulosum*, and *Botrychium simplex*. There would be an increase to the federal estate of aquatic habitats (open water or wetlands) for *Caltha natans*, *Eleocharis nitida*, *Juncus stygius* var. *americanus*, and *Torreyochloa pallida*. According to the MIH analysis, the Land Exchange Proposed Action would result in an increase to the federal estate of lowland black spruce or tamarack habitats, which could mean more habitats for *Platanthera clavellata*, *Pyrola minor*, and *Ranunculus lapponicus*.

Table 5.3.4-6 Increase or Decrease to the Federal Estate of State-listed ETSC Plant Populations under the Land Exchange Proposed Action

	Federal Lands Populations		Non-federal Lands Populations		
Plant Species (State Status/ Global Status[1])	**Total Populations[2,3]**	**Total Individuals[3]**	**Total Populations[2,3]**	**Total Individuals[3]**	**Net Species Increase/ (Decrease)**
Botrychium pallidum (SC/G3)	1	2	0	NA	(1)
Botrychium rugulosum (SC/G3)	1	4	0	NA	(1)
Botrychium simplex (SC/G5)	3	905	0	NA	(1)
Caltha natans (E/G5)	1	29	0	NA	(1)
Eleocharis nitida (SC/G4)	1	~486 ft^2	0	NA	(1)
Juncus stygius var. *americanus* (SC/G5)	1	1	0	NA	(1)
Platanthera clavellata (SC/G5)	1	5	0	NA	(1)
Pyrola minor (SC/G5)	1	10	0	NA	(1)
Ranunculus lapponicus (SC/G5)	1	~919 ft^2	0	NA	(1)
Torreyochloa pallida (SC/G5)	1	~25 ft^2	0	NA	(1)
Carex ormostachya (SC/G4)	0	NA	1	>20	1
Woodsia scopulina (T/G5)	0	NA	1	2	1
Saxifraga paniculata (SC/G5)	0	NA	1	1,000	1
Total	12	NA	3	NA	(7)

Source: MDNR 2014d.

Notes:
1 The state status is E – Endangered; T – Threatened; and SC – Species of Special Concern. The global ranks range from G1 to G5. A lower global ranking (e.g., G3) indicates a species at higher global risk than higher ranking (e.g., G5) (NatureServe 2014b).
2 Populations are interpreted from MDNR NHIS data using Element Occurrence; this differs from the DEIS, which used colonies as the population estimate.
3 Data included here were provided by the Division of Ecological Resources, MDNR, and were current as of August 5, 2014. These data are not based on an exhaustive inventory of the state. The lack of data for any geographic area shall not be construed to mean that no significant features are present.

Regional Foresters Sensitive Species

The USFS RFSS data layer indicates there are no RFSS plants on the federal lands. However, several state-listed ETSC plant species that occur on the federal lands are also listed as RFSS plants, including *Botrychium pallidum*, *Botrychium rugulosum*, *Botrychium simplex*, *Caltha natans*, *Eleocharis nitida*, *Juncus stygius* var. *americanus*, and *Pyrola minor*. The USFS would have a decrease to the federal estate in these RFSS plant species as a result of the Land Exchange Proposed Action. *Saxifraga paniculata* is a state-listed ETSC plant species that is also listed as a RFSS plant on the Tract 5 lands. The USFS would gain this RFSS plant species under the Land Exchange Proposed Action.

As with the NorthMet Project Proposed Action, the Land Exchange Proposed Action would not affect 20 RFSS plants on the Superior National Forest. In addition, the Land Exchange Proposed Action may affect individuals, but would not be likely to cause a trend to federal listing or loss of viability for the remaining 38 RFSS plants on the Superior National Forest. Please see the Biological Evaluation included in Appendix D for more information about effects to RFSS plants.

There would be the greatest increase to the federal estate in acres of lowland black spruce-tamarack forest (MIH 1; see Table 5.3.4-4) as a result of the Land Exchange Proposed Action, which means there is the highest chance to gain the RFSS plants listed under that category in Table 4.2.4-5, as long as the suitable habitats exist on the non-federal lands. There would be smaller acreage increases of both upland forest (MIH 9) and aquatic habitat (MIH 14), meaning the RFSS plants in those categories could also be gained. The largest acreage decrease to the federal estate would be upland conifer forest (MIH 5). There are no RFSS plants specifically listed under upland conifer forest (MIH 5); however, it is likely that some RFSS plants that occupy upland forest (MIH 9) habitats would also occupy upland conifer forest (MIH 5) habitats and the USFS could therefore have a decrease to the federal estate in RFSS plant species that prefer coniferous upland habitats. There would also be a gain of Rove Formation cliff microhabitats, which are important for a variety of RFSS plants in the Superior National Forest.

5.3.4.2.4 Biodiversity

Biodiversity is described in the Forest Plan as the "variety of life and its ecological processes … [as well as] ecosystems, which comprise both the communities of organisms within particular habitats, and the physical conditions under which they live" (USFS 2004b). Biodiversity is important to consider for managing natural communities in a sustainable and ecological manner. Several data sources mentioned above and in Section 4.2.4 were compared on an increase or decrease basis to the federal estate to measure or estimate the biodiversity of both the federal and non-federal lands.

The federal land contains a high level of biodiversity because the majority of the parcel has been classified for inclusion in two Sites of High Biodiversity Significance. Additionally, several different native plant communities exist on it, as do 10 state-listed ETSC plant species. Because the non-federal lands have not been fully studied yet, they contain less biodiversity classification since they lack MBS Sites of High Biodiversity Significance and native plant communities. Table 5.3.4-1 provides a summary of the various data used to estimate biodiversity.

In summary, the non-federal lands contain 116.9 acres of MBS Sites of High Biodiversity Significance in the North Shore Highlands subsection and 767.9 acres of MBS Sites of Moderate Biodiversity Significance in the Laurentian Uplands subsection. The Land Exchange Proposed Action would result in a decrease to the federal estate of 6,142.7 acres of MBS Sites of High Biodiversity Significance in the Laurentian Uplands subsection, and an increase of 116.9 acres of MBS Sites of High Biodiversity Significance in the North Shore Highlands subsection. Furthermore, the Land Exchange Proposed Action would result in an increase to the federal estate of 767.6 acres of MBS Sites of Moderate Biodiversity Significance in the Laurentian Uplands subsection. Overall, there would be a decrease to the federal estate of 6,025.8 acres of MBS Sites of High Biodiversity Significance and an increase of 767.6 acres of MBS Sites of Moderate Biodiversity Significance under the Land Exchange Proposed Action. However, several of the non-federal lands have preliminary classifications of Sites as Moderate, High, or Outstanding Biodiversity Significance, which, if approved by the MDNR MBS program, would help balance the exchange.

Native plant community rankings are largely unavailable for the non-federal lands, with the exception of Lake County South, which has one site ranked as "vulnerable" and others ranked as "apparently secure." Section 4.3.4.2.6 provides further discussion of native plant community types on the Lake County South parcel. The Land Exchange Proposed Action would result in a decrease to the federal estate of three native plant communities on the federal lands that are ranked as “imperiled” to “vulnerable” in the state. A native plant community increase or decrease comparison cannot be accurately made since rankings are unavailable for much of the non-federal lands.

Endangered, Threatened, and Special Concern Plant Species

As previously stated, the federal lands support 10 known state-listed ETSC plant species, while the non-federal lands currently support three known state-listed ETSC plant species. This would be a decrease to the federal estate in known state-listed species as a result of the Land Exchange Proposed Action.

5.3.4.3 Land Exchange Alternative B

5.3.4.3.1 Cover Types

The effects of Land Exchange Alternative B would be comparable to those from the Land Exchange Proposed Action, although to a lesser extent. A smaller portion of the federal lands (approximately 4,752.6 acres) would be transferred into private ownership for the non-federal Tract 1 lands (approximately 4,926.3 acres), which would be conveyed into USFS ownership. Under this alternative, the USFS would retain a smaller federal parcel located on the northwestern and western sides of the current federal lands, which would create additional linear boundaries for the USFS to maintain (see Section 5.3.1).

Habitat Types

This alternative would result in an overall increase to the federal estate of 173.6 acres of MDNR GAP land cover types. As under the Land Exchange Proposed Action, the greatest increase to the federal estate would be shrubland acreage (1,227.7 acres), and upland conifer forest would have the greatest acreage decrease (928.8 acres), as shown in Table 5.3.4-7 below.

Table 5.3.4-7 Net Increase or Decrease to the Federal Estate of MDNR GAP Land Cover Types under Land Exchange Alternative B

Cover Types	Alternative B: Smaller Federal Parcel Acres	Tract 1 Acres [1]	Net Increase/ (Decrease) Acres
Shrubland	436.9	1,664.6	1,227.7
Aquatic environments	26.3	251.1	224.8
Upland deciduous forest	804.7	999.9	195.2
Cropland/grassland	2.2	31.7	29.5
Lowland deciduous forest	4.7	17.4	12.7
Upland conifer-deciduous mixed forest	17.8	0.0	(17.8)
Disturbed	29.1	0.0	(29.1)
Lowland coniferous forest	2,064.8	1,524.2	(540.6)
Upland coniferous forest	1,366.1	437.3	(928.8)
Total [2]	4,752.6	4,926.2	173.6

Source: MDNR 2006b.

Notes:
1 According to Tract 1 land cover type table (see Table 4.3.4-11).
2 Total acres may be more or less than presented due to rounding.

Culturally Important Plants

As with the Land Exchange Proposed Action, Land Exchange Alternative B would result in additional wild rice beds on the federal estate from the acquisition of Tract 1, but would not result in a change in harvesting opportunities for the public. Section 5.3.4.2 provides additional information on wild rice.

As with the Land Exchange Proposed Action, see Section 4.2.9.3.3 for a discussion of natural resources culturally important to the Bands.

Minnesota Biological Survey

Land Exchange Alternative B would result in a decrease to the federal estate of 4,573.1 acres of MBS Sites of High Biodiversity Significance and a decrease of 0.3 acre of MBS Sites of Moderate Biodiversity Significance within the Laurentian Uplands subsection (see Table 5.3.4-1). Portions of the west end of One Hundred Mile Swamp would remain in federal ownership. Furthermore, Land Exchange Alternative B would result in removal from the Superior National Forest of three native plant communities that are ranked as “imperiled” to “vulnerable” in the state. As previously discussed, Tract 1 does not contain any MBS Sites of Biodiversity Significance or native plant communities, so, unlike the Land Exchange Proposed Action, the federal estate would not have an increase of either MBS sites or native plant communities under this alternative.

Management Areas

Lands included as part of Land Exchange Alternative B are currently managed under the General Forest – Longer Rotation Management Area (93 percent) and the General Forest Management Area (7 percent) (see Table 5.3.4-8). The majority of Tract 1 (94 percent) would be allocated to the General Forest Management Area upon completion of Land Exchange Alternative B, and the remaining area would be managed under the cRNA Management Area (6 percent). Land Exchange Alternative B would be comparable to the Land Exchange Proposed Action in that cRNA lands would be increased on the federal estate, but Riparian Areas would not be. Section 5.3.1 describes the management areas in detail.

Table 5.3.4-8 Net Increase or Decrease to the Federal Estate of Management Areas under Land Exchange Alternative B

Category	Alternative B: Smaller Federal Parcel		Tract 1		Net Increase/ (Decrease)
	Acres	**%**	**Acres**	**%**	**Acres**
General Forest	355.3	7	4,619.3	94	4,264.0
General Forest - Longer Rotation	4,397.3	93	0.0	0	(4,397.3)
Potential/candidate Research Natural Areas	0.0	0	306.9	6	306.9
Riparian Areas	0.0	0	0.0	0	0

Source: USFS 2011j.

Ecological Land Types

Land Exchange Alternative B would result in a decrease to the federal estate of five ELTs, including ELT 1, 2, 6, 13, and 16, which are currently located on the proposed smaller federal parcel. The ELTs are unavailable for Tract 1, and so a comparison cannot be made.

Management Indicator Habitats

Land Exchange Alternative B would result in an increase to the federal estate in upland forest (MIH 1; 1,411.8 acres) and aquatic habitat (MIH 14; 206.2 acres); however, there would be a decrease of upland conifer forest (MIH 5; 1,084.6 acres) and lowland black spruce-tamarack forest (MIH 9; 261.1 acres) (see Table 5.3.4-9). Though not considered MIH types, there would be a decrease to the federal estate of lowland shrubland habitat (272.1 acres) and an increase of lowland emergent wetlands (249.6 acres). Similar to the Land Exchange Proposed Action, the aquatic habitat (MIH 14) type is not fully mapped on lands that are part of Land Exchange Alternative B, resulting in an apparent increase to the federal estate in this category; however, this habitat type does occur on these lands.

There would be a large increase to the federal estate of immature forest stands (1,933.9 acres) with lesser amounts of young stands (262.7 acres), corresponding to a decrease of mature forest stands (2,114.5 acres). Land Exchange Alternative B would not result in a change to the federal estate of large patches (stands over 300 acres) of mature upland forest, as none exist on the Alternative B: Smaller Federal Parcel lands (USFS 2012c) and patch data does not exist for the Tract 1 lands.

Table 5.3.4-9 Net Increase or Decrease to the Federal Estate of MIH Types and Age Classes under Land Exchange Alternative B

Category	Alternative B: Smaller Federal Parcel Acres[2]	Tract 1 Acres[1,2]	Net Increase/ (Decrease) Acres
MIH Types			
MIH 1 (Upland Forest)	954.2	2,366.0	1,411.8
MIH 5 (Upland Conifer Forest)	1,138.8	54.2	(1,084.6)
MIH 9 (Lowland Black Spruce-tamarack Forest)	2,078.7	1,817.6	(261.1)
MIH 14 (Aquatic Habitats)	0.0	206.2	206.2
Lowland Shrubland	385.4	113.3	(272.1)
Lowland Emergent	115.4	365.0	249.6
Upland Grass	0.0	0.0	0.0
Age Classes			
Young	271.1	533.8	262.7
Immature	1,325.9	3,259.8	1,933.9
Mature	2,574.7	460.2	(2,114.5)

Source: USFS 2010b.

Notes:
[1] According to Tract 1 lands MIH table (see Table 4.3.4-3).
[2] Total acres may be more or less than presented due to rounding.

Landscape Ecosystems

Land Exchange Alternative B would result in a decrease to the federal estate of 1,411.6 acres of the Jack Pine-Black Spruce landscape ecosystem (0.46 percent decrease), but result in an increase of 486.2 acres of the Lowland Conifer landscape ecosystem (0.04 percent increase). Furthermore, there would be an increase in representation in the Dry-Mesic Red and White Pine landscape ecosystem (589.2 acres; 0.10 percent increase), Mesic Red and White Pine landscape ecosystem (528.0 acres; 0.69 percent increase), and the Mesic Birch-Aspen-Spruce-Fir landscape ecosystem (0.9 acres; less than 0.01 percent increase), and an overall increase to the federal estate of 192.7 acres.

Similar to the Land Exchange Proposed Action, Land Exchange Alternative B would result in an increase to the federal estate in acreage of MIH types and age classes within various landscape ecosystems, and a decrease in acreage in others (see Table 5.3.4-10). The greatest percentage increase to the federal estate in MIH acreage within a landscape ecosystem is upland forest (MIH 1) in the Lowland Conifer and Dry-Mesic Red and White Pine landscape ecosystems, while the greatest decrease is upland conifer forest (MIH 5) in the Jack Pine-Black Spruce landscape ecosystem. The largest percentage increase to the federal estate in age class acreage within a landscape ecosystem is the immature age class in the Lowland Conifer landscape ecosystem, while the largest decrease is in the immature age class in the Jack Pine-Black Spruce landscape ecosystem and the mature age classes within the Jack Pine-Black Spruce and Lowland Conifer landscape ecosystems. Overall, the Dry-Mesic Red and White Pine landscape ecosystem would have the highest acreage increase to the federal estate of MIH types and age classes and the Jack Pine-Black Spruce landscape ecosystem would have the highest acreage decrease of MIH types and age classes.

Table 5.3.4-10 Net Increase or Decrease to the Federal Estate of MIH Types and Age Classes within Landscape Ecosystems in the Superior National Forest under Land Exchange Alternative B

Landscape Ecosystem Name			Dry-Mesic Red and White Pine	Jack Pine-Black Spruce	Lowland Conifer	Lowland Hardwood	Mesic Birch-Aspen-Spruce-Fir	Mesic Red and White Pine	Sugar Maple
Category			**Net Increase/(Decrease)**						
MIH Types	MIH 1	Acres [1]	437.8	(1,007.1)	340.3	0.0	0.9	501.1	0.0
		% [2]	2	(3)	2	0	0	1	0
	MIH 5	Acres [1]	6.0	(998.2)	(100.1)	0.0	0.0	7.7	0.0
		% [2]	0	(7)	(2)	0	0	0	0
	MIH 9	Acres [1]	26.2	(290.9)	(10.5)	0.0	0.0	13.9	0.0
		% [2]	1	(6)	0	0	0	0	0
	MIH 14	Acres [1]	114.2	2.2	89.6	0.0	0.0	0.2	0.0
		% [2,3]	NA	NA	NA	NA	NA	NA	NA
Lowland Shrub		Acres [1]	0.0	(66.4)	(207.3)	0.0	0.0	0.1	0.0
		% [2]	0	(3)	(1)	0	0	0	0
Lowland Emergent		Acres [1]	5.0	(23.5)	265.7	0.0	0.0	2.4	0.0
		% [2]	1	(3)	4	0	0	0	0
Upland Grass		Acres [1]	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		% [2]	0	0	0	0	0	0	0
Age Classes	Young	Acres [1]	229.4	(21.5)	45.5	0.0	0.0	9.3	0.0
		% [2]	14	(1)	4	0	0	0	0
	Immature	Acres [1]	148.5	(528.7)	2,014.3	0.0	0.9	298.9	0.0
		% [2]	1	(3)	26	0	0	1	0
	Mature	Acres [1]	92.1	(726.1)	(1,709.8)	0.0	0.0	217.1	0.0
		% [2]	1	(3)	(3)	0	0	1	0

Source: USFS 2010b; USFS 2011g.

Notes:
1 Total acres may be more or less than presented due to rounding.
2 Percentage of acres increased or decreased on the federal estate within the entire landscape ecosystem.
3 MIH 14 is not tracked on the federal lands; thus, percentage is NA.

5.3.4.3.2 Invasive Non-native Plants

Land Exchange Alternative B would result in a reduction of occurrences of invasive non-native species on the smaller federal parcel, but in an increase to the federal estate of similar occurrences of invasive non-native species on Tract 1, including common tansy, orange hawkweed, and ox-eye daisy.

5.3.4.3.3 Threatened and Endangered Plant Species

Endangered, Threatened, and Special Concern Plant Species

Under Land Exchange Alternative B, a smaller portion of the federal lands would be exchanged for Tract 1. The same 10 ETSC plant species would be exchanged as for the Land Exchange Proposed Action, but fewer colonies would be exchanged. There is one known state-listed ETSC plant species located on Tract 1 (*Carex ormostachya*). Overall, 12 populations of 10 different species on the smaller federal parcel would be exchanged for one population of one species on Tract 1 (see Table 5.3.4-11). Rulemaking was conducted with the intent to update the list of ETSC species (*Minnesota Rules*, parts 6134.0100 to 6134.0400), with new listings becoming effective on August 19, 2013 (MDNR 2013h). This FEIS considers any new listings, or changes in the previous listings, associated with the updated list.

Table 5.3.4-11 Increase or Decrease to the Federal Estate of State-listed ETSC Plant Populations under Land Exchange Alternative B

	Alternative B: Smaller Federal Parcel Populations		**Tract 1 Populations**		
Plant Species (State Status/ Global Status[1])	**Total Populations[2,3]**	**Total Individuals[3, 4]**	**Total Populations[2,3]**	**Total Individuals[3]**	**Net Species Increase/ (Decrease)**
Botrychium pallidum (SC/G3)	1	2	0	NA	(1)
Botrychium rugulosum (SC/G3)	1	4	0	NA	(1)
Botrychium simplex (SC/G5)	3	905	0	NA	(1)
Caltha natans (E/G5)	1	29	0	NA	(1)
Eleocharis nitida (SC/G4)	1	~486 ft^2	0	NA	(1)
Juncus stygius var. *americanus* (SC/G5)	1	1	0	NA	(1)
Platanthera clavellata (SC/G5)	1	3	0	NA	(1)
Pyrola minor (SC/G5)	1	10	0	NA	(1)
Ranunculus lapponicus (SC/G5)	1	~919 ft^2	0	NA	(1)
Torreyochloa pallida (SC/G5)	1	~25 ft^2	0	NA	(1)
Carex ormostachya (SC/G4)	0	NA	1	>20	1
Total	12	NA	1	NA	(9)

Source: MDNR 2014d.

Notes:

1 The state status is E – Endangered; T – Threatened; and SC – Species of Special Concern. The global ranks range from G1 to G5. A lower global ranking (e.g., G3) indicates a species at higher global risk than higher ranking (e.g., G5) (NatureServe 2014b).

2 Populations are interpreted from MDNR NHIS data using Element Occurrence; this differs from the DEIS, which used colonies as the population estimate.

3 Data included here were provided by the Division of Ecological Resources, MDNR, and were current as of August 5, 2014. . These data are not based on an exhaustive inventory of the state. The lack of data for any geographic area shall not be construed to mean that no significant features are present. NA = Not Applicable.

4 Where the number of individuals could not be determined without damaging the population, then patch size was used as a representative abundance measure.

Regional Foresters Sensitive Species

The USFS RFSS data layer indicates there are no RFSS plants on the federal lands, which includes the smaller federal parcel. However, several state-listed ETSC plant species occur on the smaller federal parcel that are also RFSS plants, including *Botrychium pallidum*, *Botrychium rugulosum*, *Botrychium simplex*, *Caltha natans*, *Eleocharis nitida*, *Juncus stygius* var. *americanus*, and *Pyrola minor*.

As with the Land Exchange Proposed Action, the Land Exchange Alternative B would not affect 20 RFSS plants on the Superior National Forest. In addition, the Land Exchange Alternative B may affect individuals, but would not be likely to cause a trend to federal listing or loss of viability for the remaining 38 RFSS plants on the Superior National Forest. Please see the Biological Evaluation included in Appendix D for more information about effects to RFSS plants.

There would be an increase to the federal estate in acres of upland forest (MIH 1) and aquatic habitat (MIH 14) as a result of Land Exchange Alternative B (see Table 5.3.4-9), which means there would be the greatest opportunity to gain the RFSS plants listed under those categories in Table 4.2.4-5. There would be a decrease to the federal estate in acreage of upland conifer forest (MIH 5) and lowland black spruce-tamarack forest (MIH 9), which means the RFSS plant species that prefer these habitat types and have suitable microhabitats may also be decreased on National Forest System lands.

5.3.4.3.4 Biodiversity

The smaller federal parcel contains a high level of biodiversity because the majority of the parcel has been classified for inclusion in two MBS Sites of High Biodiversity Significance. Additionally, several different native plant communities exist on it, as well as 10 state-listed ETSC plant species. Because Tract 1 has not been fully studied, it is assumed to contain less biodiversity because it lacks MBS Sites of High Biodiversity Significance and native plant communities. However, inclusion of the preliminary Site of Outstanding Biodiversity Significance on Tract 1 would balance the exchange, if not make it more biodiverse than the smaller federal parcel. Table 5.3.4-1 provides a summary of the various data used to estimate biodiversity.

Land Exchange Alternative B would result in a decrease to the federal estate of 4,573.1 acres of MBS Sites of High Biodiversity Significance and a decrease of 0.3 acres of MBS Sites of Moderate Biodiversity Significance within the Laurentian Uplands subsection (see Table 5.3.4-1). Portions of the west end of One Hundred Mile Swamp would remain in federal ownership.

Furthermore, Land Exchange Alternative B would result in removal from the Superior National Forest of three native plant community sites that are ranked as “imperiled” to “vulnerable” in the state. As previously discussed, Tract 1 does not contain any MBS Sites of Biodiversity Significance or native plant communities, so, unlike the Land Exchange Proposed Action, the federal estate would not have an increase of either MBS Sites or native plant communities under this alternative.

5.3.4.4 Land Exchange No Action Alternative

Under the Land Exchange No Action Alternative, the Superior National Forest would have an ongoing responsibility for managing vegetation resources on the federal lands in accordance with the Forest Plan. The Land Exchange No Action Alternative would not change the USFS’s responsibility for managing vegetation resources and would result in no further effects on existing vegetation.

5.3.4.4.1 Cover Types

Under the Land Exchange No Action Alternative, the current federal lands would remain in federal ownership and the lands would continue to be managed under the General Forest – Longer Rotation Management Area and the General Forest Management Area. Direct and indirect effects of the Land Exchange No Action Alternative on cover types would be unchanged, as the management of these forests has occurred on site in the past. None of the federal lands currently have any vegetation management actions planned in the near future, regardless of whether the Land Exchange Proposed Action were to occur.

5.3.4.4.2 Invasive Non-native Plants

Non-native species may still invade the federal lands as a result of logging, mineral exploration, vehicle traffic, and natural disturbances, but are likely to do so much more slowly than they would under the Land Exchange Proposed Action. The proximity of the federal lands to the already-disturbed Plant Site may put the federal lands at risk of eventual colonization by invasive non-native species.

5.3.4.4.3 Threatened and Endangered Plant Species

Under the Land Exchange No Action Alternative, timber harvests are expected to continue to occur on the federal lands, though there are not any planned in the near future. Effects on ETSC plant species and RFSS plants, for different management techniques, are addressed in the Forest Plan (USFS 2004b). As discussed in the Biological Evaluation, the Land Exchange No Action Alternative would not have effects on RFSS species.

5.3.4.4.4 Biodiversity

The Land Exchange No Action Alternative would not result in any change to biodiversity on the federal lands.

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5.3.5 *Wildlife*

This section describes the environmental consequences of the Land Exchange to wildlife on the federal and non-federal lands. Effects from the change in federal ownership could be either beneficial or adverse, based on the change in species occurrences, habitat, and habitat connectivity on land that is under direct federal control. Effects due to the NorthMet Project Proposed Action are discussed in Section 5.2.5.

Rulemaking was conducted with the intent to update the list of ETSC species (*Minnesota Rules*, parts 6134.0100 to 6134.0400), with new listings becoming effective on August 19, 2013 (MDNR 2013h). This FEIS considers any new listings, or changes in the previous listings, associated with the updated list.

A Biological Assessment that provides further information on federally listed species, and a Biological Evaluation that contains further information about RFSS have been prepared. The Biological Assessment and Biological Evaluation are included in Appendix D. The Biological Assessment analyzes impacts to the Canada lynx, gray wolf, and northern long-eared bat. Land Exchange alternatives were analyzed in the Biological Assessment for the NorthMet Mining Project and Land Exchange. The organization of the methodologies and discussion in the Biological Assessment and Biological Evaluation may be different from the FEIS. Both documents also contain determinations of effect for the species discussed.

The Land Exchange Proposed Action would have mixed effects for the Canada lynx. It would result in an increase in suitable habitat for lynx and for snowshoe hare (prey species) on the federal estate (although the amount of unsuitable lynx habitat would also increase). It would also result in a decrease of denning habitat and a decrease to the federal estate within designated LAUs. Critical lynx habitat would not change regardless of ownership.

The Land Exchange Proposed Action would result in an increase in the number of occurrences and forage habitat availability for the gray wolf within the federal estate, but would result in a decrease in cover habitat. The Land Exchange Proposed Action would result in a net decrease of potential northern long-eared bat roosting habitat but an increase in foraging habitat within the federal estate.

Overall, the Land Exchange Proposed Action would result in an increase (to the federal estate) of the number of occurrences and habitat availability for two state-listed species of special concern, which include the Laurentian tiger beetle and the trumpeter swan (see Table 5.3.5-1). The Land Exchange Proposed Action is not expected to result in changes to the three additional state-listed and special concern species, which include the wood turtle, the eastern heather vole, and the yellow rail.

Under the Land Exchange Proposed Action, one additional state-listed species and 22 additional SGCN would be affected due to their presence on the federally held lands. The Land Exchange Proposed Action would result in an increase of up to 579.6 acres of habitat within the federal state in the Superior National Forest. While forested habitat would be decreased, shrubland/grassland and aquatic habitats would be increased as part of the Land Exchange Proposed Action. Under the Land Exchange Proposed Action, lands to be acquired would be managed by the USFS in accordance with the current Forest Plan. No activities are planned on these lands.

Under the Land Exchange Alternative B, one additional state-listed species but one less SGCN would be affected because they occur within the federal estate. Forest habitat under federal ownership would also decrease, though by a smaller amount than under the Land Exchange Proposed Action. Similarly, the Land Exchange Alternative B would result in an increase of 173.6 acres of habitat to the federal estate, with a distribution of habitat similar to the Land Exchange Proposed Action. As with the Land Exchange Proposed Action, lands acquired under the Land Exchange Alternative B would be managed by the USFS in accordance with the current Forest Plan. There are no activities planned on these lands.

As discussed in the Biological Evaluation, the USFS determined that the Land Exchange Proposed Action and Land Exchange Alternative B may affect individuals but are not likely to cause a trend to federal listing or loss of viability for 18 RFSS terrestrial wildlife species on the Superior National Forest.

Under the Land Exchange No Action Alternative, no action would be taken. No lands would be exchanged and no changes in wildlife species on the federal estate would be anticipated. As discussed in the Biological Evaluation, the Land Exchange No Action Alternative would have no effect on RFSS species.

Table 5.3.5-1 Increase or Decrease of Special Status Wildlife Species on the Federal Estate Resulting from the Land Exchange Proposed Action and Alternatives

	Increase or (Decrease) of Special Status Wildlife Species			
Alternative	**Federally Listed Species**	**State-listed Species**	**Regional Forester Sensitive Species**	**Species of Greatest Conservation Need**
Land Exchange Proposed Action	0	2	0	22
Land Exchange Alternative B	0	2	0	(1)
Land Exchange No Action Alternative	0	0	0	0

Table 5.3.5-2 Increase or Decrease of Key Habitat Types on the Federal Estate Resulting from the Land Exchange Proposed Action and Alternatives

	Increase or (Decrease) of Acres[1] of Key Habitat Types				
Alternative	**Mature Upland Forest, Continuous Upland/Lowland Forest (MIH1-13)**	**Open Ground, Bare Soils (no MIH)**	**Grassland and Brushland, Early Successional Forest (no MIH)**	**Aquatic Environments (MIH 14)**	**Total Net Increase or (Decrease)**
Land Exchange Proposed Action	(787.9)	(63.8)	1,224.9	206.5	579.6
Land Exchange Alternative B	(1,279.3)	(29.1)	1,257.2	224.8	173.6
Land Exchange No Action Alternative	0	0	0	0	0

Source: Tables 5.3.4-2 and 5.3.4-7.

Note:
1 Total acres may be more or less than presented due to rounding.

5.3.5.1 Methodology and Evaluation Criteria

Evaluation was conducted to determine the potential effect that the Land Exchange Proposed Action would have on wildlife on the federal estate species from the following:

- A change in federal and state-listed ETSC, SGCN, RFSS, and other wildlife species; and
- A change in habitat availability, prey species habitat availability, habitat connectivity, and adjacent land use.

Analysis of wildlife species affected by the Land Exchange Proposed Action was guided by evaluation criteria that were developed by the USFS and other Co-lead Agencies, which included a comparison of the vegetation land cover and habitat types, forest age classes (young, immature, and mature), large mature forest patches, road and trail densities, federal and state-listed ETSC, SGCN, RFSS, and other wildlife species. GIS data and field observations for these categories were gathered to the extent possible and then compared over an area of analysis that included the federal and non-federal lands and LAU.

5.3.5.2 Land Exchange Proposed Action

5.3.5.2.1 Federally Listed Species

Canada Lynx

The federal lands of the Land Exchange Proposed Action include lynx habitat and habitat for lynx prey species. Lynx habitat includes a wide variety of upland and lowland habitats and forest types/ages, shrubland, and grasslands, but excludes aquatic environments and disturbed areas. Preferred denning habitat is typically found in mature forest and is generally more dependent on forest age classes, with trees older than saplings and with a dbh greater than 5 inches (immature and mature age classes; see Table 4.3.4-3). Snowshoe hare are the primary prey species for the

Canada lynx, and hare habitat includes all types and age classes of forest and shrubland, but not aquatic environments, disturbed areas, or grassland/croplands (see Table 5.3.5-3).

Table 5.3.5-3 Increase or Decrease in Suitable Habitat Types for Canada Lynx and Prey Species on the Federal Estate Resulting from the Land Exchange Proposed Action and Alternatives

Parcel	General Suitable Lynx Habitat (Acres[1])	Suitable Denning Habitat (Acres[1])	Suitable Snowshoe Hare Forage Habitat (Acres[1])	Unsuitable Lynx Habitat (Acres[1])
Land Exchange Proposed Action				
Federal Lands	6,371.5	5,393.4	6,365.3	123.9
Non-Federal Lands Total	6,808.4	5,364.3	6,776.7	250.8
Tract 1 – Hay Lake	4,675.1	3,720.0	4,643.4	251.1
Tract 2 – Lake County North	263.3	219.5	263.3	1.8
Tract 2 – Lake County South	112.8	48.4	112.8	4.0
Tract 3 – Wolf Lands 1	125.9	113.9	125.9	0.0
Tract 3 – Wolf Lands 2	767.9	683.8	767.9	0.0
Tract 3 – Wolf Lands 3	277.4	96.7	277.4	0.0
Tract 3 – Wolf Lands 4	404.7	359.7	404.7	0.0
Tract 4 – Hunting Club	150.7	92.2	150.7	9.6
Tract 5 – McFarland Lake	30.6	30.1	30.6	0.2
Net Increase/(Decrease)	436.9	(29.1)	411.4	126.9
Land Exchange Alternative B				
Smaller Federal Parcel	4,697.2	3,912.9	4,695.0	55.4
Tract 1 – Hay Lake	4,675.1	3,720.0	4,643.4	251.1
Net Increase/(Decrease)	(22.1)	(192.9)	(51.6)	195.7

Source: Tables 5.2.5-5, 4.3.4-3, and 4.3.4-8.

Note:
[1] Total acres may be more or less than presented due to rounding.

As shown in Table 5.3.5-3, the federal lands of the Land Exchange Proposed Action include 6,371.5 acres of suitable general habitat for lynx. The non-federal lands include a total of 6,808.4 acres of potentially suitable habitat, which is an increase of 436.9 acres. Aquatic environments and disturbed areas are considered unsuitable habitat, along with lowlands with dead trees (though this habitat was not specifically called out in habitat/cover data). The Land Exchange Proposed Action would also result in an increase to the federal estate of 411.4 acres of hare habitat. However, the Land Exchange Proposed Action would result in a decrease to the federal estate of 29.1 acres of denning habitat and an increase of 126.9 acres of unsuitable lynx habitat.

Lynx may utilize snow packed trails and roads as travel corridors as they are energetically easier to navigate, but they do not rely strictly on them. The federal lands do not contain any established snow packed trails (such as snowmobile trails) but are crossed by 6.9 miles of road surface. The non-federal lands are crossed by 0.03 mile of snow packed trail (snowmobile trail) and 2.2 miles of roads. The Land Exchange Proposed Action would result in a decrease to the federal estate of 4.7 miles of road and an increase to the federal estate of 0.03 mile of snow packed trails available for lynx use (see Table 5.3.5-4).

Table 5.3.5-4 Increase or Decrease of Lynx Travel Corridors on the Federal Estate Resulting from the Land Exchange Proposed Action and Alternatives

Travel Corridor Type	Established Snow Pack Trails (Miles)	Established Roads (Miles)
Land Exchange Proposed Action		
Federal Lands	0.0	6.9
Non-Federal Lands Total	0.03	2.2
Tract 1 – Hay Lake	0.0	2.2
Tract 2 – Lake County North	0.0	0.0
Tract 2 – Lake County South	0.0	0.0
Tract 3 – Wolf Lands 1	0.0	0.0
Tract 3 – Wolf Lands 2	0.0	0.0
Tract 3 – Wolf Lands 3	0.03	0.0
Tract 3 – Wolf Lands 4	0.0	0.0
Tract 4 – Hunting Club	0.0	0.0
Tract 5 – McFarland Lake	0.0	0.0
Net Increase/(Decrease)	0.03	(4.7)
Land Exchange Alternative B		
Smaller Federal Parcel	0.0	6.9
Tract 1 – Hay Lake	0.0	2.2
Net Increase/(Decrease)	0.0	(4.7)

Source: USFS 2011e.

Land ownership immediately adjacent to the federal lands is a mix of private, state, and federal. The proximity of private lands and disturbance to the north and west may limit lynx passage and utilization of habitat on the federal lands.

Overall, the land ownership patterns surrounding the non-federal lands are mixed. Federal land proximity and, thus potential habitat connectivity, is marginal on Tract 1. Connectivity on the other tracts is generally more favorable. Located in less developed areas of the Superior National Forest, these tracts are generally bordered by federal, state, or county lands and are intended to reduce fragmentation. As such, the Land Exchange Proposed Action is likely to result in generally improved habitat connectivity overall.

Because all federal and non-federal lands are located within lynx critical habitat and would remain so regardless of ownership, the Land Exchange Proposed Action would not result in a change to lynx critical habitat to the federal estate. As previously discussed, LAU were identified for purposes of analysis and development of conservation measures for lynx (USFS 2004b). The federal lands are located within LAU 12 and the non-federal lands are located in LAU 4, 16, 21, 22, and 42. Tract 1 is not located within an LAU. The USFS indicated that no development or activities are planned on the non-federal lands, which means that there would be no increase in unsuitable habitat due to the Land Exchange Proposed Action (see Table 5.3.5-5). As such, the percentage of currently unsuitable habitat in the overall LAU is not expected to change, nor would it affect the Forest Plan condition that unsuitable habitat not exceed 30 percent of the LAU (USFS 2013).

Table 5.3.5-5 Increase or Decrease in Lynx Analysis Units on the Federal Estate Resulting from the Land Exchange Proposed Action and Alternatives

Parcel	Lynx Analysis Unit	Total Acres[1] of Proposed Land Exchange Federal/Non-Federal Land Within LAU	Overall Lynx Analysis Unit Acreage[1]	Current Percentage (%) of LAU Unsuitable (Determined by USFS)
Land Exchange Proposed Action				
Federal Parcel	12	6,495.4	70,980.5	4.0
Non-Federal Lands Subtotal		2,149.7		
Tract 1 – Hay Lake	No LAU	NA	NA	NA
Tract 2 – Lake County North	16	265.2	76,108.3	4.4
Tract 2 – Lake County South	22	116.9	58,154.2	1.6
Tract 3 – Wolf Lands 1	16	126.0	76,108.3	4.4
Tract 3 – Wolf Lands 2	21	768.0	73,265.8	4.2
Tract 3 – Wolf Lands 3	21	277.5	73,265.8	4.2
Tract 3 – Wolf Lands 4	21	404.8	73,265.8	4.2
Tract 4 – Hunting Club	4	160.4	55,071.4	4.9
Tract 5 – McFarland Lake	42	30.9	32,305.4	1.9
Net Increase/(Decrease)		(4,345.7)		
Land Exchange Alternative B				
Smaller Federal Parcel	12	4,752.7		
Tract 1 – Hay Lake	No LAU	NA	NA	NA
Net Increase/(Decrease)		(4,752.7)		

Source: Superior National Forest Monitoring and Evaluation Report (USFS 2009a)

Note:
1 Total acres may be more or less than presented due to rounding.

The Land Exchange Proposed Action would have mixed effects for the Canada lynx. It would result in an increase to the federal estate of overall suitable habitat for lynx and for snowshoe hare (prey species) to the federal estate (although the amount of unsuitable lynx habitat would also increase). It would also result in a decrease to the federal estate of denning habitat and a decrease of federal lands within designated LAU. Critical lynx habitat would not change regardless of ownership. Effects on the Canada lynx and its critical habitat are described in more detail in the Biological Assessment.

Gray Wolf

The federal lands are likely part of a territory occupied by a single pack of wolves. The federal lands are dominated by trees that range in age from immature to mature, which is adequate cover habitat for wolves. Approximately 271 acres of young forest are present for forage opportunities on the federal lands and 778 acres are present on the non-federal lands (see Table 4.3.4-3). There are 5,393.4 acres of cover habitat on the federal lands and 5,364.3 acres on the non-federal lands (see Table 5.3.5-6). Gray wolves or their sign were observed on Tracts 1, 2, 3, and 5.

Table 5.3.5-6 Increase or Decrease in Gray Wolf Habitat on the Federal Estate Resulting from the Land Exchange Proposed Action and Alternatives

Parcel	Forage Habitat (Acres)	Cover Habitat (Acres[1])
Land Exchange Proposed Action		
Federal Lands	271.1	5,393.4
Non-Federal Lands Total	778.2	5,364.3
Tract 1 – Hay Lake	533.8	3,720.0
Tract 2 – Lake County North	24.4	219.5
Tract 2 – Lake County South	43.3	48.4
Tract 3 – Wolf Lands 1	2.2	113.9
Tract 3 – Wolf Lands 2	7.6	683.8
Tract 3 – Wolf Lands 3	130.4	93.7
Tract 3 – Wolf Lands 4	9.5	359.7
Tract 4 – Hunting Club	27.0	92.2
Tract 5 – McFarland Lake	0.0	30.1
Net Increase/(Decrease)	507.1	(29.1)
Land Exchange Alternative B		
Smaller Federal Parcel	271.1	3,912.9
Tract 1 – Hay Lake	533.8	3,720.0
Net Increase/(Decrease)	262.7	(192.9)

The amount of cover habitat is similar between the federal and non-federal lands, but the non-federal lands include more potential forage habitat; therefore, the Land Exchange Proposed Action would result in a very small decrease (29.1 acres) to the federal estate of cover habitat but an increase to the federal estate of forage habitat (507.1) for the gray wolf. Overall, the Land Exchange Proposed Action would result in an increase (to the federal estate) of the number of occurrences and habitat availability for the gray wolf.

Northern Long-Eared Bat

Potential summer roosting and foraging habitat for the northern long-eared bat is present and individuals have been observed on the federal lands, though no hibernacula have been observed. Similarly, both forage and potential summer roosting habitat is present on the non-federal lands, though no hibernacula have been observed. Bats were observed, though not identified to species, on Tract 1 during field studies in 2009. The Land Exchange Proposed Action would result in a net decrease of mature forest habitat to the federal estate, but an increase in grassland/ brushland, which constitutes a decrease in potential bat roosting habitat but increase in foraging habitat within the federal estate. Effects on the northern long-eared bat are described in more detail in the Biological Assessment and Biological Evaluation.

5.3.5.2.2 State-listed Species

Moose

There is habitat present on the federal lands for the moose, and individuals and their sign have been observed during surveys. Similarly, there is habitat present, and moose individuals or their sign have been observed on Tracts 1, 2, and 3. The Land Exchange Proposed Action would result in a decrease of mature mixed forest types on the federal estate, but an increase in moose preferred habitats, including early successional forests, brushland, and aquatic environments. As moose or their sign have been observed on both the federal and non-federal lands, there would be neither an increase nor decrease in occurrences to the federal estate.

Little Brown Bat

Habitat for the little brown bat is present and individuals have been observed on the federal lands, though no hibernacula have been observed. Similarly, both forage and potential summer roosting habitat may be present on the non-federal lands, though no hibernacula have been observed. Bats were observed, though not identified to species, on Tract 1 during field studies in 2009. The Land Exchange Proposed Action would result in a net decrease of mature forest habitat to the federal estate, but an increase in grassland/ brushland, which constitutes a decrease in potential bat roosting habitat but increase in foraging habitat within the federal estate.

Eastern Pipistrelle

Habitat for the eastern pipistrelle is present on the federal lands, but no hibernacula or individuals have been observed. Similarly, both forage and potential summer roosting habitat may be present on the non-federal lands, though no hibernacula have been observed. Bats were observed, though not identified to species, on Tract 1 during field studies in 2009. The Land Exchange Proposed Action would result in a net decrease of mature forest habitat to the federal estate, but an increase in grassland/ brushland, which constitutes a decrease in potential bat roosting habitat but increase in foraging habitat within the federal estate.

Northern Goshawk

The northern goshawk may be occasionally present since northern goshawk nests have been observed on the federal parcel. Northern goshawk individuals and nests have also been identified on Tract 1 since 2010, and an active northern goshawk territory (Pike Mountain 2 territory) has been identified and is being monitored by the MDNR. According to the MDNR NHIS database, there have also been northern goshawk observations within 10 miles of the non-federal lands (Tract 1, Tract 3, and Tract 4). More forested habitat for the species is present on the federal lands than the non-federal lands (see Table 5.3.5-2). As such, the Land Exchange Proposed Action would result in a decrease of forested habitat available for the northern goshawk on the federal estate.

Boreal Owl

Mature coniferous and deciduous forests are available as potential habitat for the boreal owl on the federal lands and non-federal lands. However, there would be a decrease of these forests to the federal estate under the Land Exchange Proposed Action (see Table 5.3.5-2). No boreal owls are known to occur on the non-federal lands, and one boreal owl was observed near the federal lands in 1988 to 1989. According to the MDNR NHIS database, there have been boreal owl observations within 10 miles of the non-federal lands (Tract 2, Tract 3, and Tract 5). It is unlikely boreal owls use either the federal or non-federal lands often.

Wood Turtle

The only known population of wood turtles near the federal lands is downstream from the Mine Site, along the southern border of the federal lands. Though there is no known suitable habitat for wood turtles on the federal lands and no individuals are known to occur, wood turtles may use adjacent areas to the south of the federal lands. Similarly, no wood turtles or optimal wood turtle habitat was identified on the non-federal lands. According to the MDNR NHIS database, there have been wood turtle observations within 10 miles of the non-federal lands (Tract 1, Tract 2, and Tract 3).

Given that no wood turtles or wood turtle habitat were identified on either the federal or non-federal lands, the Land Exchange Proposed Action would not result in an increase or decrease of individuals, populations, or suitable habitat.

Eastern Heather Vole

The eastern heather vole has not been observed during field surveys or within 10 miles of the federal lands. Approximately 2,292 acres of potentially suitable habitat (upland coniferous forest, upland mixed forest, shrubland, and cropland/grassland) exists on the federal lands (see Table 4.3.4-1), so the eastern heather vole could be present, but, if so, likely in very small numbers. The eastern heather vole was not identified on the non-federal lands by surveys or in the NHIS, but the non-federal lands contain 2,626.5 acres of habitat (see Table 4.3.4-10). According to the MDNR NHIS database, there have been eastern heather vole observations within 10 miles of the non-federal lands (Tract 3). As such, the Land Exchange Proposed Action would result in an increase to the federal estate of up to 334.9 acres of habitat.

Yellow Rail

The yellow rail was not found during surveys and was not reported in the NHIS database within 10 miles of the federal lands. As previously mentioned, small, scattered areas of its preferred habitat are present on the federal lands (35.7 acres), but not the minimum nesting patch size (54 acres) needed for the species (see Table 4.3.3-1). No yellow rails or yellow rail habitat were identified on the non-federal lands. The Land Exchange Proposed Action would not result in a net change to the species or habitat.

Laurentian Tiger Beetle

The lack of suitable habitat and any recorded observations for the Laurentian tiger beetle suggest that the species does not occur on the federal lands. However, the habitat for the Laurentian tiger beetle is present at Tract 1, in an area formerly used as a sand and gravel mine. No disturbance activities are currently planned on the non-federal lands, so this potential habitat would be preserved. According to the MDNR NHIS database, there have been Laurentian tiger beetles observed within 10 miles of the non-federal lands (Tract 4). As such, the Land Exchange Proposed Action would result in an increase of suitable habitat for this species.

Taiga Alpine

Lowland coniferous swamp is present on both the federal lands and non-federal lands, which is potential habitat for the taiga alpine. However, there would be a decrease to the federal estate of lowland coniferous swamp habitat under the Land Exchange Proposed Action. According to the MDNR NHIS database, there are no known occurrences of taiga alpine within 10 miles of the federal lands, and none were observed during surveys. There have been taiga alpine observations within 10 miles of the non-federal lands (Tract 2 and Tract 3). The Land Exchange Proposed Action would result in a decrease in potential habitat for the species but unlikely result in a change in species occurrences.

Freija's Grizzled Skipper

Grassland and shrubland is present on both the federal lands and non-federal lands, which is potential habitat for the Freija's grizzled skipper. There would be an increase to the federal estate of grassland and shrubland habitats under the Land Exchange Proposed Action. According to the MDNR NHIS database, there are no known occurrences of Freija's grizzled skipper within 10 miles of the federal lands, and none were observed during surveys. There have been Freija's grizzled skipper observations within 10 miles of the non-federal lands (Tract 2 and Tract 3). The Land Exchange Proposed Action would result in an increase in potential habitat for the species but unlikely result in a change in species occurrences.

Nabokov's Blue

Upper woodland habitat is present on both the federal lands and non-federal lands for the Nabokov's blue, though the larval host plant was not observed at either. There would be a decrease to the federal estate of upland woodland habitat under the Land Exchange Proposed Action. According to the MDNR NHIS database, there are no known occurrences within 10 miles of the federal lands, and none were observed during surveys. There have been Nabokov's blue observations within 10 miles of the non-federal lands (Tract 2, Tract 3, and Tract 5). The larval host plant, dwarf bilberry, was noted to be locally moderate to common around the observation sites. The Land Exchange Proposed Action would result in a decrease in potential habitat for the species but unlikely result in a change in species occurrences.

Quebec Emerald

The Quebec emerald dragonfly can inhabit wet meadow/sedge meadow. Approximately 36 acres of this habitat type are present on the federal lands. There has only been one documented occurrence of this species in Minnesota (Lake County in 2006), and that occurrence was not on either the federal or non-federal lands. The non-federal lands do not contain any sedge/wet meadow wetlands. The Land Exchange Proposed Action would result in a decrease of potential habitat used by this species on the federal estate.

Trumpeter Swan

Trumpeter swans were observed on Tract 1 during surveys in 2009. A pair of adults with young was seen on Little Rice Lake. The species has not been observed on the federal lands. According to the MDNR NHIS database, there have been trumpeter swan observations within 10 miles of the non-federal lands (Tract 1, Tract 2, and Tract 3). Because the species has been observed on the non-federal lands and not on the federal lands, the Land Exchange Proposed Action would result in an increase of the occurrence of this listed species within the federal estate.

5.3.5.2.3 Species of Greatest Conservation Need

Sections 4.3.5.1.1 and 4.3.5.2 discuss the SGCN in the context of their habitat. The federal lands include a wide variety of habitat types, grouped into key habitat types and MIH types (see Table 5.3.5-7).

Some acreage of some key habitat types, MIH types, and cover types within the federal estate would increase through the Land Exchange Proposed Action, while others would decrease. The key habitat types that would increase or decrease under the Land Exchange Proposed Action are listed in Table 5.3.5-7. Species dependent on these habitat types are listed by ecological subsection in Tables 4.3.5-1 through 4.3.5-5.

Table 5.3.5-7 Increase or Decrease of Habitat Types on the Federal Estate Resulting from the Land Exchange Proposed Action

Key Habitat Type and Management Indicator Habitat	Federal Lands Acres	Non-Federal Lands[1,2] Tract 1 – Hay Lake Lands Acres	Tract 2 – Lake County Lands Acres	Tract 3 – Wolf Lands Acres	Tract 4 – Hunting Club Lands Acres	Tract 5 – McFarland Lake Lands Acres	Net Increase or (Decrease) Acres
Mature Upland Forest, Continuous Upland/Lowland Forest (MIH1-13)	5,719.7	2,978.8	337.2	1,479.4	105.7	30.6	(788.0)
Open Ground, Bare Soils (no MIH)	63.8	0.0	0.0	0.0	0.0	0.0	(63.8)
Grassland and Brushland, Early Successional Forest (no MIH)	651.8	1,696.3	38.9	96.5	45.0	0.0	1,224.9
Aquatic Environments (MIH 14)	60.1	251.1	5.8	0.0	9.6	0.2	206.6
Total	6,495.4	4,926.2	381.9	1,575.9	160.3	30.8	579.7

Note:
1 According to non-federal land cover type summary tables (see Tables 4.3.4-1, 4.3.4-11, 4.3.4-13-20).
2 Total acres may be more or less than presented due to rounding.

The Land Exchange Proposed Action would result in a decrease of 788.0 acres of forest habitat and 63.8 acres of open ground/bare soil to the federal estate. In addition, the Land Exchange Proposed Action would result in an increase of 1,224.9 acres of grassland/brushland and 206.6 acres of aquatic environment to the federal estate. Overall, the Land Exchange Proposed Action would result in an increase of up to 579.7 acres of habitat to the federal estate, though there would be a decrease of forest and open ground habitat. As such, forest-dependent species are more likely to be affected through habitat decrease by the Land Exchange Proposed Action. Grassland and brushland species (mostly bird species and one species of insect) would have more habitat available under the Land Exchange Proposed Action, as would species dependent on aquatic environments (bird species, reptile/amphibian species, and insect species). Overall, the Land Exchange Proposed Action would result in an increase of SGCN habitat to the federal estate.

5.3.5.2.4 Regional Forester Sensitive Species

A Biological Evaluation has been prepared that contains further information about RFSS. The Biological Evaluation is included in Appendix D. Similar to the Biological Assessment, the organization of the methodologies and discussion in the Biological Evaluation may be different from the FEIS. The Biological Evaluation also contains determinations of effect for RFSS species.

The USFS determined that the Land Exchange Proposed Action and Land Exchange Alternative B may affect individuals but are not likely to cause a trend to federal listing or loss of viability for 18 RFSS terrestrial wildlife species on the Superior National Forest.

Of the 18 terrestrial RFSS on the 2011 list for the Superior National Forest, the gray wolf, eastern heather vole, northern long-eared bat, little brown bat, eastern pipistrelle, northern goshawk, boreal owl, wood turtle, taiga alpine, Freija's grizzled skipper, Nabokov's blue, and Quebec emerald dragonfly are discussed above as federally or state-listed species. Three additional RFSS (the olive-sided flycatcher, bay-breasted warbler, and Connecticut warbler) are included as SGCN and are also discussed above. The three remaining RFSS species are discussed below. Effects on the RFSS are described in more detail in the Biological Evaluation.

Bald Eagle

As discussed in Section 5.2.5.2.2, eagles may utilize the area around the federal lands. The federal lands are located between the Embarrass and Partridge rivers, which eagles may use for foraging. Mud Lake may also be used for foraging. The nearest known nesting sites are more than 2 miles (5.8 miles south-southwest of the federal lands) from the federal lands and optimal habitat for nesting is not present. Eagles may utilize Mud Lake for nesting, though they tend to utilize larger lakes for nesting. Though optimal nesting and foraging habitat are not present in the federal lands, eagles may still utilize these areas.

Eagle habitat is present on several of the non-federal lands. Though they are smaller waterbodies than are optimal for eagles, Tract 1 includes the Pike River, Hay Lake, and Rice Lake. Tracts 2 and 3 are located near large lakes such as Pine and Greenwood. Tract 5 borders McFarland Lake, which is connected to other lakes within the BWCAW. With the exception of Tract 1, these lands are also further from developed mining areas and disturbances are less likely than on the federal lands. Overall, the Land Exchange Proposed Action would result in an increase (to the federal estate) of the number of occurrences and habitat availability for the bald eagle.

Great Gray Owl

Though not observed during call surveys, the great gray owl may be occasionally present on the federal lands. Because owl calling surveys (ENSR 2005) found no great gray owls, populations in the area are likely small and/or occasional. No observations of great gray owls have been made on the non-federal lands. However, because the species utilizes forested habitat and the Land Exchange Proposed Action would result in a decrease of 788.0 acres of forested habitat, the Land Exchange Proposed Action would result in a decrease of this species' habitat on the federal estate.

Three-Toed Woodpecker

A three-toed woodpecker was identified on the federal lands during surveys in 2000 and was observed on the parcel again in 2007. Area populations are expected to be low, and these habitat specialists require standing dead or dying trees where they can forage for bark beetles. The species has not been observed on the non-federal lands. As such, the Land Exchange Proposed Action would result in a decrease of this species' occurrence. Since the Land Exchange Proposed

Action would result in a decrease of approximately 788.0 acres of forest, the Land Exchange Proposed Action would also result in a habitat decrease for this species on the federal estate.

Other factors, such as lower disturbance levels and increase of contiguous habitat, would potentially increase RFSS utilization of the non-federal lands. The federal lands contain two stands of contiguous forest habitat greater than 300 acres (340.6 acres and 1,352.3 acres) while the non-federal lands include one forest stand greater than 300 acres (598.2 acres – Tract 3, Wolf Lands 2). The Land Exchange Proposed Action would result in a net decrease of 1,094.7 acres of contiguous habitat stands greater than 300 acres to the federal estate.

5.3.5.2.5 Other Wildlife Species

Other regionally common wildlife species, such as ravens, grouse, beaver, wolves, black bear, white-tailed deer, fox, marten, and snowshoe hare, have been observed on both the federal and non-federal lands. Effects on wildlife species important to the Bands are discussed in Section 5.2.9 on a connected ecosystems level. Similar to SGCN, habitat for some other species of wildlife would increase via the Land Exchange Proposed Action while habitat would decrease for others. As previously discussed, forested habitat would decrease via the Land Exchange Proposed Action, but grassland/shrubland habitat and aquatic habitat would increase. Grassland and brushland species would have more habitat available under the Land Exchange Proposed Action, as would species dependent on aquatic environments. The Land Exchange Proposed Action would result in 579.7 additional acres of wildlife habitat to the federal estate.

Game species such as white-tailed deer and black bear are of significant concern to the Bands. As mentioned above, forested habitat on the federal estate would decrease under the Land Exchange Proposed Action, but grassland and brushland and aquatic habitat would increase. The Land Exchange Proposed Action would result in increased hunting opportunities on the federal estate, as the non-federal lands would become available for use while the federal lands, which currently have limited access, would become private.

5.3.5.3 Land Exchange Alternative B

Under the Land Exchange Alternative B, a smaller federal parcel would be exchanged for only one non-federal parcel, Tract 1. The effects that would result from this alternative are similar to those of the Land Exchange Proposed Action.

5.3.5.3.1 Federally Listed Species

Canada Lynx

As shown in Table 5.3.5-3, the smaller federal parcel includes 4,697.2 acres of suitable general habitat for lynx. Tract 1 has a total of 4,675.1 acres of habitat potentially suitable for the Canada lynx, which would result in a decrease of 22.1 acres to the federal estate. The Land Exchange Alternative B would also result in a decrease of 192.9 acres of denning habitat. Snowshoe hare habitat would increase by 51.6 acres, but there would also be an increase of 195.7 acres of unsuitable lynx habitat to the federal estate under the Land Exchange Alternative B.

The smaller federal parcel does not contain any established snow packed trails (such as snowmobile trails) but is crossed by 6.9 miles of road surface. Tract 1 is crossed by 2.2 miles of roads and no established snow trails. Since lynx use snow packed trails and roads as travel corridors, the Land Exchange Alternative B would result in a decrease to the federal estate of 4.7 miles of road use for lynx.

Land ownership under the Land Exchange Alternative B would be similar to the Land Exchange Proposed Action, but the smaller federal parcel would be bordered to the west by USFS-managed federal lands. Tract 1 is bordered by federal lands to the north, west, and partially east, but the area is generally surrounded by private lands and developed areas. Habitat connectivity to Tract 1 is marginal. The Land Exchange Alternative B is likely to result in limited habitat connectivity overall. Similar to the Land Exchange Proposed Action, the smaller federal parcel and non-federal lands are located within lynx critical habitat and would remain so regardless of ownership; the Land Exchange Alternative B would not result in a change to lynx critical habitat. As shown in Table 5.3.5-5, the Land Exchange Alternative B would result in the decrease of 4,753 acres of land within an LAU because the federal parcel is within an LAU, but the Tract 1 lands are not.

The Land Exchange Alternative B would have mixed habitat effects for the Canada lynx. It would result in a decrease of overall suitable habitat for lynx and denning habitat, but would result in an increase of suitable snowshoe hare habitat. It would also result in a decrease of federal lands within designated LAUs. Critical lynx habitat would not change regardless of ownership. As such, the Land Exchange Alternative B is not likely to have either a net increase or decrease on Canada lynx on the federal estate.

Gray Wolf

Gray wolves have been observed on both the smaller federal parcel and on Tract 1. Approximately 271 acres of forage habitat is present on the smaller federal parcel (young age class, see Table 5.3.4-4) and 533.8 acres are present on Tract 1. There are 3,912.9 acres of cover habitat on the smaller federal parcel (immature and mature age classes) and 3,720.0 acres on Tract 1. This would result in an increase of 262.8 acres of forage habitat but also in a decrease of 192.9 acres of cover habitat on the federal estate under Land Exchange Alternative B.

Northern Long-Eared Bat

Potential summer roosting and foraging habitat for the northern long-eared bat is present and individuals have been observed on the smaller federal parcel, though no hibernacula have been observed. Bats were observed, though not identified to species, on Tract 1 during field studies in 2009. The Land Exchange Alternative B would result in a net decrease of mature forest habitat to the federal estate, but an increase in grassland/brushland, which constitutes a decrease in potential summer roosting habitat but increase in foraging habitat within the federal estate.

5.3.5.3.2 State-listed Species

Wood Turtle

No wood turtles or optimal wood turtle habitat were identified on Tract 1 or the smaller federal parcel. According to the MDNR NHIS database, there have been wood turtles observed within 10 miles of the non-federal lands (Tract 1). As such, the Land Exchange Alternative B would not result in an increase or decrease of habitat for the species on the federal estate.

Eastern Heather Vole

The eastern heather vole has not been observed during field surveys within 10 miles of the federal lands. There are 1,261.6 acres of potentially suitable habitat on the smaller federal parcel (see Table 4.3.4-6). Eastern heather voles were not identified on the non-federal lands by surveys or in the NHIS, but Tract 1 contains 2,133.6 acres of habitat, which would result in an increase of 872.0 acres of habitat for the eastern heather vole on the federal estate. As such, the Land Exchange Alternative B would result in an increase of habitat for this species.

Yellow Rail

The yellow rail was not found during surveys and was not reported in the NHIS database within 10 miles of the federal lands. As previously mentioned, small, scattered areas of its preferred habitat are present on the federal lands (34.9 acres), but not the minimum nesting patch size (54 acres) needed for the species. Similar to the Land Exchange Prosed Action, the Land Exchange Alternative B would not result in a net change to the species or its habitat on the federal estate.

Laurentian Tiger Beetle

Similar to the Land Exchange Proposed Action, the lack of suitable habitat and any recorded observations for the Laurentian tiger beetle suggest that the species does not occur on the smaller federal parcel. However, habitat for the Laurentian tiger beetle is present on Tract 1, in an area formerly used as a sand and gravel mine. No disturbance activities are currently planned on Tract 1, so this potential habitat would be preserved. As such, the Land Exchange Alternative B, similar to the Land Exchange Proposed Action, would result in an increase of suitable habitat for the species on the federal estate.

Taiga Alpine

There is potential habitat present for the taiga alpine on both the Alternative B: Smaller Federal Parcel and Tract 1 lands. Under the Land Exchange Alternative B, there would be a decrease to the federal estate of lowland coniferous swamp habitat, and therefore a decrease in potential habitat for the species, but it is unlikely this would result in a change in species occurrences.

Freija's Grizzled Skipper

There is potential habitat present for the Freija's grizzled skipper on both the Alternative B: Smaller Federal Parcel and Tract 1 lands. Under the Land Exchange Alternative B, there would be an increase to the federal estate of grassland and shrubland habitats, and therefore an increase in potential habitat for the species, but it is unlikely this would result in a change in species occurrences.

Nabokov's Blue

There is potential habitat present for the Nabokov's blue on both the Alternative B: Smaller Federal Parcel and Tract 1 lands, though the larval host plant was not observed at either. Under the Land Exchange Alternative B there would be a decrease to the federal estate of upland woodland habitat and a decrease in potential habitat for the species; but it is unlikely this would result in a change in species occurrences.

Quebec Emerald

The Quebec emerald dragonfly has not been identified on the smaller federal parcel, as there has only been one documented occurrence of this species in Minnesota in Lake County in 2006 (Minnesota Odonata Survey Project 2012). Tract 1 does not contain any sedge/wet meadow wetlands, and so the Land Exchange Alternative B would result in a decrease of potential habitat used by this species on the federal estate.

Trumpeter Swan

Trumpeter swans were observed on Tract 1 during surveys in 2009. A pair of adults with young was seen on Little Rice Lake. The species has not been observed on the smaller federal parcel. Similar to the Land Exchange Proposed Action, because the species has been observed on Tract 1 but not on the smaller federal parcel, the Land Exchange Alternative B would result in an increase of the occurrence of this listed species within the federal estate.

5.3.5.3.3 Species of Greatest Conservation Need

Like the Land Exchange Proposed Action, the SGCN for the Land Exchange Alternative B are discussed in the context of their habitat. The smaller federal parcel also includes a wide variety of habitat types, grouped into key habitat types and MIH types (see Table 5.3.5-8).

Similar to the Land Exchange Proposed Action, the Land Exchange Alternative B would result in a decrease of forest habitat (1,279.3 acres) and open ground/bare soil (29.1 acres) on the federal estate. The Land Exchange Proposed Action, however, would result in an increase of grassland/brushland (1,257.2 acres) and aquatic environments (224.8 acres) on the federal estate. Overall, the Land Exchange Proposed Action would result in an increase of up to 173.6 acres of habitat to the federal estate, though there would be a decrease of forest and open ground habitat. As such, forest-dependent species are more likely to be affected through habitat decrease under the Land Exchange Alternative B. Grassland and brushland species (mostly bird species and one species of insect) would have more habitat available under the Land Exchange Alternative B, as would species dependent on aquatic environments (bird species, reptile/amphibian species, and insect species). Overall, the Land Exchange Alternative B would result in an increase of SGCN habitat to the federal estate.

Table 5.3.5-8 Increase or Decrease of Habitat Types on the Federal Estate Resulting from Land Exchange Alternative B

Key Habitat Type and Management Indicator Habitat	Smaller Federal Parcel (Acres)	Non-Federal Land Tract 1 (Acres)	Net Increase or (Decrease) (Acres)
Mature Upland Forest, Continuous Upland/Lowland Forest (MIH1-13)	4,258.1	2,978.8	(1,279.3)
Open Ground, Bare Soils (no MIH)	29.1	0.0	(29.1)
Grassland and Brushland, Early Successional Forest (no MIH)	439.1	1,696.3	1,257.2
Aquatic Environments (MIH 14)	26.3	251.1	224.8
Total[1]	4,752.6	4,926.2	173.6

Note:

[1] Total acres may be more or less than presented due to rounding.

5.3.5.3.4 Regional Forester Sensitive Species

Bald Eagle

As under the Land Exchange Proposed Action, the smaller federal parcel and surrounding areas may be utilized by bald eagles. Similar to the Land Exchange Proposed Action, the smaller federal parcel is also located between the Embarrass and Partridge rivers, which eagles may use for foraging. However, the smaller federal parcel excludes a portion of Mud Lake. The nearest known nesting sites are greater than 2 miles (5.8 miles south-southwest of the smaller federal parcel) from the federal lands and optimal habitat for nesting is not present.

Tract 1 contains waterbodies (Pike River, Hay Lake, and Rice Lake) and large trees, which eagles may use for nesting, though no nests have been observed. The nearest known eagle nest is approximately 4 miles southwest of the parcel.

Great Gray Owl

Though not observed during call surveys, the great gray owl may be occasionally present on the smaller federal parcel, as an individual was observed along Dunka Road south of the Mine Site in 2009. No observations of great gray owls have been made on Tract 1. However, because the species utilizes forested habitat and the Land Exchange Alternative B would result in a decrease of 1,279.3 acres of forested habitat, the Land Exchange Alternative B would result in a decrease of this species' habitat on the federal estate.

Three-Toed Woodpecker

Three-toed woodpeckers were observed on or near the smaller federal parcel in 2000 and again in 2007. Area populations are expected to be low, and the species has not been observed on Tract 1. As such, the Land Exchange Alternative B would result in the decrease of this species' occurrence. Since the Land Exchange Alternative B would result in a decrease of 1,279.3 acres of forest, this would result in a habitat decrease for this species on the federal estate.

Other factors, such as lower disturbance levels and increase of contiguous habitat, would potentially increase RFSS utilization of Tract 1 lands. The smaller federal parcel contains two stands of contiguous forest habitat greater than 300 acres (340.6 and 926.1 acres) while there are no stands greater than 300 acres on Tract 1.

5.3.5.3.5 Other Wildlife Species

Similar to the Land Exchange Proposed Action, forested habitat within the federal estate would decrease under the Land Exchange Alternative B, but grassland/shrubland habitat and aquatic habitat would be increased. Grassland and brushland species would have more habitat available under the Land Exchange Alternative B, as would species dependent on aquatic environments. The Land Exchange Alternative B would result in 173.6 additional acres of wildlife habitat on the federal estate.

5.3.5.4 Land Exchange No Action Alternative

Under the Land Exchange No Action Alternative, the current federal lands would remain in federal ownership and would continue to be managed under the General Forest – Longer Rotation Management Area and the General Forest Management Area. Wildlife would be directly affected by logging, mineral exploration, vehicle traffic, natural disturbances, and thinning activities, which would occur as planned by the USFS, and would be indirectly affected by changes in habitat caused by forest management. However, these activities would affect wildlife to a lesser degree than under the Land Exchange Proposed Action. Section 5.2.4.3.1 provides further discussion of the effects on management of cover types and habitat on the federal lands. Under the Land Exchange No Action Alternative, the USFS has an ongoing responsibility for managing wildlife resources on Superior National Forest lands in accordance with the Forest Plan (USFS 2004b). The Land Exchange No Action Alternative would not change the Forest Service's responsibility for managing wildlife resources and would result in no change in anticipated effects on existing wildlife.

Under the Land Exchange No Action Alternative, the non-federal lands would not go into USFS ownership, and land use would be determined by the private land owners. Effects on wildlife species are difficult to predict given the uncertainty of future potential land use. Lands may be developed, resulting in potential effects on individuals and local populations, habitat decrease, and effects on wildlife travel corridors.

5.3.6 Aquatic Species

This section describes the environmental consequences of the Land Exchange alternatives on aquatic biota, using comparisons of the existing conditions presented in Sections 4.2.6 and 4.3.6 to conditions after the Land Exchange alternatives in terms of net increase or decrease in aquatic biological resources for the federal and non-federal lands.

The Land Exchange Proposed Action would result in a net increase to the federal estate of surface waters (MIH 14), including 99.1 acres of lakes, 3.8 miles of rivers, and 8.1 miles of third-order streams. It would also result in a decrease to the federal estate of 0.3 miles of first-order streams and 4.0 miles of second-order streams. The Land Exchange Proposed Action would result in an increase in watershed riparian connectivity and aquatic connectivity for the federal estate. Based on available data, the Land Exchange Proposed Action would potentially result in an increase of nine additional fish species to the federal estate, while the macroinvertebrate assemblage would be similar. The Land Exchange Proposed Action could result in an increase to the federal estate of six new potential SGCN species, based on ecoregion data.

Land Exchange Alternative B would result in a net increase to the federal estate of surface waters (MIH 14), including 120.7 acres of lakes, 2.8 miles of rivers, and 8.1 miles of third-order streams. Additionally, it would result in a decrease to the federal estate of 1.3 miles of first-order streams and 4.0 miles of second-order streams, and an increase to the federal estate of. Land Exchange Alternative B would result in an increase in watershed riparian connectivity and aquatic connectivity for the federal estate. Based on available data, Land Exchange Alternative B would potentially result in a decrease to the federal estate of four fish species, while the macroinvertebrate assemblage would likely be similar. Land Exchange Alternative B would result in no net change of SGCN species, based on ecoregion data.

The Land Exchange No Action Alternative would not result in any increase or decrease of aquatic habitats or SGCN species to the federal estate.

Rulemaking was conducted with the intent to update the list of ETSC species (*Minnesota Rules*, parts 6134.0100 to 6134.0400), with new listings becoming effective on August 19, 2013 (MDNR 2013h). The FEIS considers any new listings, or changes in the previous listings, associated with the updated list. The FEIS also considers any federal listing changes. A Biological Evaluation has been prepared that contains further information about RFSS species. The Biological Evaluation is included in Appendix D.

5.3.6.1 Methodology and Evaluation Criteria

The criteria used to describe the direct and indirect effects of the Land Exchange alternatives focused on the ecological integrity of the aquatic systems present at the federal lands and non-federal lands where physical, chemical, and biological characteristics that are important to biotic quality were considered. The spatial and temporal area of analysis for aquatic resources included the federal and non-federal lands that are proposed for the exchange based on current conditions.

The methodology used for analysis of the Land Exchange alternatives included review and evaluation of available literature, aerial photography review, and GIS analysis of all surface waters and aquatic species habitat present within the Land Exchange areas. Both quantitative and qualitative analyses were used. The analysis of the aquatic resources affected by the Land Exchange alternatives was guided by evaluation criteria that were developed by the USFS and other Co-lead Agencies as follows:

- Change in the amount of Superior National Forest MIHs (MIH 14 [aquatic habitat]) available for species on the federal and non-federal lands;
- Changes in the length of stream segments;
- Changes in the area of lake or deepwater wetland;
- Qualitative determination of community habitat and ecological value;
- Qualitative assessment of the aquatic connectivity (network created by streams, rivers, and lakes as they flow into one another) and the potential for barriers to fish passage; and
- Net change in aquatic species.

5.3.6.2 Land Exchange Proposed Action

5.3.6.2.1 Surface Water Features (MIH 14)

Comparing the footprints of the surface water features present within the federal and non-federal lands provides a direct assessment of the increase or decrease to the federal estate in aquatic environments that support aquatic biota and associated habitats. This comparison was made by analyzing the linear shoreline frontage and frontage index of the surface water features within the federal and non-federal lands, where the frontage index indicates the linear ft of lake and shoreline frontage per acre of land.

The Land Exchange Proposed Action would result in a net increase of surface water resources to the federal estate (see Table 5.3.6-1). A net increase of 99.1 acres of lake and 3.8 miles of rivers would be added to the federal estate from the Land Exchange Proposed Action. For both lakes and streams, the frontage index would increase substantially by 34.0 shoreline/acre units as a result of the exchange.

Table 5.3.6-1 Federal and Non-federal Land Surface Water Comparisons

	Lake			Rivers/Creeks/Streams		
Parcel	**Acres**	**Frontage (ft)**	**Frontage Index (shoreline/acre)**	**Miles**	**Frontage (linear ft)[1]**	**Frontage Index (shoreline/acre)[2]**
Lands Conveyed						
Federal Lands	30.5	4,550.0	0.7	5.3	55,968.0	8.6
Lands Acquired						
Tract 1 – Hay Lake	129.6	16,424.0	3.5	8.1	72,864.0	15.3
Tract 2 – Lake County	0.0	0.0	0.0	0.0	0.0	0.0
Tract 3 – Wolf Lands						
Wolf Lands 1	0.0	0.0	0.0	0.0	0.0	0.0
Wolf Lands 2	0.0	0.0	0.0	0.0	0.0	0.0
Wolf Lands 3	0.0	0.0	0.0	0.1	1,056.0	3.9
Wolf Lands 4	0.0	0.0	0.0	0.9	9,504.0	23.5
Tract 4 – Hunting Club	0.0	0.0	0.0	0.0	0.0	0.0
Tract 5 – McFarland Lake	0.0	990.0	32.1	0.0	0.0	0.0
Total Non-federal lands	129.6	17,414.0	35.6	9.1	83,424.0	42.6
Net Change						
Net Increase/(Decrease)	99.1	12,864.0	34.9	3.8	27,456.0	34.0

Notes:

Surface water shoreline distance calculated by GIS analysis.

1 Includes shoreline distance on both sides of streams.
2 Frontage Index calculated by dividing total acres of parcel by total shoreline within parcel.

5.3.6.2.2 Differences of Strahler Stream Orders and Habitat

For the purposes of this FEIS, the Strahler Order (USEPA 2011a) is used to describe the hierarchical ordering of streams, where a first-order stream describes a headwater type stream with no branching. Where two first-order streams meet, they become larger second-order streams and where two second-order streams meet, they become larger third-order streams, etc. A quantitative comparison of the Strahler Stream Order indicates the Land Exchange Proposed Action would result in a decrease of 0.3 miles of first-order headwater streams and 4.0 miles of second-order streams, and an increase in 8.1 miles of third-order streams to the federal estate (see Table 5.3.6-2).

The net increase of third-order streams and decrease in second-order streams would likely add more habitat diversity to the Superior National Forest since, generally, stream habitat diversity increases with higher-order streams. No significant habitat changes would likely occur associated with the slight decreases in first-order, headwater streams acquired as a result of the Land Exchange Proposed Action; however, the net reduction to the Superior National Forest of 0.3 mile of first order streams may result in slightly less habitat available for headwater stream dependent species.

Table 5.3.6-2 Increase or Decrease of Stream Orders from the Land Exchange Proposed Action

	Stream Distance (miles)		
Parcel (Stream)	**1st Order**	**2nd Order**	**3rd Order**
Lands Conveyed			
Federal Lands (Yelp Creek and Partridge River)	1.3	4.0	0.0
Lands Acquired			
Tract 1 – Hay Lake (Pike River)	0.0	0.0	8.1
Tract 2 – Lake County	0.0	0.0	0.0
Tract 3 – Wolf Lands			
Wolf Lands 1	0.0	0.0	0.0
Wolf Lands 2	0.0	0.0	0.0
Wolf Lands 3 (Coyote Creek)	0.1	0.0	0.0
Wolf Lands 4 (Coyote Creek)	0.9	0.0	0.0
Tract 4 – Hunting Club	0.0	0.0	0.0
Tract 5 – McFarland Lake	0.0	0.0	0.0
Total Non-federal Lands	1.0	0.0	8.1
Net Increase/(Decrease)	**(0.3)**	**(4.0)**	**8.1**

Note:

Surface water shoreline distance calculated by GIS analysis.

5.3.6.2.3 Watershed Level Riparian and Aquatic Connectivity

Riparian Connectivity

Intact riparian areas are an important factor contributing to diverse and productive aquatic ecosystems and function to maintain available water quality and physical habitat. The streams present on the federal and non-federal lands (Partridge River, Pike River, and Coyote Creek) are each part of a network of streams, creeks, and rivers that makes up a larger watershed. The connections between these surface water features are affected by the vegetated, undisturbed riparian edges bordering these water bodies. A comparison of the watersheds using the RCI is presented in Table 5.3.6-3. The index was developed from GIS analysis of vegetative cover along riparian areas where agriculture and land development have affected natural riparian vegetative cover.

The Land Exchange Proposed Action would result in a slight increase in watershed riparian connectivity, which indicates that the streams on both the federal and non-federal lands are located within watersheds with existing high-quality riparian connectivity.

Table 5.3.6-3 Watershed Riparian Connectivity Index Comparison

Surface Water	Tract	Watershed	Percent Agriculture in Riparian Zone	Percent Development in Riparian Zone	RCI Score[1]
Lands Conveyed					
Partridge River/Yelp Creek	Federal Lands	St. Louis	0	5	95
Lands Acquired					
Pike River	1 - Hay Lake	Vermillion	0	1	99
Coyote Creek	3 - Wolf Lands 3 and 4	Rainy River-Headwaters	0	0	100
Net Increase/(Decrease)[2]			0	(4)	4.5

Source: Adopted from MDNR 2015a.

Notes:

[1] RCI score calculated with MDNR formula using Percent Agriculture and Percent Development in Riparian Zone; scale is from 0 to 100 where 100 indicates excellent riparian conductivity.
[2] Non-federal lands RCI score averaged to determine net increase/decrease.

Aquatic Connectivity

Structures within streams, such as dams, bridges, and culverts reduce the longitudinal and lateral connectivity of the watershed. These structures can degrade the aquatic habitat in the watershed by slowing stream flow, increasing sedimentation, incising stream channels, changing the depth, and disconnecting portions of streams from the floodplain. The ACI was developed from GIS analysis of number of structures per stream mile for each watershed, and the watershed ACI scores were used to provide a comparison of each watershed.

The Land Exchange Proposed Action would result in the Superior National Forest acquiring streams located in watersheds with better aquatic connectivity values (see Table 5.3.6-4).

Table 5.3.6-4 Watershed Aquatic Connectivity Index Comparison

Surface Water	Tract	Watershed	Aquatic: Bridges and Culverts (miles stream/# structures)	Aquatic: Dams (miles stream/# structures)	ACI Score[1]
Lands Conveyed					
Partridge River/Yelp Creek	Federal Lands	St. Louis	15	6	11
Lands Acquired					
Pike River	1 - Hay Lake	Vermillion	41	11	26
Coyote Creek	3 - Wolf Lands 3 and 4	Rainy River-Headwaters	89	19	54
Net Increase/(Decrease)[2]			50	9	29

Source: Adopted from MDNR 2015b.

Notes:

[1] ACI score calculated by dividing total miles of streams and ditches per watershed by total number of culverts, bridges, and dams; scale is from 0 to 100 where 100 indicates free flowing streams (no structures) and 0 indicates one structure for every 20 miles of flowing water.
[2] Non-federal lands averaged to determine net increase/decrease.

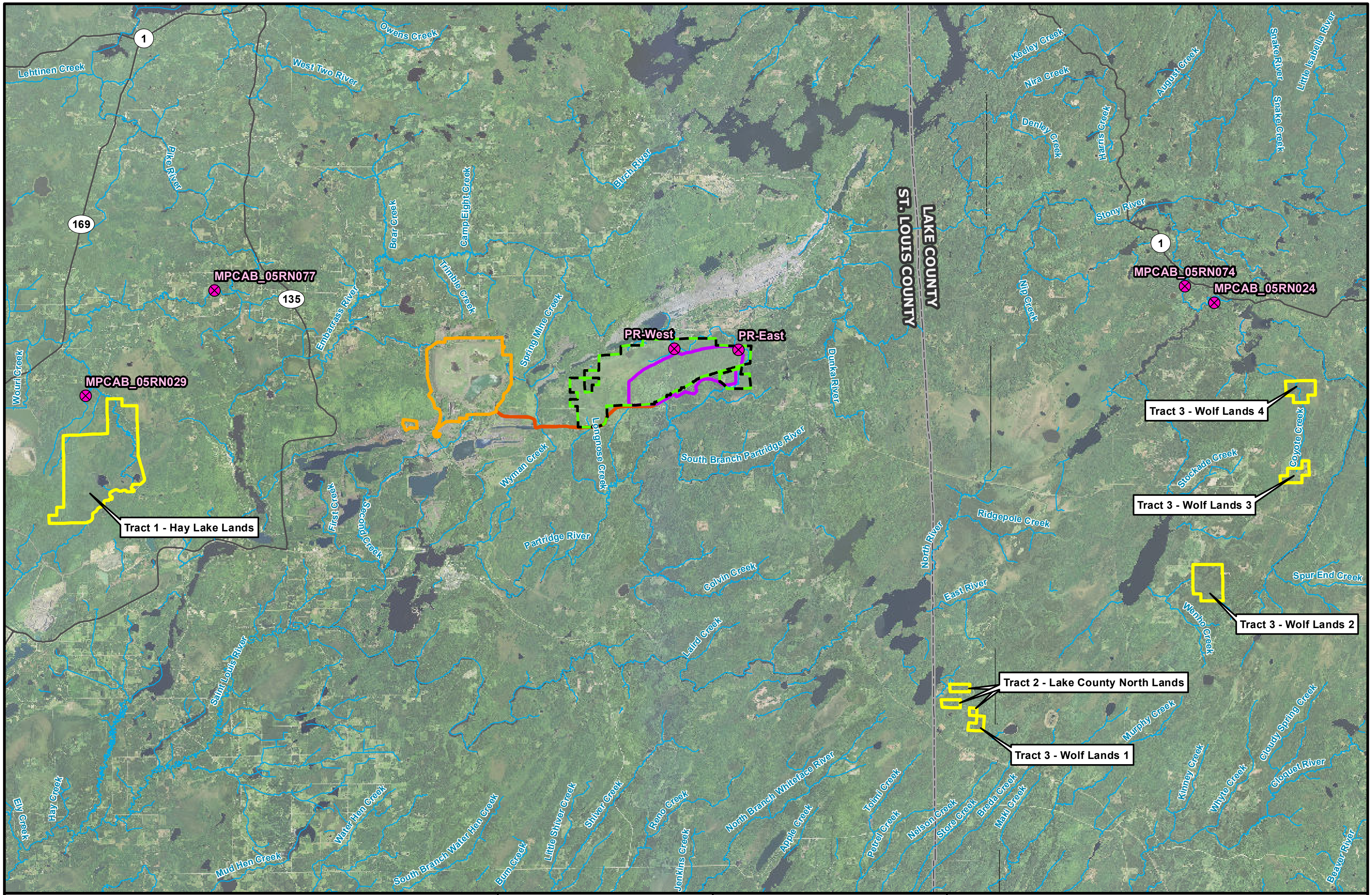
5.3.6.2.4 Aquatic Species Assemblages

A complete quantitative comparison of the net increase or decrease of aquatic species cannot be made for the purposes of the Land Exchange Proposed Action due to the absence of complete baseline information. Only the federal lands had aquatic biota and habitat sampling sites within the parcel boundaries. . A qualitative comparison can be made for species located at the two sites within the federal parcels and the four sites near the non-federal parcels (see Section 4.2.6). The exception to this statement includes the differences between the Coyote Creek headwater stream habitat and the Stony River sampling sites chosen to qualitatively represent Tract 3, which are summarized below.

Fish Assemblages

Two survey sites were analyzed within the vicinity of the federal lands while four survey sites were analyzed among the non-federal lands (in the vicinity of Pike River and Coyote Creek; see Figure 5.3.6-1). The federal lands and the survey sites within the vicinity of the non-federal lands had 11 species in common (see Table 5.3.6-5). The Land Exchange Proposed Action would result in a potential increase to the federal estate of 12 additional species, including two pollution-intolerant species and two pollution-tolerant species (see Tables 5.3.6-5 and 5.3.6-7). There would be a potential decrease to the federal estate of one different pollution-intolerant species and one different pollution-tolerant species. Given the fact that the survey sites used for non-federal lands may not be representative, it is possible that some species are more or less prevalent than is noted here.

The fish assemblages located at each survey site indicate that the Land Exchange Proposed Action potentially would result in minimal change to the fish assemblages for the streams the Superior National Forest would acquire. Additionally, the dominant fish species present at each site (see Table 5.3.6-6) indicate that the stream characteristics were consistent with slower moving, glide pool features with the exception of the segment on the Stony River where the MCAB_05RN024 survey site was located. Longnose dace dominate the fish community at the site, which indicate riffle-run habitats are likely present as described in Section 4.2.6. Note that Coyote Creek, within Tract 3, likely exhibits first order, headwater stream characteristics and if riffle-run habitat is present there, it would likely be smaller and support a less diverse fish community than the Stony River sampling site.



Study Site
Federal Lands
Non-federal Lands
Mine Site
Plant Site
Trasportation and Utility Corridor
Streams/Rivers
Existing Road

MNDNR | US Army Corps of Engineers St. Paul District | Forest Service U.S. Department of Agriculture

N W E S

0 1.5 3 6 Miles

Figure 5.3.6-1
Federal and Non-federal Lands Aquatic Study Area
NorthMet Mining Project and Land Exchange FEIS
Minnesota

November 2015

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Table 5.3.6-5 Potential Increase or Decrease of Stream Fish Assemblage for the Land Exchange Proposed Action

Species	Common Name	Tolerance Designation[1]	Federal Land Parcel	Non-federal Land Parcels (study areas within vicinity of Tract 1 and Tract 3-Wolf Lands 3 and 4)
Catostomus commersonii	White sucker	Tolerant	X	X
Luxilus cornutus	Common shiner	Intermediate	X	X
Notemigonus crysoleucas	Golden shiner	Tolerant		X
Notropis heterolepis	Blacknose shiner	Intolerant		X
Notropis hudsonius	Spottail shiner	Intermediate		X
Notropis volucellus	Mimic shiner	Intolerant		X
Etheostoma nigrum	Johnny darter	Intermediate	X	X
Perca flavescens	Yellow perch	Intermediate		X
Sander vitreus	Walleye	Intermediate		X
Percina caprodes	Logperch	Intermediate		X
Lota lota	Burbot	Intermediate	X	X
Ambloplites rupestris	Rock bass	Intermediate		X
Micropterus dolomieu	Smallmouth bass	Intermediate		X
Esox lucius	Northern pike	Intermediate	X	X
Phoxinus eos	Northern redbelly dace	Tolerant	X	
Culaea inconstans	Brook stickleback	Intermediate	X	X
Phoxinus neogaeus	Finescale dace	Intermediate		X
Rhinichthys atratulus	Blacknose dace	Intolerant	X	
Rhinichthys cataractae	Longnose dace	Intolerant	X	X
Semotilus margarita	Pearl dace	Intermediate	X	
Noturus gyrinus	Tadpole madtom	Intermediate	X	X
Umbra limi	Central mudminnow	Tolerant	X	X
Hybognathus hankinsoni	Brassy minnow	Intermediate	X	
Pimephales promelas	Fathead minnow	Tolerant	X	X
Cottus bairdii	Mottled sculpin	Intolerant	X	X
Semotilus atromaculatus	Creek chub	Tolerant		X
Coregonus clupeaformis	Lake whitefish	Intermediate		X
Total Species			15	23
# Intolerant Species			3	4
# Tolerant Species			4	5
Net Increase or Decrease Species			(8)	8
Net Increase or Decrease Intolerant Species			(1)	1
Net Increase or Decrease Tolerant Species			(1)	1

Note:

[1] Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates, and Fish - Second Edition EPA 841-B-99-002 (USEPA 2012b).

Table 5.3.6-6 Dominant Fish Species Present at Study Sites

Attributes	Federal Land (within parcel)		Non-federal Land (study areas within vicinity of Tract 1)		Non-federal Land (study areas within vicinity of Tract 3- Wolf Lands 3 and 4)	
Study site	PR-west	PR-east	MPCAB-05RN029	MPCAB-05RN077	MPCAB-05RN024	MPCAB-05RN074
Dominant Species	Brook stickleback	Northern redbelly dace	White sucker	White sucker	Longnose dace	Blacknose shiner

Sources: Adopted from Barr 2011b and MPCA 2011c.

Table 5.3.6-7 Increase or Decrease of Stream Fish Assemblage for the Land Exchange Proposed Action

Combined Studies Within, or Within Vicinity of, Surface Water	Tract	Total Species (#)	Pollution-Intolerant Species (#)	Pollution-Tolerant Species (#)
Lands Conveyed				
Partridge River	Federal Lands	15	3	4
Lands Acquired				
Pike River	Tract 1	11	0	4
Coyote Creek	Tract 3 - Wolf Lands 3 and 4	18	4	4
Total Non-Federal Lands		21[1]	4	5[2]
Net Increase/(Decrease)		12 species (4) other species	1	1

Source: Adopted from Section 4.3.6.

Notes:

[1] Species would overlap between Tract 1 and Tract 3; thus, 21 species are distinct number of species for combined non-federal lands.

[2] Does not equal sum of non-federal lands since some species overlap or vary between Tract 1 and Tract 3.

Benthic Macroinvertebrate Assemblages

Macroinvertebrate baseline surveys completed within and in the vicinity of the federal lands ranked macroinvertebrate assemblages as fair within the second-order stretches of the Partridge River, as indicated by the HBI (see Table 5.3.6-8). The first-, third-, and fourth-order segments of the streams within the vicinity of the non-federal lands indicated macroinvertebrate assemblages ranging from good to fair. A qualitative comparison using the attributes of HBI, stream order, total families (diversity), and percent pollution-tolerant organisms indicate that the macroinvertebrate assemblages likely would remain the same under the Land Exchange Proposed Action. This qualitative comparison assumes the habitat and associated macroinvertebrate assemblages are similar in the stream segments within the non-federal lands boundaries including the third-order segment of the Pike River on Tract 1 and the first-order segments of Coyote Creek within Tract 3 (see Figure 5.3.6-1).

Table 5.3.6-8 Stream Macroinvertebrate Assemblage Comparisons for the Land Exchange Proposed Action

Attributes	**Federal Parcel (within parcel)**		**Non-federal Land (study areas within vicinity of Tract 1)**		**Non-federal Land (study areas within vicinity of Tract 3- Wolf Lands 3 and 4)**	
Study site	PR-west	PR-east	MPCAB-05RN029	MPCAB-05RN077	MPCAB-05RN024	MPCAB-05RN074
Stream order	2	2	1	4	3	4
HBI score	6.4	6.0	5.7	5.1	5.9	5.2
HBI ranking	Fair	Fair	Fair	Good	Fair	Good
Total families	11	10	11	31	23	27
Percent pollution-tolerant	8	18	3	5	10	26

Sources: Adopted from Barr 2011b and MPCA 2011c.

5.3.6.2.5 Aquatic Species of Greatest Conservation Need

The MDNR and USFS have developed the ECS for ecological mapping and landscape classification (MDNR 2011a), which defines uniform ecological features within a mapped area. The federal and non-federal lands are located in the Northern Superior Uplands Section of the Laurentian Mixed Forest Province. These lands are further divided into several subsections. The federal lands include the Laurentian and Nashwauk Uplands subsections while the non-federal lands include these two subsections and the Border Lakes subsection.

As discussed in Section 4.2.6.1.4, SGCN aquatic species are associated with these ecological subsections based on occurrence and habitat considerations. Using the approach of comparing SGCN species by subsection association only, the Land Exchange Proposed Action could result in an increase of six new potential SGCN species (see Table 5.3.6-9). Of these, the spoonhead sculpin, lake chub, and longear sunfish have the highest potential to be found near the shoreline habitat of Tract 5 (within the Border Lakes subsection).

Regardless of the potential indicated by subsection association, no SGCN species were identified within the boundaries of the federal or non-federal lands during field surveys. While habitat is present in at least some locations within these boundaries for SGCN species, the surveys performed within the vicinity of the federal lands found no SGCN aquatic species, suggesting that SGCN species are likely not present on the federal lands. Conversely, occurrences of the creek heelsplitter, an SGCN species, have been documented within the vicinity of the non-federal lands on segments of the Pike River (downstream of Tract 1) and the Stony River (downstream of Tract 3) as discussed in Section 4.3.6.2. The predominant sand substrate documented in survey areas within the vicinity of these SGCN occurrence locations and the possibility that similar substrates exist within the boundaries of Tract 1 and Tract 3 indicate the creek heelsplitter may exist within the river segments of these non-federal lands. A qualitative review of these data indicates the Land Exchange Proposed Action may result in the added presence of the creek heelsplitter.

The USFS determined that the Land Exchange Proposed Action would not affect three RFSS aquatic species on the Superior National Forest, which include lake sturgeon, nipigon cisco, and shortjaw ciscoe. In addition, the Land Exchange Proposed Action may affect individuals, but would not be likely to cause a trend to federal listing or loss of viability for the remaining six RFSS aquatic species on the Superior National Forest. Please see the Biological Evaluation listed on the USFS website (http://www.fs.usda.gov/goto/superior/northmet) for more information about effects on RFSS aquatic species.

Table 5.3.6-9 Ecoregion SGCN Species Comparisons for the Land Exchange Proposed Action

SGCN Species	Common Name	Federal Land (Laurentian and Nashwauk Uplands)	Non-federal Lands (Laurentian Uplands, Nashwauk Uplands, Border Lakes)
Fish			
Acipenser fulvescens	Lake sturgeon		X
Coregonus nipigon	Nipigon cisco		X
Coregonus zenithicus	Shortjaw cisco		X
Cottus ricei	Spoonhead sculpin		X
Couesius plumbeus	Lake chub		X
Ichthyomyzon fossor	Brook lamprey	X	X
Lepomis megalotis	Longear sunfish		X
Mussels			
Lasmigona compressa	Creek heelsplitter	X	X
Ligumia recta	Black sandshell	X	X
Total species		3	9

Source: Adopted from Section 4.3.6.

5.3.6.3 Land Exchange Alternative B

5.3.6.3.1 Surface Water Features (MIH 14)

Land Exchange Alternative B would result in a net increase of lake and river surface water features to the federal estate (see Table 5.3.6-10). A total of 120.7 acres of lake and 2.8 miles of rivers would be added to the Superior National Forest under this alternative. The increase in lake and river frontage would provide a net increase to the federal estate of habitat for aquatic species (MIH 14). The frontage index would increase in the federal estate for both lakes and streams as a result of Land Exchange Alternative B.

Table 5.3.6-10 Frontage of Waterways for Land Exchange Alternative B

Parcel	Lake			Rivers/Creeks/Streams		
	Acres	Frontage (ft)	Frontage Index (shoreline/acre)	Miles	Frontage (linear ft)[1]	Frontage Index (shoreline/acre)[2]
Lands Conveyed						
Land Exchange Alternative B	8.9	1,200.0	0.3	5.3	55,968.0	11.8
Lands Acquired						
Tract 1	129.6	16,424.0	3.5	8.1	72,864.0	15.3
Net Change						
Net Increase/(Decrease)	120.7	15,224.0	3.2	2.8	16,896.0	3.5

Note:

Surface water shoreline distance calculated by GIS analysis.

[1] Includes shoreline distance on both sides of streams.
[2] Frontage Index calculated by dividing total acres of parcel by total shoreline within parcel.

5.3.6.3.2 Differences of Strahler Stream Orders and Habitat

A quantitative comparison of the Strahler Stream Order indicates that Land Exchange Alternative B would result in a decrease of 1.3 and 4.0 miles of first- and second-order streams, respectively, and an increase of 8.1 miles of third-order streams to the federal estate (see Table 5.3.6-11).

As with the Land Exchange Proposed Action, the net increase of third-order streams and decrease in first- and second-order streams would likely add more habitat diversity to the Superior National Forest. The net decrease to the federal estate of first-order streams would slightly reduce the amount of available spawning habitat for some aquatic species as headwater streams provide specialized spawning habitat for some species.

Table 5.3.6-11 Increase or Decrease of Stream Orders from Land Exchange Alternative B

Parcel (Stream)	Stream Distance (miles) 1st Order	2nd Order	3rd Order
Lands Conveyed			
Federal Lands (Yelp Creek and Partridge River)	1.3	4.0	0.0
Lands Acquired			
Tract 1 – Hay Lake (Pike River)	0.0	0.0	8.1
Net Increase/(Decrease)	**(1.3)**	**(4.0)**	**8.1**

Note:

Surface water shoreline distance calculated by GIS analysis.

5.3.6.3.3 Watershed Level Riparian and Aquatic Connectivity

Riparian Connectivity

A comparison of the watersheds containing streams present on the federal lands (Partridge River) and Tract 1 (Pike River) using the RCI is presented in Table 5.3.6-12. The index was developed from GIS analysis of vegetative cover along riparian areas where agriculture and land development have affected natural riparian vegetative cover.

Under Land Exchange Alternative B, there would be a slight increase to the federal estate in watershed riparian connectivity. The streams on both the federal lands and Tract 1 are located within watersheds with existing high quality riparian connectivity.

Table 5.3.6-12 Watershed Riparian Connectivity Index Comparison

Surface Water	Tract	Watershed	Percent Agriculture in Riparian Zone	Percent Development in Riparian Zone	RCI Score[1]
Lands Conveyed					
Partridge River/Yelp Creek	Federal Lands	St. Louis	0	5	95
Lands Acquired					
Pike River	1 - Hay Lake	Vermillion	0	1	99
Net Increase (Decrease)			0	(4)	4.0

Source: Adopted from MDNR 2015a.

Note:

1 RCI score calculated with MDNR formula using *Percent Agriculture and Percent Development in Riparian Zone*; scale is from 0 to 100 where 100 indicates excellent riparian conductivity.

Aquatic Connectivity

A comparison of the watersheds containing streams present on the federal lands (Partridge River) and Tract 1 (Pike River) using the ACI is presented in Table 5.3.6-13. The index was developed from GIS analysis of structures (i.e., dams, bridges, and culverts) along stream systems in the watershed.

Land Exchange Alternative B would result in the Superior National Forest acquiring streams located in watersheds with significantly better aquatic connectivity values, indicating increased aquatic habitat.

Table 5.3.6-13 Watershed Aquatic Connectivity Index Comparison

Surface Water	Tract	Watershed	Aquatic: Bridges and Culverts (miles stream/# structures)	Aquatic: Dams (miles stream/# structures)	ACI Score[1]
Lands Conveyed					
Partridge River	Federal Lands	St. Louis	15	6	11
Lands Acquired					
Pike River	1 - Hay Lake	Vermillion	41	11	26
Net Increase (Decrease)			26	5	15

Source: Adopted from MDNR 2015b.

Note:

1 ACI score calculated by dividing total miles of streams and ditches per watershed by total number of culverts, bridges, and dams; scale is from 0 to 100 where 100 indicates free flowing streams (no structures) and 0 indicates one structure for every 20 miles of flowing water.

5.3.6.3.4 Aquatic Species

As with the Land Exchange Proposed Action, a semi-quantitative comparison of the net increase or decrease to the federal estate of aquatic species was made for species located within the vicinity of the Tract 1 parcel boundaries since representative survey sites located in the vicinity of the parcel are likely similar to the existing aquatic habitats present at the parcel (see Section 4.2.6).

Fish Assemblages

Two survey sites were analyzed within the vicinity of both the smaller federal parcel and within the vicinity of Tract 1. The smaller federal parcel and Tract 1 had six species in common. Land Exchange Alternative B would potentially result in a net decrease to the federal estate of four species, including two pollution-intolerant species (see Table 5.3.6-14). Given the fact that only representative survey sites were used for Tract 1, it is possible that some species are more or less prevalent than is noted here. The attributes of the fish assemblages located at each survey site indicate that Land Exchange Alternative B would result in minimal change to the fish habitat for the portions of the river the Superior National Forest would acquire. The dominant fish species present at each site indicate that the stream characteristics were consistent with slower-moving, glide pool features.

Table 5.3.6-14 Increase or Decrease of Stream Fish Assemblage for Land Exchange Alternative B

Combined Studies Within, or Within Vicinity of, Surface Water	Tract	Total Species (#)	Pollution-Intolerant Species (#)	Pollution-Tolerant Species (#)
Lands Conveyed				
Partridge River/Yelp Creek	Federal Lands	15	4	4
Lands Acquired				
Pike River	Tract 1	11	2	4
Net Increase (Decrease)		(4)	(2)	0

Source: Adopted from Section 4.2.6.

Benthic Macroinvertebrate Assemblages

Macroinvertebrate baseline surveys completed within, and in the vicinity of, the smaller federal parcel ranked macroinvertebrate assemblages as fair within the second-order stretches of the Partridge River, as indicated by the HBI pollution index (see Table 5.3.6-15). The first- and fourth-order segments of the streams within the vicinity of Tract 1 indicated macroinvertebrate assemblages ranging from good to fair. A qualitative comparison using the attributes of HBI, stream order, total families (diversity), and percent pollution-tolerant organisms indicate that the macroinvertebrate assemblages would likely be similar under Land Exchange Alternative B. This qualitative comparison assumes the habitat and associated macroinvertebrate assemblages are similar in the stream segments within the third-order segment of the Pike River on Tract 1.

Table 5.3.6-15 Stream Macroinvertebrate Assemblage Comparisons for Land Exchange Alternative B

Attributes	Federal Lands		Non-federal Lands (study areas within vicinity of Tract 1)	
Study site	PR-west	PR-east	MPCAB-05RN029	MPCAB-05RN077
Stream order	2	2	1	4
HBI score	6.4	6.0	5.7	5.1
HBI ranking	Fair	Fair	Fair	Good
Total families	11	10	11	31
Percent pollution-tolerant	8	18	3	5

Source: Adopted from Barr 2011b and MPCA 2011c.

5.3.6.3.5 Aquatic Species of Greatest Conservation Need

The smaller federal parcel includes the Laurentian and Nashwauk Uplands ecological subsections, while Tract 1 includes only the Nashwauk Uplands.

As discussed in Section 5.3.6.2.5, SGCN species are associated with these ecological subsections based on occurrence and habitat considerations. Using the approach of comparing SGCN species by subsection association only, Land Exchange Alternative B would likely result in no net change to the federal estate of SGCN species (see Table 5.3.6-16).

Regardless of the potential indicated by subsection association, no SGCN species were identified within the boundaries of the smaller federal parcel. Habitat is present in at least some locations within these boundaries for SGCN species. Although no surveys were completed within the boundaries of Tract 1, occurrences of the creek heelsplitter, an SGCN species, have been documented within the vicinity of Tract 1 on segments of the Pike River (downstream of Tract 1). The predominant sand substrate documented in survey areas within the vicinity of this SGCN occurrence location and the possibility that similar substrates exist within the boundaries of Tract 1 indicate the creek heelsplitter may exist within the Pike River segments of Tract 1. A qualitative review of these data indicates that Land Exchange Alternative B may result in the added presence to the federal estate of the creek heelsplitter.

Table 5.3.6-16 Ecoregion SGCN Species Comparisons for Land Exchange Alternative B

SGCN Species	Common Name	Federal Lands (Laurentian and Nashwauk Uplands)	Tract 1 (Nashwauk Uplands only)
Fish			
Ichthyomyzon fossor	Brook lamprey	X	X
Mussels			
Lasmigona compressa	Creek heelsplitter	X	X
Ligumia recta	Black sandshell	X	X
Total species		3	3

Source: Adopted from Section 4.3.6.

5.3.6.4 Land Exchange No Action Alternative

Under the Land Exchange No Action Alternative, the Superior National Forest would have an ongoing responsibility for managing aquatic resources on the federal lands in accordance with the Forest Plan. The Land Exchange No Action Alternative would not change the USFS responsibility for managing aquatic resources and would result in no further effects on existing aquatic species or habitats.

Fish and other aquatic life on the federal lands would be exposed to the water quality, hydrologic, and physical habitat conditions that currently exist as a result of past mining activities. There would be no change from existing conditions, although it is expected that the water quality of the Embarrass River may improve as a result of corrective actions potentially required by the reissuance of existing NPDES/SDS permits in the NorthMet Project area. Future actions conducted under the Cliffs Erie Consent Decree may also change these conditions.

The non-federal lands would not go into USFS ownership, and land use would be determined by the private land owners. Effects to aquatic resources are difficult to predict given the uncertainty of future potential land use. Some lands may be developed, resulting in potential effects to aquatic species at the individual and local population levels, decreases in habitat, and adverse effects on habitat connectivity.

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5.3.7 Air Quality

Because there are no current operations or activities on the non-federal parcels that would result in a change to ambient air quality, the Land Exchange Proposed Action (and alternatives) would not result in new effects on the federal estate. Indirect effects from the NorthMet Project Proposed Action on the non-federal parcels are considered under Class I area modeling and are discussed in Section 5.2.7.

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5.3.8 Noise and Vibration

Evaluation of potential noise, vibration, and airblast effects in the areas of the Land Exchange Proposed Action used the same methodologies and criteria that were described previously for the NorthMet Project Proposed Action. The results of the modeling indicate that noise, vibration, and airblast levels that would be experienced at or by sensitive receptors would be below the Minnesota standards. Therefore, operations at the Mine Site and Plant Site would not have a significant effect on human receptors within the federal and non-federal lands, including people that may use the non-federal lands for recreational activities such as hunting and hiking (if the Land Exchange Proposed Action were to occur and the non-federal lands were added to the Superior National Forest). As discussed in Section 5.2.8, tribal users of archaeological sites (Spring Mine Lake Sugarbush, *Mesabe Widjiu*, and BBLV Trail; see Section 4.2.9) in the immediate vicinity of the Mine Site and Plant Site could experience some effects from noise. The non-federal land tracts are approximately 10 to 90 miles from operations at the Mine Site and Plant Site; tracts located 50 to 90 miles away from the federal lands are outside the area of analysis for noise modeling and would be not affected by noise from operations at the Mine Site and Plant Site.

5.3.8.1 Methodology and Evaluation Criteria

The noise and vibration impact assessment area for the Land Exchange Proposed Action would involve transferring 6,495.4 acres of federal lands from public to private ownership, and up to 7,075.0 acres of land from private to public ownership. The spatial and temporal area of analysis assessed for noise, vibration, and airblast as part of the Land Exchange Proposed Action included the indirect effects resulting from the mining activities; therefore, the area of analysis is the same as that described in Section 5.2.8.1. As indicated before, three desktop computer models (ISO 9613-2 sound-propagation model, the Site Law formula, and the Terrock model) were used to evaluate noise, ground vibration, and airblast effects, respectively, on the federal and non-federal lands.

5.3.8.2 Land Exchange Proposed Action

5.3.8.2.1 Federal Lands

The topography and land cover of the federal lands are similar to those of the Mine Site previously discussed, but include additional area to the west and northwest that are mostly wetland. NorthMet Project Proposed Action-related activities that would result in noise, vibration, or airblast would not occur on the additional federal lands (3,776.1 acres) situated west and northwest of the Mine Site, so no additional noise, vibration, or airblast effects would occur in this area. It should be noted that the federal land excludes private lands (295.2 acres) situated south of Dunka Road. There are no residential areas or individual houses within the federal lands that could be affected by the NorthMet Project Proposed Action's noise and vibration-related activities (see Figures 5.3.8-1 to 5.3.8-4). As discussed in Section 5.2.8.2, noise and vibration levels from the Mine Site would be too low to significantly affect the recreational use of the federal land (i.e., minor effects in 11,456 acres around the Mine Site).

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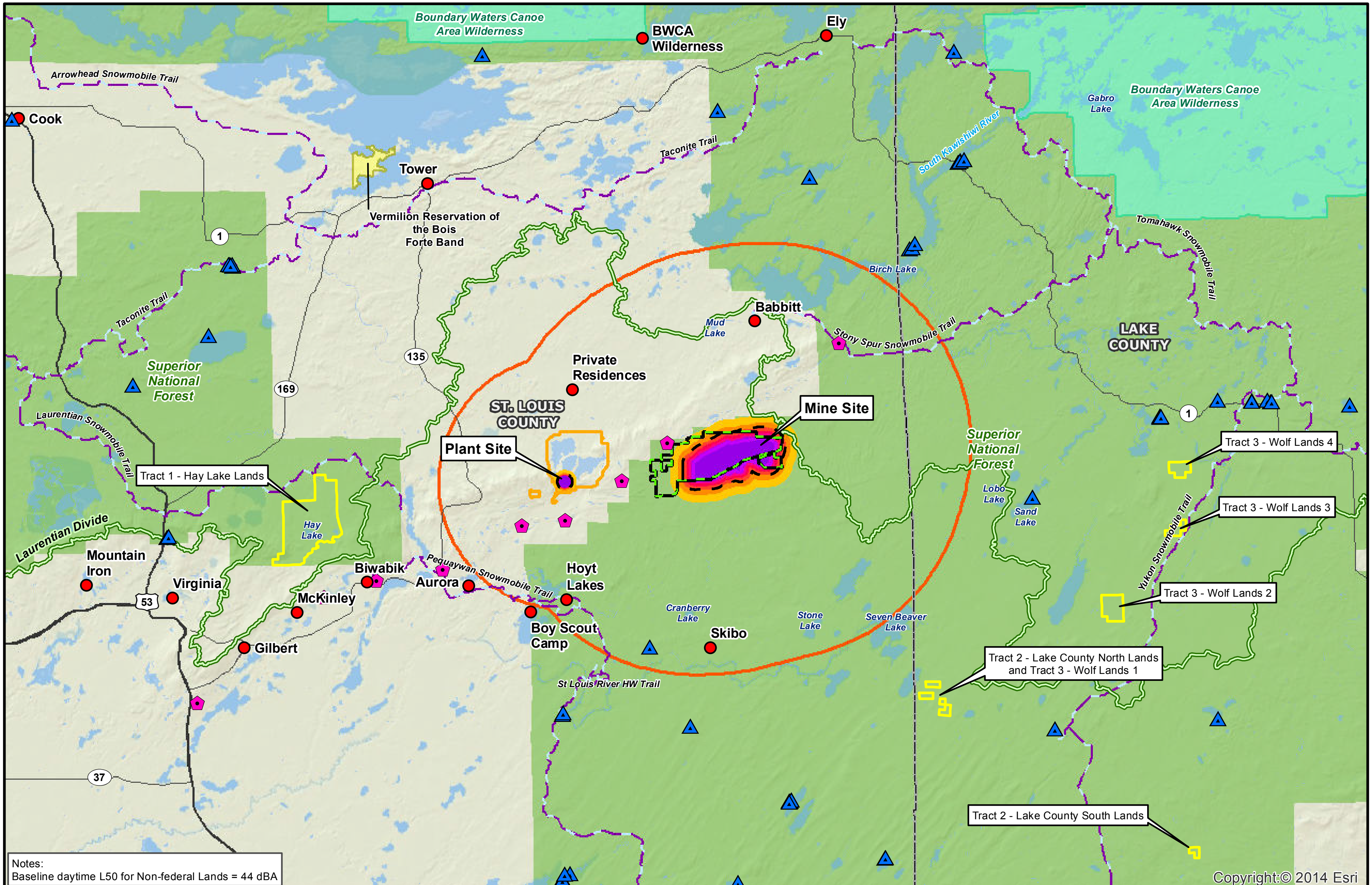

Noise Sensitive Receptor
Non-federal Lands
Federal Lands
Plant Site
Mine Site
Wildlife Travel Corridor
Recreational Site
Native American Reservation
Boundary Waters Canoe Area Wilderness
National Forest
MN L50 Daytime Noise Standard: 60 dBA
L50 Audibility Limit
L50 dBA Levels
50-54.9
55-59.9
60-64.9
65-69.9
70-74.9
75-79.9
80+

MNDNR
US Army Corps of Engineers St. Paul District

N S W E

0 2 4 8 Miles

Figure 5.3.8-1
Predicted Daytime L50 Noise Contours at Non-federal Tracts (Includes Baseline L50 Levels)
NorthMet Mining Project and Land Exchange FEIS
Minnesota

November 2015

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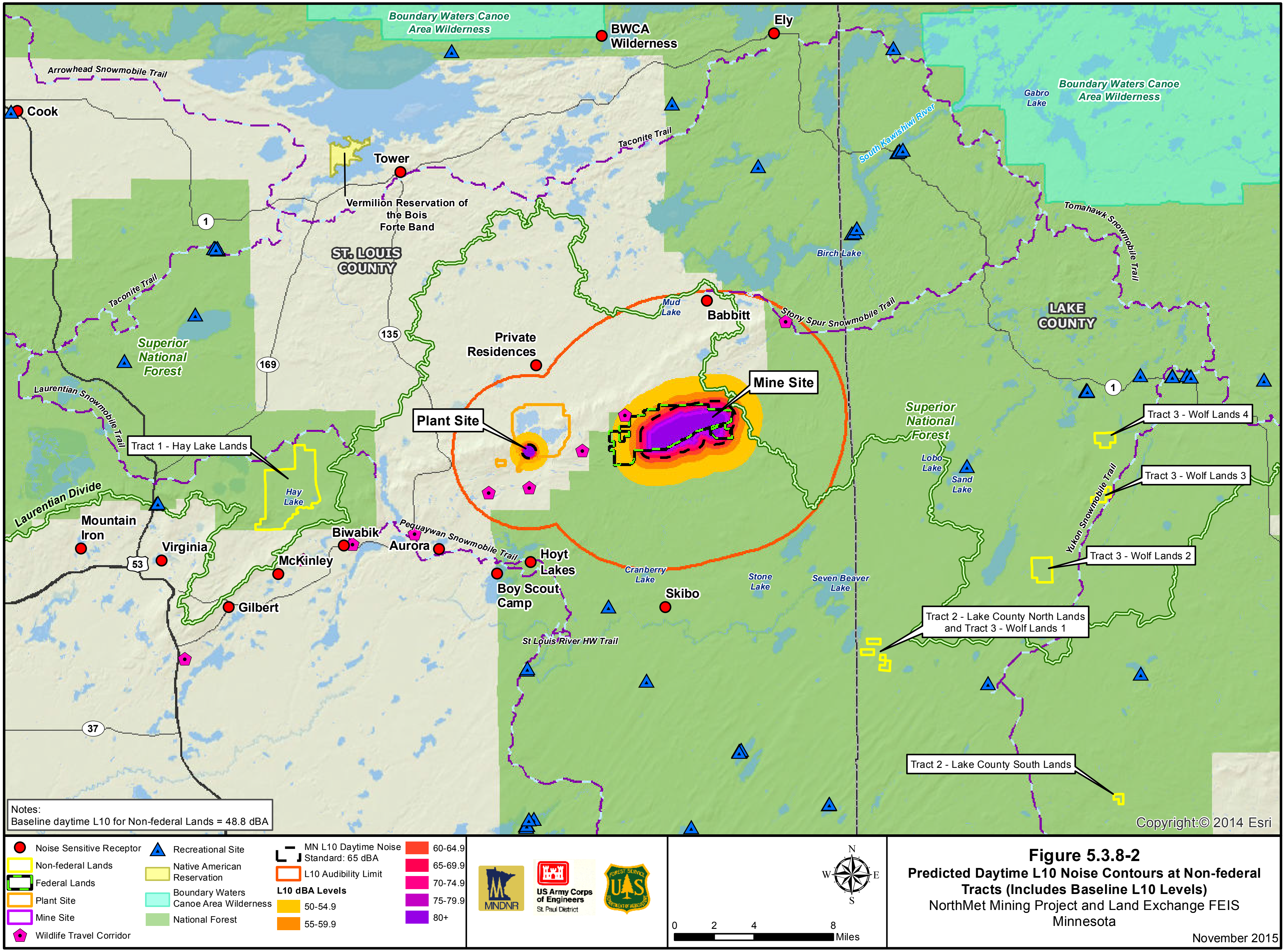

Figure 5.3.8-2
Predicted Daytime L10 Noise Contours at Non-federal Tracts (Includes Baseline L10 Levels)
NorthMet Mining Project and Land Exchange FEIS
Minnesota

November 2015

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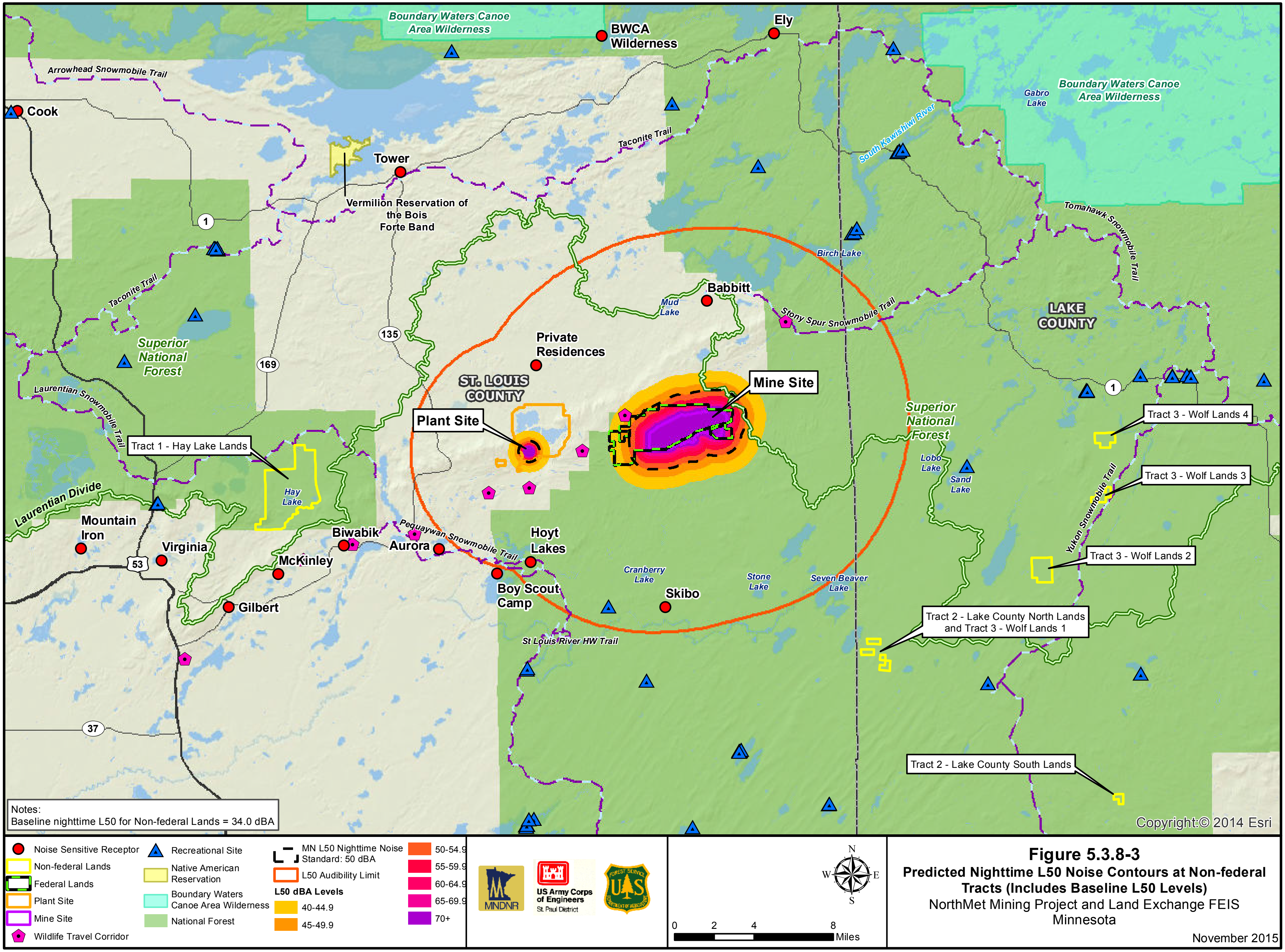

Figure 5.3.8-3
Predicted Nighttime L50 Noise Contours at Non-federal Tracts (Includes Baseline L50 Levels)
NorthMet Mining Project and Land Exchange FEIS
Minnesota

November 2015

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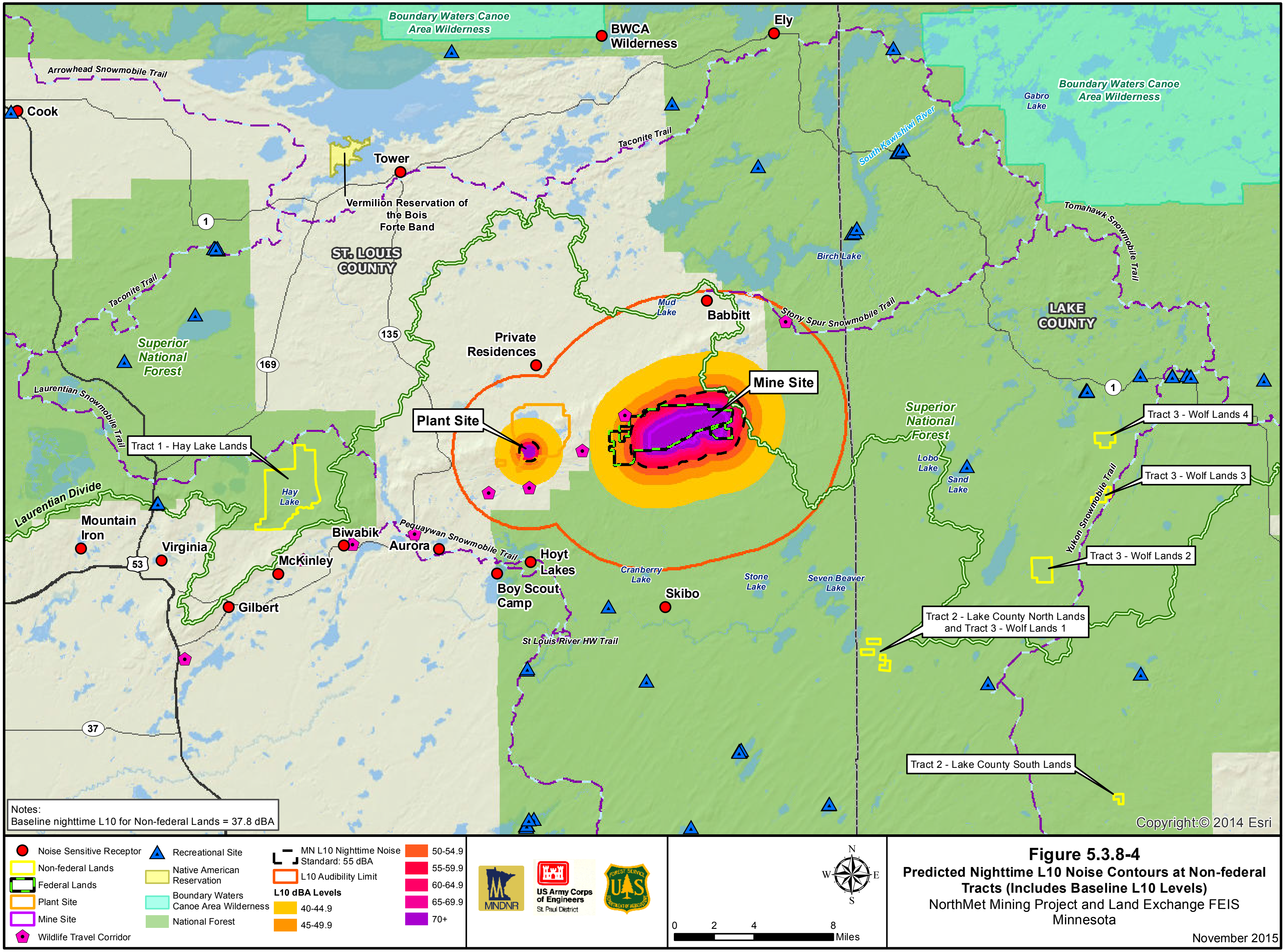

Figure 5.3.8-4

Predicted Nighttime L10 Noise Contours at Non-federal Tracts (Includes Baseline L10 Levels)

NorthMet Mining Project and Land Exchange FEIS

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5.3.8.2.2 Non-federal Lands

The non-federal lands would be managed consistent with the adjacent forest lands management (see Section 4.3.1). No direct effects from the Land Exchange Proposed Action are anticipated since the USFS currently has no plans for operations on the non-federal lands and no NorthMet Project Proposed Action-related activity (e.g., drilling, blasting, excavation work, material haulage via trucks, and ore crushing) would occur within the non-federal lands.

Review of the most-up-to-date aerial maps indicates that there are no human or residential receptors within or adjacent to the non-federal lands (Tracts 1 to 5). If the Land Exchange Proposed Action were to occur and the non-federal lands were added to the Superior National Forest (i.e., if the tracts became federal lands), public recreational use such as hiking and hunting would likely occur on these tracts.

To determine the indirect effect of operations at the Mine Site and Plant Site on people that may use the non-federal lands for recreational activities such as hiking and hunting, the modeled area was expanded to a 20-mile radius from both the Mine Site and the Plant Site. Daytime and nighttime noise contours (L_{50} and L_{10}) generated from the modeling are shown in Figures 5.3.8-1 through 5.3.8-4. During the daytime, all potential receptors within the non-federal lands were outside the 50-dBA (L_{50} and L_{10}) noise contours. During the nighttime, all potential receptors within the non-federal lands were outside the 40-dBA (L_{50} and L_{10}) noise contours. This shows that the predicted daytime and nighttime noise levels at the non-federal lands due to operations at the Mine Site and Plant Site are well below Minnesota's noise standards. The results of the noise assessment indicate that operations at the Mine Site and Plant Site would add no perceptible noise (0 dBA) to the current baseline levels experienced at the non-federal lands. Non-federal Tracts 4 and 5 are approximately 50 and 90 miles away, respectively, from the federal lands and are outside the area of analysis for noise modeling; neither tract would be affected by noise from operations at the Mine Site and Plant Site.

Based on the information above, it is anticipated that noise from typical mining and hauling operations at the Mine Site and ore-crushing operations at the Plant Site would not affect the people that may use the non-federal lands for recreational activities such as hiking and hunting under the Land Exchange Proposed Action. However, as discussed in Section 5.2.8, tribal users of archaeological sites (Spring Mine Lake Sugarbush, *Mesabe Widjiu*, and BBLV Trail; see Section 4.2.9) in the immediate vicinity of the Mine Site and Plant Site could experience some effects from noise. The non-federal lands are far from the Mine Site and Plant Site (10 to 90 miles away), so indirect vibration levels from operations at both locations would not affect potential receptors within the non-federal lands that would be acquired under the Land Exchange Proposed Action.

5.3.8.3 Land Exchange Alternative B

Under the Land Exchange Alternative B, 4,752.6 acres would be conveyed to PolyMet. The type, quantity, and location of noise- and vibration-related sources (i.e., drilling, blasting, excavation work, haul trucks, trains, and crushers) for the Land Exchange Alternative B would be the same as that for the Land Exchange Proposed Action. Therefore, the Land Exchange Alternative B would not change noise and vibration levels experienced at the federal lands or modify noise and vibration effects on nearest receptors. If the 4,752.6 acres of land were to become privately owned, public recreational use currently associated with the smaller federal parcel would no longer occur on that portion of the federal lands (i.e., the Land Exchange Alternative B would have no effects associated with public recreational use on that portion). Sections 5.2.8.2.1 and 5.2.8.2.2 provide a discussion of the noise and vibration effects on the federal lands.

Under the Land Exchange Alternative B, Tract 1 (4,926.3 acres) would be acquired by the USFS. The type, quantity, and location of noise- and vibration-related sources (i.e., drilling, blasting, excavation work, haul trucks, trains, and crushers) for this alternative would be the same as that for the Land Exchange Proposed Action. Therefore, the Land Exchange Alternative B would not change noise and vibration levels experienced at the non-federal lands or modify noise and vibration effects on the nearest receptors.

As indicated above, during the daytime, all modeled potential receptors within Tract 1 were outside the 50-dBA (L_{50} and L_{10}) noise contours (see Figure 5.3.8-1 and 5.3.8-2). Similarly, during the nighttime, all potential receptors within Tract 1 were outside the 40-dBA (L_{50} and L_{10}) noise contours (see Figure 5.3.8-3 and 5.3.8-4). The predicted daytime and nighttime noise levels at Tract 1 due to operations at the Mine Site and Plant Site are well below Minnesota's noise standards. The results of the noise assessment indicate that operations at the Mine Site and Plant Site would add no additional noise (0 dBA) to the current baseline levels experienced at Tract 1.

5.3.8.4 Land Exchange No Action Alternative

Under the Land Exchange No Action Alternative, the transfer of lands would not occur and there would be no increase in noise and vibration levels at the federal and non-federal lands. Therefore, there would be no change in noise and vibration levels at the nearest receptors.

5.3.9 Cultural Resources

This section summarizes the environmental consequences of the Land Exchange Proposed Action on historic properties that are present on the federal and non-federal lands, including the potential effects, types of avoidance, effect minimization measures, and potential mitigation measures that are relevant to these historic properties. Additionally, this section summarizes the environmental consequences of the Land Exchange Proposed Action and alternatives on 1854 Treaty resources—i.e., those areas and species that are traditionally or culturally important to the Bands. Under the Land Exchange Proposed Action and alternatives, the Superior National Forest would retain its ongoing responsibility for managing cultural resources on Superior National Forest lands in accordance with the Forest Plan.

The federal Co-lead Agencies, after consulting with the SHPO, Bands, and PolyMet, have determined that the Partridge River Segment of the BBLV Trail is eligible for inclusion in the NRHP. The SHPO concurred in this determination. All other cultural resources identified as part of the Land Exchange Proposed Action, as identified in Section 4.3.9.1.1, were determined to be not eligible for inclusion in the NRHP, and therefore did not receive further consideration under Section 106 during review of the Land Exchange Proposed Action.

After consultation with the SHPO, Bands, and PolyMet, the federal Co-lead Agencies have determined that the BBLV Trail Segment would be adversely affected by the Land Exchange Proposed Action. The SHPO agreed with this finding. This determination was used to facilitate consultation with the SHPO, Bands, and PolyMet pertaining to the resolution of adverse effects. The ACHP was notified of adverse effect by letter on May 21, 2015, but declined to participate. The federal Co-lead Agencies are currently in the process of developing a Memorandum of Agreement (MOA), which identifies the steps the federal Co-lead Agencies would take to avoid, minimize, or mitigate the adverse effect.

5.3.9.1 Methodology and Evaluation Criteria

Potential effects associated with the Land Exchange Proposed Action would be the destruction of historic properties and the loss of the historic information and cultural significance that these properties could represent. An additional potential effect would be the loss of federal protection for any unknown historic properties, such as those provided under the NHPA, the Archaeological Resource Protection Act, and the Native American Graves and Repatriation Act. The methodology and evaluation criteria used to determine potential effects on cultural resources from the Land Exchange Proposed Action are similar to those used for the NorthMet Project Proposed Action (see Section 5.2.9).

The analysis of cultural resources for the non-federal lands was performed based on readily available information, and no additional field work was performed. Intensive analysis is only needed for the federal parcel leaving federal ownership. The non-federal lands that would be going into federal ownership would not be of primary concern since future management of these lands would be per Forest Plan direction for heritage resources.

The spatial area of analysis for Land Exchange Proposed Action effects on cultural resources included the boundaries of the federal tracts proposed for the exchange, while the temporal area of analysis was the point in time at which the change in ownership would occur. The geographic extent is appropriate because it includes all cultural resources that would be affected by a change in site protection. In a temporal sense, the change in ownership is appropriate because this is when there would be a gain or loss of legal protections.

The analysis of the cultural resources affected by the Land Exchange Proposed Action was guided by effects criteria that were developed by the USFS and the USACE. The analysis included a review of known and recorded heritage resources (i.e., historic structures, artifacts, TCPs) within or immediately adjacent to the federal and non-federal lands and a qualitative assessment to determine if there were portions of the federal and non-federal lands that have not been surveyed previously and would have a high probability to yield heritage resources.

5.3.9.2 Land Exchange Proposed Action

5.3.9.2.1 Federal Lands

As outlined in Section 5.2.9, the federal Co-lead Agencies have determined, and the SHPO concurred, that the BBLV Trail Segment is eligible for inclusion in the NRHP. The federal Co-lead Agencies, after consultation with the SHPO, Bands, and PolyMet, have determined that the eligible property will be adversely affected and the SHPO agreed with that finding. Cultural resources located on private lands being transferred to federal ownership would not be considered as adversely affected, but would be considered to have greater preservation protection under federal law in the event the Land Exchange Proposed Action were to occur. The federal Co-lead Agencies are currently in the process of developing an MOA, which identifies the steps the federal Co-lead Agencies would take to avoid, minimize, or mitigate the adverse effect.

The 1854 Treaty resources located within the Land Exchange Proposed Action would be similar to the Mine Site portion of the NorthMet Project area previously discussed in Section 4.2.9. Section 4.2.9 provides further discussion of the existing conditions on the Mine Site and associated federal lands. The Land Exchange Proposed Action represents an exchange of private and federal land, but it is also represents an exchange of access to natural resources expressed in treaties made between the United States and Bands of Ojibwe Indians in the 19th Century. Due to the nature of a land exchange, therefore, the effects would be limited to access to such resources versus direct or indirect effects, as would be the case with the Land Exchange Proposed Action.

An analysis of effects on 1854 Treaty resources, as described and discussed in Section 4.2.9, is limited by the lack of specific information concerning the use of such resources in the Land Exchange area. The cultural resources investigations conducted as part of the Land Exchange Proposed Action included Band member interviews with Bois Forte, Fond du Lac, and Grand Portage, although only Bois Forte's results were made available. The results of the interviews and the cultural resources investigation did not find any natural resources that would be considered a TCP or other traditional cultural place.

There is also no quantitative analysis of current use of 1854 Treaty resources in or near the federal lands. This lack of data also precludes the analysis of how Band members would be quantitatively affected socioeconomically by effects on 1854 Treaty resources, further discussed in Section 5.2.10. The primary source of data for assessing effects on 1854 Treaty resources is from the analysis of the environment in other chapters of this FEIS as discussed in Section 4.2.9.4 and 5.2.9.2.2.

As discussed above, the Land Exchange Proposed Action could have effects on 1854 Treaty resources—i.e., lack of access to those areas and species that are traditionally or culturally important to the Bands. For example, coniferous bogs contain several plant species that are tribally harvested resources (e.g., cranberries, Labrador tea, creeping snowberry, etc.). Because the non-federal lands contain fewer acres of coniferous bogs than the federal lands, the Land Exchange Proposed Action would result in a net decrease of coniferous bog wetlands on the federal estate.

Band members' use of the federal lands is not well-defined through research at this time and did not emerge through interviews. A good faith effort was made on the part of the federal Co-lead Agencies to identify use areas in or adjacent to the federal lands; however, those efforts resulted in little specific information concerning historic subsistence use and no information regarding recent subsistence activity within the federal lands. As such, cultural effects on the Bands would be difficult to quantify in regards to such incremental increases below standards or effects on species where appropriate mitigation is used.

5.3.9.2.2 Non-federal Lands

There are no known cultural resources on the non-federal lands, except known 1854 Treaty resources consisting of wild rice beds within the Hay Lake lands. Cultural resources located on private lands being transferred to federal ownership would not be considered adversely affected, but would be considered to have greater preservation protection under federal law in the event the Land Exchange Proposed Action were to occur. No wild rice beds would be affected as a result of the Land Exchange Proposed Action as no activities are proposed on the non-federal lands and the proposed mining activities would not affect these lands.

The Land Exchange Proposed Action represents an exchange of non-federal and federal land, but it also represents an exchange of access to natural resources expressed in treaties made between the United States and Bands of Ojibwe Indians in the 19th Century. Due to the nature of a land exchange, therefore, the 1854 Treaty resources would be available for resource gathering and subsistence use by the Bands and would receive greater protection under federal law than they are currently receiving.

5.3.9.3 Land Exchange Alternative B

5.3.9.3.1 Federal Lands

All of the cultural resources and 1854 Treaty resources identified and discussed in Section 5.3.9 are located within the Land Exchange Alternative B. Effects on these resources would be the same as discussed in Section 5.3.9.

5.3.9.3.2 Non-federal Lands

There are no known cultural resources on the non-federal lands, except known 1854 Treaty resources consisting of wild rice beds within the Hay Lake lands. The non-federal lands that would be going into federal ownership would not be of primary concern for cultural resources since future management of these lands would be as per the Forest Plan direction for cultural resources. Cultural resources located on private lands being transferred to federal ownership would not be considered adversely affected, but would be considered to have greater preservation protection under federal law in the event the Land Exchange Proposed Action were to occur. No wild rice beds would be affected as a result of the Land Exchange Alternative B as no activities are proposed on the non-federal lands and the proposed mining activities would not affect these lands. The Land Exchange Alternative B represents an exchange of private and federal land, but it also represents an exchange of access to natural resources expressed in treaties made between the United States and Bands of Ojibwe Indians in the 19th Century. Due to the nature of a land exchange, therefore, the 1854 Treaty resources would be available for resource gathering and subsistence use by the Bands and would receive greater protection under federal law than they are currently receiving.

5.3.9.4 Land Exchange No Action Alternative

There would be no effects on cultural resources or 1854 Treaty resources under the Land Exchange No Action Alternative.

5.3.10 Socioeconomics

This section describes the potential socioeconomic consequences of the Land Exchange Proposed Action. Overall, the Land Exchange Proposed Action would have the following socioeconomic effects:

- Positive economic effects due to the value of forestry products made available on the non-federal lands, as well as jobs and revenue due to increased visitation of the non-federal lands;
- Undetermined effects for EJ populations and subsistence activities, due to the net increase in the amount of land available for subsistence activities, but unknown changes in the type and extent of subsistence resources on the federal and non-federal lands; and
- Negligible effects on other socioeconomic considerations.

5.3.10.1 Methodology and Evaluation Criteria

As discussed in Section 5.2.10, the study area for socioeconomics differs from the study area used for much of the rest of this FEIS. It includes Cook, Lake, and St. Louis counties. This includes, where appropriate, the St. Louis County municipalities listed in Section 4.2.10. The primary issues related to socioeconomics on and near the non-federal lands, and therefore the potential for effects, would include the following:

- The amount of annual property taxes lost to the county from non-federal lands going to federal ownership;
- The potential change in payment in lieu of taxes to the county from the Land Exchange Proposed Action;
- The differences in assessed market values of federal lands compared to non-federal lands proposed for exchange;
- The difference between present values of recently harvested (past 10 years) products from the federal parcels and the value of products from the federal parcels;
- The difference between present and future values of potential forest products in Land Exchange Proposed Action parcels;
- The change in forestry employment on federal and non-federal parcels (estimated);
- A qualitative assessment of public visitation to the federal tract and estimated/potential visitation to non-federal tracts;
- The difference between present and future estimated spending on recreational tourism;
- The difference between present and future amounts of 1854 Treaty resources in Land Exchange Proposed Action parcels; and
- A qualitative assessment of tribal use of the federal parcels and estimated/potential use of the non-federal parcels.

5.3.10.2 Land Exchange Proposed Action

This section describes the potential socioeconomic effects of the Land Exchange Proposed Action on communities in the socioeconomics study area. The Land Exchange Proposed Action would create moderate positive economic effects through increased opportunity for forestry and recreation and associated employment, earnings, and revenue. The Land Exchange Proposed Action would have negligible negative effects on other socioeconomic factors, including housing, public facilities and services, EJ populations, and subsistence.

5.3.10.2.1 Economic Activity

There is no current economic activity (e.g., forestry, etc.) on the federal lands, although harvesting of forest products is permitted by the Forest Plan. More importantly, the federal lands are not accessible to the public for economically measurable use, such as forestry or recreation (see Section 5.2.11). Thus, while the federal lands may hold some theoretical economic value for timber harvest, their practical economic value is zero. Table 5.3.10-1 lists data and observations relevant to the economic value of the federal and non-federal lands.

Tax Payments

Implementation of the Land Exchange Proposed Action would transfer ownership of the federal lands to PolyMet, and would result in an active mining operation that would generate federal, state, and local tax revenue, in addition to employment. As described in Section 5.2.10.2.3, total annual direct tax payments from the NorthMet Project Proposed Action during operations are expected to be in the range of $37 to $80 million, a positive economic effect, both on an absolute basis and when compared with the minimal current economic activity within the NorthMet Project area.

The amount of property taxes that would be paid to St. Louis County for the federal lands has not yet been determined; however, property taxes would be included in the overall taxes paid by PolyMet, shown in Table 5.2.10-3. For the non-federal lands, increases to federal payments in lieu of taxes to study area counties as a result of the Land Exchange Proposed Action would be negligible (compared to the current payment in lieu for the federal lands).

Table 5.3.10-1 Economic Value of Federal and Non-federal Lands (in 2012 dollars)

Land	Acreage	Annual Property Tax[1]	Annual Payment in Lieu of Taxes (PILT)[2]	Market Value of Land[3]	Other Economic Value
Federal Lands	6495.4	NA[3]	$2,273.39	TBD	NA
Tract 1	4,926.3	$20,714.68	$1,724.10	TBD	Potential recreational value due to the presence of Hay Lake (boating, fishing), existing trails, evidence of ongoing hunting, and other recreational activity (see Section 4.3.11).
Tract 2	381.9	$2,563.54	$133.70	TBD	NA
Tract 3	1,575.8	Unknown	$551.60	TBD	NA
Tract 4	160.2	$739.30	$56.00	TBD	NA
Tract 5	30.8	$1,938.00	$10.85	TBD	Potential recreational value. Former site of a cabin and camp site owned by Carleton College. Adjacent to highly scenic McFarland Lake (boating, fishing, access to BWCAW) (see Section 4.3.11).
Subtotal, Non-Federal Lands	7,075.0	$25,995.52	$2,476.25	TBD	NA
Net Change[5]	**579.6**	**NA**	**$202.86**	**TBD**	**NA**

Notes:
1 Source: PolyMet, Pers. Comm., April 17, 2012.
2 Source: DOI 2012
3 See Market Value section below.
4 Table 5.2.10-3 describes total estimated taxes that PolyMet expects to pay for the federal lands. The amount specifically anticipated for property taxes has not been determined.
5 Calculated as (non-federal) minus (federal).

TBD = To be determined

Market Value

Federal regulations governing land exchanges, contained in 36 CFR 254.12, require that the assessed value of non-federal land being exchanged be equal to or within 25 percent of the assessed value of the federal land being exchanged. Assessment data have been updated and are included in this FEIS.

Recreation Value

Tracts 1 and 5 also have the potential for recreational use (whereas the federal lands are not easily accessible for any purpose). To the degree that the USFS manages these lands (and the other non-federal lands) for active recreational activity, the Land Exchange Proposed Action could increase economic activity associated with recreation and tourism. The non-federal lands comprise less than half of 1 percent of the 2,171,603.9 acres of Superior National Forest that are managed by USFS, so any such increase would be small.

Timber

There is no ongoing forestry activity on the federal lands, and no evidence of recent past forestry activity. Portions of Tracts 2, 3, and 4 show some evidence of timber harvesting, and a timber harvest agreement is in place through 2013 for the Wolf Lands 3 parcel (see Section 4.3.1). Likely USFS management area designations for the non-federal lands would allow timber harvesting on 6,547.1 acres of the non-federal lands (the lands designated General Forest or General Forest – Longer Rotation; see Table 5.3.1-1). Thus, the Land Exchange Proposed Action could increase timber production in Superior National Forest.

On average, 1 percent of timber land in Superior National Forest is harvested each year, with an estimated value of $400 (gross) per harvested acre (MDNR, Pers. Comm., April 26, 2012). Timber harvesting on the non-federal lands (and any other USFS lands) would occur only after completion of forest planning, when acres that are eligible for harvest are identified and the offered for sale. For planning purposes, if 1 percent of the non-federal lands would therefore generate gross proceeds of approximately $26,188 per year. This represents approximately 2 percent of the $1,435,900 value of timber harvests in Superior National Forest in 2011 (MDNR, Pers. Comm., April 26, 2012), although the markets for timber, and thus the value of harvested timber, can change dramatically. This additional activity would be estimated to generate fewer than 20 new jobs in the region. Minnesota averages approximately one forestry job (including logging and primary manufacturing) per 350 acres of annual harvest, and each direct forestry job generates another 3.6 indirect and induced jobs (MDNR, Pers. Comm., April 26, 2012). Using these estimates, the Land Exchange Proposed Action could generate four direct and 12 indirect jobs. As of 2009, forestry activities employed approximately 1,287 individuals in the study area (Headwaters Economics 2009).

Environmental Justice and Subsistence

Potential EJ populations, as well as the EJ and subsistence effects of the Land Exchange Proposed Action on the federal lands, are described in Section 5.2.10.2.7. Although tribal entities possess usufructuary rights to hunt, fish, and gather throughout the 1854 Ceded Territory, the federal lands are not easily accessible for such subsistence activities. The Land Exchange Proposed Action would involve the transfer of 6,495.4 acres of inaccessible federal lands from public to private ownership, and up to 7,075.0 acres of publicly accessible land from private to public ownership. To the degree that increased availability of publicly accessible land improves property value and generates revenue (see above) in the study area, the Land Exchange Proposed Action could have positive effects on EJ populations.

As a result of the Land Exchange Proposed Action, the current federal lands would become unavailable for subsistence use. Resource-specific sections of the FEIS address the degree to which subsistence species and resources are likely to be available on the non-federal lands. As described in Section 5.2.9, subsistence has both economic and cultural components; for the Bands, the harvest of a particular animal or plant is intrinsically linked to the place and nature in which it was harvested. Thus, a "net change" in subsistence activity associated with the Land Exchange Proposed Action cannot be calculated in the same way as, for example, the net change in employment or income. The Land Exchange Proposed Action would result in the loss of subsistence resources and opportunities on the federal lands, and a gain in subsistence resources and opportunities on the non-federal lands.

Other Socioeconomic Considerations

The Land Exchange Proposed Action would result in slight increases in demand for public safety services to assist recreational or other users of the non-federal lands. This is a demand that currently does not exist on the inaccessible federal lands. The non-federal lands represent 0.2 percent of the Superior National Forest. Thus, any such increased demand would be marginal. No new housing (and thus no increased demand for educational facilities) is anticipated on the non-federal lands. Any utilities extended to the non-federal lands (such as electricity) would likely be minimal in nature (given the ROS categories assigned to the non-federal lands—see Section 5.3.11). Thus, the Land Exchange Proposed Action would have negligible effects on other socioeconomic considerations.

The Land Exchange Proposed Action would result in a loss of some of the ecosystem functions provided by the forest, wetland, and other natural habitats on the federal lands, particularly the portions of the federal lands (i.e., the Mine Site) where habitat would be replaced by mine facilities. Some of these functions could be restored during the post-closure period, when the federal lands (as well as the Plant Site) are revegetated. In exchange, the Land Exchange Proposed Action would enable the USFS to directly manage the ecosystems functions on the non-federal lands.

5.3.10.3 Land Exchange Alternative B

Under the Land Exchange Alternative B, 4,752.6 acres of federal lands would be exchanged for the 4,926.3-acre Tract 1. The remainder of the federal lands would remain inaccessible by land. The Land Exchange Alternative B would create moderate positive economic effects through increased opportunity for forestry and recreation and associated employment, earnings, and revenue (see Table 5.3.10-1); however, these benefits would be less than from the Land Exchange Proposed Action. Similarly, the Land Exchange Alternative B would have negligible negative effects on other socioeconomic factors, including housing, public facilities and services, EJ populations, and subsistence, although less so than the Land Exchange Proposed Action.

5.3.10.4 Land Exchange No Action Alternative

Under the Land Exchange No Action Alternative, the NorthMet Project Proposed Action would not be developed, there would be no change to the federal lands, and the non-federal lands would remain inaccessible to the public (including tribal entities). Given other private ownership (e.g., the Dunka Road and railroad), the federal and non-federal lands would remain generally inaccessible to the public. Therefore, there would be no direct or indirect effects on socioeconomics.

5.3.11 Recreation and Visual Resources

This section describes the potential environmental consequences of the Land Exchange Proposed Action on recreational facilities and activities that typically take place on the federal and non-federal lands. In this section, effects on the federal and non-federal lands are discussed together, to facilitate calculation of net changes in recreation and scenic classes. Under the Land Exchange Proposed Action and Land Exchange Alternative B, the Superior National Forest would retain its ongoing responsibility for managing recreational resources on National Forest System lands in accordance with the Forest Plan.

Overall, the Land Exchange Proposed Action would increase opportunities for recreational activity through the acquisition of up to 7,075.0 acres of publicly accessible land (the non-federal lands) in exchange for 6,495.4 acres of federal land that are not publicly accessible by land, and thus cannot be practically used for recreation. The Land Exchange Proposed Action would also increase the amount of land controlled by the USFS in the Superior National Forest with Moderate and High SIOs.

The Land Exchange Alternative B would have a lesser degree of the same type of benefits for recreation and visual resources as the Land Exchange Proposed Action, due to the reduced land area involved.

Table 5.3.11-1 shows the effects of the Land Exchange Proposed Action and the Land Exchange Alternative B on acreage of various ROS classes; Table 5.3.11-2 shows the effects on SIO classes.

Table 5.3.11-1 Net Increase or Decrease of Recreation Opportunity Spectrum Classes

	Increase (Decrease) of ROS Class (Acres)			
Alternative	**Semi-Primitive Motorized**	**Semi-Primitive Non-Motorized**	**Roaded Natural**	**Total**
Land Exchange Proposed Action	(2,243.3)	2,309.9	513.0	579.6
Land Exchange Alternative B	(2,972.7)	2,162.2	984.2	173.7

Table 5.3.11-2 Net Increase or Decrease of Scenic Integrity Objectives

	Increase (Decrease) of Scenic Integrity Objective (Acres)			
Alternative	**High**	**Moderate**	**Low[1]**	**Total[1]**
Land Exchange Proposed Action	136.3	1,644.6	(1,170.8)	610.1
Land Exchange Alternative B	20.4	1,315.4	(1,153.2)	182.6

Note:
[1] Mud Lake would not be managed by the USFS, and therefore does not have an SIO.

5.3.11.1 Methodology and Evaluation Criteria

5.3.11.1.1 Recreation

The primary issues related to recreational facilities and activities associated with the Land Exchange Proposed Action on and near the federal lands and non-federal lands include the following:

- Change in areas of ROS classes within the Superior National Forest; and
- Qualitative difference in recreation opportunities, as measured using ROS classes, between outgoing federal land and non-federal lands to be acquired.

ROS classes are defined by the USFS (1982) and ROS classes for the non-federal lands were mapped to match the existing mapped ROS Spectrum areas on surrounding adjacent federal lands. GIS analysis was employed to determine the net change in acreage by ROS class. ROS classes are discussed in Section 4.2.11.1.1.

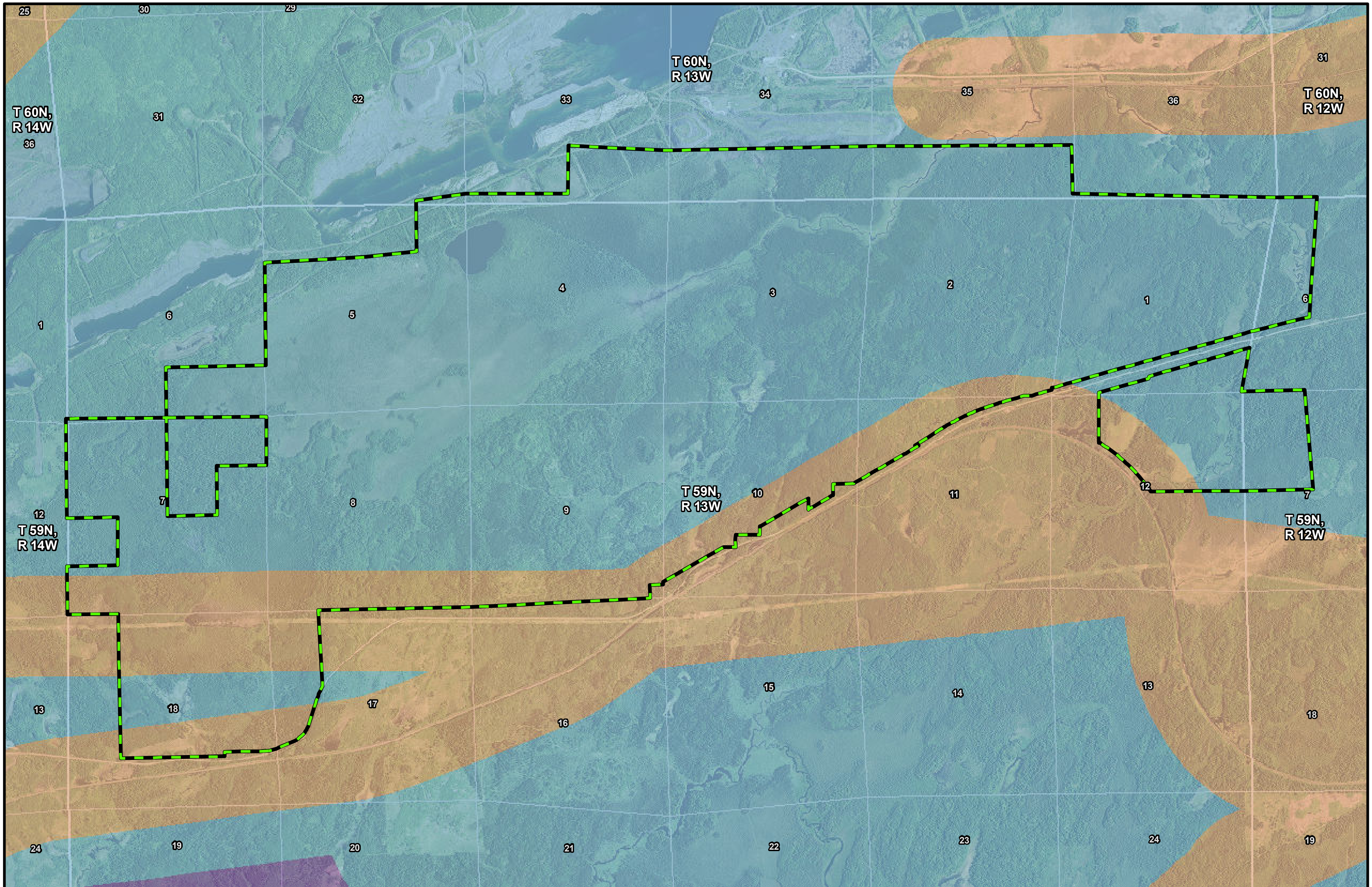
5.3.11.1.2 Visual Resources

The primary issue related to visual resources on and near the non-federal lands is the change in acreage of High, Moderate, and Low SIO classified land within Superior National Forest lands. SIOs were provided by USFS (1995), and as with ROS classes, SIOs for the non-federal lands were mapped to match the existing mapped SIOs on surrounding adjacent federal lands. GIS analysis was employed to determine the net change in acreage by SIO. SIOs are discussed in section 4.2.11.1.2. This quantitative analysis was supplemented by a qualitative description of loss of scenery opportunities on federal lands that would be conveyed to PolyMet and the gain of scenery opportunities on non-federal lands to be acquired and managed by USFS.

5.3.11.2 Land Exchange Proposed Action

5.3.11.2.1 Recreation

ROS classes for the federal lands are shown on Figure 5.3.11-1; the classes that would be applied to the non-federal lands are also shown on Figures 5.3.11-2 and 5.3.11-3. These classifications are summarized in Table 5.3.11-3. No developed recreational sites or opportunities are planned at this time. All of the tracts would be open for non-motorized, dispersed recreational activities. The federal lands in the Land Exchange Proposed Action consist of 967.0 acres designated as Roaded Natural and 5,528.4 acres designated Semi-Primitive Motorized (see Table 5.3.11-3). As described in Sections 4.2.11 and 4.3.11, the Semi-Primitive (Motorized and Non-Motorized) classes indicate areas where interaction between visitors is rare, but where human activities may be visible. The Roaded Natural class indicates an area where evidence of human activity and interactions are more frequent, and occasionally prevalent.



Federal Lands
Section Boundary
1 Section Label
Recreation Opportunity Spectrum
Semi-Primitive Motorized
Semi-Primitive Non-motorized
Roaded Natural
Rural

MNDNR
US Army Corps of Engineers
St. Paul District

N W E S
0 1,000 2,000 4,000 Feet

Figure 5.3.11-1
Recreation Opportunity Spectrum
Federal Lands
NorthMet Mining Project and Land Exchange FEIS
Minnesota

November 2015

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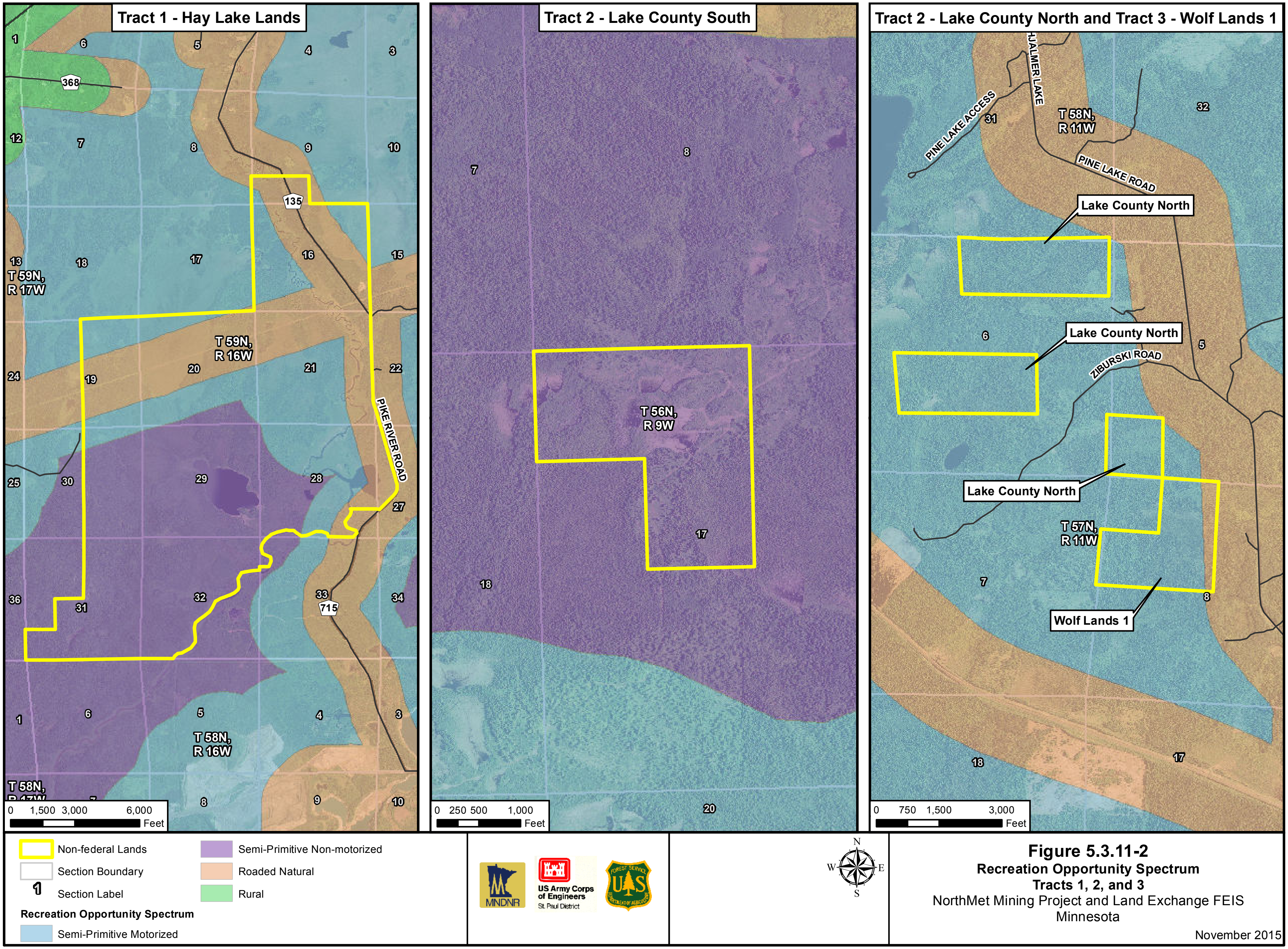

Figure 5.3.11-2
Recreation Opportunity Spectrum
Tracts 1, 2, and 3
NorthMet Mining Project and Land Exchange FEIS
Minnesota

November 2015

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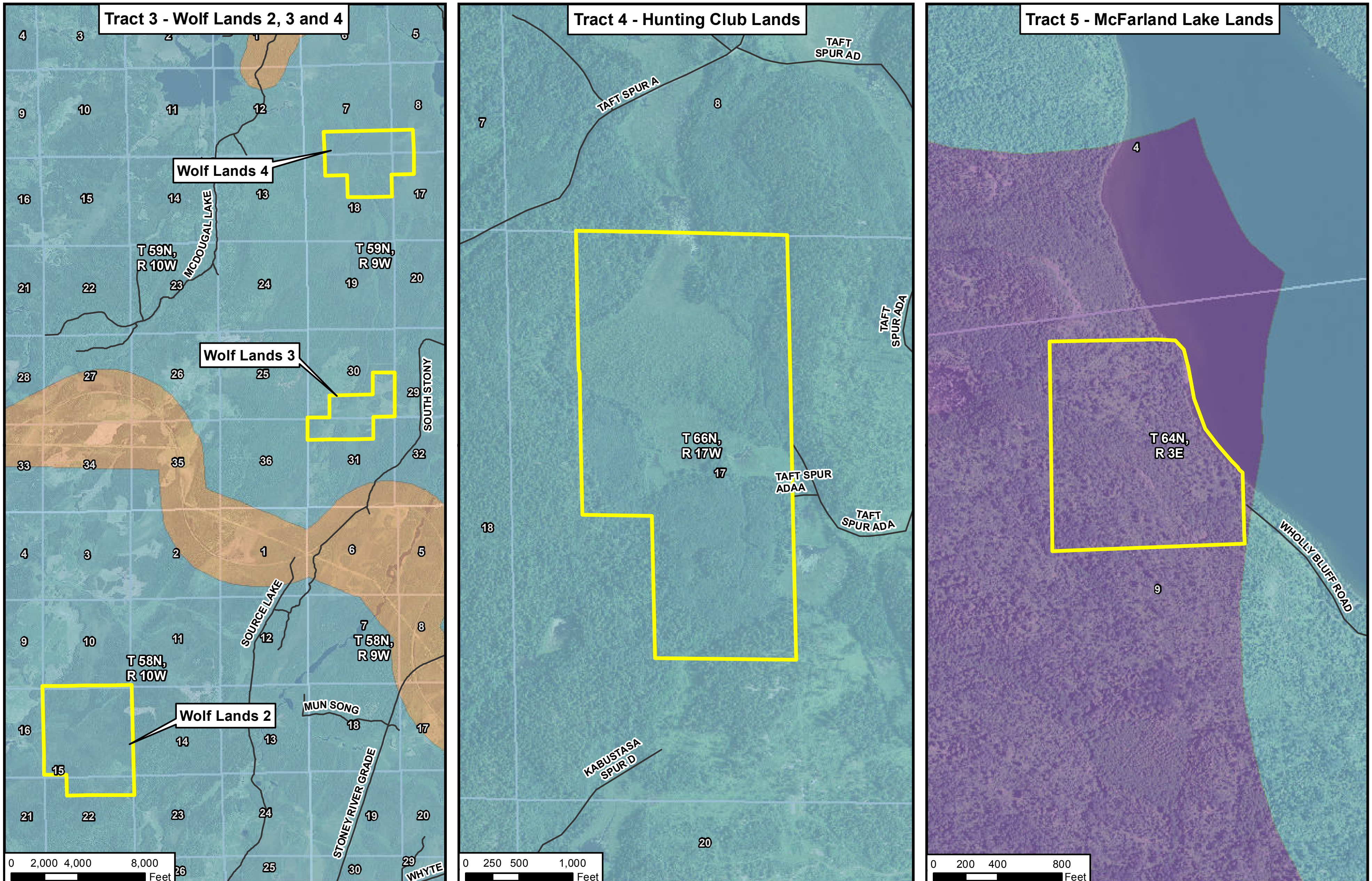

Non-federal Lands

Section Boundary

1 Section Label

Recreation Opportunity Spectrum

Semi-Primitive Motorized

Semi-Primitive Non-motorized

Roaded Natural

Rural

MNDNR

US Army Corps of Engineers St. Paul District

N W E S

Figure 5.3.11-3

Recreation Opportunity Spectrum

Tracts 3, 4, and 5

NorthMet Mining Project and Land Exchange FEIS

Minnesota

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Table 5.3.11-3 Recreation Opportunity Spectrum Classifications of Federal and Non-Federal Lands (Land Exchange Proposed Action)

	Acres of ROS Class			
Parcel	**Semi-Primitive Motorized**	**Semi-Primitive Non-Motorized**	**Roaded Natural**	**Total**
Lands Conveyed				
Federal lands	5,528.4	0.0	967.0	6,495.4
Lands Acquired				
Tract 1 - Hay Lake	1,303.8	2,162.2	1,460.3	4,926.3
Tract 2 - Lake County North	265.0	0.0	0.0	265.0
Tract 2 - Lake County South	0.0	116.9	0.0	116.9
Tract 3 - Wolf Lands 1	106.1	0.0	19.7	125.8
Tract 3 - Wolf Lands 2	767.9	0.0	0.0	767.9
Tract 3 - Wolf Lands 3	277.4	0.0	0.0	277.4
Tract 3 - Wolf Lands 4	404.7	0.0	0.0	404.7
Tract 4 - Hunting Club	160.2	0.0	0.0	160.2
Tract 5 – McFarland Lake	0.0	30.8	0.0	30.8
Subtotal: Non-federal Lands	3,285.1	2,319.9	1,480.0	7,075.0
Net Change				
Net Increase/(Decrease)	(2,243.3)	2,309.9	513.0	579.6

Source: USFS, Pers. Comm., November 29, 2011.

There is no public land access to and no practical opportunity for recreational activity on the federal lands, and the federal lands would remain inaccessible after completion of the Land Exchange Proposed Action. By comparison, the non-federal lands would be accessible to varying degrees, and therefore could host recreational activities, as defined by their respective ROS class. Tract 1 is the most accessible and therefore has the greatest potential for public recreational use. Tract 5 would likely be accessible from adjacent Superior National Forest land and/or the lake itself, while Tract 4 is also accessible via road and trail. Tracts 2 and 3 would be more difficult to access.

As Table 5.3.11-3 shows, the Land Exchange Proposed Action would result in a net decrease to the federal estate of 2,243.3 acres of land designated Semi-Primitive Motorized, an increase to the federal estate of 2,309.9 acres of land designated Semi-Primitive Non-Motorized, and an increase to the federal estate of 513.0 acres of Roaded Natural land. Although there would be a decrease of Semi-Primitive Motorized land to the federal estate, the Land Exchange Proposed Action overall would affect less than one-quarter of one percent of the total area of the Superior National Forest (approximately 3 million acres), and the reduction to the federal estate of this ROS type would be exceeded by the increase to the federal estate in other ROS types.

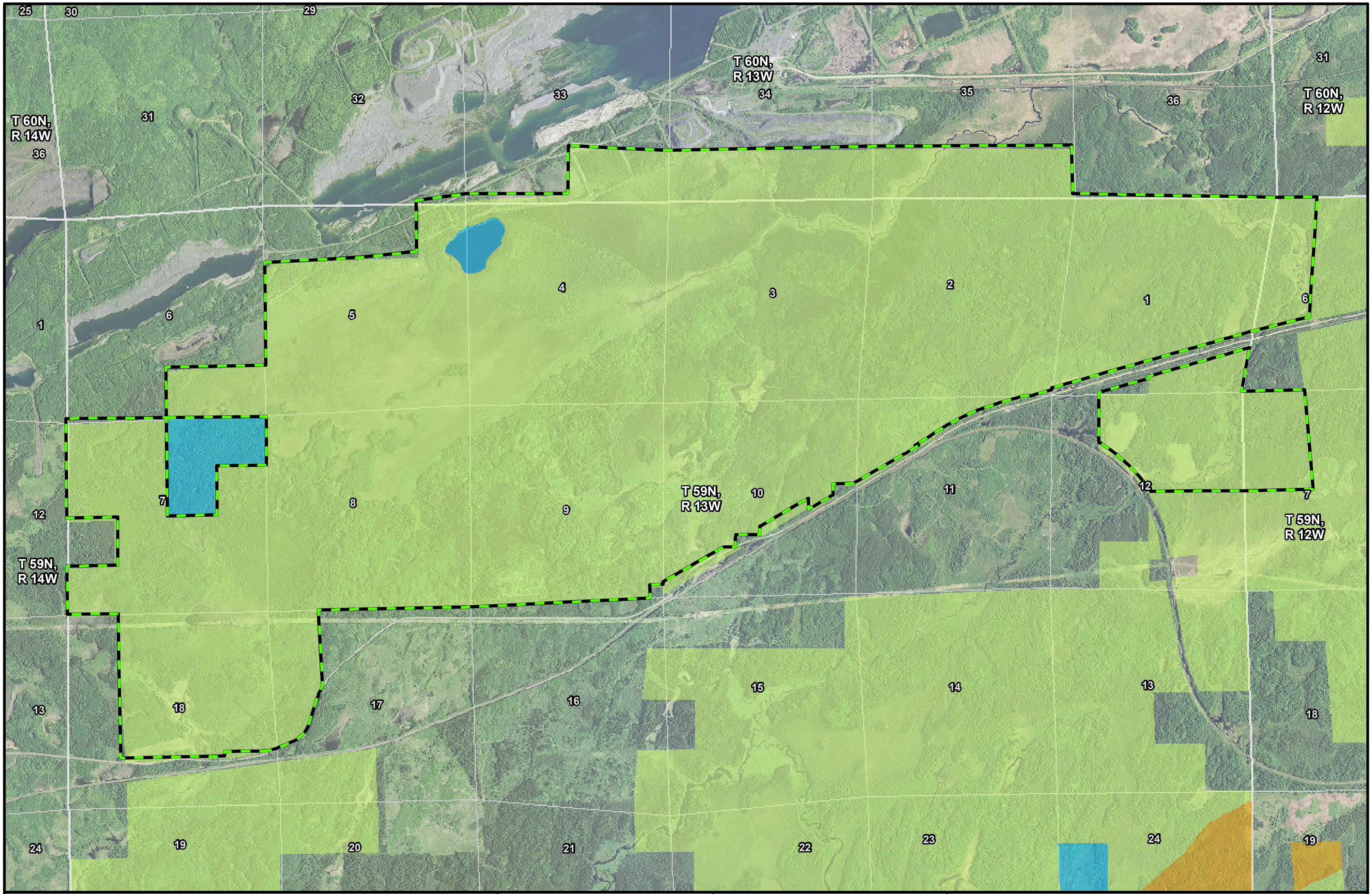
Because the federal lands are not accessible to the public by land, the Land Exchange Proposed Action represents an addition to the amount of potential publicly accessible land in the Superior National Forest. As a result, the Land Exchange Proposed Action would increase opportunities for hunting, fishing, and other recreational activities.

5.3.11.2.2 Visual Resources

SIOs for the federal lands are shown on Figure 5.3.11-4, while the SIOs that would be applied to the non-federal lands are shown in Figures 5.3.11-5 and 5.3.11-6. These are summarized in Table 5.3.11-4. The Low SIO of the federal lands indicates that the area may be dominated by management activities. Effects on visual resources on the federal lands are similar to those at the Mine Site, as discussed in Section 5.2.11.2.1.

The non-federal lands are only somewhat visible from public roads, few of which are elevated enough to afford views of the tracts themselves. Still, transfer of the non-federal lands to Superior National Forest ownership would generally help to preserve the scenic quality of those parcels. The NorthMet Project area would not be visible from any of the Land Exchange Proposed Action parcels.

The Land Exchange Proposed Action would result in a net decrease to the federal estate of 1,170.8 acres of land with a Low SIO and an increase to the federal estate of 136.3 acres of land with a High SIO and 1,644.6 acres of land with a Moderate SIO (see Table 5.3.11-4). This change in the composition of the visual character of the Superior National Forest, which affects less than one-quarter of one percent of the total area of the forest, would have generally positive effects. The addition of land with Moderate and High SIO (in lieu of land with a Low SIO) could affect the types of forestry and management activities that could occur on those lands. The USFS would acquire land with a wider diversity of SIOs (i.e., the addition of land with Moderate and High SIOs) and the Land Exchange Proposed Action would result in a net increase to the federal estate.



Federal Lands
Section Boundary
Section Label

Scenic Integrity Objective
High
Moderate
Low
N/A

MNDNR
US Army Corps of Engineers St. Paul District

0 1,000 2,000 4,000 Feet

Figure 5.3.11-4
Scenic Integrity Objective
Federal Lands
NorthMet Mining Project and Land Exchange FEIS
Minnesota

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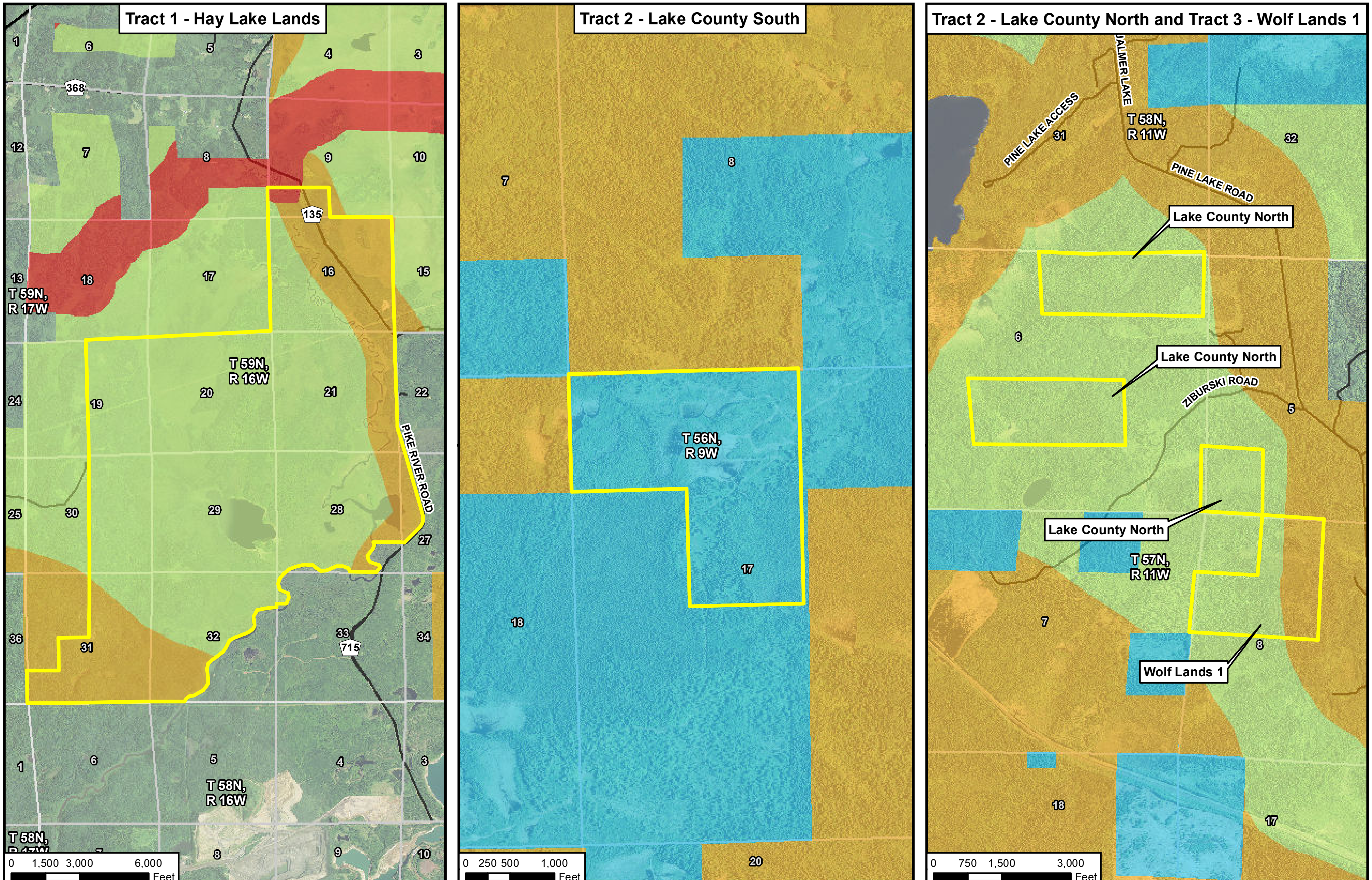

Non-federal Lands

Section Boundary

1 Section Label

Scenic Integrity Objective

- High
- Moderate
- Low
- N/A

MNDNR

US Army Corps of Engineers St. Paul District

N W E S

Figure 5.3.11-5

Scenic Integrity Objective

Tracts 1, 2, and 3

NorthMet Mining Project and Land Exchange FEIS

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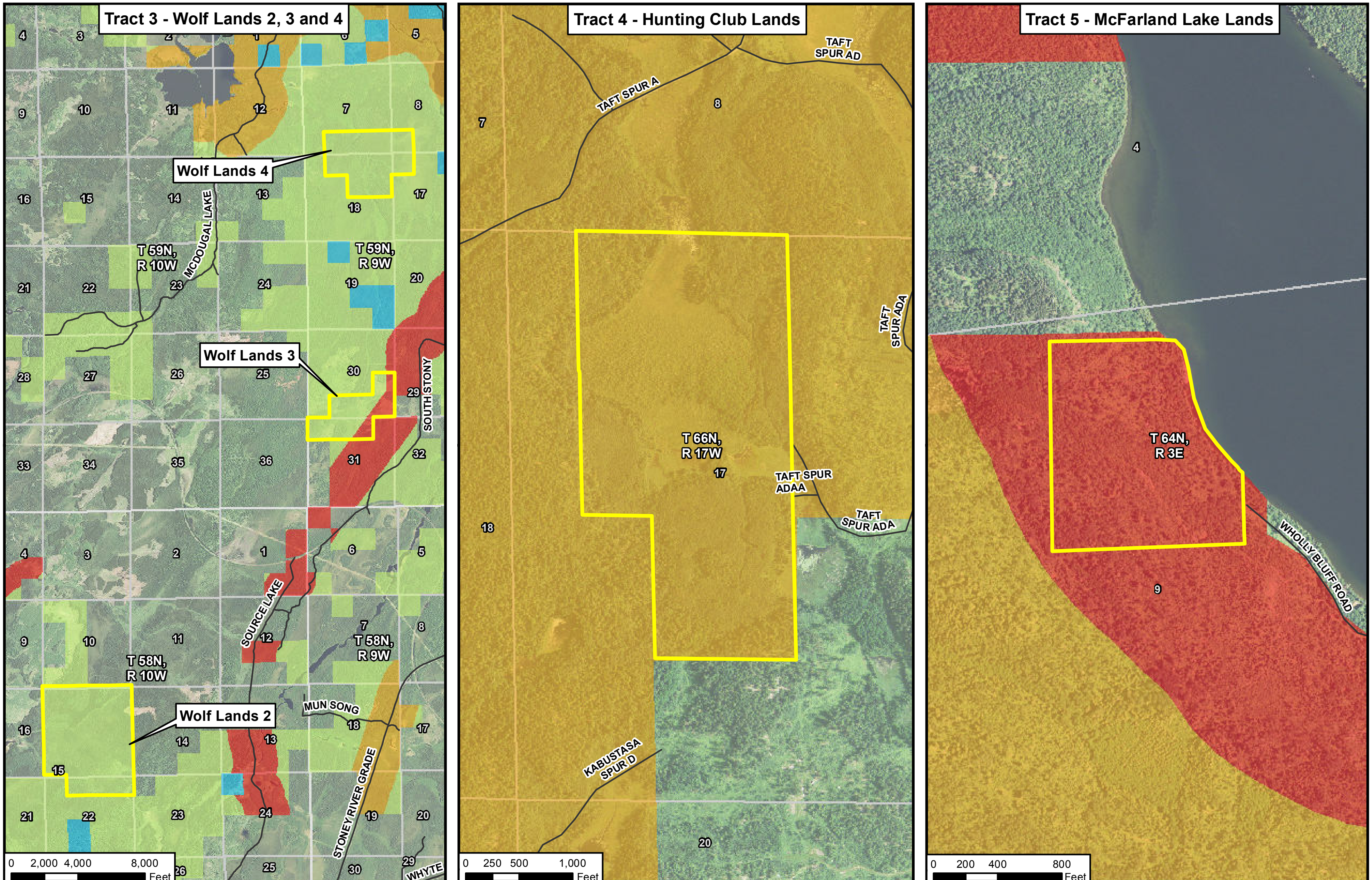

Non-federal Lands
Section Boundary
1 Section Label

Scenic Integrity Objective
- High
- Moderate
- Low
- N/A

MNDNR
US Army Corps of Engineers St. Paul District

Figure 5.3.11-6
Scenic Integrity Objective
Tracts 3, 4, and 5
NorthMet Mining Project and Land Exchange FEIS
Minnesota

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Table 5.3.11-4 Scenic Integrity Objectives of Federal and Non-Federal Lands (Proposed Action)

Parcel	Acres of Scenic Integrity Objective			
	High	Moderate	Low	Total
Lands Conveyed				
Federal lands	0.0	0.0	6,464.9[(1)]	6,464.9[(1)]
Lands Acquired				
Tract 1 - Hay Lake	20.4	1,315.4	3,590.5	4,926.3
Tract 2 - Lake County North	0.0	0.0	265.0	265.0
Tract 2 - Lake County South	0.0	116.9	0.0	116.9
Tract 3 - Wolf Lands 1	0.0	52.1	73.7	125.8
Tract 3 - Wolf Lands 2	0.0	0.0	767.9	767.9
Tract 3 - Wolf Lands 3	85.1	0.0	192.3	277.4
Tract 3 - Wolf Lands 4	0.0	0.0	404.7	404.7
Tract 4 - Hunting Club	0.0	160.2	0.0	160.2
Tract 5 – McFarland Lake	30.8	0.0	0.0	30.8
Subtotal: Non-federal Lands	136.3	1,644.6	5294.1	7,075.0
Net Change				
Net Increase/(Decrease)	136.3	1,644.6	(1,170.8)	610.1

Source: USFS, Pers. Comm., November 29, 2011.

Note:
1 Mud Lake (comprising 30.5 acres of the 6,495.4 acres in the federal lands) would not be managed by USFS, and therefore does not have a SIO.

5.3.11.3 Land Exchange Alternative B

5.3.11.3.1 Recreation

Under the Land Exchange Alternative B, 4,752.6 acres of federal lands would be exchanged for the 4,926.3-acre Tract 1. ROS classes for the federal lands portion of the Land Exchange Alternative B are shown on Figure 5.3.11-7 (Tract 1 classes would remain unchanged from the Land Exchange Proposed Action). Table 5.3.11-5 summarizes the ROS classes of these lands.

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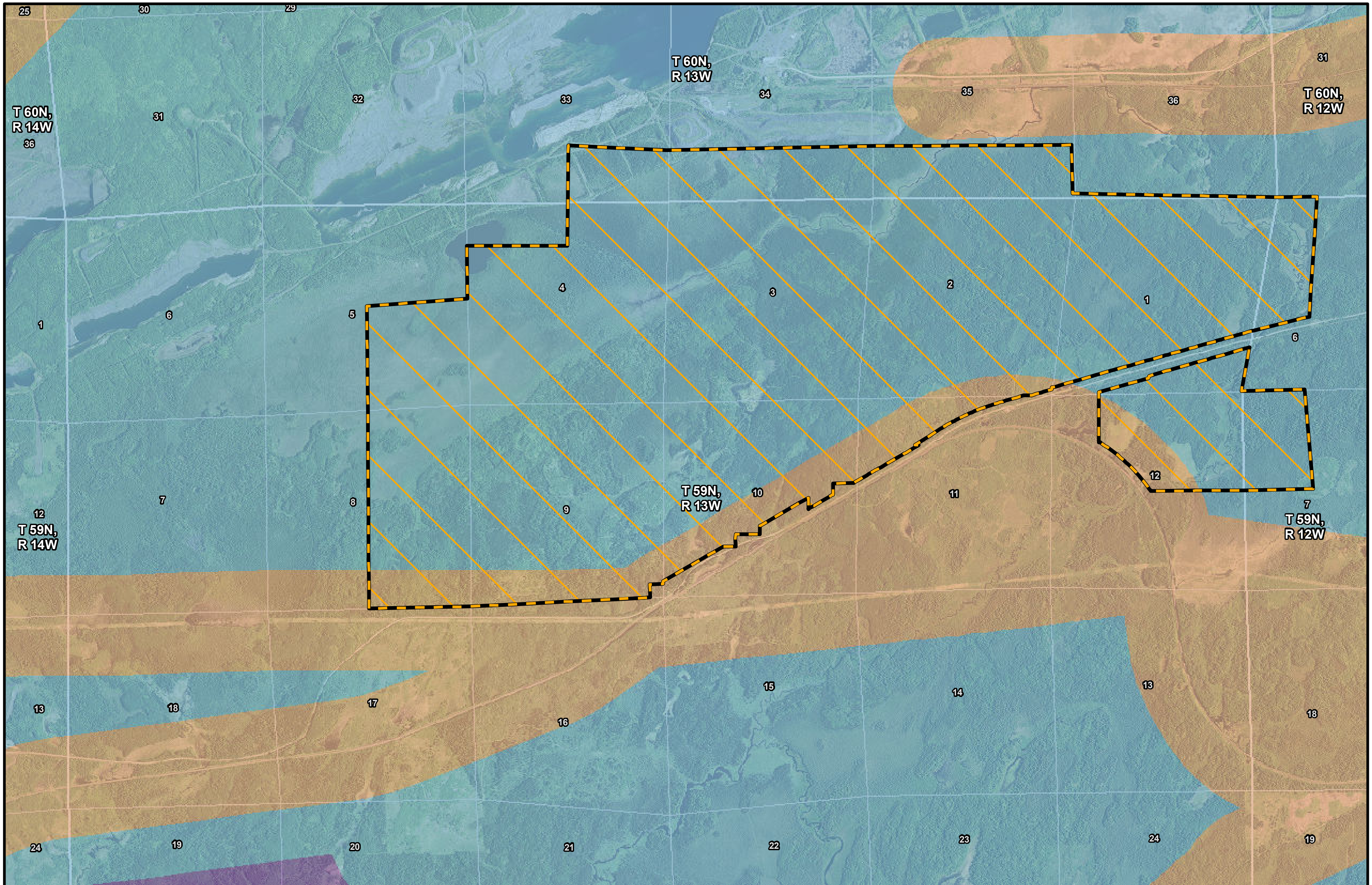

Alternative B: Smaller Federal Parcel
Section Boundary
1 Section Label

Recreation Opportunity Spectrum

Semi-Primitive Motorized
Semi-Primitive Non-motorized
Roaded Natural
Rural

MNDNR
US Army Corps of Engineers St. Paul District

N W E S

0 1,000 2,000 4,000 Feet

Figure 5.3.11-7

Recreation Opportunity Spectrum

Alternative B: Smaller Federal Parcel

NorthMet Mining Project and Land Exchange FEIS

Minnesota

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Table 5.3.11-5 Recreation Opportunity Spectrum Class of Federal and Non-federal Lands (Land Exchange Alternative B)

	Acres of ROS Class			
Parcel	**Semi-Primitive Motorized**	**Semi-Primitive Non-Motorized**	**Roaded Natural**	**Total**
Lands Conveyed				
Alternative B	4,276.5	0.0	476.1	4,752.6
Lands Acquired				
Tract 1 - Hay Lake	1,303.8	2,162.2	1,460.3	4,926.3
Net Change				
Net Increase (Decrease)	(2,972.7)	2,162.2	984.2	173.7

Source: USFS, Pers. Comm., November 29, 2011.

Similar to the Land Exchange Proposed Action, there is no public land access to and no opportunity for recreational activity on the federal lands, and the smaller federal parcel would remain inaccessible after completion of the Land Exchange Alternative B. By comparison, the non-federal lands (Tract 1) would be accessible (to varying degrees), and therefore would be capable of hosting recreational activities, as defined by their respective ROS classes. Tract 1 is accessible and therefore would result in the greatest potential for public recreational use.

As Table 5.3.11-5 shows, the Land Exchange Alternative B would result in a net decrease to the federal estate of 2,972.7 acres of land designated as Semi-Primitive Motorized, and an increase to the federal estate of 2,162.2 acres of Semi-Primitive Non-Motorized land and 984.2 acres of Roaded Natural land. Although there would be a decrease of Semi-Primitive Motorized land, the Land Exchange Alternative B overall would affect less than one-quarter of one percent of the total area of the Superior National Forest, and the reduction to the federal estate of this ROS class would be exceeded by the increase to the federal estate in other ROS classes.

As with the Land Exchange Proposed Action, because the federal lands are not accessible to the public, the Land Exchange Alternative B represents an addition to the amount of potential publicly accessible land in the Superior National Forest. As a result, the Land Exchange Alternative B would increase opportunities for hunting, fishing, and other recreational activities. Overall, the effects of the Land Exchange Alternative B on recreation are similar to those of the Land Exchange Proposed Action, but smaller in magnitude, due to the reduced amount of land involved.

5.3.11.3.2 Visual Resources

SIO classifications for the smaller federal parcel are shown on Figure 5.3.11-8 (Tract 1 classifications would remain unchanged from the Land Exchange Proposed Action) and are summarized in Table 5.3.11-6. As with the Land Exchange Proposed Action, the Land Exchange Alternative B has a Low SIO, indicating the lands may be dominated by management activities; however, Tract 1 would only be somewhat visible from public roads and would generally help to preserve the scenic quality of the parcel. The NorthMet Project area would not be visible from Tract 1.

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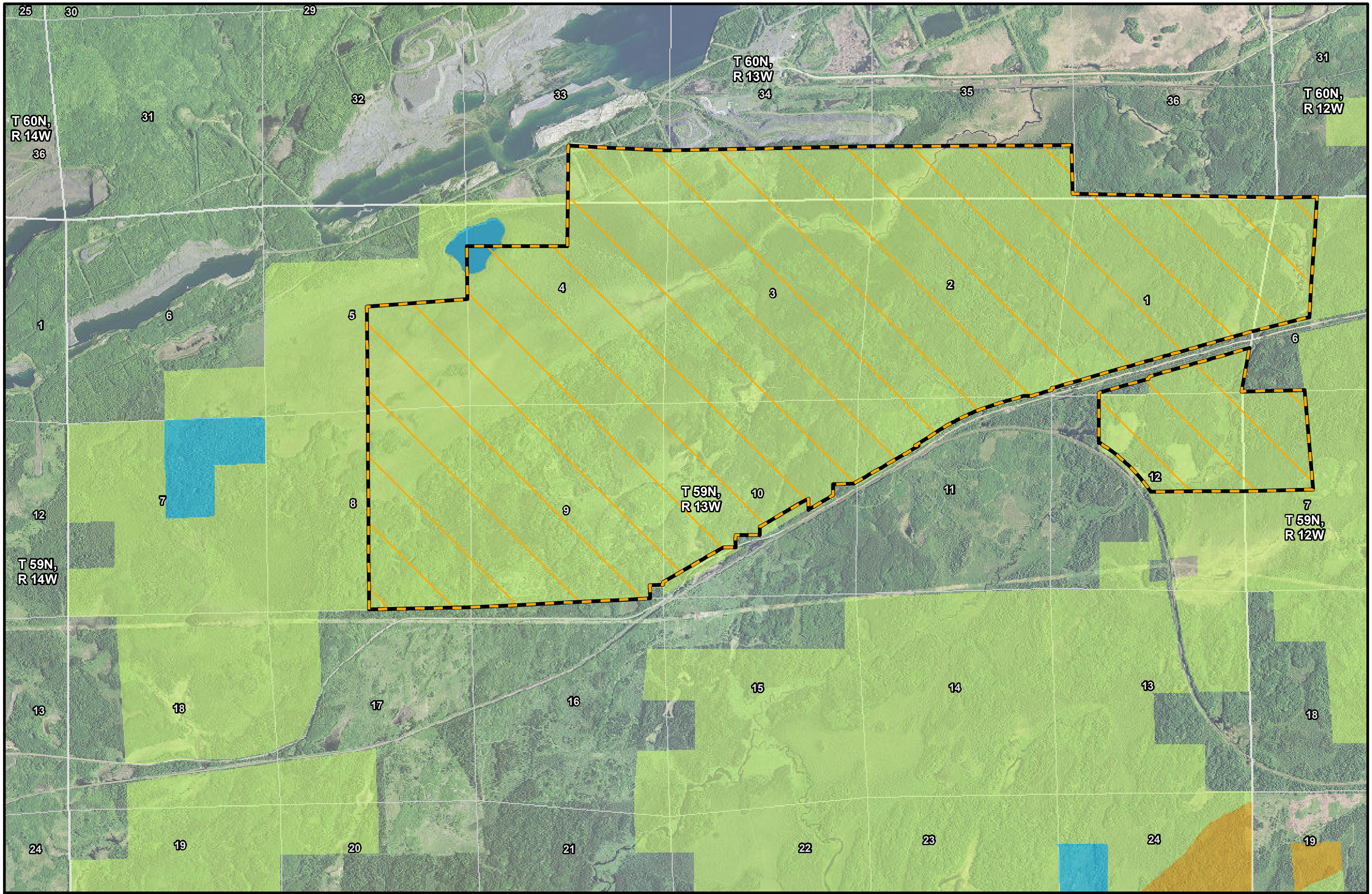

Figure 5.3.11-8
Scenic Integrity Objective
Alternative B: Smaller Federal Parcel
NorthMet Mining Project and Land Exchange FEIS
Minnesota

November 2015

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The Land Exchange Alternative B would result in a net decrease to the federal estate of 1,153.2 acres of land with a Low SIO, in exchange for an increase to the federal estate of 20.4 acres of land with a High SIO and 1,153.2 acres of land with a Moderate SIO. This change in the composition of the visual character of the Superior National Forest, which affects less than one-tenth of one percent of the total area of the Superior National Forest, would have generally positive effects. The addition of land with Moderate and High SIOs (in lieu of land with a Low SIO) could affect the types of forestry and management activities that can occur on those lands. The USFS would acquire land with a wider diversity of SIOs and the Land Exchange Alternative B would result in a net increase to the federal estate, although less than in the Land Exchange Proposed Action.

Table 5.3.11-6 Scenic Integrity Objectives of Federal and Non-federal Lands (Land Exchange Alternative B)

	Acres of Scenic Integrity Objective Classification			
Parcel	**High**	**Moderate**	**Low**	**Total**
Lands Conveyed				
Alternative B	0	0	4,743.7[(1)]	4,743.7[(1)]
Lands Acquired				
Tract 1 - Hay Lake	20.4	1,315.4	3,590.5	4,926.3
Net Change				
Net Increase (Decrease)	20.4	1,315.4	(1,153.2)	182.6

Source: USFS, Pers. Comm., November 29, 2011.

Note:
[1] Mud Lake (comprising 8.9 acres of the 4,752.6 acres in the smaller federal parcel), would not be managed by USFS, and therefore does not have a SIO.

5.3.11.4 Land Exchange No Action Alternative

5.3.11.4.1 Recreation

Under the Land Exchange No Action Alternative, the federal and non-federal lands would remain generally inaccessible to the public for recreation or other uses.

5.3.11.4.2 Visual Resources

Under the Land Exchange No Action Alternative, the visual appearance of the federal and non-federal lands would remain unchanged.

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5.3.12 Wilderness and Other Special Designation Areas

This section describes the potential environmental consequences of the Land Exchange Proposed Action on wilderness and other special designation area resources that are on or near the federal and non-federal lands.

The Land Exchange Proposed Action would not result in a net increase or decrease in any wilderness areas. However, the Land Exchange Proposed Action would result in a net increase of 306.9 acres of cRNAs to the federal estate through exchange of Tract 1. Land Exchange Alternative B would still include exchange of Tract 1; therefore, it would result in the same net changes to cRNA acreage as the Land Exchange Proposed Action.

The Land Exchange No Action Alternative would not affect wilderness or special-designation areas as the Land Exchange would not occur.

5.3.12.1 Methodology and Evaluation Criteria

An evaluation was conducted to determine the potential effect that the Land Exchange Proposed Action would have on the wilderness character of the area. Potential effects on noise, water resources, and recreation and visual resources were evaluated. The analysis of the wilderness character affected by the Land Exchange Proposed Action was guided by evaluation criteria that were developed by the USFS and other Co-lead Agencies.

Estimated ambient noise levels at each of the sensitive receptor sites adjacent to the federal lands were compared with modeled noise levels to determine effects. An appropriate noise propagation model was used to generate noise contours from the Mine Site and Plant Site. To determine effects on water resources, in addition to available information from field efforts already performed by PolyMet for the NorthMet Project Proposed Action, analysis of air photos and available GIS layers for federal and non-federal lands included data layers and other collected data such as NWI maps, soil maps/ecological land type maps, and FEMA floodplain maps. Scenic quality and integrity of lands being acquired and conveyed was determined based on desktop study and limited field observations where necessary. The Forest Plan uses a nationally recognized classification system, the ROS, to describe different recreation settings, opportunities, and experiences. Reviewing existing information and consultation with area land managers provided the information needed to understand the existing and potential recreation opportunities.

5.3.12.2 Land Exchange Proposed Action

The Land Exchange Proposed Action would result in a net increase of cRNAs to the federal estate. As indicated in Section 5.3.1, the USFS has determined that Tract 1 would have the following management area designations: General Forest and cRNA. Therefore, the Land Exchange Proposed Action would include the Pike Mountain and Loka Lake cRNAs (southwest corner and northeast corner of the tract, respectively). The addition of Tract 1 into the federally managed areas would extend the Pike Mountain cRNA by 135.7 acres of primarily hardwoods plant community, and would extend the Loka Lake cRNA by 171.2 acres of lowland black spruce and tamarack swamp. The remaining 4,619.3 acres would be allocated to General Forest.

Tracts 2, 3, 4, and 5 would not result in a net change to wilderness or other special designation areas.

5.3.12.3 Land Exchange Alternative B

The Land Exchange Alternative B would result in the same net increase of cRNAs to the federal estate as the Land Exchange Proposed Action. The Land Exchange Alternative B would not result in a net change to any wilderness area.

5.3.12.4 Land Exchange No Action Alternative

Under the Land Exchange No Action Alternative, the Superior National Forest would have an ongoing responsibility for managing the wilderness and other special designations on or near the federal lands in accordance with the Forest Plan. The Land Exchange No Action Alternative would not change the USFS's responsibility for managing these resources and would result in no further effects on existing wilderness areas or other special designated areas.

5.3.13 Hazardous Materials

The Land Exchange Proposed Action and the Land Exchange Alternative B would not include operations or activities that involve the use of hazardous materials on federal or non-federal lands beyond those activities specific to the NorthMet Project Proposed Action described in Section 5.2.13. AOCs associated with legacy contamination by hazardous materials from former activities and operations on these lands are discussed in Section 5.3.1.

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5.3.14 Geotechnical Stability

Geotechnical stability considerations for the proposed stockpiles that would be located on federal land subject to the Land Exchange Proposed Action or Land Exchange Alternative B within the NorthMet Project area are discussed in Section 5.2.14. There are no other existing or proposed large-scale waste material storage facilities on land subject to the Land Exchange Proposed Action or Land Exchange Alternative B.

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