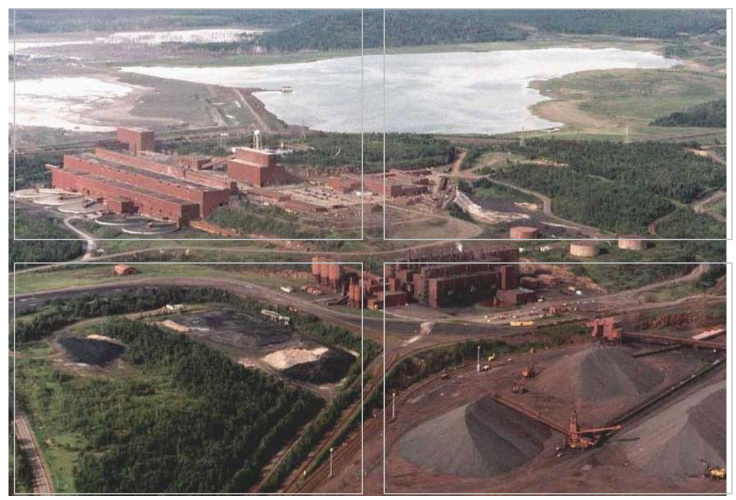

Minnesota Department of Natural Resources

U.S. Army Corps of Engineers

NorthMet Project

Complete Preliminary Draft

Environmental Impact Statement

Devcember 2008

COVER SHEET

Complete Preliminary Draft Environmental Impact Statement
NorthMet Project
PolyMet Mining, Inc.

The Minnesota Department of Natural Resources and the U.S. Army Corps of Engineers have jointly prepared the Draft Environmental Impact Statement to evaluate the proposed project in accordance with the National Environmental Policy Act 42 U.S.C. § § 4321-4347, and the Minnesota Environmental Policy Act, Minnesota Statues. §116D

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Abstract: This Complete Preliminary Draft Environmental Impact Statement documents the analysis of potential impacts associated with the PolyMet Mining, Inc. proposed NorthMet Project. The proposed project includes open pit mining operations with ore hauled to the processing facility on a largely existing rail line owned by PolyMet. Waste rock, lean ore, and deferred ore stockpiles from the mining operations are proposed to be located near the mine pits. Stockpiles would be segregated into reactive and non-reactive stockpiles. Non-reactive stockpiles would be constructed and managed in a manner similar to those associated with taconite mining. These stockpiles would be designed and built to prevent sedimentation and erosion from stormwater runoff and provide beneficial use of these areas. Reactive stockpiles are proposed to be placed on engineered liner systems that capture any runoff and direct the runoff to a wastewater treatment system. Ore would be processed at a refurbished and modified taconite processing facility (formerly the LTV Steel Mining Company Erie Plant). The hydrometallurgical process of flotation and autoclave leach facilities would be used with refurbished crushing and grinding facilities to produce copper metal and precipitates of nickel, cobalt, palladium, platinum, gold, and flotation concentrations. Precipitates and flotation concentrates are proposed for shipment off-site to third party treatment. The flotation process will generate flotation tailings that are proposed for disposal on top of a portion of an existing taconite tailings disposal facility. The hydrometallurgical process would generate some waste residue that is proposed for disposal in lined cells on top of the existing taconite tailings adjacent to the area proposed for disposal of flotation tailings.

Approved for Issuance for Public Comment:

Date

Mr. Stuart Arkley
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List of Acronyms

- Above mean sea level (amsl)
- Area of Potential Effect (APE)
- Air quality related values (AQRV)
- Acid rock drainage (ARD)
- Aboveground storage tank (AST)
- Best available control technology (BACT)
- Best available retrofit technology (BART)
- Below ground surface (bgs)
- British thermal unit (BTU)
- Boundary Waters Canoe Area Wilderness (BWCAW)
- Clean Air Act (CAA)
- Council on Environmental Quality (CEQ)
- Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)
- Code of Federal Regulations (CFR)
- Central Pumping Station (CPS)
- County Road (CR)
- Chronic Standard (CS)
- Clean Water Act (CWA)
- Deposition Analysis Threshold (DAT)
- Decibel (dB)
- Decibels as measured on the A-weighted scale (dB(A))
- Draft Environmental Impact Statement (DEIS)
- Environmental Assessment Worksheet (EAW)
- Environmental Impact Statement (EIS)
- Ecological Land Types (ELT)
- U.S. Environmental Protection Agency (EPA)
- Emergency Planning and Community Right to Know Act (EPCRA)
- Emergency Response Plan(ERP)
- Endangered Species Act (ESA)
- Evapotranspiration (ET)
- Endangered, Threatened, and Special Concern (ETSC)
- Electrowinning (EW)
- Final Acute Value (FAV)
- Flotation Collector (FC)
- Federal Emergency Management Agency (FEMA)
- Final Environmental Impact Statement (FEIS)
- Federal Land Manager (FLM)
- Final Scoping Document (FSD)
- Full-time Equivalent (FTE)
- Gap Analysis Program(GAP)
- Geosynthetic Clay Liner(GCL)
- Geographic Information System(GIS)
- Great Lakes Indian Fish and Wildlife Commission (GLIFWC)
- Ground Water Monitoring and Assessment Program (GMAP)
- Gallons per Minute (GPM)
- Global Positioning Satellite (GPS)
- Hazardous Air Pollutant (HAP)
- High Density Polyethylene Pipes (HDPE)
- Human Resources (HR)
- Health Risk Value (HRV)
- U.S. Department of Housing and Urban Development (HUD)
- Intergovernmental Panel on Climate Change (IPCC)
- Integrated Risk Information System (IRIS)
- Isle Royale National Park (IRNP)
- Iron Range Resources (IRR)
- Iron Range Resources and Rehabilitation Board (IRRRB)
- Low Density Polyethylene (LDPE)
- Local Governmental Units (LGU)
- Liquid Propane Gas(LPG)

- LTV Steel Mining Company (LTVSMC)
- Minnesota Ambient Air Quality Standard (MAAQS)
- Maximum Achievable Control Technology (MACT)
- Maximum Contaminant Level (MCL)
- Management Classification System (MCS)
- Minnesota Comprehensive Wildlife Conservation Strategy (MCWCS)
- Minnesota Department of Natural Resources (MDNR)
- Minnesota Environmental Policy Act (MEPA)
- Minnesota Environmental Quality Board (MEQB)
- Minnesota Fish Consumption Advisory (MFCA)
- Minnesota Forest Resource Council (MFRC)
- Methyl Isobutyl Carbine (MIBC)
- MPCA’s Mercury Risk Estimation Method(MMREM)
- Minnesota Department of Natural Resources (MnDNR)
- Minnesota Department of Health (MnDOH)
- Minnesota Department of Transportation (MnDOT)
- Minnesota Routine Assessment Method (MNRAM)
- Mining Protection Area (MPA)
- Minnesota Pollution Control Agency (MPCA)
- miles per hour (mph)
- Maximum Standard (MS)
- Material Safety Data Sheet (MSDS)
- mean sea level (msl)
- megawatt (MW)
- National Ambient Air Quality Standards (NAAQS)
- North American Industry Classification System (NAICS)
- National Climatic Data Center (NCDC)
- National Environmental Policy Act (NEPA)
- Natural Heritage Program (NHP)
- National Historic Preservation Act (NHPA)
- National Institute for Occupational Safety and Health (NIOSH)
- National Oceanic and Atmospheric Administration (NOAA)
- Notice of Intent (NOI)
- National Pollutant Discharge Elimination System (NPDES)
- National Park Service (NPS)
- National Response Center (NRC)
- Natural Resources Conservation Service (NRCS)
- National Register of Historic Places (NRHP)
- National Resources Research Institute (NRRI)
- Noise Sensitive Area (NSA)
- New Source Performance Standard (NSPS)
- National Wetland Inventory (NWI)
- National Weather Service (NWS)
- Off-Highway Vehicle (OHV)
- Official Soil Series Description (OSD)
- Potassium Amyl Xanthate (PAX)
- Polarized light microscopy (PLM)
- Particulate matter (PM)
- Publicly Owned Treatment Works (POTW)
- Parts per million (ppm)
- Prevention of Significant Deterioration (PSD)
- Resource Conservation and Recovery Act (RCRA)
- Regional Forester Sensitive Species (RFSS)
- Responsible Governmental Unit (RGU)
- Rainbow Lakes Wilderness (RLW)
- Record of Decision (ROD)
- Reportable Quantity (RQ)

- Superfund Amendments and Reauthorization Act (SARA)
- Scoping Decision Document (SDD)
- State Disposal System (SDS)
- Single Event Noise Level (SEL)
- Species of Greatest Conservation Need (SGCN)
- State Historic Preservation Office (SHPO)
- Standard Industrial Classification (SIC)
- Significant Impact Level (SIL)
- State Implementation Plan (SIP)
- Superior National Forest (SNF)
- Standard Occupational Classification System (SOC)
- Spill Prevention, Control, and Countermeasure Plan (SPCC)
- Storm Water Pollution Prevention Plan (SWPPP)
- Tailings Basin (TB)
- Total Dissolved Solids (TDS)
- tons per day (tpd)
- tons per year (tpy)
- total suspended particles (TSP)
- total suspended solids (TSS)
- University of Minnesota Duluth (UMD)
- U.S. Army Corps of Engineers (USACE)
- U. S. Environmental Protection Agency (USEPA)
- U.S. Forest Service (USFS)
- U.S. Geological Survey (USGS)
- Voyagers National Park (VNP)
- Wetland Conservation Act (WCA)
- Wastewater Treatment Facility (WWTF)

Definitions

Air dispersion model : A computer program that incorporates a series of mathematical equations used to predict downwind concentrations in the ambient air resulting from emissions of a pollutant. Inputs to a dispersion model include the emission rate; characteristics of the emission release such as stack height, exhaust temperature, and flow rate; and atmospheric dispersion parameters such as wind speed and direction, air temperature, atmospheric stability, and height of the mixed layer.

Air quality: The cleanliness of the air as measured by the levels of pollutants relative to standards of guideline levels established to protect human health and welfare. Air quality is often expressed in terms of the pollutant for which concentrations are the highest percentage of a standard (e.g., air quality may be unacceptable if the level of one pollutant is 150% of its standard, even if levels of other pollutants are well below their respective standards).

Area of Potential Effect: the geographic region that may be impacted as a result of the construction and operation of the Proposed Action or alternatives.

Aquifer: A subsurface saturated rock unit (formation, group of formation, or part of a formation) of sufficient permeability to transmit groundwater and yield usable quantities of water to wells and springs.

Attainment: Air quality in the locality that meets the established standards.

Autoclave: A vessel for conducting chemical reactions under high pressure.

Bedrock: The rock of Earth's crust that is below the soil and largely unweathered.

Berm: A mound or wall of earth.

Blowdown: The portion of a stream or water removed from a boiler at regular intervals to prevent excessive accumulation of dissolved and suspended materials.

Class I area: Under the Clean Air Act, a Class I area is one in which visibility is protected more stringently than under the national ambient air quality standards, with only a small increase in pollution allowed. Class I areas include national parks, wilderness areas, monuments, and other areas of special national and cultural significance.

Class II area: Under the Clean Air Act, Class II areas are all other clean air regions not designated Class I areas, with moderate pollution increases allowed. See **Class I area**.

Contaminant: A substance that contaminates (pollutes) air, soil, or water. It may also be a hazardous substance that does not occur naturally or that occurs at levels greater than those that occur naturally in the surrounding environment.

Contamination: The intrusion of undesirable elements (unwanted physical, chemical, biological, or radiological substances; or matter that has an adverse effect) to air, water, or land.

Cooling water: Water that is heated as a result of being used to cool steam and condense it to water.

Decibel: A unit for expressing the relative intensity of sounds on a logarithmic scale from zero for the average least perceptible sound to about 130 for the average level at which sound causes pain to humans.

dB(A): Decibels as measured on the A-weighted scale (dB(A))

Dike: (1) An embankment for controlling or holding back waters; (2) A bank of earth formed of material being excavated.

Endangered species: A species that is in danger of extinction throughout all or a significant part of its range; a formal listing of the U.S. Fish and Wildlife Service under the Endangered Species Act.

Environmental Justice: The fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies. Fair treatment means that no group of people, including racial, ethnic, or socioeconomic groups, should bear a disproportionate share of the negative environmental consequences resulting from industrial, municipal, and commercial operations or the execution of Federal, state, local, and tribal programs and policies. Executive Order 12898 directs Federal agencies to make achieving environmental justice part of their missions by identifying and addressing disproportionately high and adverse effects of agency programs, policies, and activities on minority and low-income populations.

Evapotranspiration: The amount of water removed from a land area by the combination of direct evaporation and plant transpiration.

Fill material: Material used for the primary purpose of replacing an aquatic or wetland area with dry land, or changing the bottom elevation of a waterway.

Fugitive dust: Particulate matter composed of soil; can include emissions from haul roads, wind erosion or exposed surfaces, and other activities in which soil is removed and redistributed.

Fugitive emissions: Emissions releases directly into the atmosphere that could not reasonably pass through a stack, chimney, vent, or other functionally equivalent opening.

Glacial till: Direct glacial deposits that are unsorted and unstratified.

Hazardous Air Pollutant: Air pollutants that are not covered by ambient air quality standards, but may present a threat of adverse human health effects or adverse environmental effects, and are specifically listed on the Federal list of 189 hazardous air pollutants in 40 CFR 61.01

Hazardous waste: A category of waste regulated under RCRA.To be considered hazardous, a waste must be a solid waste under RCRA and must exhibit at least one of four characteristics described in 40 CFR 261.20 through 40 CFR 261. 24 (i.e., ignitability, corrosivity, reactivity, or toxicity) or be specifically listed by the EPA in 40 CFR 261.31 through 40 CFR 261.33.

Hydrology: (1) The study of water characteristics, especially the movement of water; (2) The study of water, involving aspects of geology, oceanography, and meteorology.

Hydrometallurgical: Pertaining to hydrometallurgy; involving the use of liquid reagents in the treatment or reduction of ores.

Integrated Gasification Combined Cycle: A process that uses synthetic gas derived from coal to drive a gas combustion turbine and exhaust gas from the gas turbine to generate steam from water to drive a steam turbine.

Infiltration: The process of water entering the soil at the ground surface and the ensuing movement downward. Infiltration becomes percolation when water has moved below the depth at which it can return to the atmosphere by evaporation or evapotranspiration.

L_{10}: Sound levels not to be exceeded for 10% of the time

L_{50}: Sound levels not to be exceeded for 50% of the time

L_{dn}: Day-night average sound level

Laydown area: Material and equipment storage area during the construction phase of a project.

Leachate: Solution of product obtained by leaching, in which a substance if dissolved by the action of a percolating liquid.

Mining district: An area usually designated by name with described or understood boundaries where minerals are found and mined under rules prescribed by the miners, consistent with the General Mining Law of 1872.

Noise: Any sound that is undesirable because it interferes with speech and hearing; if intense enough, it can damage hearing.

New Source Performance Standard: Regulation under Section 111 of the

Clean Air Act enforcing stringent emission standards for power plants constructed on or after January 30, 2004.

Overburden: Waste earth and rock covering a mineral deposit.

pH: A measure of relative acidity or alkalinity of a solution, expressed on a scale from 0 to 14, with the neutral point at 7. Acid solutions have pH values lower than 7, and basic (alkaline) solutions have pH values higher than 7.

Particulate matter: Fine liquid or solid particles such as dust, smoke, mist, fumes, or smog, found in air or emissions.

Riparian: Of, on, or pertaining to the bank of a river or stream, or of a pond or small lake.

Significant Impact Level: Used at the screening level to determine whether more refined modeling is required to evaluate impacts.

Slag: Molten inorganic material collected at the bottom of a combustor and discharged into a water-filled compartment where it is quenched and removed as glassy particles resembling sand.

Sludge: A semi-solid residue containing a mixture of solid waste material and water from air or water treatment processes.

Slurry: A watery mixture or suspension of fine solids, not thick enough to consolidate as sludge.

Subaqueous: Existing or situated under water.

Taconite: A low-grade iron ore, containing about 27% silica and 51% silica; found as a hard rock formation in the Lake Superior region.

Tailings Basin: An on-site water-filled enclosure that receives discharges of wastewater containing solid residues from processing of minerals. The solid residues settle due to gravity and separate from the water.

Threatened species: A species that is likely to become an endangered species within the foreseeable future throughout all or a significant part of its range.

Till: Glacial drift consisting of an unsorted mixture of clay, sand, gravel, and boulders.

Ton: A unit of measurement equivalent to 2,000 pounds.

Water table: (1) The upper limit of the saturated zone (the portion of the ground wholly saturated with water);
(2) The upper surface of a zone of saturation above which the majority of pore spaces and fractures are less than 100 percent saturated with water most of the time (unsaturated zone) and below which the opposite is true (saturated zone).

Wetlands: Those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence or vegetation typically adapted for life in the saturated soil conditions. Wetlands generally include swamps, marshes, bogs and similar areas.

1.0 Introduction

1.1. BACKGROUND AND LOCATION OF THE NORTHMET PROJECT

The Minnesota Department of Natural Resources (MnDNR) and the U.S. Army Corps of Engineers (USACE), in cooperation with the U.S. Forest Service (USFS), the Bois Forte Band of Chippewa (Bois Forte Band), and the Fond du Lac Band of Chippewa (Fond du Lac Band), have prepared a joint state and federal Complete Preliminary Draft Environmental Impact Statement (CPDEIS) for the NorthMet Mine and Ore Processing Facilities Project (NorthMet Project or Project) proposed by PolyMet Mining, Inc. (PolyMet). The purpose of the Project would be to extract low-grade disseminated sulfide mineral ore and process the extracted ore into bulk concentrate; copper concentrate; nickel concentrate; copper metal; and nickel, cobalt, and precious metal precipitates. The CPDEIS evaluates the NorthMet Project in accordance with the National Environmental Policy Act (NEPA; 42 U.S.C. Sections 4321-4347) and the Minnesota Environmental Policy Act (MEPA; Minnesota Statutes 116D).

For purposes of this CPDEIS, the Project consists of the following major components:

- Mine Site – includes mining pits; stockpiles, Lean Ore Surge Pile, Overburden Laydown and Storage Area, waste water treatment facility and central pumping station (see Figure 3.1-2).
- Plant Site – includes processing plant, tailings basin, Area 2 Shops, guard shack, Area 1 Shops, and the railroad connection (see Figure 3.1-18).
- Additional segments - Dunka Road segment, railroad segment, pipelines and transmission lines between Mine Site and Plant Site.
- Project Area –includes lands within 5 miles of the Project (Plant Site; Mine Site; and road, railroad, pipeline and transmission line segments) (Figure 1.1-2).

PolyMet proposes to mine an average of approximately 91,200 tons per day (tpd) of rock (and process up to 32,000 tpd of ore) from ultimately three open pit mines (i.e., East, Central, and West pits). PolyMet would also process approximately 228 million tons of base and precious metal ore over an estimated 20 year mine life using the nearby and refurbished former LTV Steel Mining Company (LTVSMC) taconite processing facility. The processing plant would include a beneficiation (i.e., crushing, grinding, and flotation) plant and a hydrometallurgical plant, which would produce concentrates, copper metal, and precipitates of nickel, cobalt, palladium, platinum, zinc, and gold. The concentrates and/or precipitates would be shipped to a third party for off-site processing. Prior to completion and startup of the hydrometallurgical process equipment, and during certain maintenance or operational conditions throughout the life of the operation where economically feasible, PolyMet may elect to produce and ship flotation concentrates of metallic sulfide minerals for further processing off site. Product output could be 100% flotation concentrate or 100%

metal/precipitates or, in cases where only one of the two autoclaves in the hydrometallurgical process is operational, a mix of flotation concentrate and metals/precipitates; however, the mine would not operate in a “concentrate only” mode for the life of the Project.

The Project would also generate approximately 394 million tons of waste rock and lean ore over the life of the mine. The mine contains sulfide mineral deposits, which have the potential to generate acid rock drainage and leach heavy metals into the environment. Therefore, the waste rock and lean ore would be segregated into stockpiles with various levels of reactivity (Categories 1 and 2, 3, and 4) near the mine pit. Stockpiles would have cover systems to reduce the amount of water contacting waste rock stockpiles, and liner systems that would collect and direct water that has contacted stockpiled materials to a wastewater treatment system.

The proposed NorthMet Project would be located on the south flank of the Mesabi Iron Range in St. Louis County, approximately 70 miles north of the City of Duluth, and 25 miles east of the City of Virginia (Figure 1.1-1). The Project area is part of the land in northeastern Minnesota ceded to the United States by the Chippewa Nation in 1854 (1854 Ceded Territory), although the Chippewa Nation retains usufructuary[i] rights to the land. The Boundary Waters Canoe Area (BWCA) and Voyageurs National Park are approximately 20 miles north and 50 miles northwest, respectively, of the proposed Project Area. The Mine Site would be located at a previously unmined area in the Superior National Forest two miles southeast of the active Northshore-Mining Company’s Peter Mitchell taconite mine and approximately six miles south of the City of Babbitt (Figure 1.1-2). The Plant Site would be approximately eight miles west of the NorthMet Mine Site and six miles north of the City of Hoyt Lakes at a currently inactive taconite processing facility along the south flank of the Mesabi Iron Range. The Plant and Mine Sites are connected by a private railway and private all-weather gravel road, the Dunka Road.

The National Forest System lands, on which the Mine Site is located, were acquired in two separate land purchases in 1935 by the USFS. These purchases covered the surface rights to these lands. The mineral rights were retained by the private entities and are currently under lease to PolyMet. It is the position of the United States that the mineral rights alone do not include the right to mine the National Forest land using open pit methods. The USFS and PolyMet have been working together to complete a land exchange to resolve the current split estate between Federal surface overlying private mineral rights. The USFS has identified approximately 6,700 acres of National Forest land to exchange to PolyMet for yet to be determined non-federal land. The USFS will prepare a separate EIS for the proposed land exchange, which is

[i] The right to the advantages derivable from the use of USFS land, as far as is compatible with the land management policies and programs.

consistent with the Superior National Forest Land and Resource Management Plan (Forest Plan, USDA Forest Service 2004, pages 2-51 - 2-52). This CPDEIS identifies and analyzes the potential alternatives and impacts for the proposed NorthMet Project based on the successful completion of the proposed land exchange.

1.2. PROJECT PURPOSE AND NEED

The purpose and need of the NorthMet Project is to produce, at the former LTVSMC processing Plant Site, by uninterrupted operation of the facility for the life of the operation, base and precious metals, precipitates, and flotation concentrates from ore mined at the NorthMet deposit to help meet domestic and global demand by sale of these products to domestic and world markets.

1.3. PURPOSE OF THE CPDEIS

The purpose of this CPDEIS is to evaluate the potential impacts of the proposed open pit mining operations and ore processing facility and to recommend measures to avoid, reduce, and mitigate environmental impacts. The USACE received an application from PolyMet to discharge fill material in waters of the United States, including wetlands, to develop the NorthMet Project. The USACE has determined that its action on the permit would be a major federal action that could significantly affect the quality of the human environment, requiring the preparation of an EIS pursuant to the NEPA and its implementing regulations (40 C.F.R. parts 1500-1508). The preparation of an EIS is also mandatory for this project pursuant to the State of Minnesota statutes (Minnesota Rules 4410.2000, subpart 2).

1.4. REGULATORY FRAMEWORK

The proposed ore mining and processing operations as well as the disposal and reclamation of waste materials are subject to a combination of federal and state regulations aimed to protect human health and the environment. This section discusses the federal, state, and local regulations that apply to the NorthMet Project.

1.4.1. National Environmental Policy Act (NEPA)

NEPA requires that federal agencies consider potential environmental consequences of proposed actions in their decision-making process. The law's intent is to protect, restore, or enhance the environment through well-informed federal decisions. The Council on Environmental Quality (CEQ) was established under NEPA for the purpose of implementing and overseeing federal policies as they relate to this process.

In 1978, the CEQ issued Regulations for Implementing the Procedural Provisions of the National Environmental Policy Act (40 C.F.R. Section 1500-1508 [CEQ, 1978]). Section 102(2)(c) of NEPA mandates that the lead federal agency must prepare a "detailed statement for legislation and other major federal actions significantly affecting the quality of the human environment." Such projects include any actions under the jurisdiction of the federal government or subject to federal permits; actions requiring partial or complete federal funding; actions on federal lands or affecting Federal facilities; continuing federal actions with effects on land or facilities; and new or revised federal rules, regulations, plans, or procedures. Any significant action requires the preparation of an EIS and a Record of Decision (ROD).

The USACE, during its review of PolyMet's Clean Water Act Section 404 permit application, determined that the NorthMet Project would require the preparation of an EIS in accordance with the requirements of NEPA and the CEQ regulations. To comply with other relevant environmental statutes described below, in addition to NEPA, the decision-making process for the Proposed Action involves a thorough examination of all pertinent environmental issues and selection of a preferred alternative.

1.4.2. Minnesota Environmental Policy Act (MEPA)

In addition to the NEPA process, Minnesota Statutes (Chapter 116D) also require environmental review of the project. The MEPA environmental review process is a decision-making tool for state agencies. It informs the subsequent permitting and approval processes and describes mitigation measures that may be available. The MEPA process operates according to rules adopted by the Minnesota Environmental Quality Board (MEQB), however, the actual reviews are usually conducted by a local governmental unit or a state agency. The organization responsible for conducting the review is referred to as the responsible governmental unit (RGU). The primary role of the MEQB is to advise RGUs and state agencies on the proper procedures for environmental review and to monitor the effectiveness of the process in general. The MnDNR is the responsible RGU for the proposed NorthMet Project as established under Minnesota Rule 4410.4400, subpart 8.

Minnesota Rules dictate that an EIS shall be prepared because the Project exceeds the threshold listed in part 4410.4400, subpart 8, for construction of a new metallic mineral mining and processing facility. Under MEPA, the draft EIS must be consistent with Minnesota Rules 4410.0200 to 4410.7800 and the scoping determination. The adequacy of the final EIS is governed by Minnesota Rules 4410.2800.

In accordance with Minnesota Rules 4410.2100, subpart 2, all projects requiring an EIS must have an Environmental Assessment Worksheet (EAW) filed with the RGU which shall be the basis for the scoping process. For projects requiring an EIS, the EAW will be used solely as a scoping document. For such projects, the RGU shall prepare and circulate with the EAW a draft scoping decision document that addresses the contents specified by Minnesota rules to the extent that information is already available. The purpose of the draft scoping decision document is to facilitate the delineation of issues and analyses to be contained in the EIS. The information in a draft scoping decision document is considered as preliminary and subject to revision based on the entire record of the scoping process. Refer to Section 2.1 for discussion of the scoping decision document and EAW for the NorthMet Project

1.4.3. Applicable Regulations

In accordance with the Minnesota Rule 4410.3900, to reduce duplication to the fullest extent between the Minnesota Statutes and NEPA, a joint state / federal EIS will be prepared. As such, the proposed NorthMet Project will comply with all applicable federal and state regulations for protection of human health and the environment in accordance with NEPA and MEPA regulations. In addition, PolyMet will be required to obtain the required federal, state, and local permits (Table 1.1-1) summarized below.

1.4.3.1. Permit to Mine

To control the possible environmental effects of mining, to preserve the natural resources, and to encourage the planning of future land utilization, Minnesota Statutes require the submission of an application for a Permit to Mine. A Permit to Mine is required for any nonferrous metallic operations, pursuant to Minnesota Rules 6132.0300, and is issued by the MnDNR. To complete the permit process, MnDNR requires organizational data, mine waste characterization data and results, environmental setting maps, environmental setting analysis, mining and reclamation maps, mining and reclamation plans, an operating plan, a wetland replacement plan, and financial assurance. Once a permit has been issued, the applicant is required to provide operating plans for forthcoming years of operation, not to exceed five years; an annual report for each year of operation; a deactivation plan submitted at least two years prior to deactivating any portion of the mining area; and a request for release submitted upon completion of approved deactivation plans.

Table 1.1-1 Government Permits and Approvals for the NorthMet Project

Agency	Permit/Approval
Federal	
U.S. Army Corps of Engineers	Section 404 Individual Permit
U.S. Fish and Wildlife Service	Section 7 Endangered Species Act (ESA) Consultation
U.S. Forest Service	No permits are needed, however, a land exchange will be required to resolve the split estate between Federal surface rights overlying private mineral rights.
State	
Minnesota Historic Preservation Office	Section 106 Consultation
Minnesota Department of Natural Resources	Permit to Mine
	Water Appropriations Permit (for mine dewatering)
	Endangered Species Taking Permit (if required)
	Water Appropriations Permit for plant make up water (tailings basin)
	Dam Safety Permit Amendment for tailings basin, reactive residue cells, and dikes at mine
	Permit for Work in Public Waters for possible modifications and diversions of local streams
	Wetland Replacement Plan approval under Wetland Conservation Act
	Burning Permit (if required)
Minnesota Pollution Control Agency	Section 401 Water Quality Certification
	National Pollutant Discharge Elimination System (NPDES) Permits (storm water)
	State Disposal System (SDS) Permit (construction and operation of a wastewater treatment system, discharge to groundwater)
	Solid Waste Permit
	Minnesota Air Emissions Permit (Part 70 Permit)
	Waste Tire Storage Permit
	General Storage Tank Permit
Minnesota Department of Health	Radioactive Material Registration (for measuring instruments)
	Permit for Non-Community Public Water Supply System and a Wellhead Protection Plan
	Notification of Water Supply Well Construction
	Permit for Public On-site Sewage Disposal System
Local	
City of Hoyt Lakes	Zoning Permit
City of Babbitt	Building Permit
	Zoning Permit

1.4.3.2. Wetlands

There are three major programs that regulate wetlands in Minnesota at the federal, state, and local level:

Federal

USACE via Section 404 of the Clean Water Act: Section 404 of the Clean Water Act regulates the discharge of dredged or fill material into Waters of the United States, including jurisdictional wetlands. Activities in waters of the United States regulated under this program include fill for development, water resource projects (such as dams and levees), infrastructure development (such as highways and airports), and mining projects. Section 404 requires a permit before dredged or fill material may be discharged into waters of the United States, unless the activity is exempt from Section 404 regulation (e.g., certain farming and forestry activities). This permit must also meet the state water quality standards (see section 1.4.3.5).

Section 10 of the Rivers and Harbors Act: Section 10 of the Rivers and Harbors Act requires authorization from the USACE for the construction of any structure in or over any navigable waters of the United States, the excavation/dredging or deposition of material in these waters, or any obstruction or alteration in a "navigable water" (see below). Structure or work outside the limits defined for navigable waters of the United States require a Section 10 permit if the structure or work affects the course, location, condition, or capacity of the water body.

The USACE and MnDNR have developed a combined permit application process that coordinates the application requirements in response to their overlapping jurisdictions. The wetland impacts from the proposed NorthMet Project would be greater than 3.0 acres, therefore, an individual permit from the USACE would be required.

State

MnDNR via the Public Waters Work Permit Program (Minnesota Statutes 103G and Minnesota Rules 6115): Permits are required for any activity affecting the course, current, or cross-section of public waters or public water wetlands as mapped on the MnDNR Public Waters Inventory maps.

Local

Local governmental units (LGU) via the Minnesota Wetland Conservation Act (WCA): The MnDNR is the LGU with wetland replacement plan approval authority as included within the Permit to Mine. The WCA was developed to protect wetlands not regulated under the MnDNR's public waters permit program and requires that "wetlands must not be drained or filled, wholly or partially, unless replaced by restoring or creating wetland areas of at least equal public value under a[n approved] replacement plan" (Minnesota Statutes 103G.222, subdivision 1(a)).

1.4.3.3. Water Appropriation

The appropriation and diversion of waters of the State of Minnesota are governed by Minnesota Statute 103G and Minnesota Rules 6115. These regulations require a water appropriation permit from the MnDNR for any appropriation or use of "waters of the state". Waters of the state, as defined in this statute, include "surface or underground waters, except surface waters that are not confined but are spread and diffused over the land." 'Appropriating' water is defined in Minnesota Statute 103G.005 as "withdrawal, removal, or transfer of water from its source regardless of how the water is used." For the NorthMet Project, this would include withdrawal of water from Colby Lake and mine dewatering activities.

1.4.3.4. Public Waters

The MnDNR will require a permit for Work in Public Waters during the closure period for construction of the West Pit outfall to the Partridge River.

1.4.3.5. Wastewater/Water Quality

Water quality and wastewater in Minnesota are regulated under Section 401 of the Clean Water Act and the associated National Pollutant Discharge Elimination System (NPDES)/State Discharge System (SDS) permit program (Minnesota Statute 115). The Minnesota Pollution Control Agency (MPCA) is responsible for implementing Section 401 of the Clean Water Act (33 U.S.C. Section 1341) in Minnesota including the NPDES/SDS permit program and the water quality certification required for Section 404 permits issued by the USACE. Section 401 requires that activities authorized under Section 404 permits be conducted in compliance with state water quality standards. The MPCA is the delegated agency responsible under Minnesota Statute 115.03 Powers and Duties for making certification determinations on federal permits that affect waters of the state. The USACE will initiate coordination with the MPCA during the Section 404 permit process.

The MPCA, which was delegated NPDES permitting authority by the U.S. Environmental Protection Agency (USEPA), regulates wastewater and storm water discharges to lakes, streams, wetlands, and other surface waters in Minnesota. The SDS permit program regulates the construction and operation of wastewater disposal systems, including land treatment systems. Together, NPDES/SDS permits establish specific limits and requirements to protect Minnesota's surface and groundwater quality for a variety of uses, including drinking water, fishing, and recreation. In circumstances where both federal and state permits are required, the programs are administered as a joint application to MPCA.

For Minnesota industrial facilities, the MPCA issues these permits as consolidated water quality management permits. An individual NPDES/SDS permit for an industrial facility may cover a number of different wastewater types and activities, including industrial process wastewater, cooling water, mine pit dewatering, and storm water.

The NorthMet Project proposes a wastewater management strategy that would eliminate the need for a surface discharge of process wastewater, including mine pit dewatering, to surface waters of the state from either the Mine or Plant Sites. At the Mine Site, leachate from stockpiles and 'contact' storm water (i.e., storm water that has contacted the stockpiles) from disturbed surfaces would be collected and treated in a wastewater treatment system prior to being transferred to the tailings basin, where it would be stored for reuse in the processing plant. There would be no discharge from the facility with the exception of seepage to ground water from the tailings basin. Discharges of industrial and construction storm water from the facility would still occur. As such, the proposed facility would require the following water quality permits, discussed individually below.

State Disposal System Permit

An SDS permit would be required for the construction and operation of the Mine Site stockpile pore water and contact water runoff collection and treatment systems, and for operation of the tailings basin and hydrometallurgical residue storage facility. The SDS permit would include specific requirements and monitoring necessary to ensure proper design, construction, and operation of wastewater facilities and to regulate the discharge of seepage from facilities to ground water such that ground and surface water standards are protected.

NPDES/SDS Storm Water Permit for Construction Activity

Construction projects in Minnesota that disturb one acre or more of land must obtain a NPDES/SDS general storm water discharge permit for construction activity. The permit application certifies that temporary and permanent erosion and sediment control plans have been prepared and will be implemented to prevent soil from being transported off-site both during and after construction. The permit requires the applicant to prepare a Storm Water Pollution Prevention Plan (SWPPP) that applies best management practices for controlling and managing storm water runoff during and after construction, as well as sediment and erosion controls. Erosion control related to reclamation would also be addressed by the MnDNR in the Permit to Mine based on the requirements of the Nonferrous Metallic Mineral Mineland Reclamation Rules (Minnesota Rules 6132).

1.4.3.6. Public Water Supply System

Permits for a non-community public water supply system, wellhead protection plan, and public on-site sewage disposal system would be obtained from the Minnesota Department of Health (MnDH).

1.4.3.7. Dam Safety

Minnesota Rules 6115.0300 through 6115.0520, for Public Water Resources describe the requirements pertaining to dam safety permits for new construction, repair, alteration, removal, and transfer of property containing a dam. For the NorthMet Project, a dam safety permit would be needed from the MnDNR for alteration of existing dams, construction and maintenance of starter dams and tailings dams in the proposed tailings basin, and reactive residue cells.

1.4.3.8. Air Quality

The MPCA has authority delegated from the USEPA for administration of the Part 70 federal operating permit program (see 40 C.F.R. 70, Appendix A) and for the implementation of the Prevention of Significant Deterioration (PSD) regulations under Minnesota Rules 7007.3000. The NorthMet Project is not subject to PSD review, but requires a Part 70 operating permit to ensure compliance with the requirements of title V of the Clean Air Act, based upon its potential emissions of regulated air pollutants.

1.4.3.9. Noise

Current noise standards for the State of Minnesota are located in Minnesota Rules 7030.0040, subpart 2. The rules for permissible noise vary according to which “Noise Area Classification” is involved. In a residential setting, for example, the noise restrictions are more stringent than in an industrial setting. The rules also distinguish between nighttime and daytime noise, where less noise is permitted at night. The standard for sound levels not to be exceeded for 10 and 50 percent of the time in a one-hour survey (L10 and L50) in a commercial setting is 65 and 70 decibels (dB) for daytime (7 am to 10 pm) and nighttime (10 pm to 7 am), respectively.

1.4.3.10. Land Use

Land use in Minnesota is primarily regulated by county zoning ordinances and municipal regulations. The majority of the Project is within the incorporated limits of the cities of Babbitt and Hoyt Lakes and under the land use jurisdiction of those municipalities. The City of Hoyt Lakes requires a zoning permit to indicate that the proposed NorthMet Project is an allowable use within the zoned Mining District (personal communication, Rich Bradford, City of Hoyt Lakes administrator, 2007). In the event the area is not within the zoned Mining District, the applicant would be required to obtain a conditional use permit from the city and, if accepted, the city would rezone the area. Hoyt Lakes has not adopted the state building permit requirements, however, the City of Babbitt has. Therefore, the state building permit would only be applicable within the City of Babbitt’s municipal boundary. The City of Babbitt has adopted a comprehensive plan and zoning ordinance within the incorporated limits. All development projects must be compatible with those regulations. A small portion of the NorthMet Project that is in Waasa Township would be subject to the St. Louis County zoning ordinance, which applies to “that portion of St. Louis County, Minnesota, outside the incorporated limits of municipalities.” Additionally, the St. Louis County shoreline management setback requirement of 75-300 feet from lakes and rivers would supersede municipal regulations.

1.4.3.11. Threatened and Endangered Species

The Federal Endangered Species Act of 1973, as amended (16 U.S.C. Sections 1531 – 1544), defines the regulations pertaining to plant and animal species that have been federally-designated as threatened or endangered. Section 7 of the Endangered Species Act requires federal agencies to consult with the U.S. Fish and Wildlife Service (USFWS) to ensure that actions they authorize, permit, or carry out would not jeopardize the continued existence of any listed species or adversely modify designated critical habitats. Section 7(a)(2) defines the consultation process, which is further developed in regulations promulgated at 50 C.F.R. Section 402. The USACE will cooperate with the USFS to fulfill the requirements of Section 7 as part of the Section 404 permitting process.

Minnesota's endangered species statute (Minnesota Statutes 84.0895) requires the MnDNR to adopt rules designating species meeting the statutory definitions of endangered, threatened, or species of special concern. The resulting list is codified as Minnesota Rules 6134. The endangered species statute also authorizes the MnDNR to adopt rules that regulate treatment of species designated as endangered and threatened (Minnesota Rules 6212.1800 to 6212.2300).

Minnesota's endangered species statute and the associated rules impose a variety of restrictions, a permit program, and several exemptions pertaining to the taking of species designated as endangered or threatened. At the NorthMet Project, the results of field studies and detailed project plans will determine if endangered and threatened species are present and if a takings permit is required.

In accordance with Minnesota Statutes 84.0895, a person may not take, import, transport, or sell any portion of an endangered or threatened species unless authorized by MnDNR permit. The permit application must identify the lack of feasible alternatives to avoid or minimize loss of the listed species, show that the removal of the given population will not negatively affect the state status of that species, and develop a compensatory mitigation plan to offset the loss of the individual or individuals.

1.4.3.12. Solid Waste

Solid wastes generated during construction and operation of the NorthMet Project that would be disposed of on-site would need to be permitted in accordance with Minnesota Rules 7035. These solid wastes would include, but not be limited to, construction debris and sludges.

1.4.3.13. Storage Tanks

Storage tank permits are required for aboveground storage tanks (ASTs) and underground storage tanks (USTs) containing petroleum products or hazardous materials. These permits include operational limits and construction requirements that help prevent or minimize the potential for significant environmental effects. Requirements include tank registration with the MPCA; a secondary containment (ASTs) or other leak detection (USTs); routine monitoring for leaks; corrosion protection; overfill prevention equipment; and spill containment for areas where substances are transferred.

1.5. AGENCY ROLES AND RESPONSIBILITIES (LEAD AGENCIES, COOPERATING AGENCIES, OTHERS)

The MnDNR and USACE are serving as co-lead agencies in preparation of this CPDEIS, with MnDNR serving as the RGU under MEPA. The USFS, Bois Forte Band, and Fond du Lac Band are serving as cooperating agencies with the USACE and MnDNR. The Mine Site for the NorthMet Project is located on USFS land; therefore, the USFS is required to negotiate the operating conditions of the mining operation. The Mine Site and Plant Site are also located within the 1854 Treaty ceded territory where the Boise Forte Band and Fon Du Lac Band retain hunting, fishing, and gathering rights and have therefore requested to be cooperating agencies in the preparation of this CPDEIS.

1.6. ORGANIZATION OF CPDEIS

This CPDEIS follows the CEQ's recommended organization (40 C.F.R. 1502.10) and MEPA content requirements at Minnesota Rule 4410.2300:

- Chapter 1.0 provides descriptions of the purpose of and need for the Proposed Action, agency roles in the EIS process, and the required regulatory actions;
- Chapter 2.0 describes the scoping process, including public participation and the consultation and coordination undertaken to prepare the CPDEIS, and the alternatives and issues identified during the scoping process;
- Chapter 3.0 describes the Proposed Action, including the No-Action Alternative;
- Chapter 4.0 summarizes the affected environment and the direct, indirect, and cumulative impacts associated with the Proposed Action and alternatives; possible mitigation to reduce or minimized impacts; and any residual adverse effects following the implementation of mitigation;
- Chapter 5.0 presents the mitigation and monitoring program;
- Chapter 6.0 describes the irreversible and irretrievable commitment of resources;
- Chapter 7.0 contains the references; and
- Chapter 8.0 is the list of preparers.

2.0 EIS Development

This section of the CPDEIS describes the public and agency involvement process to develop the scope of, and identify the major issues to be discussed, in the CPDEIS. This includes a discussion of the scoping process, alternatives to the proposed Project, and opportunities for public and agency involvement.

2.1. SCOPING PROCESS

The scoping process is a preliminary, open public process initiated prior to the preparation of an EIS to define a reasonable scope and reduce the bulk of an EIS by:

- Identifying only those potentially significant issues relevant to the proposed project;
- Defining the form, level of detail, content, alternatives, time table for preparation, and preparers of the EIS; and
- Identifying the required permits to facilitate the collection of information during the EIS process to support those permits.

The scoping process involved the preparation of three documents: the Scoping Environmental Assessment Worksheet (EAW); the Draft Scoping Decision Document (Draft SDD); and the Final Scoping Decision Document (Final SDD). The scoping process was followed as outlined by Minnesota Rules 4410.0200, subpart 24. MEPA contains the legal basis for the preparation of the scoping documents and the MEQB is responsible for the environmental review program. The scoping process in Minnesota includes all procedural and substantive requirements to satisfy scoping for preparation of a federal EIS under NEPA.

2.1.1. Identification of Scoping Documents

The NorthMet Project falls into the mandatory EIS category; therefore, the EAW was intended solely as a scoping document. The Scoping EAW provided information on required permits, informed the public about the Project, and identified ways to protect the environment.

The Draft SDD is a companion to the Scoping EAW. The primary purpose of a Draft SDD is to communicate the issues and analyses to be contained in the EIS. The information in a draft scoping decision document is preliminary and subject to revision based on the entire record of the scoping process. It is also used to disclose information about alternatives and impacts. The Draft SDD is typically published concurrently with the Scoping EAW as the first report for projects in the mandatory EIS category under MEPA. It is distributed prior to the public scoping meeting(s) so that comments on the Project can be received and used to prepare the Final SDD.

The Scoping EAW and Draft SDD were noticed to the public in the EQB Monitor on June 6, 2005 for a 30-day comment period. The MnDNR and the USACE issued press releases about the availability of the Scoping EAW, Draft SDD, and the public meeting to local area newspapers. The public meeting, as required by Minnesota Rules 4410.2100, was held on June 29, 2005 at the Hoyt Lakes Arena in the City of Hoyt Lakes, Minnesota. The public comment period ended July 6, 2005 and a total of 29 comment letters/emails and two verbal comments were received. A Response to Public Comments document was developed to address those comments. The USACE issued a Notice of Intent (NOI) to prepare an EIS on behalf of federal agencies in the Federal Register on July 1, 2005.

The Draft SDD was revised based on the public and agency comments and the Final SDD was issued on October 25, 2005. This document serves as the “blueprint” for the EIS.

2.1.2. Proposed Action and Supporting Documentation

PolyMet submitted an initial Project Description (PD) for the NorthMet Mine and Ore Processing Facilities Project on April 26, 2006; however, additional data and agency consultation led to a revised PD in July 2007. The majority of supporting documentation for the PD and potential impacts of the proposed Project were submitted between July 2006 and October 2008, including RS documents and other technical memorandums and reports as listed in Section 7.0.

2.2. ALTERNATIVES IDENTIFIED DURING THE EIS SCOPING PROCESS

The MEQB rules require that an EIS include at least one alternative for each of the following categories of alternatives, or provide an explanation as to why no alternative is included in the EIS (Minnesota Statutes 116D, sections 04 and 045; and Minnesota Rules 4410, section 0200 through 7500):

- alternative sites;
- alternative technologies;
- modified designs or layouts;
- modified scale or magnitude; and
- alternatives incorporating reasonable mitigation measures identified through comments received during the EIS scoping and draft EIS comment periods.

The alternatives discussed below were identified during the Scoping EAW and SDD process. During development of the CPDEIS, the list of reasonable alternatives was revised to include additional alternatives, while others were eliminated. The reasonable alternatives included for consideration in the CPDEIS are discussed in Section 3.2 Project Alternatives.

An alternative may be excluded from analysis in the EIS if "it would not meet the underlying need for or purpose of the project, it would likely not have any significant environmental benefit compared to the project as proposed, or another alternative, of any type, that will be analyzed in the EIS would likely have similar environmental benefits but substantially less adverse economic, employment, or sociological impacts" (Minnesota Rules 4410.2300, subpart G). Section 3.2.3 of this CPDEIS discusses alternatives considered but eliminated.

2.2.1. Site Alternatives

In the Final SDD, the MnDNR and USACE identified three site alternatives to be considered for the proposed Project:

- In-pit Reactive Waste Rock Disposal;
- Off-Site Non-Reactive Waste Rock Disposal; and
- In-pit Tailings Disposal

2.2.2. Alternative Technologies

In the Final SDD, the MnDNR and USACE identified underground mining as the only alternative technology to be considered for the proposed Project.

2.2.3. Modified Designs or Layouts

In the Final SDD, the MnDNR and USACE identified six alternative designs or layouts to be considered for the proposed Project:

- Two Mine Pits;
- Chemical Modification of Reactive Waste Rock Stockpiles;
- Co-disposal of Reactive Waste Rock and Tailings on a Lined Tailings Basin;
- Pretreatment of Mine Site Reactive Runoff and Discharge to Publicly Owned Treatment Works (POTW);
- Pretreatment of Tailings Basin Process Water and Discharge to the City of Hoyt Lakes POTW; and
- Use of Mine Site reactive runoff as make-up water for processing plant with single wastewater treatment at the Processing Plant. This option could also include pretreatment and discharge to a POTW.

2.2.4. Alternative Scale or Magnitude

During the Scoping EAW process, multiple ore processing rates were analyzed to determine the economic feasibility of the Project at various scales. Reduced scale operations (e.g., processing ore at 18,000 tpd) offered significant environmental benefits relative to the Proposed Action (processing ore at 32,000 tpd) but was not economically feasible and therefore did not meet the Purpose and Need for the Project. It was also determined that a lesser degree of variability around the Proposed Action would be economically feasible; however, these smaller changes to the processing rate did not offer significant environmental benefits when compared to the Proposed Action. Therefore, no alternative scale and magnitude alternatives were carried forward for further consideration.

2.2.5. Alternatives Incorporating Reasonable Mitigation Measures

In the Final SDD, the MnDNR and USACE identified two alternatives incorporating reasonable mitigation measures to be considered for the proposed Project:

- Monitor Waste Rock Stockpiles and Tailings Basin including the material being placed in the stockpile/basin, performance of liners, trenches, and collection systems, and water quality and quantity associated with the stockpile/basin (i.e., drainage, groundwater, and surface water); and
- Develop a lined tailings storage facility on top of Cell 2W of the existing LTVSMC tailing basin to provide storage for five years of tailings while waste characterization testing develops additional data. Waste characterization would continue during this period and the field data collected during operations would determine if the tailings are reactive. If during the initial five-year operation period the tailings are determined to be non-reactive, construction of an unlined tailings basin would be possible thereafter. Conversely, if the tailings are ultimately determined to be reactive, Cells 1E and 2E would possibly be lined for the entire life of the operation to prevent reactive runoff from seeping into the ground and surrounding environment. Any discharge from the tailings basin would be monitored and, if necessary, directed to a water treatment plant for appropriate treatment prior to discharge.

2.2.6. Alternatives Incorporated into the Proposed Project

Following the scoping process, PolyMet incorporated the following modified design and layout alternatives into the Proposed Project:

- Two Mine Pits (The East and Central pits will ultimately become one pit, with the West Pit being the second);
- Use of Mine Site reactive runoff as make-up water for the processing plant with a single wastewater treatment plant at the Mine Site; and
- Relocation of the overburden stockpile to avoid USFS land with a mineral interest (e.g., PolyMet-owned land west of current stockpile site) or use as capping material over reactive rock placed in the East Pit.

2.3. ISSUES IDENTIFIED DURING THE EIS SCOPING PROCESS

2.3.1. Potentially Significant Issues

The MnDNR and USACE also identified the following topics in the Final SDD that may result in potentially significant impacts and would include a substantial amount of additional information in the EIS beyond that included in the Scoping EAW. These specific topics are addressed in Chapter 4.0 of this CPDEIS and include:

- Fish and Wildlife Resources;
- Threatened and Endangered Species;
- Physical Impacts on Water Resources;
- Water Appropriations;
- Surface Water Runoff and Erosion/Sedimentation;
- Wastewater; and
- Solid Waste.

The additional information would include the results of the project-specific special studies and research relative to process design, hydrology, water, wastewater, solid waste, chemical modification of reactive waste rock, and the mine closure plan. Additionally, the Final SDD determined that the EIS would also address the potential cumulative impacts associated with combined environmental effects of the Proposed Project and of past, present, and reasonably foreseeable future actions relative to:

- Air Quality - Hoyt Lakes area projects and air concentration in Class II areas, Class I areas PM10 increment, ecosystem acidification resulting from deposition of air pollutants, mercury deposition and bioaccumulation in fish, and visibility impairment; Biological Resources - Loss of threatened and endangered plant species, loss of wetlands, and loss or fragmentation of wildlife habitat;
- Water Quality - Streamflow and lake level changes, and water quality changes;
- Economic impacts; and
- Social impacts.

The cumulative impacts analyses are presented by resource in Chapter 4.0 of this CPDEIS. A summary of the cumulative effects is presented in Section 4.13.

The Final SDD stated that the EIS would also determine the most feasible mine reclamation strategy, including evaluation of alternative designs, layouts, siting, and reclamation requirements and strategies for reactive waste rock. The evaluation would be based on protection of natural resources, minimization of long-term maintenance, and the ability to meet eventual land use objectives including local community land use goals. The EIS would also evaluate the recommendations of the Mining, Minerals, and Sustainable Development Project Final Report[i] for additional reclamation provisions as well as evaluate the reclamation costs and their effect on facility design, construction, and closure. Financial assurance estimates associated with corrective actions cannot be developed until the corrective action is known; therefore, discussion of the assurance costs would not be included in the EIS. The EIS would, however, describe the corrective action procedure and how financial assurance would be addressed should a corrective action be needed.

2.3.2. Other Issues

The MnDNR and USACE determined that the following topics are not expected to present significant impacts, but would be addressed in the EIS using limited information beyond that provided in the Scoping EAW commensurate with the anticipated impacts. These specific topics are addressed in Chapter 4.0 of this CPDEIS and include:

- Cover Types;
- Vehicle Related Air Emissions;
- Air Emissions;
- Noise;
- Archeology;
- Visibility;
- Compatibility with Plans and Land Use Regulations;
- Infrastructure;
- Asbestiform Fibers; and
- 1854 Ceded Territory.

2.3.3. Issues Considered But Eliminated During Scoping

The following topics were reviewed and considered by the MnDNR and the USACE in the Scoping EAW, and it was determined that they were not relevant or were so minor that they would not be addressed in the EIS:

- Land Use;
- Water-related Land Use Management District;

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[i] The Mining, Minerals and Sustainable Development Project was an independent study completed in 2002 aimed at understanding how the mining and minerals sector could maximize its contribution to sustainable development at the global, national, regional and local level.

- Water Surface Use;
- Geologic Hazards and Soil Conditions;
- Traffic;
- Odors ; and
- Water Recreation.

2.4. PUBLIC AND AGENCY INVOLVEMENT

Public and agency notification and opportunity to comment on the Project began during the Project scoping process. The USACE issued a Section 404c Permit Public Notice for the PolyMet Project on May 10, 2005. In June 2005, the MnDNR, in partnership with the USACE and USFS, prepared a Scoping EAW and a Draft SDD to provide information about the Project, identify potentially significant environmental effects, and determine what issues and alternatives will be addressed in the EIS and the level of analysis required.

The public review period for the Scoping EAW and Draft SDD began on June 6, 2005 and concluded on July 6, 2005. A public meeting was held during the comment period on June 29, 2005, in the City of Hoyt Lakes to provide additional information on the Project and allow for comments (verbal and written) and questions. Approximately 70 people attended the meeting. On July 1, 2005, the USACE published the Notice of Intent (NOI) to prepare a Draft EIS in the Federal Register. The comments received during the scoping period were considered by the MnDNR and the USACE prior to the issuance of the Final SDD on October 25, 2005.

The MnDNR maintains a webpage at: http://www.dnr.state.mn.us/input/environmentalreview/polymet/index.html to enable the public to have access to most of the Project documents that led to the preparation of this CPDEIS. This web page also provides contact information so that members of the public may submit questions and comments about the Project.

This CPDEIS will be published and circulated for a 45-day comment period in accordance with Minnesota Rules 4410, and MEPA and NEPA requirements. Public comments will be accepted during this period.

Two public information meetings will take place during the DEIS comment period: one in the City of Hoyt Lakes and one in the Minneapolis - St. Paul Metropolitan area. Comments received will be taken into account in assessing Project impacts and potential mitigation. Following the end of the comment period, responses to substantive comments will be prepared and a Final EIS will be issued. Following issuance of the Final EIS and a ten-day comment period, the MnDNR will review the

EIS for adequacy with MEPA. Once the EIS is determined to be adequate, the MnDNR will prepare the state notice of adequacy and USACE will prepare the federal Record of Decision (ROD). The state notice of adequacy will be noticed in the EQB Monitor and the federal ROD will be noticed in the Federal Register. The USACE will issue a public notice regarding the availability of the ROD.

3.0 Proposed Action and Project Alternatives

3.1. PROPOSED ACTION

The NorthMet Project calls for surface mining and mineral processing of approximately 228 million tons[i] of base- and precious-metal ore over approximately a 20-year mine life.

The NorthMet Project would be the first large-scale copper-nickel sulfide mineral mine in the State of Minnesota. As a result, the environmental impacts associated with the mine are different and require a level of analysis that may differ from those performed for other types of mines.

3.1.1. Proposed Mine Site – Location and Ownership

The NorthMet Project would primarily consist of a proposed Mine Site and a largely existing Plant Site (see Figure 3.1-1 and Section 3.1.6). The Processing Plant within the Mine Site would require some modifications to process the ore. The Mine Site, which contains the NorthMet copper-nickel-platinum group element (PGE) deposit, is located eight miles east of the Plant Site, six miles south of the town of Babbitt, and two miles south of the Northshore Mining Company's Peter Mitchell open pit taconite mine. A layout of the Mine Site can be seen in Figure 3.1-2. The Mine Site is connected to the Plant Site by a private railroad and a segment of the private Dunka Road. PolyMet has acquired ownership or the right to use additional lands, trackage, and other railroad assets to secure the access between the Mine Site and the Plant Site.

Mine Site surface and mineral ownership is shown in Figure 3.1-3. The majority of the mineral rights of the area proposed for the Mine Site were originally held by U.S. Steel (USS). In 1989, 4,102 acres covering the deposit and adjacent areas were leased to PolyMet (previously Fleck Resources of Vancouver, BC). Subsequently, USS sold the mineral and mining rights to RGGS Inc. (RGGS), but RGGS maintained PolyMet's exclusive lease on the minerals. As can be seen in Figure 3.1-3, there are three 40-acre tracts of land for which the mineral rights are owned by the Longyear Mesaba Company and are not currently under lease to PolyMet. PolyMet is proceeding with negotiations with Longyear Mesaba Company to acquire a mineral lease for these tracts.

[i] Unless specified otherwise, all tons in this document are short tons.

The majority of the land surface ownership at the Mine Site is held by the USFS, with smaller portions owned by PolyMet, Allete, Cliffs Erie (Cleveland-Cliffs, Inc.) and the State of Minnesota. In 2007, PolyMet entered into discussions with the USFS to acquire surface ownership of lands above and adjacent to the mineral lease through a land exchange or purchase. At the time that this EIS was drafted, the land exchange or purchase was still being discussed between USFS and PolyMet and no decisions had been made (see Section 1.0 for more information). PolyMet also acquired approximately 400 acres around the Mine Site impact area from Cliffs Erie in 2006 to serve as a buffer for the primary mining area. In summary, at the Mine Site, the land owned or leased by PolyMet totals 4,552 acres of which 3,016 acres are predicted to have ground-level impacts due to Project construction and operations.

3.1.2. Proposed Mining Activities – inputs/processes/outputs

A Mine Site map, which includes the proposed pit and stockpile outlines and mining infrastructure, is shown in Figures 3.1-4 – 3.1-8. Cross-sections of the proposed pits during their maximum depths and with maximum footprints over 5-year increments are shown on Figure 3.1-9. Similarly, cross-sections of the proposed stockpiles during their maximum heights and with maximum footprints are shown on Figure 3.1-10.

PolyMet expects to mine 91,200 tons per day (tpd) of material, which would include about 32,000 tpd of ore and 59,200 tpd of waste, including 3,900 tpd of overburden and 55,300 tpd of rock (RS18 Mine Design and Schedule with Backfill). This would result in annual metal production of 38,821 tons of copper, 9,037 tons of nickel, 400 tons of cobalt, 22,184 ounces of platinum, 87,129 ounces of palladium, and 13,824 ounces of gold. This would require the removal of about 19.7 million tons of waste rock and 1.2 million tons of overburden annually, although most overburden is moved during the construction period at the beginning of the project.

As can be seen in the above-mentioned figures, four categories of waste rock would be handled. PolyMet's proposed categories of waste rock are defined according to their geochemical properties and associated acid-producing and metals-leaching capabilities as follows:

- Category 1 – Least reactive waste rock. This material is not predicted to generate acid rock drainage (ARD), but may leach heavy metals in excess of anticipated water quality discharge limits. This material has a sulfur content less than or equal to 0.12%. Category 1 Waste Rock comprises about 74% of the total waste rock volume. PolyMet proposes that this waste rock be used for construction material at the Mine Site. The Category 1 waste rock that could not be used as construction material would be placed on the Category 1 and 2 stockpile (See Figures 3.1-4 – 3.1-8). (See GC 07 Construction Rock Memo).

- Category 2 – Low reactivity waste rock. This material is not predicted to generate ARD, but may leach heavy metals resulting in drainage with metal concentrations in excess of anticipated water quality discharge limits. The sulfur content of this material is greater than 0.12% but less than or equal to 0.31% with a copper/sulfur (Cu/S) ratio of less than or equal to 0.3. Category 2 material comprises approximately 9% of the total waste rock volume and would be placed on the Category 1 and 2 stockpile.
- Category 3 – Medium reactivity waste rock. This material may eventually generate ARD and is predicted to leach heavy metals resulting in drainage with heavy metal concentrations in excess of anticipated water quality discharge limits. This material has a sulfur content greater than 0.12% with a Cu/S ratio of more than 0.3, or sulfur content greater than 0.31%, but less than or equal to 0.6%. Category 3 material comprises approximately 14% of the total waste rock volume and would be placed on the Category 3 or Category 3 Lean Ore stockpiles.
- Category 4 – High reactivity waste rock. This material would generate ARD rapidly and leach heavy metals resulting in drainage with heavy metal concentrations in excess of anticipated water quality discharge limits. This material has a sulfur content greater than 0.6% and includes all Virginia Formation rock regardless of sulfur content. This category comprises approximately 3% of the total waste rock volume and would be placed on the Category 4 or Category 4 Lean Ore Surge Pile.
- Overburden (composed of glacial drift, mostly till) – This material represents the remainder of the non-ore volume (about 9% of the total excavated volume). This is generally considered non-reactive and is presumed by PolyMet to be suitable for construction use. Waste characterization of this material is in progress to assess the reactivity of this material.

As indicated above, Category 3 and Category 4 rock are further divided into waste rock and lean ore. The criterion for lean ore is economic rather than geochemical. Lean ore would be material that is not economic to process at the time of mining, but could become economic in the foreseeable future.

The management of waste rock is further discussed in Section 3.1.4.

3.1.2.1 Pre-production Mine Development

Several construction activities would be completed during the estimated 9 to 12 months of pre-production mine development. These activities include upgrading the existing Dunka Road; constructing site access roads; constructing surface water exclusion dikes and ditches; constructing mine infrastructure (e.g., wastewater treatment plant, Central Pumping Station, rail spur, Rail Transfer Hopper, substation drop from the 138KV transmission line, mine to plant water pipeline, and the field service and fueling facility); constructing engineered foundations, liners and water collection/transport systems for waste rock stockpiles; and constructing surface water collection and drainage ditches, water collection ponds, and sumps (See RS21

Hydrology-Mine Water Model & Balance, RS22 Mine Waste Water Management Systems, and RS24 Mine Surface Water Runoff Systems/Runoff Characterization).

Clearing, grubbing, and harvesting of marketable timber would be completed prior to the initiation of mining. The surface overburden, which overlays hard, consolidated bedrock, consists of glacial till and organic wetland soils. The wetland soils would be removed and stockpiled separately for reuse. The overburden would be removed and hauled from the mine pit and stockpile footprint areas and placed in a separate portion of the Category 1 and 2 waste rock stockpile. The stockpile would be constructed in a series of lifts and managed in accordance with the requirements of Minnesota Statute Sections 93.44 to 93.51 and the MDNR Mineland Reclamation Rules for Nonferrous Metallic Mineral Mining (Minnesota Rules 6132).

In addition to the separate portion of the Category 1 and 2 waste rock stockpile, an overburden storage area would be constructed to the west of the Rail Transfer Hopper. This area would be used to screen, sort and temporarily store overburden intended for use as site construction material (e.g., for engineered waste rock and lean ore stockpile foundations, exclusion dikes around the mine perimeter, pit rims and stockpile construction areas, access roads and process water ponds) and for covering and reclamation of completed sections of waste rock stockpiles. Should characterization of overburden from the Project indicate that it is not suitable for these construction purposes, rock and overburden from the nearby and inactive LTVMC Area 5 mine site (see Figure 3.1.1) to the north and east of the tailings basin would be considered for these purposes. However, characterization of the material has not yet been conducted.

Once bedrock is exposed, pre-production mine development would generate Category 1 waste rock that would be used as appropriate to construct the foundations of waste rock stockpiles and provide fill and surfacing material for the construction of mine access roads, haul roads, railroad roadbed, the Rail Transfer Hopper platform, and safety berms around the pit.

The pre-production mine development would be followed by a gradual ramp-up of ore output over 6 to 12 months to reach full capacity. Since the process plant feed rate would progressively increase as plant operations ramp up, mining would be scheduled so that the amount of exposed ore available in the pit also progressively increases to provide an adequate supply to ensure continuity of plant feed.

3.1.2.2 Open Pit Mining

The NorthMet Project would use open pit methods of mining. The mining method would be similar to those currently in use at other locations on the Iron Range. The mine would consist of three separate open pit excavations known as the East, Central and the West Pits, as shown in Figure 3.1-2. For about half of the mine life, mining would continue in the East and West Pits simultaneously, with the Central Pit mining occurring between Years 11 and 13 (see RS22 Mine Waste Water Management Systems). It is planned that the East Pit would be mined out by the end of production Year 11, thereby providing space for waste rock from the West and Central Pits. With completion of mining from the Central Pit by Year 13, the East and Central Pits form one large pit (East/Central Pit).

By placing Category 1 and 2 waste rock (the least reactive/lowest reactivity material) into the East/Central Pit through the end of the mine life with a carefully managed inflow of water, the rock would be stored in a sub-aqueous environment to reduce the environmental impact associated with the oxidation and decomposition of sulfide minerals. Moreover, once backfilled, the combined East/Central Pit would provide a viable location for the creation of wetlands.

The pit configuration, staging, mine schedule and stockpile layout would be progressively refined prior to the start of mining and throughout the approximately 20-year life of the mine to account for prices of metals, energy, labor, and other factors. The final mine configuration, prior to filling any pit with waste rock, is shown in Figure 3.1-8. The maximum size of each pit is projected to have the approximate area and approximate maximum depth shown in Table 3.1-1:

Table 3.1-1 Year 20 Pit Dimensions

Pit	Area (acres)	Maximum Depth (feet below ground surface)
West	278	840
Central	54.5	550
East	118	760

The northwest edge (footwall) of the mine would be constrained by the northward extent of the Duluth Complex, which hosts the mineral deposit. The footwall side of the pit would follow the mineralization, which dips southeast at about 25 degrees, and roughly parallels the top of the Virginia Formation. The mine would be developed in a series of benches that would be approximately 40 feet high. These benches would be accessed by ramps approximate 85 feet wide (to accommodate broken ore, mine traffic, and water sumps) and having additional width for safety berms and possibly ditches, power lines/cables, and pipes on an as-required basis.. Initial pit slope design based on geotechnical testwork and and modeling indicated safe overall pit slope angles of approximately 51 degrees. This would be continuously monitored and refined during the mine life.

3.1.2.3 Drilling and Blasting

Although the details of the drilling and blasting design would be refined and optimized as the mining operation continues, the proposed typical blasting parameters are presented in Table 3.1-2.

Table 3.1-2 Proposed Blasting Parameters

Blast hole diameter (range)	10 – 16 inch
Explosive type/blasting agent	ANFO and emulsion
Burden (distance from free face) and spacing (distance between holes)	Approximately 20 feet x 30 feet
Powder factor	Approximately 0.45 pounds ANFO equivalent/ton
Drilling rate – approximate	20 feet/hour
Assumed drilling time/rig	24 hours/day

Because Project ore has physical characteristics very similar to Project waste rock, drilling and blasting would share a common drilling fleet and similar blast design specifications. Conventional electric or diesel powered rotary drilling rigs would be used. Based on a proposed annual ore movement rate of 11.7 million tons, and a blast design as shown in Table 3-2, it is estimated that the total annual amount of blasting agent used for breaking ore would be 5.256 million pounds, including initiators and blasting accessories. Secondary breaking of oversize boulders would be done using a wheel loader mounted, drop weight hammer. Blasting of ore and waste rock would take place approximately every 2 to 3 days. This would usually include separate blasts of ore and waste rock benches totaling about 200,000 – 300,000 tons broken per blast.

3.1.2.4 Excavation and Haulage

After being drilled and blasted, the ore would be loaded by excavators into haul trucks that would transport the rock to the Rail Transfer Hopper. Diesel-hydraulic or electric-hydraulic excavators (31 cubic yard [CY] capacity) would be the primary rock loading tools in the mining fleet with a large front-end loader (21.5 CY capacity) available to provide operational flexibility and additional loading capacity.

The haul truck fleet would consist of up to a maximum of nine conventional 240 ton diesel-powered rear dump trucks. Haul trucks would be able to be rapidly re-assigned between excavators loading ore, waste rock, and overburden.

Should a delay or shutdown of any part of the rail haulage system occur, a small temporary ore stockpile (about 8 hours of production or 12,800 tons) would be placed adjacent to the Rail Transfer Hopper and within the controlled drainage of the ore handling area. This stockpile would allow for haul trucks already loaded with ore to have a controlled location to dump and stockpile material. Once the rail haulage system is operational again, temporarily stockpiled ore would be loaded by front-end loader into the haul trucks for the short haul to the Transfer Hopper dumping platform.

3.1.2.5 Lean Ore Surge Pile

Table 3.1-3 show tons of ore moved for Years 0 (pre-production site preparation) through 20. A Lean Ore Surge Pile is proposed near the Rail Transfer Hopper to allow for temporary storage of marginal ore until it can be fit into the processing schedule. Use of this surge pile would ensure delivery of a steady annual flow and assist to provide a uniform grade of ore to the process plant. Lean ore would flow into and out of this pile allowing it to reach a maximum tonnage of 5.5 million tons and a footprint of 54.5 acres in Year 13.

Table 3.1- 3 Ore Movement

Ore Movement (tons)					
			Lean Ore Surge Pile		
Year	**Mined**	**To Plant**	**To**	**From**	**Balance**
0	78,335		78,335	0	78,335
1	6,468,692	6,497,515	0	28,823	49,512
2	11,934,642	11,680,000	254,642	0	304,154
3	13,903,050	11,680,000	2,223,050	0	2,527,204
4	10,469,506	11,680,000	0	1,210,494	1,316,710
5	12,691,704	11,680,000	1,011,704	0	2,328,414
6	12,599,220	11,680,000	919,220	0	3,247,633
7	12,729,069	11,680,000	1,049,069	0	4,296,702
8	9,878,679	11,680,000	0	1,801,321	2,495,381
9	11,079,752	11,680,000	0	600,248	1,895,133
10	14,013,411	11,680,000	2,333,411	0	4,228,544
11	11,120,755	11,680,000	0	559,245	3,669,298
12	12,735,906	11,680,000	1,055,906	0	4,725,205
13	12,443,434	11,680,000	763,434	0	5,488,638
14	11,271,732	11,680,000	0	408,268	5,080,370
15	6,857,189	11,680,000	0	4,822,811	257,559
16	11,422,441	11,680,000	0	257,559	0
17	15,663,317	11,680,000	3,983,317	0	3,983,317
18	11,660,624	11,680,000	0	19,376	3,963,941
19	11,794,752	11,680,000	114,752	0	4,078,693
20	7,286,269	11,364,962	0	4,078,693	0
Total	**228,102,477**	**228,102,477**	**13,786,839**	**13,786,839**	**0**

The Lean Ore Surge Pile would have one 40 foot high lift and slopes at angle of repose. A large front-end loader would excavate the lean ore from the south end of the stockpile and transport it either to the Rail Transfer Hopper or to the Direct Rail Loadout Area. Because material in this stockpile is classified as Category 4 waste rock, a lined base and foundation would be constructed to Category 4 specifications (see Section 3.1.4.2). All active areas at the Mine Site, including the Lean Ore Surge Pile, will be subject to a Fugitive Dust Control Plan that would be designed by PolyMet to manage fugitive dust generated at rock dumping and loading locations. The stockpile would be removed at the completion of mining activities and no cover system is proposed. Drainage from the lean ore surge pile would be directed to the process water pond located in the vicinity of the surge pile (PW-2 as shown in Figures 3.1-11 to 3.1-13).

3.1.2.6 Rail Transfer Hopper

To load rail cars at the Mine Site, the same type of Rail Transfer Hopper system used by LTVSMC is proposed. The Rail Transfer Hopper would be constructed to the south of the ultimate open pits and would be connected to the existing main line track by a new spur line.

3.1.2.7 Other Equipment

In addition to the drilling, excavating, and hauling equipment described above, the Project would use auxiliary and support equipment as shown in Table 3.1-4 at the Mine Site.

Table 3.1-4 Proposed Mine Auxiliary Equipment Fleet

Typical Machine Type	Power	Number	Duties
Cat D10R tracked dozer	582 hp	2	Stockpile maintenance, construction, stockpile reclamation
Cat 834G wheel dozer	450 hp	2	Excavator pit maintenance, pit clean-up
Cat 16H Grader	275 hp	2	Haul road maintenance
Cat 777D Water Truck	937 hp	2	Haul road maintenance, dust suppression, auxiliary fire fighting duties
Cat 992G Wheel Loader (construction, site reclamation and misc.)	800 hp	1	General purpose loading, reclamation 15-16 cu yd
Cat 446D Backhoe with Hammer	110 hp	1	Secondary breakage
Cat IT62H INtegrated Tool Carrier	230 hp	1	Miscellaneous tasks (e.g. snow plaowing, fork lift, sweeper, etc.
Field service trucks	114 hp	6	Field maintenance flat bed trucks fitted with hydraulic arm lift
Fuel truck	150 hp	2	Field fueling of excavators, dozers
Line truck	100 hp	1	Excavator service and power line maintenance
Low bed transporter, tractor and 120T capacity low loader	200 hp	1	Transporting tracked equipment around mine and to service area/workshops
Haul truck retriever	1,120hp	1	Retrieving and transporting haul trucks unable to move under their own power
Light vehicles 4x4	74 hp	20	Supervisors transport, general duties

3.1.2.8 Fueling and Maintenance Facilities

Equipment fueling and minor service and repair work would be done at the Mine Site. A field service and fueling facility is proposed in the vicinity of the Rail Transfer Hopper. The fueling bay would consist of a roofed structure with enclosed sides, but open at each end to allow equipment to drive through. The field service bay would be similar to the fueling bay, but with one end enclosed and a large overhead door at the other end. Equipment would not be able to drive through the field service bay. The field service bay would also be equipped with overhead doors built into the sides to allow tire changes. The structures would have a reinforced concrete floor graded to drain to a sump to collect any spillage and oil-contaminated water. A suitably licensed disposal contractor would periodically pump out the sump.

In addition to fueling systems, there would also be dispensing equipment for lubricating and hydraulic oils. The building would contain limited-capacity storage tanks. Three 12,000 gallon bulk diesel storage tanks, enclosed with a suitable spill containment system, would be provided at a safe distance. Interior and area lighting would be provided to enable safe operation at nighttime. In addition, a metering system would accurately record the amount of fuel dispensed to each vehicle and emergency shut-off valves would be present at all necessary locations.

Stationary or slow-moving equipment such as excavators, dozers, and drill rigs would be fueled from mobile fuel tankers specially equipped with pumping and metering devices. The fueling tankers would arrive with fuel or be replenished at the service and fueling facility.

Major scheduled maintenance and repair work on mobile equipment would be done in the refurbished and reactivated former LTVSMC Area 1 Shop located about one mile west of the processing plant. The Area 1 Shop is a fully enclosed maintenance facility built specifically to handle maintenance and repair work. A heavy-duty low bed trailer and tractor would be used to transport tracked equipment (dozers and drill rigs) to the Area 1 Shop from the mine. A large scale tow-truck, also known as a truck retriever, would haul trucks that are unable to move on their own. The truck shop would collect and store used oils and antifreeze/coolant as well as residue from steam cleaning equipment. Used oils and solvents would be collected by a specialist contractor for recycling, while used filters, oily rags and other oil-contaminated waste would be collected for disposal in suitably licensed disposal facilities.

To access the Area 1 Shop, mine vehicles would follow an access road through parts of the former LTVSMC taconite mine area. Heavy equipment would cross County Road 666 at an established haul truck crossing point formerly used by LTVSMC. This crossing point would be illuminated at night and during inclement weather and would have amber flashers when in use by heavy equipment.

The former LTVSMC Area 2 Shop, located about 7 miles west of the Mine Site, would be reactivated to provide for mining and railroad operations supervision and management, as well as including change house facilities, toilets, lunch rooms, first aid facility, emergency response center and training and meeting rooms for mining and railroad crews. The Area 2 Shop facilities would include a Locomotive Fueling Station, Locomotive Service Building, and Mine Reporting Building. The Locomotive Fueling Station, where locomotives would be fueled and lubricated, has a roof and sides, but is open at the ends to allow access. The concrete floor would collect any spilled fuel and route it to a collection sump for proper disposal. It also has a 15,000-gallon bulk fuel storage tank, with appropriate containment systems. Direct vendor fueling of locomotives would be allowed, assuming proper procedures are followed to protect the environment, since this is a well established practice with other local mines and railroads.

Because of the size and weight of the primary excavators and blast hole drill rigs, most of their maintenance and repair work would be done in the field. PolyMet would ensure this work is conducted according to requirements of the facility's NPDES/SDS Permit and associated Mine Site SWPPP.

3.1.2.9 Mine Water Management

Both non-contact storm water and process water would be managed at the Mine Site. Non-contact storm water, the result of precipitation that falls on natural or reclaimed vegetated surfaces, would be routed through sedimentation ponds to remove total suspended solids (TSS). Process water, which includes precipitation runoff and groundwater (pit dewatering water) that has contacted disturbed surfaces as well as water collected on stockpile liners, would be treated at the Mine Site Wastewater Treatment Facility (WWTF) prior to being pumped to the Tailings Basin for use as plant make-up water. Process water would also be used to supplement flooding of the East Pit while the East Pit is being backfilled (see RS22 Mine Waste Water Management Systems). Additional details regarding the Mine Site WWTF are discussed in Section 4.1.1 of this document and RS29T Wastewater Treatment Technology – Mine and Plant; and RS45 Water Treatment Studies-Waste Rock, Lean Ore.

Figures 3.1-11, 3.1-12, and 3.1-13 show the process water management systems, including the pump and pipe networks that dewater the pits in Mine Years 1, 10, and 20. Figure 3.1-14 shows the existing drainage subwatershed boundaries and flows of the Mine Site, while Figures 3.1-15, 3.1-16, and 3.1-17 show proposed surface water management at the Mine Site in Mine Years 1, 10, and 20. Existing drainage patterns and the proposed storm water management system are described in further detail in Section 3.1.2.10. Also, see RS22 Mine Waste Water Management Systems for more detail regarding Mine Site water management.

3.1.2.10 Mine Site Perimeter and Pit Rim Dike and Ditch Systems

Dikes

A system of dikes and ditches constructed at the mine site perimeter would minimize the amount of surface water flowing onto the site, minimize the amount of surface runoff flowing into the mine pits, and eliminate process water and control non-contact storm water flowing off the site (Figures 3.1-15, 3.1-16, and 3.1-17).

Dikes would be constructed of silty sands or glacial till material that would be excavated during construction of ditches and removal of overburden. Side slopes would be vegetated to control erosion. Small dikes would be constructed at the rims of the mine pits in all areas where the existing ground surface does not naturally drain surface runoff away from the pit. These pit rim dikes would be rebuilt as the pit perimeter expands.

Small dikes would also be constructed, as needed, along interior stormwater ditches and around stockpile construction areas to separate storm water and process water around the Mine Site. See RS24 Mine Surface Water Runoff Systems/Runoff Characterization and RS25 Mine Diking/Trenching Effectiveness Study for more detail on pit rim dikes.

Non-Contact Storm Water Ditches

In order to convey non-contact storm water adjacent to the dikes, prevent surface runoff from entering the mine pits, intercept storm water prior to reaching process water areas, and prevent water from pooling in areas where the dikes cut across low areas, ditches would be constructed along the interior of most of the perimeter dike system and throughout the interior of the Mine Site. In addition, there would be some areas along the site perimeter where the existing ground is already relatively high so that a ditch would be able to capture the site surface runoff without a dike.

Non-contact storm water captured by the ditches would be directed to sedimentation ponds and then routed into a natural drainage system. The layout of drainage ditches is illustrated in Figures 3.1-15, 3.1-16, and 3.1-17 for Years 1, 10 and 20, respectively.

See RS24 Mine Surface Water Runoff Systems/Runoff Characterization and RS25 Mine Diking/Trenching Effectiveness Study for more detail on non-contact storm water ditches.

3.1.2.11 Dike Design for Shallow Groundwater Control

Where dikes intersect wetlands, seepage control measures would be installed to restrict movement of groundwater through high permeability areas. This would help prevent drawing down wetland water levels and reduce inflows to the pit. Seepage control would be needed where glacial till is present in the dike foundation zone below the water table and where inspection trenching (conducted at the time of construction) indicates potential for high-permeability conditions or where peat is present.

Seepage control measures in areas where glacial till is present would include soil cut-off trenches constructed of compacted silty sand or compacted glacial till, or slurry trenches. The decision on which to use would depend on depth to bedrock and soil type in which the dike was being built.

In areas where peat is present, seepage would be prevented by compressing the peat with earthen dike materials to create a low-permeability layer. If a sand seam or other high-permeability material is found in the dike foundation zone below the peat deposit, a soil cutoff trench, slurry wall, or sheetpile wall would be installed (depending on depth to bedrock) to cut off seepage.

Geotechnical testing indicated that silty sand soils found at the Mine Site are a relatively low-permeability material in their natural state. Therefore, seepage cutoffs are generally not planned to be used in these areas.

See RS25 Mine Diking/Trenching Effectiveness Study for more detail on dike design for shallow groundwater control.

3.1.2.12 Pit Dewatering

While the dikes, ditches, and seepage control measures help to keep some water out of the pit, precipitation and groundwater flow to the pits would still occur. It is therefore necessary to dewater the pits during mining. Precipitation runoff and groundwater flow would be directed to low areas in the pits where it would be collected in sumps and pumped through high density polyethylene (HDPE) pipes to the WWTF located south of the West Pit. The mine pit sump areas and pump capacities were designed to minimize delay to mining operations during the typical spring snowmelt or major precipitation events. See RS-22 Mine Waste Water Management Systems, RS-29T Wastewater Treatment Technology – Mine Plant for more detail on pit dewatering.

3.1.2.13 East and Central Pit Filling

After mining activities were complete in the East and Central Pits, the pits would be filled with Category 1 and 2 waste rock from the West Pit, along with groundwater, in-pit runoff from surrounding wetlands, and precipitation.. Subsequent flooding of these backfilled pits with water would minimize the amount of pit wall that is exposed to the atmosphere, thus limiting the oxidation of the sulfide minerals in the pit walls and reducing the amount of metals leaching to the pit water.

The quantity of waste rock placed in the East and Central pits would change every year of operation, depending on the quantity of Category 1 and 2 rock generated. During filling, the water elevation would be kept slightly below the surface of the waste rock to avoid work in the water and to maximize the amount of rock used to fill the pit. At closure, the water level in the East and Central Pits would be allowed to increase above the level of the waste rock. The backfilled pit would be designed to function as a wetland. Wetland construction cannot begin until closure because backfilling is scheduled to be complete at the end of mine life.

If natural inflow of water into the East and Central Pits is insufficient, water can be pumped from the Central Pumping Station (CPS), which is designed to send water that has been treated at the Mine Site WWTF to the Tailings Basin, to keep the water surface at the required level. During periods of high precipitation or during spring snowmelt, dewatering may be required to allow placement of the waste rock. Given the estimates for combined pit inflows, it is predicted that additional water would be needed from the CPS during most years of the pit filling operation. As shown in Table 3.1-5, there are two years, Years 13 and 14, when water balance estimates indicate that excess water in the East and Central Pits would need to be diverted to the WWTF.

The job titles and numbers of positions shown on Table 3.1-6 are PolyMet's estimates of mine operations positions for preliminary planning and environmental impact assessment purposes. The total staffing and job titles for the mine operations would depend on such detailed operational planning factors as the equipment fleet size and mix, optimal maintenance strategy, and optimal shift roster arrangements.

In addition, post-closure and reclamation activities are expected to generate 20 to 50 jobs for many years. Employment is discussed further in Chapter 4.10 Socioeconomics.

Table 3.1-5 Water Balance for East and Central Pit Filling

Mine Year	Combined Pit Inflows[1] (gpm)	Annual Flow Required to Fill Pits[2] (gpm)	Additional Water Needed from CPS (gpm)	Excess Pit Water Diverted to WWTF (gpm)
Year 12	960	1,001	41	0
Year 13	953	432	0	521
Year 14	946	328	0	618
Year 15	940	1,427	487	0
Year 16	781	1,274	493	0
Year 17	622	1,122	500	0
Year 18	415	913	498	0
Year 19	209	1,024	816	0
Year 20	2	976	973	0

[1]Combined pit water includes direct precipitation, in-pit runoff, and groundwater inflows for the East and Central Pits.
[2]Annual flow required to fill pits is the volume required to keep the water surface within 5 feet from the backfilled rock elevation and varies with the rock volume placed in the pits.

3.1.2.14 Employment

The job titles and numbers of positions shown on Table 3-6 are PolyMet's estimates of mine operations positions for preliminary planning and environmental impact assessment purposes. The total staffing and job titles for the mine operations would depend on such detailed operational planning factors as the equipment fleet size and mix, optimal maintenance strategy, and optimal shift roster arrangements. Employment is discussed further in Section 4.10.3.1

3.1.2.15 Table 3.1-6 Mine Operations Staffing Listing of Positions

Job Title	Positions*
Senior mine management and clerical	3
Safety coordinator	1
Environmental coordinator	1
Environmental technician	1
Mine engineering and production planning staff	2
Geology, grade control and geotechnical (technicians)	6
Blasting crew	4
Field sampling crew	2
Pumping and power distribution	2
Surveying	2
Maintenance management and planning	2
Warehouse and stores management	2
Production coordinators	3
Dispatch	1
Equipment operators	69 *

Job Title	Positions*
Mine maintenance crews	24 *
Railroad operations and maintenance	12
Total	**137 ***

* Numbers are preliminary and would vary according to the maturity of the operation, equipment, and fleet size.

3.1.3. Proposed development drilling

The management of waste rock (and ore) would begin during the 9 to 12 month pre-production phase of mining. A geological resource block model (RS 78 Mine Pit Development and Waste Block Models) of the deposit was developed by PolyMet from diamond drill hole data, geological mapping, and any additional information that was known. This block model would be used as a starting point, with greater precision gained during the gradual ramp-up of output over the 6 to 12 months it would take to reach full capacity. At that time, pre-production in-fill core drilling and assaying would continue for further delineation of ore and waste zones and for detailed planning and scheduling of pre-stripping and early phase production mining activities (see RS 43 Mine Waste Management Plan).

3.1.4. Proposed management of mine waste materials

3.1.4.1 Waste Rock Drilling and Blasting

Waste rock would require drilling and blasting prior to excavation. Conventional diesel or electrically powered rotary drilling rigs are proposed to be used. Blasting design would be refined and optimized as the mining operation matures and additional data is collected and analyzed.

Based on an average annual waste rock movement rate of 19.7 million tons, the total amount of blasting agent used annually for waste rock would be 9.81 million pounds, including initiators and blasting accessories.

Secondary breakage of oversize boulders would be by a mechanical drop hammer mounted on a wheel loader. After being drilled and blasted, the waste rock would be loaded into haul trucks and removed from the mine. Waste rock would be loaded into diesel haul trucks by a combination of a rubber tired front end loader and track-mounted, diesel-hydraulic or electric-hydraulic excavators. Waste rock would be hauled to one of four main waste rock stockpiles - Category 1 and 2 Waste Rock, Category 3 Waste Rock, Category 3 Lean Ore and Category 4 Waste Rock. Category 4 Lean Ore would be hauled to the Lean Ore Surge Pile or the Rail Transfer Hopper. The decision on where to haul to would depend on sulfur and metals content as described below.

3.1.4.2 Waste Rock Stockpiles

Based on the schedule shown in Table 3.1-7, approximately 151 million tons of waste rock (38% of the total) would be available for in-pit disposal after year 11. Approximately 125 MT (32% of the total) would be placed back in the East and

Central Pit in such a way that wetlands could be created (see RS 18 Mine Design and Schedule with Backfill) . The waste rock would be categorized according to its sulfur and metals content using an on site or local lab to provide fast turn around of blast hole samples. The rock would then be placed in the East Pit or segregated into one of the waste stockpiles designed specifically for each of the waste rock categories. The maximum size of each stockpile is projected to have the approximate area and approximate height and elevation shown in Table 3.1-8.

Table 3.1-7 Waste Rock Stockpiles

	Waste Rock Stockpiles in Tons						
Year	**Category 1 and 2 Waste Rock**	**Category 3 Waste Rock**	**Category 3 Lean Ore**	**Category 4 Waste Rock**	**Category 4 Lean Ore**	**East Pit**	**Total**
0	18,203	0	0	74,559	0		92,762
1	6,187,320	214,660	1,605,061	8,208	0		8,015,248
2	16,503,153	225,169	1,793,557	252,209	9,005		18,783,092
3	13,715,483	597,893	2,129,494	1,254,741	0		17,697,612
4	14,636,063	854,261	1,701,833	1,025,464	0		18,217,621
5	22,776,226	561,879	1,070,203	1,173,278	71,027		25,652,613
6	17,198,285	627,254	1,347,766	1,398,799	124,855		20,696,959
7	10,907,307	469,536	1,288,444	637,857	140,799		13,443,943
8	28,131,562	743,072	2,495,861	498,023	160,832		32,029,350
9	15,480,940	604,242	1,093,809	581,364	125,119		17,885,475
10	18,988,087	431,299	1,769,310	464,726	178,297		21,831,718
11	11,078,713	703,394	1,251,543	653,878	186,248		13,873,776
12	0	1,243,567	3,202,453	188,528	187,144	20,819,956	25,641,648
13	0	1,027,466	2,861,908	98,160	158,747	16,077,320	20,223,601
14	0	919,439	2,330,837	26,241	88,532	14,286,631	17,651,680
15	0	860,386	4,775,347	77,016	34,564	22,878,678	28,625,991
16	0	547,644	3,650,319	110,320	88,755	18,526,917	22,923,956
17	0	715,639	1,491,121	59,945	168,404	14,580,631	17,015,740
18	0	931,031	1,903,476	58,422	52,919	17,036,139	19,981,987
19	0	886,215	1,605,809	59,243	8,723	13,620,063	16,180,054
20	0	1,591,732	2,101,973	191,726	106,190	13,625,514	17,617,135
Total	**175,621,343**	**14,755,777**	**41,470,125**	**8,892,706**	**1,890,162**	**151,451,850**	**394,081,962**
% Total	**83.0%**	**3.7%**	**10.5%**	**2.3%**	**0.5%**		**100.0%**

Approximately 125 million tons of Category 1 and 2 waste rock would be placed in the East and Central Pit for pit backfilling, and the remainder (26.4 million tons) would be used for MnDNR-approved on-site construction or placed in additional lifts on the Category 1 and 2 waste rock stockpile (see RS 22 Mine Waste Water Management Systems).

Table 3.1-8 A Year 20 Stockpile Dimensions

Stockpile	**Area (acres) =**	**Max Height (feet)**	**Max Elevation (feet above sea level)**
Category ½	464.4 *	240	1840
Category 3	72.0	160	1760

Stockpile	Area (acres) =	Max Height (feet)	Max Elevation (feet above sea level)
Category 3 Lean Ore	156.8	200	1800
Category 4	63.3	130	1730
Category 4 Lean Ore Surge Pile**	N/A	0	N/A

* The area for the Category 1 and 2 stockpile includes 27.4 acres of overburden area with liner system. The Category 1 and 2 stockpile is 563.5 acres in total including all overburden.

**Refer to section 3.1.2.5 for more discussion of the Category 4 Lean Ore Surge Pile

Waste Rock Liner and Cover Systems

Waste rock stockpiles would include liner systems to capture water passing through the rock. In addition, the waste rock stockpiles would have cover systems to limit water infiltration into the stockpile after the stockpiles are closed. Liner and cover system design are based on the degree of predicted heavy metal leaching expected from each waste rock classification type. Local till soils used for construction would be generated from the processing of overburden removed from the mine pit and stockpile footprint areas. The overburden would be screened and sorted and stored at the overburden storage area (see RS 18 Mine Design and Schedule with Backfill). The volume of overburden generated is estimated to be about four times more than the construction material needed in the first five years, and two and a half times more than what would be needed overall. In the event that there are insufficient soils with the proper characteristics, additional overburden would be available in PolyMet-owned stockpiles at LTVSMC Area 5 (see Figure 3.1-1).

The proposed liner and cover systems are as follows (see RS 23T Reactive Waste Rock, Lean Ore, Deferred Grade Ore Segregation for information regarding liner performance):

Category 1 and 2 Waste Rock Stockpile

This liner system would include a minimum of a one foot compacted soil layer topped by a drainage layer. Local till soils would be used for this liner with bentonite admixing or other conventional techniques, as required, to obtain the design permeability. The cover system would consist of a minimum 2-foot evapotranspiration (ET) layer constructed of local till soils and revegetated to support an evergreen forest vegetative cover.

Category 3 Waste Rock Stockpile

This liner system would include a compacted subgrade layer constructed from the local till soils, covered by a geomembrane liner and overliner drainage layer. The cover system would consist of a three-foot ET layer constructed of local till soils and revegetated to support an evergreen vegetative cover on the regraded side slopes. However, on the top and bench surfaces of the stockpile, a textured geomembrane barrier covered by 1.5 feet of cover soil vegetated with grass would be used.

Category 3 Lean Ore Stockpile

This liner system would be the same as for the Category 3 Waste Rock Stockpile. The cover system would be the same as the cover system proposed for the Category 3 stockpile.

Category 4 Waste Rock Stockpile

This liner system would be the same as the liner system proposed for Category 3 Lean Ore. The cover system would consist of a textured geomembrane barrier covered by a 1.5 foot thick soil layer vegetated with grass.

Lean Ore Surge Pile

This liner system would be the same as the liner system proposed for Category 3 Lean Ore. Any remaining material in this pile would be removed at closure so no cover system is proposed. All liner systems would be constructed using foundation underdrains for maximum liner integrity (see RS 23T Reactive Waste Rock, Lean Ore, Deferred Grade Ore Segregation).

Waste rock stockpiles would be located around the pit perimeter. The Category 1 and 2 stockpile and Category 3 waste rock stockpile would be located north of the mine pits. The Category 3 lean ore stockpile, the Lean Ore Surge Pile, and the Category 4 waste rock stockpile would be sited south of the mine pits along the Dunka Road near the Rail Transfer Hopper. Surface overburden would be temporarily stockpiled in the Overburden Storage area along Dunka Road, and ultimately screened and sorted for use in foundations and reclamation. Permanent overburden storage would be located in a separate portion of the Category 1 and 2 waste rock stockpile (see Figures 3.1-4 – 3.1-8).

3.1.4.3 Other Wastes

Wastes would be generated from the Mine Site vehicle maintenance facilities. These wastes would include typical maintenance wastes and would be handled and disposed of according to waste characterization requirements (e.g., hazardous, non-hazardous, special waste) established under the Resource Conservation and Recovery Act (RCRA), the primary federal law governing the disposal of solid and hazardous waste.

3.1.5. Proposed transport of ore

PolyMet would use three trains, each consisting of up to twenty 100-ton side dumping ore cars and one 2,100 hp diesel-electric “Gen-Set” locomotive, to move the ore from the Mine Site to the Process Plant. The cars would have hinged sides that drop down when the cars are tipped at the crusher for unloading. Small amounts of ore could escape the confines of the rail cars during transport via two primary routes:

1) Fines through the gaps at the hinges - the Rail Transfer Hopper discharge feeder and track alignment is designed so that cars would be loaded along the centerline. In this loading procedure, ore size is classified as the car is loaded so that fines would be at the center of the car and the larger ore pieces would be at the edge. This would keep much of the fines from reaching the edge of the car where they would be subject to spillage through the hinge gaps. PolyMet has noted that no evidence of fines spillage was observed at LTVSMC using this same loading system and cars.

2) Large pieces of ore over the tops - Standard operating procedure would be to use a rubber tired dozer to push any large ore pieces that extend out of the car into or off of

the car near the Rail Transfer Hopper because these pieces can damage the crusher building and car dumping equipment. In the unlikely event that a large ore piece would fall over the top edge of the cars during transit, it would be recovered during routine track maintenance

The route of track from the Mine Site to the Process Plant would be from a new spur at the Rail Transfer Hopper, to existing track between Mile Posts 8.4 and 3.9 on the Cliffs Erie LLC private railroad, to a new approximately 5,750-foot-long connecting track between the Cliffs Erie track and existing PolyMet track that serves the Coarse Crusher Building at the Process Plant.

3.1.6. Proposed processing site – location and ownership

The proposed Plant Site includes a Processing Plant, Area 1 Shop, Area 2 Shop, and the Tailings Basin, plus additional land around these facilities to serve as a buffer. The entire Processing Plant, which is in an area that was previously disturbed by mineral processing operations, would include a beneficiation facility and a hydrometallurgical processing facility (including a Hydrometallurgical Residue Facility and Tailings Basin). The Beneficiation Plant would use the existing Coarse Crusher Building, Fine Crusher Building, and Concentrator Building that were part of the LTVSMC taconite plant. The Hydrometallurgical Plant would be located in three new buildings - the Hydrometallurgical Facility, the Cu Solvent Extraction Building, and the Cu Electrowinning Tank House. The existing General Shop Building would be used for rail car repair and mixing/storage of process consumables in a designated Reagents Area. A layout of the complete Plant Site can be seen in Figure 3.1-18. In addition, Figure 3.1-18a shows the Processing Plant buildings.

PolyMet has acquired surface ownership of approximately 7,000 acres of real property and portions of the taconite processing facility formerly owned by LTVSMC, and approximately 8,100 additional acres from Cleveland-Cliffs, Inc. Some of this land was additional acreage that will not be used for the NorthMet project. PolyMet has acquired the necessary surface licenses, easements, and rights-of-way for the remainder of the Plant Site (e.g., roadways, railroad, electrical service, gas pipeline, and water facilities) to enable production at the Plant Site (Figure 3.1-19). PolyMet has also acquired the necessary easements and rights-of-way to use an 8-mile segment of Dunka Road, which is co-owned by Minnesota Power, PolyMet, and Cliffs Erie.

In summary, at the Plant Site, the surface owned or leased by PolyMet is 15,100 acres of which 4,304 acres are predicted to have ground-level impacts due to PolyMet operations. Most of the area that would be disturbed has already been impacted by LTVSMC operations. The exceptions are the 36.2 acres of wetlands north of tailings basin Cell 2E that would have a rock buttress at the toe of the existing LTVSMC dam and the 19.1 acres of wetlands to the east of tailings basin Cell 1E that would be covered with tailings because the natural terrain would be used as a dam. At the Rail

Connection Area the area owned or leased by PolyMet and the area impacted by PolyMet operations are included in the Plant Site areas above.

3.1.7. Proposed processing of ore – inputs/processes/outputs and options

The Process Plant would consist of a beneficiation plant and hydrometallurgical processing facility that would process the ore to recover base metals, gold, and platinum group metals. The processing steps that would be involved in each are described below. The Process Plant would also include a tailings basin, Hydrometallurgical Residue Facility, and a General Shop that would be used for rail car maintenance.

3.1.7.1 Beneficiation Plant

The purpose of the Beneficiation Plant would be to produce final bulk flotation concentrate (all metallic minerals) or two separate saleable concentrates (one of mostly nickel and a second of mostly copper metallic minerals) that could be shipped to customers, used as a feedstock to the hydrometallurgical process, or split approximately in half for both uses (see PolyMet July 2007 Supplemental DPD). The Beneficiation Plant processes would include ore crushing, grinding, and flotation; and concentrate regrinding, separation, dewatering, and shipping concentrate.

Ore Crushing

During the Ore Crushing process (Figure 3.1-20), ore as large as 48 inches in diameter would be delivered by rail from the mine to the Coarse Crusher Dump Pocket where each car would be emptied into a Primary Crusher (gyratory) at an average feed rate of 1,667 tons/hour[ii] (t/hr). From the Primary Crusher, ore would be discharged to the Product Surge Bin, and then moved by gravity into four parallel Secondary Crushers (gyratory). A conveyor system would move the ore, 80% of which would now be smaller than 2.5 inches, to the Coarse Ore Bin.

The coarse crushed ore would be fed into one of three operating Fine Crushing lines. Each line would consist of a Tertiary Crusher (cone), two Quaternary Screens, and two Quaternary Crushers (cone). The material would pass from the Tertiary Crushers through Vibrating Feeders and onto a Double Deck Screen. The material that did not pass through the screen (oversize material) would discharge to the Quaternary Crusher, while material that passed through the screen (undersize material) would pass

[ii] Average is calculated using the hours the Primary Crasher is actually running as it would not run continuously.

directly to a conveyor below the Fine Crushing Area. This conveyor would collect all screen undersize material and Quaternary Crusher products that would then discharge to a second conveyor where the crushed ore would be transferred to the Fine Ore Bin. At this stage of the process, approximately 80% of the ore in the Fine Ore Bin would be smaller than 0.315 inch.

Ore Grinding

The ore grinding process (Figure 3.1-20), which occurs in the Concentrator Building, would reduce the ore particle size to the point at which 80% of the product is less than 120 microns (4.7×10^{-3} inches). During ore grinding, the Fine Ore Bin would feed groups of twelve vibrating feeders - one group for each mill line. The feeders would discharge to a Rod Mill Feed Conveyor with a belt scale that would be used to adjust the vibrating feeders and regulate delivery of crushed fine ore to each Rod Mill. In the Rod Mills, the ore would pass through the mill once and the ground product would be delivered to the feed end of a matched Ball Mill. Once in the Ball Mills, the ore would re-circulate through the mill and the Primary Cyclones until the particle size was small enough to become overflow from the Primary Cyclones. Overflow from the Primary Cyclone would be suitable for flotation and would flow by gravity to a collection sump and be pumped to the flotation area, while the larger material (i.e., the underflow) would be returned to the Ball Mill feed chute.

Metal alloy balls and rods used as grinding media would maintain a constant mill power draw. In addition, water would be added to each mill feed at a rate sufficient to maintain the mill discharge density at nominally 70-75% solids by weight.

Flotation

Once at 120 microns (4.7×10^{-3} inches), the ore would be processed using flotation to recover a bulk sulfide product that contains the greatest possible concentration of the base and precious metals. The flotation process would consist of two flotation roughing and scavenging lines that would share common cleaning stages, all completely contained within the Concentrator Building (Figure 3.1-21).

Each rougher/scavenger flotation line would consist of one Rougher Flotation and five Scavenger Flotation cells. Flotation of the liberated sulfide minerals would be achieved using a collector/frother combination. Each cell would be mechanically agitated to create a layer of bubbles or froth. The frother (methyl isobutyl carbinol and polyglycol ether, or MIBC/DF250), would provide strength to the bubbles formed in the flotation cells and the collector (potassium amyl xanthate, or PAX) would cause the bubbles to attach to the sulfide minerals.

The Rougher Flotation concentrate from both Rougher Flotation lines would be pumped to the cleaner circuit via a single Cleaner 1 Conditioning Tank. Additional frother and collector would be added before the slurry flows by gravity to a bank of six Cleaner 1 Flotation cells. The Rougher Flotation tailings from both lines would go to a bank of five Scavenger Flotation cells through the Scavenger Conditioning Tank. Collector and frother would be added, along with copper sulfate as a flotation activator. The activator would ensure that the particles that are difficult to float (i.e., contain minor amounts of sulfide) are recovered in the concentrate, which reduces total sulfide content of the tailings. The concentrates from the first cell of each of the Scavenger Flotation lines would go to the cleaning circuit, while the remainder would be pumped to a common regrind milling circuit.

Two stages of concentrate cleaning would be provided. The first stage cleaner flotation would be conducted in six Cleaner 1 Flotation cells. The Cleaner 1 Flotation tailings would go to the Regrind Hopper, while the concentrate is pumped to four Cleaner 2 Flotation cells. The Cleaner 2 Flotation tailings would be recycled back to the Cleaner 1 Conditioning Tank. The Cleaner 2 concentrate would be pumped to a single Concentrate Thickener, where flocculant would be applied to promote particle settling. This material would feed the Concentrate Regrind area.

The regrind milling circuit, which would be designed to grind Scavenger Flotation concentrate and Cleaner 1 Flotation tailings to a size suitable for liberating partially locked sulfides, would consist of a Regrind Cyclone and Regrind Mill. The combined streams in the Regrind Hopper would be pumped to the Regrind Cyclone. Cyclone overflow (small particles) would be re-circulated to the Rougher Flotation cells, while underflow (larger particles) would return to the Regrind Mill feed chute.

The Scavenger Flotation tailings from each circuit, projected by PolyMet to be approximately 645 t/hr solids and have a solids density of 37%, would be pumped to the Flotation Tailings Basin where the solids would settle and be stored permanently. The clear water would be re-circulated to the mill process water system.

Concentrate Regrinding

The next process that would occur in the Beneficiation Plant is Concentrate Regrinding (Figure 3.1-22a), which would occur completely within the Concentrator Building. During this step, the thickened underflow from the Concentrate Thickener would go to a Concentrate Fine Grinding IsaMill. The IsaMill is a grinding technology based on high intensity stirred milling. Here, the particle size would be reduced from 120 microns (4.7×10^{-3} inches) to 15 microns (5.9×10^{-4} inches), which is the size required to enhance the efficiency of the pressure oxidation process in the Hydrometallurgical Plant. The finely ground concentrate would then flow to the Concentrate Storage Tank that provides surge capacity between the Beneficiation and Hydrometallurgical Plants when producing feedstock for the Hydrometallurgical Plant, and between the Concentrate Regrinding and Concentrate Separation and Dewatering when producing final concentrate products (Concentrate Mode).

Concentrate Separation and Dewatering – Concentrate Mode[iii]

During this step, which occurs only in the Concentrate Mode, the bulk copper/nickel flotation concentrate would be delivered to a Concentrate Separation Conditioning Tank where the pH would be adjusted to approximately 12.5 by adding lime (see Figure 3.1-22a). The Concentrate Conditioning Tank would feed a series of Concentrate Flotation cells. In the Flotation Cells, the high pH would cause the copper to remain highly floatable, forming the majority of the new concentrate. The high pH would also depress the floatability of nickel, which would cause the nickel to remain in the tailings slurry. Because copper and other associated minerals would be removed here, this tailings slurry would have higher nickel concentration and would now be considered a nickel concentrate.

The nickel and copper concentrates would each be delivered to an identical dewatering line consisting of a Concentrate Thickener, Concentrate Filter, and Concentrate Dryer. Each Thickener underflow, containing the thickened concentrate portion, would be transferred to a storage tank and to a filter where the filtered concentrate moistures would be reduced to approximately 8 to 10%. The filtered concentrate would then be conveyed into a dryer that would reduce the moistures to 1 to 2%. The dried concentrate would be delivered to an existing Concentrate Storage Silo (former Soda Ash Silo) for storage.

In the above process, each Concentrate Thickener overflow would be returned to the Beneficiation Plant process water tank and provisions would be made to neutralize the nickel return water if it is determined that the high pH water cannot be returned directly. The filtrate water would be returned to the corresponding concentrate thickener.

Concentrate Shipping – Concentrate Mode

While processing in the Concentrate Mode, the Concentrate Shipping area would be used to store dried copper and nickel concentrate and to load the concentrates into covered and sealed rail cars, which would be specifically built for this purpose . The Concentrate Shipping area would be within the Heating Plant and Additive Building and a Car Loading Shed extension to that building. Additional railroad tracks on disturbed ground are also proposed as part of this area.

[iii] Note that the proposed project would only operate in Concentrate Mode temporarily. A more extensive Concentrate Mode operation would not occur unless additional environmental review was completed.

Dried concentrate would be transferred from the Concentrate Separation and Dewatering area to one of two Concentrate Storage Silos for loading into rail cars. Each of the two silos would have about 3.5 days of production capacity for its concentrate (copper or nickel) if all flotation concentrate is directed to the Concentrate Separation and Dewatering area. Refer to Figure 3.1-22a for the concentrate shipping flow diagram.

Depending on the customer's requirements, two methods would be considered for loading the dried concentrate into storage containers and unloading the concentrate from those containers into rail cars for shipping:

1) Shipping a *very dry* concentrate that would flow like ground dry cement. In this option, the concentrate would be conveyed pneumatically in a sealed tube to covered hoppers, such as those used to transport ground cement. These cars have a filling valve that would directly connect to the sealed pneumatic tube, and a vent valve that would be connected to a sealed tube, which would route the air exhausted from the sealed car back to the concentrate storage bin. This bin would have a vent, with a small baghouse attached, that vents to atmosphere.

2) Shipping a *less dry* concentrate that would be produced by filtering a concentrate slurry and having the filter cake drop from the filter into an open rail car with a sealed bottom. Once the car is loaded, a rigid cover would be placed over the car for shipping. In this option, the concentrate would be stored as a slurry in a tank.

In both cases, car loading would be indoors with concrete floors and rail cars would be enclosed.

Processing Summary

Table 3-10 shows PolyMet's estimates for daily production rates, size reduction, and percent sulfur (%S) through the processing steps in the beneficiation process.

Water needed for the milling and flotation circuits would primarily be return water from the Flotation Tailings Basin. Tailings Basin water would include water that is treated as necessary from pit dewatering, stockpile drainage, un-reclaimed stockpile runoff and other water that would have contacted the mine rock. Any shortfall in water requirements would be made up by raw water from Colby Lake using an existing pump station and pipeline.

*Table 3.1-10 Key Processing Parameters**

	Input				Output			
Step	**Material**	**Rate*** *(stpd)**	**Size*** (inches)**	**%S****	**Material**	**Rate*** *(stpd)**	**Size*** *(inches)**	**%S****
Ore Crushing	ore	32,000	48	0.88	Ore	32,000	0.315	0.88
Ore Grinding	ore	32,000	0.315	0.88	Ore	32,000	4.7×10^{-3}	0.88
Flotation	ore	32,000	4.7×10^{-3}	0.88	Concentrate	1,038	4.7×10^{-3}	20.60
					Tailings	30,962	4.7×10^{-3}	0.12
Concentrate Grinding	concentrate	1,038	4.7×10^{-3}	20.60	Concentrate	1,038	5.9×10^{-4}	20.60
Concentrate Separation and Dewatering	concentrate	0 to 1,038	4.7×10^{-3}	20.60	Dried nickel and copper concentrates	0 to 1,038	4.7×10^{-3}	20.60

*From January 2007 DPD, Table 3.3-A.
**This value is from the Pilot Plant test that represents final full scale plant design and is the average of 4 samples.
***Plant design parameters

Consumable	**Quantity**	**Mode of Delivery**	**Delivery Condition**	**Storage Location**	**Containment**
Grinding Media (metal alloy grinding rods and balls)	15,600 t/yr	Rail (13 rail cars/ mo)	Bulk	Concentrator Building	None required
Flotation Collector (PAX)	600 t/yr	Truck (2 trucks/mo)	Bulk bags	Concentrator Building	None required
Flotation Frother (MIBC and DF250	358 t/yr	Tank truck (1-2 trucks/mo)	Bulk	Concentrator Building	Separate 13,200 gallon storage tanks
Flotation Activators (copper sulfate)	650 t/yr	Reuse from oxidation autoclave*	NA	Concentrator Building	9,200 gallon Activator Storage Tank
Flocculant (MagnaFlox 10)	16.5 t/yr	Truck (1 truck/2 mo)	1,875 lb bulk bags	Concentrator Building	None required

Table 3.1-11 Beneficiation Plant Consumables

3.1.7.2 *Copper sulfate is generated by leaching of copper minerals in the pressure oxidation autoclave located in the hydrometallurgical plant (see Section 3.3.2.1) and 650 short tons per year is reused as an activator for the flotation process. The remaining copper sulfate progresses through the hydrometallurgical plant to be eventually recovered as copper metal. The copper sulfate for flotation is stored in a 9,200 gallon Activator Storage tank located in Concentrator Building near the Upper Repair Bay.

Process Consumables

PolyMet anticipates the following raw materials would be consumed by the Beneficiation Plant processes:

3.1.7.3 Hydrometallurgical Plant

Hydrometallurgical processing technology would be used for the treatment of concentrates. This process would involve high pressure and temperature autoclave leaching followed by solution purification processes to extract and isolate platinum group, precious metals, and base metals. All equipment proposed for use in the hydrometallurgical process would be located in the Hydrometallurgical Facility, Copper (Cu) Solvent Extraction Building, or the Copper (Cu) Electrowinning Tank House (Figure 3.1-18).

High Pressure Oxidation Autoclave

The hydrometallurgical process would begin with the combination of flotation concentrate, WWTP sludge, and a recycle stream from the Leach Residue Thickener underflow in an Autoclave Feed Tank (see Figure 3.1-22b). Hydrochloric acid would be added to maintain the proper chloride concentration in the leach solution to enable leaching of the gold and platinum group metals (See "PolyMet proposed response to 040308 letter 072408"). This mixture would then be pumped to two autoclaves operating in parallel.

Each autoclave would be injected with oxygen gas supplied by a 770 tpd cryogenic oxygen plant at a rate that is controlled to ensure complete oxidation of all sulfide sulfur in the autoclave feed. Partially neutralized copper SX raffinate[iv] from the Raffinate Neutralization Thickener overflow would be pumped to each of the autoclaves to control the leaching temperature.

In the autoclaves, the sulfide minerals in the flotation concentrate would be oxidized and dissolved in a solution containing copper sulfate, nickel sulfate, cobalt sulfate, zinc sulfate, ferric sulfate, and sulfuric acid. Gold and platinum group metals would dissolve as soluble chloride salts. The solid residue produced would contain iron oxide, jarosite (iron sulfate) and any insoluble gangue (non-ore silicate and oxide minerals) from the flotation concentrate. Generation of acid from the oxidation of major sulfide minerals would result in leaching of the silicate, hydroxide, and carbonate minerals present in the flotation concentrate. To remove excess heat from the leached slurry, a dedicated Autoclave Flash Vessel would be used to reduce the slurry to atmospheric pressure and allow the release of steam.

[iv] Raffinate is a solution that has upgraded or refined by a process step.

Slurry discharging from the Autoclave Flash Vessel would be further cooled using dedicated spiral heat exchangers. The majority of heat transferred here would be used to pre-heat the feed solution for the Residual Copper Removal Precipitation Tank. The remainder of the heat transferred would be used to heat the mill process water. The cooled slurry would be pumped to the Leach Residue Thickener where the solids would be settled with the aid of a flocculent. The underflow would be split with the majority being recycled to the Autoclave Feed Tanks and the remainder to the Leach Residue Filter. The Leach Residue Filter would separate the leached autoclave residue solids from the process solution that contains the solubilized metals. Residual entrained metals would be recovered by washing the autoclave residue. The washed residue would be repulped, combined with other hydrometallurgical residues, and pumped to the Hydrometallurgical Residue Facility.

Gold and Platinum Group Metals Precipitation

To begin gold and platinum group metals precipitation (see Figure 3.1-22c), Leach Residue Thickener overflow and Leach Residue Filter wash water would go to the first of three gold and platinum group metals Precipitation Reactors where sulfur dioxide gas would be added to reduce ferric ions to ferrous ions.

Complete reduction of ferric ions would be achieved by the addition of copper sulfide (CuS) recycled from the Residual Copper Removal Thickener underflow. Recycled CuS would also be used to recover precious metals; specifically platinum, palladium and gold from the autoclave leach solution. Produced here would be a mixed gold and platinum group metals sulfide with a relatively large proportion of CuS (an important substrate for gold and platinum group metals reduction) and elemental sulfur. The discharge from the Gold and Platinum Group Metals Precipitation Reactors is pumped directly to the Gold and Platinum Group Metals Thickener where CuS enriched with gold and platinum group metals settles with the aid of a flocculant and produces thickened slurry suitable for filtration. The resultant filter cake would contain platinum, palladium, gold, copper chloride, and sulfur.

The Gold and Platinum Group Metals Thickener underflow would be pumped to the Gold and Platinum Group Metals Filter Feed Tank. This Feed Tank would provide additional storage capacity between the Gold and Platinum Group Metals Filter and Gold and Platinum Group Metals Thickener. The Gold and Platinum Group Metals Filter would separate the gold and platinum group metals precipitate solids from the process stream that would contain solubilized metals. Residual metals still being carried along in the process stream would be recovered by washing the gold and platinum group metals precipitate with demineralized water and recycling that the precipitate to the Gold and Platinum Group Metals Thickener. The Gold and Platinum Group Metals Filter would produce a Gold and Platinum Group Metals Concentrate cake that would be bagged for sale to a third party refinery.

The Gold and Platinum Group Metals Thickener overflow would be pumped to a Candlestick Filter to ensure all residual solids containing the remaining gold and platinum group metals were recovered. The resultant clear solution would go to the Solution Neutralization area while the captured solids would be returned to the Gold and Platinum Group Metals Thickener.

Solution Neutralization

During solution neutralization (See Figure 3.1-22c), the copper-rich solution from the Gold and Platinum Group Metals Precipitation circuit would be pumped to a plate heat exchanger to cool the solution and heat the process water. Once cooled, the solution would be discharged into the first of four agitated Solution Neutralization Tanks. Limestone slurry and recycled gypsum slurry from the Solution Neutralization Thickener underflow would be added to the first tank and stage added to the remaining neutralization tanks. Slurry from the last neutralization tank would flow to the Solution Neutralization Thickener to produce a thickened underflow, 75% of which would be recycled to the first Solution Neutralization Tank, and the remainder of which would be pumped to the Gypsum Filter to produce a separate gypsum residue. A final Gypsum Filter Cake would be washed with acidified wash water, re-pulped, combined with other hydrometallurgical residues and pumped to the Hydrometallurgical Residue Facility. The Solution Neutralization Thickener overflow would go to the Copper Solvent Extraction circuit.

Copper Solvent Extraction (Copper SX)

During this phase (See Figure 3.1-22d), the feed solution from the Solution Neutralization circuit would be pumped to a Pinned Bed Clarifier, which would use coagulant and flocculent to remove ultra-fine solids that would be returned to the Solution Neutralization Thickener. The clarified solution would be pumped to the Copper SX Feed Tank.

From the Copper SX Feed Tank, solution would be pumped to the copper extraction stages. Each stage would include two mixer tanks where a specialized organic based extractant (a liquid used to remove material from a solution) and the aqueous (water-based) solution containing copper would be mixed. During mixing, copper would be extracted into the organic extractant and removed from the aqueous solute ion.

The aqueous/organic mixture would flow from the final mixer tank into a reverse flow settler. Here, the two phases would separate and be collected in separate launders. Next, the aqueous and organic streams would be sent to flow countercurrent through the SX circuit. The aqueous solution would enter the first extractions stage and flow sequentially through to the second and third stages. Raffinate leaving the third stage would pass through a residual organic filter and would then be pumped to the Copper Raffinate Tanks.

Flowing in the reverse of the aqueous solution, the organic extractant would be continuously extracting copper until the fully loaded organic would exit the extraction stages. The organic would flow to a coalescer wash stage where the water-based parts of the solutions would be reduced, then would be pumped to the stripping stages. By mixing the copper loaded organic stream with acidic spent electrolyte from the EW plant, the copper loading process would be reversed so that copper would be transferred from the organic to the electrolyte. The unloaded organic would be recycled back to the extraction circuit to mix with copper bearing aqueous feed solution and the cycle would begin again.

Copper rich electrolyte would be discharged from the last stripping stage to the Electrolyte Filter Feed Tank and then pumped to a coalescing dual media anthracite/garnet filter. The filter would trap organic droplets and any solids remaining in the electrolyte. Periodically, the filter would be drained and backwashed with water. The backwash solution would be held in a storage tank and bled at a controlled rate to the Copper Raffinate Tank. New organic would be manually added to the circuit to maintain the organic inventory. From the Electrolyte Filter, clean electrolyte would be discharged into the Advance Electrolyte Tank.

Crud, or the accumulation of solids (dust particles or precipitates) at the organic/aqueous interface in the settlers, is known to inhibit the copper extraction process and contribute to organic loss. Therefore, crud would be routinely removed from the settlers by decanting and draining using a portable air operated crud pump. Crud would be pumped to a crud/spillage holding tank where it would accumulate and then be treated on a batch basis to recover entrained organic. The remaining crud, estimated to be approximately 45 – 65 tons per year, would be disposed of in the Hydrometallurgical Residue Facility.

Copper Electrowinning

During this process, copper rich electrolyte would be pumped from the Advanced Electrolyte Tank in the SX area to the Electrolyte Recirculating Tank. In this tank, electrolyte would be mixed with spent electrolyte recycled from the electrowinning (EW) circuit, demineralized water make-up, spillage (if free of solids), plating agents such as guar gum, and cobalt sulfate (added to maintain a required cobalt concentration in the electrolyte).

Over a period of approximately seven days, metallic copper would be electroplated onto stainless steel cathode blanks. When the desired thickness of copper was plated, an overhead traveling gantry crane would remove the cathodes. The cathodes would be water washed to remove the copper-bearing electrolyte and immediately stripped in an automatic stripping machine. Stripped cathodes would be bundled, sampled and weighed in the stripping machine and then removed by forklift to a lay down area prior to shipping.

The majority of the spent electrolyte would be recirculated to the electrowinning cells via the Electrolyte Recirculation Tank with sufficient spent electrolyte being recycled to the SX stripping stage to balance the copper bearing electrolyte flow entering EW. A small amount of electrolyte would be bled out of the EW circuit to prevent impurity build-up in the electrolytic circuit. The bleed solution would be pumped back to the extraction stages.

Raffinate Neutralization

After the SX/EW process has recovered the copper, the raffinate would be neutralized in four Raffinate Neutralization Tanks (see Figure 3.1-22d). Limestone would be used to further reduce the acidity produced during the copper extraction process and to precipitate iron and aluminum from solution. The Raffinate Neutralization circuit would use similar equipment and processes to those in the Solution Neutralization circuit.

The copper SX raffinate would be pumped to the first of four agitated Raffinate Neutralization Tanks. Limestone slurry would be added to the first tank along with recycled gypsum slurry from the underflow of the Raffinate Neutralization Thickener and stage added to the subsequent precipitation tanks. The neutralized slurry would flow to the Raffinate Neutralization Thickener, producing a thickened underflow that is predominantly gypsum, iron hydroxide and aluminum hydroxide. Approximately 75% of this underflow would be recycled to the first Raffinate Neutralization Tank and the remainder would be pumped to the Raffinate Neutralization Filter.

The filter cake from the Raffinate Neutralization Filters would be washed with acidified wash water, repulped, combined with other hydrometallurgical residues and pumped to the Hydrometallurgical Residue Facility. Most of the Raffinate Neutralization Thickener overflow would go to the Residual Copper Removal circuit while some would be returned to the Autoclaves as quench water.

Residual Copper Recovery

To begin the Residual Copper Recovery circuit (see Figure 3.1-22e), solution from the Raffinate Neutralization Thickener Overflow Tank would be heated to 149 ^{o}F by indirect contact with Autoclave discharge slurry in the Autoclave Residue Heat Exchangers. The heated solution would be discharged to the first of two Residual Copper Removal Precipitation Tanks where sodium hydrosulfide (NaHS) and nitrogen are introduced. Nitrogen gas would keep oxygen from entering the precipitation tanks so that the precipitation of copper sulfide would be maximized and sulfate generation reduced.

Slurry from the final Residual Copper Removal Precipitation Tank would flow to the Residual Copper Removal Thickener. A minimum of 75% of the underflow would be recycled to the first Residual Copper Removal Precipitation Tank while the remaining 25% would be pumped to the Gold and Platinum Group Metals Precipitation Reactors. Any excess underflow would be returned to the Autoclave Feed Tank for re-processing. The Residual Copper Removal Thickener overflow, containing less than 1 part per million (ppm) copper, would go to the Mixed Hydroxide Precipitation circuit.

Mixed Hydroxide Precipitation

During the Mixed Hydroxide Precipitation circuit (see Figure 3.1-22f), copper-free solution from the Residual Copper Removal Thickener Overflow Tank would be reacted with magnesium hydroxide in a two-stage process with the majority of the nickel and cobalt being precipitated in the first stage. The pH would be controlled to limit manganese co-precipitation so that a clean precipitate is produced. The resulting discharge from 1st Stage Mixed Nickel/Cobalt/Zinc (Ni/Co/Zn) Hydroxide Precipitation Tanks would flow to the 1st Stage Mixed Ni/Co/Zn Hydroxide Precipitation Thickener. The underflow containing the precipitated metals would be pumped to a filter feed tank. The slurry from the filter feed tank would be pumped at a controlled rate into the Hydroxide Filter to produce a filter cake. The filter cake would be washed with raw water to remove entrained process solution. The final Mixed Hydroxide Product would have an approximate composition of 97% nickel, cobalt and zinc hydroxides with the remainder as magnesium hydroxide. The high quality mixed hydroxide filter cake would be packaged for shipment to a third party refiner.

The 1st Stage Mixed Ni/Co/Zn Hydroxide Precipitation Thickener overflow would be pumped to the first of two 2nd Stage Mixed Ni/Co/Zn Hydroxide Precipitation Tanks. Lime would be added to these tanks to raise the pH, ensuring precipitation of all remaining nickel and cobalt. Slurry from the second stage would flow to the 2nd Stage Mixed Ni/Co/Zn Hydroxide Precipitation Thickener. Flocculant would be added to settle the hydroxide precipitates. The underflow product would be recycled to the Autoclave Residue Tank where the higher acidity would ensure that the metals contained in the precipitate were redissolved. The 2nd Stage Mixed Ni/Co/Zn Hydroxide Thickener overflow would then be pumped to the Magnesium Removal circuit.

Magnesium Removal

During the Magnesium Removal phase, solution from the Mixed Hydroxide Precipitation circuit would be pumped to the first of the Magnesium Removal Tanks. Lime slurry would be added to each tank to facilitate magnesium (Mg) precipitation. The resulting slurry would be pumped to the Hydrometallurgical Residue Facility along with other residues as described in Section 3.1.8.2 Hydrometallurgical Residue Management, where the solids would settle to be stored permanently while the clear water would be reclaimed continuously to the Hydrometallurgical Plant process water system. This would result in approximately 50% of the remaining Mg being precipitated to produce process water containing no metal species.

Process Consumables

The raw materials described below as well as those summarized in Table 3-12 would be consumed by the Hydrometallurgical Plant processes.

Anodes

Anodes are constructed from a lead–calcium–tin alloy with a solid copper suspension bar and typically have a life of 6 to 7 years due to corrosion with subsequent failure. Chloride excursions may also impact unfavorably on anode life. Maintenance in the early years of operation is anticipated to be low, increasing in the later years of the NorthMet Project. Anodes would be delivered by truck and held in covered storage in the Main Warehouse.

Cathodes (finishing plates)

Cathodes are constructed from stainless steel with solid copper suspension bar. Manual handling generally damages cathodes made of stainless steel) during the operation of stripping the plated copper and by chloride attack. PolyMet expects an annual replacement rate of approximately 4%. Cathodes would be delivered by truck and held in covered storage in the Main Warehouse.

Electrolyte Filter Media

A stock of filter sand, garnet and anthracite equivalent to the inventory replacement quantities of media for all the electrolyte filters would be delivered by truck held in covered storage in the Main Warehouse.

Process Water – Hydrometallurgical Plant

A separate Hydrometallurgical Plant process water system would be required due to the different nature of the process solutions involved in the Hydrometallurgical Plant and Beneficiation Plant. Hydrometallurgical process water would contain significant levels of chloride relative to the water in the milling and flotation circuits. The system would distribute water to various water addition points throughout the Hydrometallurgical Plant and would receive water from the Hydrometallurgical Residue Facility (water that was used to transport hydrometallurgical residue to the facility). Make-up water would come from flotation concentrate water and raw water.

Required Process Services

The Process Plant would require various services to perform its functions. These services are in addition to plant switching and site infrastructure needs that are described in Sections 3.1.9 and 3.1.10, respectively. These services are summarized in Table 3-13.

Table 3.1-12 Materials Consumed by the Hydrometallurgical Plant processes

Consumable	Quantity	Mode of Delivery	Delivery Condition	Storage Location	Containment
Sulfuric acid	12,800 t/yr	Rail (3 tank cars/ mo)	Bulk	Adjacent to General Shop Building	78,700 gallon storage tank with secondary containment
Hydrochloric acid	13,707 t/yr	Rail (6 tank cars/mo)	Bulk	Adjacent to General Shop Building	59,500 gallon storage tank with secondary containment
SX Extractant	24 t/yr	Freight (1 delivery/mo)	265 gallon tanks	General Shop Building	265 gallon tanks
SX Diluent	130 t/yr	Freight (1 delivery every 2 mo)	Bulk	General Shop Building	7,400 gallon storage tank
Cobalt Sulfate	7 t/yr	Freight (1 delivery/mo)	67 lb bags in powder form	General Shop Building	In bags and batch mixed when needed
Guar Gum (Galactosol)	9 t/yr	Freight (1 delivery/mo)	70 lb bags in powder form	General Shop Building	Batch mixed on a daily basis (0.5% solution w/w)
Liquid Sulfur Dioxide	3,800 t/yr	Rail (3 tank cars/mo)	Bulk	Adjacent to General Shop Building	30,000 gallon pressurized storage tank with secondary containment
Sodium Hydrosulfide	2,897 t/yr	Tanker Truck (2 tankers/mo)	Bulk as a 45% solution with water (w/w)	Adjacent to General Shop Building	52,600 gallon storage tank
Limestone	250,000 t/yr	Rail (2 100-car trains/week from April to October)	Bulk	Stockpiled on site	Berms/ditches around outdoor stockpile with water that has contacted limestone collected and added to the plant process water.
Lime	58,100 t/yr	Freight (150 loads/mo)	Bulk	Adjacent to General Shop Building	Lime Silo
Magnesium Hydroxide	17,500 t/yr	Rail (11 tank cars/mo)	60% w/w magnesium hydroxide slurry	Adjacent to General Shop Building	Magnesium Hydroxide Storage Tank
Caustic (NaOH)	66 t/yr	Tanker Truck (1 load /mo)	50% w/w solution	General Shop Building	1,100 gallon storage tank
Flocculant (MagnaFloc 342)	1 t/yr	Freight	1,875 lb bulk bags of powder	Main Warehouse	In bags and batch mixed regularly as 0.5% w/w solution
Flocculant (MagnaFloc 351)	224 t/yr	Freight	1,875 lb bulk bags of powder	Main Warehouse	In bags and batch mixed regularly as 0.5% w/w solution

Table 3.1-13 Process Plant Services

Service	Source	Source Location	Needed for
Compressed Air	Duty/standby arrangement of rotary screw type compressors	General Shop Building	Provide air at a pressure of 101 psig for plant services
Instrument Air	Air withdrawn from the plant air receiver to an instrument air accumulator and dried in a duty/standby arrangement of driers and air filters	General Shop Building	Provide air for instruments
Steam	Natural gas-fired boiler	Hydro-metallurgical Facility	Generates heat needed for start up of the autoclaves
Diesel Fuel Storage	Existing Locomotive Fuel Oil facility (storage is discussed in more detail in Section 3.1.2.8)	Area 2 Shop	Diesel for locomotives
Gasoline Storage	Existing storage facility – two 6,000 gallon tanks	Main Gate	Gasoline for vehicles
Raw Water	Water from Colby Lake via an existing pumping station and pipeline (see Section 4.1)	Stored in the Plant Reservoir	Plant fire protections systems, plant potable water systems, make up water for grinding and flotation process water, and hydrometallurgical plant process water (see Sections 3.1.7.1.8 and 3.1.7.2.10)
Potable Water	Existing process plant potable water treatment plant would be refurbished and reactivated	Near the Plant Reservoir	Potable water distribution system includes the Area 1 and Area 2 Shops
Fire Protection	Existing fire protection system would be refurbished, reactivated and extended to new buildings	Plant Reservoir	Area 1 and Area 2 Shops have independent fire protection systems
Oxygen	770 tpd oxygen plant. Plant process takes in ambient air, compresses it, and separates the oxygen from nitrogen and other trace atmospheric gases. Oxygen is transported via pipeline to plant processes and nitrogen and trace gases are returned to the atmosphere.	Adjacent to hydrometallurgical facility (see Figure 3.1.7.2)	Plant processes

3.1.8. Proposed management of process waste products

3.1.8.1 Flotation Tailings

Flotation tailings would be placed in Cells 1E and 2E of the existing former LTVSMC tailings basin (Figure 3.23). Tailing basin construction would be based on placing PolyMet flotation tailings in Cell 2E for about 8 years until the level of the north dam of Cell 1E is reached. Once tailings in Cell 2E reached that level, Cells 1E and 2E would be combined to form a single cell. Tailings would be deposited around the basins to facilitate the segregation of the coarse tailings for dam construction. Dams would be raised using the upstream construction method. The projected flotation tailings generation rate would be 11.27 million tons annually. Table 3.1-14 summarizes the tailings production information.

Table 3.1-14 Summary of Tailings Information – Cell 2E/1E

Year of Production	Cumulative Tailings Produced (mcy)	Cell 2E Average Basin Elevation (feet)	Cell 1E Average Basin Elevation (feet)
0	0	1575	1675
1	9.82	1585	1675
2	19.65	1600	1675
3	29.47	1615	1675
4	39.30	1630	1675
5	49.12	1640	1675
6	58.95	1650	1675
7	68.77	1665	1675
8	78.60	1675	1675
9	88.42	‘1679	1679
10	98.25	1683	1683
11	108.07	1687	1687
12	117.90	1692	1692
13	127.72	1696	1696
14	137.55	1700	1700
15	147.37	1705	1705
16	157.20	1709	1709
17	167.02	1713	1713
18	176.85	1718	1718
19	186.67	1721	1721
20	196.50	1726	1726

- Tailing production – 1,167 MT/hour (1287 U.S. ton/hr) on a 24-hour basis; tailing dry density = 85 pcf

3.1.8.2 Hydrometallurgical Residue Management

The Hydrometallurgical Process would generate residues from five sources:

- Autoclave residue from the Leach Residue Filter;
- High purity gypsum from the Gypsum Filter (depending on the market, this may become a saleable product, but is currently planned as a waste);
- Gypsum, Iron and Aluminum hydroxide from the Raffinate Neutralization Filter;
- Magnesium hydroxide precipitate from the Magnesium Removal Tank; and
- Crud and other minor plant spillage sources.

These hydrometallurgical residues would be combined and disposed of in the Hydrometallurgical Residue facility, which would consist of lined containment cells within the southern portion of Cell 2W of the former LTVSMC tailings basin (see 28T Reactive Residue Facility Design and Location). The projected hydrometallurgical residue generation rate would be 794,000 tons annually. This includes 261,000 tons of gypsum filter cake (gypsum), which would be produced annually in the solution neutralization circuit.

Hydrometallurgical Residue Cell Design and Operations

The first hydrometallurgical residue cell would be developed over a two year period. Most of the earthwork and placing the liner in the cell would occur in the first year of construction. The remaining earthwork and completion of the liner installation would occur in the second year of construction. Subsequent cells would be developed in a similar fashion. Cell layout and cross-sections are shown in Figures 3.1-24 and 3.1-25. Hydrometallurgical residue cells would be lined to minimize release of water that has contacted the residue. The liner would consist of a composite liner system utilizing a geomembrane liner above a geosynthetic clay liner (GCL). The water balance of the cells is described in Chapter 4.1 Water Resources.

Each cell would be filled by pumping the hydrometallurgical residue as slurry from the Hydrometallurgical Plant. The discharge point into the cell would be relocated as needed to distribute the residue throughout the cell. Residue solids would be expected to settle and remain in the cell and excess water would be pumped back to the plant for reuse. This process is shown in Figure 3.1-26.

The initial hydrometallurgical residue cell is planned to have sufficient capacity for approximately 5 years of service. Construction of subsequent cells is anticipated on a 5-year cycle through the operating life of the facility. Once a cell was full, it would be dewatered by an initial decanting of ponded water and then via the pore water collection system installed in the floor of the cell. The collected pore water would be recycled to the Hydrometallurgical Plant. A typical plan and cross-section for the pore water collection system is shown on Figure 3.1-27.

Hydrometallurgical Residue Cell Closure

Cell closure would begin once a cell's capacity was fully utilized. During each cell's closure activities, LTVSMC tailings would be placed on the cell as needed to create a foundation layer of tailings within the cell. This would create a sloping final cover surface that would support subsequent cell closures and promote surface water runoff from the entire cell area. A geo-membrane barrier would be placed over the tailings, which would be in turn covered by additional LTVSMC tailings to form a protective cover over the geo-membrane. The surface of the cover would be vegetated to limit erosion and to promote evapotranspiration of precipitation. A typical cross-section for the final cover is shown on Figure 3.1-28. During final closure activities, the hydrometallurgical residue facility would be reclaimed as discussed in Section 3.1.11.

3.1.8.3 Water management

Various water management methods are proposed at the Plant Site. These include:

- Collecting water that has contacted hydrometallurgical residues in the Hydrometallurgical Plant and recycling it back to the Hydrometallurgical Plant;
- Collecting water that has contacted hydrometallurgical residues in the lined Hydrometallurgical Residue Facility and recycling it back to the Hydrometallurgical Plant;
- Collecting and returning water that seeps from the Tailings Basin to the Tailings Basin for reuse;
- Using treated water piped from the Mine Site (via the Tailings Basin) as Plant Site make-up water; and
- Supplementing the Mine Site make-up water with new water from Colby Lake.

These water management methods would result in no surface discharge of process water at the Plant Site or Mine Site and would minimize water needed via water appropriation from Colby Lake.

3.1.9. Proposed transport of products

A 1,500 to 2,000 hp locomotive would transfer loaded and empty cars carrying process consumables and concentrates to and from the interchange location with the Canadian National Railroad and the plant site. Table 3-11 provides additional information regarding processing reagents deliveries, capacity, and nominal use at the site. Locomotive fueling and routine inspection facilities used by LTVSMC would be reactivated, while locomotives needing major repair would be sent off-site. The ore cars would be maintained at the General Shop facility used by LTVSMC.

3.1.10. Proposed On-site Infrastructure Improvements

3.1.10.1 Mine Site

Electrical service would be provided by a new Minnesota Power electrical substation located on Minnesota Power property south of the Mine Site near the Dunka Road. This substation would be fed from an existing 138 kV transmission line that passes just south of the Dunka Road and would feed a 13.8Kv mine power distribution line that would supply electrical service to the mine pits, WWTF, CPS, Rail Transfer Hopper, pit dewatering pumps, stockpile foundation pumps, and the field service and refueling facility. This power line would form a loop around the perimeter of mine pits (Figure 3.1-29).

Heating required by the WWTF, CPS, Rail Transfer Hopper, service and fueling facility, and railroad switch heaters would be provided by LPG suppliers. No natural gas service would be provided.

Sanitary services would be portable facilities provided and serviced by a supplier. A bottled water supplier would provide drinking water.

The WWTF and CPS would be constructed south of the West Pit. Mine pit dewatering, stockpile drainage, haul road runoff, surface water runoff from the Rail Transfer Hopper area, and surface water runoff from stockpiles that have not been covered would all be pumped to the WWTF for treatment prior to reaching the CPS. From the CPS, all Mine Site process water would be pumped to the Tailings Basin or the East Pit.

3.1.10.2 Plant Site

The Plant Site already has required service infrastructure available, as follows:

- County Road 666 ends at the Main Gate for the industrial area that would include the NorthMet Project Process Plant, Area 1 Shop and Area 2 Shop;
- The Canadian National Railroad serves the industrial area that would include the Process Plant, and existing PolyMet track connects to the Area 1 Shop and the Area 2 Shop;
- Three Minnesota Power Company 138Kv transmission lines serve the Project substation; and
- The existing Sanitary Treatment Plant would be replaced or upgraded to meet current construction and performance standards and sized as appropriate.

3.1.11. Project Closure

The NorthMet Project is expected to complete mining approximately 20 years after operations begin. PolyMet has developed a conceptual Closure Plan (see RS 52 Mine Closure Plan Report, July 2007) that would be updated as part of its application for the Permit to Mine. The Closure Plan would be finalized with additional information to provide details for the final closure of the actual as-built facilities during Project operations. In addition, PolyMet would also submit an annual contingency reclamation plan to identify activities that would be implemented if operations cease in that upcoming year per Minnesota Rule 6132.1300 Subp. 4.

Closure activities at the Mine Site are shown in Figure 3.1-30, with features that would remain at the Mine Site during the closure and post-closure period shown in Figure 3.1-31. Closure activities at the Plant Site are shown in Figure 3.1-32.

3.1.11.1 Building and Structure Demolition and Equipment Removal

Within three years after closure begins, all buildings and structures would be removed and foundations razed and covered with a minimum of two feet of soil and vegetated according to the applicable Minnesota Rules (6132.2700 and 3200). Demolition waste from structure removal would be disposed in the existing on-site demolition landfill

(SW-619) located northwest of the Area 1 Shops. Concrete from demolition would be placed in the basements of the coarse crusher, fine crusher and concentrator.

Most roads, parking areas, or storage pads built to access these facilities would be demolished during the three year schedule. Utility tunnels would be sealed and closed in place. Asphalt from paved surfaces would be removed and recycled and the disturbed areas reclaimed and vegetated according to Minnesota Rules 6132.2700. Railroad track and ties that were not used by common carriers would be removed and recycled. Any roads, which include mine pit access roads (Minnesota Rules 6132.3200) that may develop into unofficial off-road vehicle trails, would require a variance from MnDNR reclamation rules to allow a 15-foot-wide unpaved, unvegetated track down the centerline of the road. Such approvals would also be coordinated with the St. Louis County Mine Inspector's Office.

All mine, railroad, service, and electrical equipment would be moved from the pit to ensure they are above pit water elevations until they can be scrapped, decommissioned or sold.

Rail Transfer Hopper Demolition and Reclamation

At closure, it is possible that the Rail Transfer Hopper would contain ore residuals, which would have acid and metal leaching potential. Therefore, a specific plan for handling the demolition and reclamation of this structure has been developed (see RS 55 Tailings Basin Modifications).

The locations of above-ground concrete and steel structures would be razed within 3 years after closure begins and the area covered with at least two feet of soil and vegetated according to Minnesota Rules 6132.2700 and 3200. If constructed with Category 1 and 2 waste rock, the rock platform from which trucks dumped into the hopper would be sloped and covered in the same manner as the Category 1 and 2 waste rock stockpile. If constructed of inert material, the platform would be sloped and vegetated according to Minnesota Rules 6132.2700 and 3200 (see RS 52 Mine Closure Plant Report, July 2007).

Any ore remaining in the hopper, the direct ore loadout area, the Lean Ore surge pile or anywhere else in the vicinity of the Rail Transfer Hopper[v], as well as sediment removed from ditches and sedimentation ponds in the Ore Handling Area would be placed in the Category 4 Waste Rock Stockpile or back in the mine pits.

[v] During a "planned shutdown", this remaining ore would be only the small amount that was not able to be picked up by mining equipment.

Finally, any remaining material located at the top of the rail loading platform would be tested and placed in an appropriate waste disposal location (e.g., the Category 3 or 4 Waste Rock Stockpile, returned to the mine pits, or covered with at least two feet of soil and vegetated according to Minnesota Rules 6132.2700 and 3200).

Special Material Disposal

Special materials on-site at the time of closure would be disposed of as follows:

- Asbestos-Containing Materials (ACMs) – A detailed survey of ACMs (e.g., pipe and electrical insulation in utility tunnels , siding, hot water heating system insulation, lube system insulation, floor tile) would be conducted prior to demolition. Appropriate controls would be put in place or ACMs would be removed intact, properly packaged, and disposed in the on-site demolition landfill. ACM locations in the landfill would be noted on the property deed. Any ACMs found in utility tunnels would be sealed before the utility tunnel is sealed.

- Nuclear sources (from Nuclear Density Gages that would be used to measure slurry density during processing) – These sources would be removed and properly disposed.
- Partially used paint, chemical, and petroleum products – These materials wold be collected and properly disposed.

Product and Product Tank Disposal

The reagent suppliers, which would be under contract to PolyMet, would remove any reagents remaining at closure. In many cases, the suppliers of chemicals and equipment would be responsible for furnishing tanks and would therefore be required to remove and dispose of those tanks during closure. Those tanks for which PolyMet would be responsible would be demolished as follows:

- Tanks cleaned to remove remaining materials and sludge;
- Remaining materials and sludges and wash materials sent to an appropriate recycling or waste disposal facility;
- Large above-ground storage tanks tested for lead paint prior to demolition; where found, disposal/recycling would be modified to accommodate the lead content;
- All tanks disassembled for disposal or recycling, as appropriate;
- Below-grade foundations left in place and buried; and
- Smaller above-ground storage tanks cleaned and removed without disassembly.

Other Closure Details

There are several places where concentrate having up to 20% S could accumulate (e.g., dry concentrate storage bins, froth launders/sumps, concentrate thickeners, concentrate filters). Because this would be a high value material, there would be an effort to ship as much as can be recovered. However, the small amount of this material remaining in the equipment and process piping would be properly disposed in the hydrometallurgical residue cells or subaqueously in the tailings basin.

PolyMet would also close, according to proper regulatory requirements, on-site sewer and water systems, powerlines, pipelines (including Hydrometallurgical Residue pipelines), and culverts. Additional details on all aspects of facility closure can be seen in RS 52 Mine Closure Plan Report.

3.1.11.2 Proposed reclamation of mining site

Mine Pit - Removal of Dewatering System

Prior to closure, the East/Central Pit would be backfilled with Category 1 and 2 waste rock. The primary dewatering systems, including power lines, substations, pumps, hoses, pipes and appurtenances, would be removed from both pits and the pits would be allowed to fill with water. All areas disturbed during pipe removal would be graded and revegetated.

Some temporary pumps may remain in the pits for selected dewatering that would be performed during pit flooding.

In addition, the following piping would remain:

- The pipe between the WWTF and the East/Central Pit could be used during closure to convey treated water to the East/Central Pit if there was insufficient water entering the East/Central Pit to maintain water levels.

- The pipe from the West Pit to the WWTF could be used in closure to convey treated water from the WWTF to the West Pit in situations where there was insufficient water entering the West Pit.

Mine Pit – East/Central and West Pit Overflows and Outlet Control Structures

The East/Central and West pits are expected to fill and have a net outflow of surface water. Outlet structures would establish the steady-state water levels in the East/Central and West Pits after closure. Overflows from the East/Central Pit would be directed to the West Pit through a channel running from the southwest corner of the East/Central Pit to the northeast corner of the West Pit (see Figures 3.1-36) The East/Central Pit outlet structure would be formed out of bedrock (preferred) or a reinforced concrete weir that is cast-in-place.

The West Pit outlet structure would be constructed on the southeastern side of the West Pit near the natural overflow. The structure would be formed out of bedrock (preferred) or a reinforced concrete weir that is cast-in-place. The West Pit outlet structure would direct overflows into an existing wetland (see Figure 3.1-36) that flows toward Dunka Road at Outlet Structure OS-5 and eventually into the Partridge River through an existing channel. Although current modeling predicts that the West Pit outlet would not require additional treatment, the wetland could be modified to provide a final stage of treatment before discharge. Modifications could include the installation of flow control structures to promote a series of biological and chemical transformations to naturally treat the water as it flows through the wetland. If such alterations would be necessary, the details would be included in the facility's NPDES Permit and may also require inclusion in, or modification to, the facility's wetland permits.

West Pit Filling

Upon completion of mining operations and removal of pit dewatering systems as described above, the West Pit would begin to fill naturally with groundwater, precipitation, and surface runoff from the tributary watershed. The backfilled East/Central Pit would also fill naturally up to the outlet structure elevation and begin overflowing into the West Pit in approximately Year 21.

In addition, to the above sources, surface runoff/stockpile drainage from the Mine Site would be diverted to expedite West Pit filling and decrease the potential for rock oxidation, acid generation, and metal leaching from the walls of the West Pit that could occur if left exposed. This is projected to result in filling the West Pit in 50 years. Surface water overflow from the West Pit to the Partridge River is expected to begin about 40 years after closure of the mining operations. (See "PolyMet proposed response to 040308 letter 072408")

Mine Pit – Mine Wall Sloping and Revegetation

The toe of the overburden portion of all pit walls would be set back at least 20 feet from the crest of the rock portion of the pit wall. The overburden portions of the pit walls would be sloped and graded at no greater than 2.5H:1V and would be vegetated to conform to Minnesota Rules by a qualified reclamation contractor.

Mine Pit – East/Central Pit Category 4 Foot-Wall Cover

Upon completion of mining, approximately 5,000 lineal feet of the north wall of the East/Central Pit is expected to consist of Virginia Formation or other Category 4-type rock material.[vi] If left exposed to the air, oxidation of this surface would occur,

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[vi] While the mitigation is targeting the Virginia Formation, the Virginia Formation is not continuous along the wall and there are some Category 4 portions that would also be covered.

resulting in elevated concentrations of dissolved salts (sulfate) and metals entering the East/Central Pit surface water. To mitigate this potential impact to surface water quality, a geosynthetic membrane cover system would be placed over the Virginia Formation and other Category 4-type rock surfaces as shown on Figure 3.1-34. The cover system would be similar to the membrane cover system that would be placed over the Category 4 stockpile.

The cover system over the north wall of the East/Central Pit would be constructed by placing overburden above the waste rock to approximately one-foot above the top of the bedrock. The slope of the fill material would be 3.5H:1V on the surface entering the backfilled water. Overburden fill would be used for the core of the membrane cover system, followed by a select bedding layer used to prepare the core-fill surface for installation of a textured geo-membrane. The membrane would be keyed into both the upper and lower limits of the fill. A vegetative soil layer would be placed above the membrane cover. The toe of the slope would include additional fill for the establishment of wetland vegetation that would help to further stabilize the slope cover system.

Mine Pit - Pit Fencing and Access

A pit perimeter fencing system would be installed that would consist of fences, rock barricades, ditches, stockpiles, and berms. The fencing system plan would be submitted to and approved by the St. Louis County Mine Inspector before installation. Fencing would consist of 5 strands of barbed wire in most locations and 5 foot non-climbable mesh fencing with two strands of barbed wire at the top in areas where roads would remain adjacent to the fences unless other means are agreed to with the mine inspector.

Safe access would be provided to the bottom of each mine pit (Minnesota Rules 6132.3200) via selected original haul roads built during pit development. The access road would be selected such that, as pit water level rises, there would always be a clear path to the water surface. A gated entrance would be placed at each of the pit access locations.

Stockpiles-Waste Rock Stockpile Design and Cover

At the end of closure activities, all permanent waste rock stockpiles would be covered. To provide an adequate base for sloping of cover materials, waste rock stockpile side slopes would be no steeper than 2.5H: 1V, and the outermost layer would consist of local till soils (also known as “surface overburden” per Minnesota Rules 6132.2400, subp. 2.C) adequate for vegetation growth. To provide erosion control, catch benches at least 30 feet in width would remain on all waste rock stockpiles.

Vegetated soil cover systems are proposed for some stockpiles. Based on the limited preliminary geotechnical investigation (Golder, 2006), the soils at the Mine Site are predicted to perform favorably as soil cover materials. The soil cover would be designed to promote runoff with minimal erosion and provide storage of moisture during the period when the vegetation is dormant. The specific cover methods planned for each type of waste rock stockpile are described as follows:

Category 1 and 2 Waste Rock:Stockpile

The Category 1 and 2 waste rock stockpile would have a 2-foot-thick soil cover system constructed with local till soils and coniferous evergreen plantings, principally red pine, which has the capability of achieving maximum uptake within 10 years (see RS 52 Mine Closure Plan Report, which references Verry, 1976 and Ohmann et al,1978). It would take several years for these plantings to develop a full root system, but infiltration rates into the stockpile would decrease as the soil cover becomes established. It is anticipated that it may take between 10 and 30 years after planting to obtain the predicted rates of flow collected at the sumps and the minimum resulting liner leakage (see RS 74 Surface Water and Groundwater Quality Modeling: Mine Site).

Category 3 Waste Rock and Category 3 Lean Ore Stockpiles

The cover system for the Category 3 stockpiles would include a 3-foot-thick soil cover on 2.5(H):1(V) regraded side slopes constructed of local till soils and revegetated to support an evergreen forest dominated by red pines. A textured geo-membrane barrier with an overlying 1.5-foot-thick grass vegetated cover soil would be used for the top and bench areas to block further precipitation from entering the stockpiles in these areas. Tree growth would be restricted from the top or bench areas to avoid rupture of the geo-membrane barrier.

Even though precipitation would still enter the stockpiles through the soil cover, once mature coniferous forests are developed on the slopes, the expected process water flows from the liner (i.e., the stockpile liner yield, or the amount of precipitation that reaches the bottom of the stockpile) would decrease as infiltration rates into the stockpile decrease. Process water flow from the liner is generally expected to decrease.[vii]

[vii] Although both liner yield and liner leakage would decrease over time as the amount of infiltration decreases due to full establishment of vegetation, such a decrease was not accounted for in the water quality modeling. The values for liner yield and liner leakage rate in RS74A-Draft 02 (Tables 4-5, 4-6, 4-35 and 4-38) do not consider any reduction during or after closure due to mature coniferous forests.

Category 4 Waste Rock Stockpile

The Category 4 stockpile cover system would consist of a textured geo-membrane with a 1.5-foot-thick grass vegetated cover soil. This would prevent precipitation from contacting the waste. The side slopes would be graded to 3.75(H):1(V) to allow placement of the geo-membrane. The average annual process water flow rates would decrease over time as the moisture content of the stockpile decreases. Depending on such variables as the amount of precipitation that occurs during the 20 years of operation, the field capacity of the rock, and the development of preferential flow paths, the length of time this stockpile would continue draining could vary from a few years to approximately year 20 or closure (See GW01A Groundwater Impacts – Mine Site, May 2008).

Overburden:

Similar to the waste rock stockpiles, the surface overburden portion of the Category 1 and 2 stockpile would have lift heights no higher than 40 feet and would be sloped no steeper than 2.5H:1V to conform to Minnesota Rules 6132.2400. To provide erosion control, catch benches at least 30 feet in width would separate the lifts. All side slopes and flats would be vegetated to conform to Minnesota Rules 6132.2700 by a qualified reclamation contractor. Cross sections of the final grade overburden stockpiles are shown in Figure 3.1-10.

Stockpiles - Pump and Pipeline Removal and Rerouting

During mining operations, pumps would convey process water collected from stockpile liners to the WWTF. In closure, some modifications would be made to these systems.

If stockpile drainage ceases or meets water quality discharge limits via treatment through the East Pit wetland treatment system, the drainage would not be collected for treatment at the WWTF. However, as long as there is drainage that does not meet discharge limits, that drainage would be conveyed to the WWTF. Effluent from the WWTF would then be pumped to the East Pit wetland treatment system.

As illustrated on Figure 3.1-33, the pump and pipeline configuration used for stockpile drainage collection and conveyance from the stockpiles to the WWTF would remain in place through closure and post-closure until water quality analyses show the drainage water quality meets water discharge limits at compliance locations or unless other sufficient treatment means are provided (see RS 52 Mine Closure Plan Report).

The pump and pipeline design proposed for the Lean Ore Surge Pile and Overburden Storage Area would be removed during closure with the removal and reclamation of these areas. The Lean Ore Surge Pile, Overburden Storage Area, and all associated appurtenances, including the pumps and drainage systems that would no longer be required, would be removed and the area restored at closure. This includes removal of Sumps S-6 and S-7 and the pumps and drainage systems from all six process water

Sedimentation Ponds (PW-1 through PW-6). The overburden portion of the Category 1 and 2 stockpile would be entirely reclaimed, so that all surface runoff would only be storm water.

Stockpiles - Runoff and Drainage during Closure

All waste rock stockpiles would be reclaimed by the the final year of project closure. Once the stockpile has a final cover or established vegetation, runoff from the tops and sides of the reclaimed stockpiles would be classified as non-contact stormwater and would be routed to sedimentation ponds through a system of ditches prior to being discharged into the natural drainage system. Ditches on the stockpile surface would direct stormwater flows into channels that would route flows down the sides of the stockpile.

Water draining from stockpile liners and water collected in the stockpile foundation underdrains after closure would be monitored and treated, if necessary (See RS 22).

The Lean Ore Surge Pile and the Overburden Storage and Laydown area southeast of the West Pit would be depleted during Year 20. Once this occurs, the liner of the Lean Ore Surge Pile would be removed, while the Overburden Storage and Laydown area would be reclaimed. Should the project operations cease prematurely (before year 20), the material in the Lean Ore Surge Pile would be placed into the Category 4 Stockpile or placed back in the pit.

Watershed Restoration

During mining operations, stormwater runoff from reclaimed stockpiles and natural (undisturbed) areas would be routed through a network of dikes and ditches to stormwater sedimentation ponds. During and after mine closure, PolyMet would modify these water management systems as described below.

Dike Removal

Once the stockpiles are reclaimed, the perimeter dikes that are no longer needed to provide access or separation from the areas outside the Mine Site would be removed during closure (see Figure 3.1-35). The dike located north of the Central and East Pits would remain in place with the purpose of minimizing mixing of the Partridge River flows with the East Pit water and preventing gully development on the northern side of the pit in the segments not protected by the ditches that would be maintained during closure (see Figure 3.1- 36). In addition, the dike located north of the Category 1 and 2 stockpile and along the east boundary of the Mine Site would remain in place to allow access to groundwater monitoring locations.

During closure, surface runoff inflows would be routed to the mine pits using a combination of existing and new ditches (see Figure 3.1-36). Some portions of the pit rim dikes may be left in place after closure if they were needed to prevent an uncontrolled flow to or from the pits and potential erosion (head cutting) of the pits walls. A more detailed evaluation of this requirement would be conducted prior to closure.

In all cases of dike removal, material from the main body of the dikes would be removed and used at the site for restoration of disturbed surfaces. To minimize disturbance of subsurface soils, the subsurface seepage control component of the dikes would remain in place.

As part of the dike removal work, typical construction erosion control measures would be used. These might include installing silt fencing on the down slope side of disturbed areas and controlling surface water runoff. The reclaimed surface would then be scarified, topsoil placed, and the area revegetated with native species within three years as specified in the Permit to Mine rules.

Ditch Filling/Rerouting and Pond Filling

During mine development, ditches would have been constructed to divert non-contact stormwater runoff from undisturbed (natural) and reclaimed areas away from process areas (stockpiles, pits, haul roads, etc.). Figure 3.1-17 shows the alignment of the proposed ditches and the location of seven sedimentation ponds and outlet structures that would convey stormwater runoff collected in the ditches to the Partridge River.

In contrast, Figure 3.1-36 shows the ditches that would be rerouted or filled during the closure period and the alignment of ditches that would be maintained during closure to direct non-contact stormwater into the West Pit for filling. Use of existing ditches would be maximized, but several new ditches would need to be constructed to direct stormwater runoff from the Mine Site into the East/Central or West pits during closure.

During closure, all seven stormwater ponds and all six process water ponds would be filled, covered with topsoil, and revegetated, or turned into wetlands. If the process water ponds are converted into wetlands, any sedimentation that occurred within the pond would be removed or capped prior to restoration.

Outlet control structures OS-1, OS-3, and OS-6 would be removed to restore the drainage flow paths to their natural conditions, where possible. Outlet control structure OS-2 would remain in place along with the dike located north of the East/Central Pit (Dike 2) with the purpose of minimizing the mixing of the Partridge River flows with the East/Central Pit water and preventing gully development on the northern side of the pit in the segments not protected by the ditches that would be maintained during closure. Outlet control structures OS-4, OS-5, and OS-7 would remain in-place to direct water under Dunka Road and the railroad to the Partridge River along natural drainage paths. As a requirement of the NPDES permit and/or Closure Plan for the facility, discharges from these outlet control structures would be monitored as necessary to ensure that runoff to the Partridge River would meet water quality standards.

PolyMet would develop a final Mine Closure and Reclamation Plan as part of the Permit to Mine, which would include sections on watercourse restoration, mine and plant site reclamation, structure demolition, site remediation, and ongoing maintenance/water treatment. An estimate for all closure costs would be included. The final closure and reclamation plan would be updated annually to reflect changes in closure costs and integration with area mine reclamation/reuse strategies.

3.1.11.3

3.1.11.4 Proposed reclamation of Plant Site

Flotation Tailings Basin

During closure of the Tailings Basin, fugitive dust would be controlled by mulching and temporary vegetation. The seepage collection system that would have been implemented during operations is expected to have continued use into closure, although seepage collection would be occurring at progressively reduced rates.

Reclamation – Tailings Basin

Upon closure, construction of a cover on the crest of the tailings dam and on the exposed coarse tailing beach would be required. The cover construction would require preparation of the subgrade by removal of vegetative cover and regrading the tailings surface, construction of a dam/beach cover system, placement of protective cover fill, establishment of vegetation and surface water controls. Once water levels in the remainder of the basin naturally recede or stabilize, upland/meadow vegetation would be established in upland areas not previously covered and wetlands would be created in lowland areas, in accordance with Minnesota Rules 6132.2700.

Emergency overflow channels and/or outfall structures would be constructed to carry excess storm water from the basin to the adjacent wetland only when needed during extreme precipitation events. The channels and/or outfall structures would be sized and designed to safely discharge the design discharge and minimize surface erosion. These channels and/or outfall structures would be lined with vegetation or rip rap to protect the channel from erosion or would consist of clog-resistant inlet structures and discharge pipes. A rip rap delta would be installed where the drainage channel or pipe enters the wetland to distribute the storm water. Sediment control and energy dissipation structures would be incorporated at channel/outfall structure discharge points if needed based on final design determinations. The conceptual location of the emergency spillway from the combined Cell 1E and Cell 2E to the adjoining land is shown on Figure 3.1-32.

Dewatering/Drainage

At closure, several sources of water from the tailings basin would require management. The sources and a summary of the type of management needed are described as follows:

- Ponded water within the basin – a pond would remain in the tailings basin in closure. Water would continue to be pumped from Colby Lake as needed to maintain the pond. The pond would also receive surface runoff from the crest and beaches of the basin. The pond would continue to lose water via seepage during closure.
- Stored water held in the void spaces of the tailings basin – a portion of this water would be released as the pond level within the basin stabilizes at a lower elevation during closure. The volume of water that would drain from the tailings would depend on climatic conditions and the rate of drainage through the tailings perimeter embankments and to the foundation. It would also depend on the volume of water permanently retained in the tailings.
- Surface water runoff from the crest and beaches and Precipitation falling on the basin - Most of this water would flow into the pond (see 1 above). Some of this water would be collected through a series of horizontal drain pipes and lateral headers located in the northern basin dam and by the seepage barrier located south of the basin at the headwaters of Second Creek. This water would be recycled back into the pond water (see 1 above). As the pond reduces in size during closure to about ¼ of its size during operations, the rate of drainage would be expected to decrease over time so that in the long run, the volume of water requiring handling would decline. Therefore, the remaining closure activity would only consist of periodic inspection of the closed dams and water collection systems to ensure continuing integrity. Additionally channels and/or outfall structures would be constructed to carry excess storm water, due to an extreme precipitation event, from the basin to the adjacent wetland.

Cover and Revegetation

In order to achieve a closure system at the Tailings Basin that is largely maintenance-free as required by MNDR rules,, the closure surface would be graded to provide a gently sloping surface that effectively routes surface water runoff to the interior of the basin, accommodates future differential settlement of the underlying tailings, and maximizes ponding of water in the closed tailings basin pond for the development of constructed wetlands.

Once the entire facility is closed, any water collected by the seepage collection systems would be returned to the pond until it can be demonstrated that it is no longer necessary to actively manage tailings basin seepage.

Emergency Basin

An existing 35-acre Emergency Basin is located adjacent to the Tailings Basin and contains material that overflowed from sumps in the concentrator during LTVSMC operations (see Figure 3.1-37).

As part of the LTVSMC closure process, the Emergency Basin was identified as an Area of Concern under the MPCA's Voluntary Investigation and Cleanup (VIC) program. Based on a Sampling and Analysis Plan submitted to the MPCA, PolyMet plans to extract multiple samples from the sediments and the groundwater in the Emergency Basin for analysis. These samples would determine if any further work would be required to identify possible contamination. If no contamination requiring cleanup is found, the area would be contoured to create wetlands and vegetated according to Minnesota Rules 6132.2700. If contamination requiring cleanup is found, a Corrective Action Plan to address the contamination would be developed and submitted to the MPCA for approval. PolyMet's concept for the plan would be to minimize the amount of stormwater reaching the contaminated soil and, therefore, reduce the potential for contamination to be transported out of the Emergency Basin area.

Regardless of whether contamination is found, detailed plans for any required drainage channels and/or outfall structure would be based on relevant hydrologic data and would be submitted to the MPCA for approval. The emergency basin stormwater outflow would be monitored and inspected as approved by the MPCA or as defined in the SDS permit for the tailings basin.

The Emergency Basin currently overflows through a T culvert which is used to prevent any petroleum products floating on the surface of the basin water from escaping the basin. The Emergency Basin would be reclaimed to create wetlands, and therefore an earthen overflow spillway berm would be constructed near the existing outlet to maintain water levels in the created wetlands and reduce long-term maintenance costs associated with a T culvert.

Hydrometallurgical Residue Facility Reclamation

At the time of Mine Site and Plant Site closure, one of the four hydrometallurgical residue cells would still require closure. The other three cells would have been closed as part of routine operations at the site as described in Section 3.1.8.2. Reclamation of the remaining open hydrometallurgical residue cell 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.

Ponded Water

As described earlier, the hydrometallurgical residue facility would be developed in 5-year increments over the 20-year operating life of the ore processing operations. Each increment would include construction of individually lined cells. A portion of each cell would be reserved for ponded water that would be used to facilitate settling of the hydrometallurgical residue solids discharged into the operating cell and would help clarify the water before it was returned to the plant for reuse. This ponded water from the final cell closure would need to be removed and treated.

Ponded water removed from the cell would be pumped or hauled by tanker truck to the Mine Site WWTF for treatment and subsequent discharge to the East Pit wetland treatment system, or the water would be treated using a mobile temporary water treatment plant temporarily stationed at the hydrometallurgical residue facility and discharged to the flotation tailings basin pond. Once the majority of ponded water was removed so that it was no longer reasonable to maintain transport of the water to the Mine Site WWTF or to an on-site temporary treatment facility, the remaining water would be collected by tanker truck for off-site treatment and discharge at a permitted wastewater treatment plant.

Drainage

Because the hydrometallurgical residue cells would be constructed to act as sedimentation basins, they would remain full or partially full of water during operations. At closure, the residue void spaces would be full of water, a portion of which would be retained in the residue (stored water) while the other portion would drain from the residue (drainage). Drainage would be collected from the base of the cells at the geocomposite drainage system and managed as noted previously for ponded water.

The rate of drainage would decrease over time as the pore water within the hydrometallurgical residue was collected and removed. Once the entire facility was closed, the volume of water draining from the drainage collection systems would decline and continued operation of the pipeline to the WWTF may no longer be justified, if it was initially used for this purpose. In the long term, the volume of water requiring treatment would decline to the point that the remaining closure activity may consist of periodic pumping of remaining drainage into tank trucks for transport, treatment and disposal as appropriate, and of inspection of the closed cells to verify integrity of the closure systems.

Cover and Surface Water Runoff Control

The closure surface of the hydrometallurgical facility would be graded into a gently sloping surface that provides the following benefits:

- easily sheds surface water runoff,
- accommodates future differential settlement of the underlying residue, and
- minimizes ponding of water on the fill surface.

The cover used at closure would consist of a layer of LTVSMC tailings immediately above the hydrometallurgical residue. This would be topped, if necessary, with a non-woven needle-punched geotextile fabric to create a working surface on which to place the geo-membrane barrier. Next, a 40-mil low density polyethylene (LDPE) or similar agency-approved geo-membrane barrier layer would be placed. If LTVSMC tailings particle size and angularity make it necessary to protect the geo-membrane from puncture, another geotextile layer would be placed on top of the geo-membrane. Finally, additional LTVSMC tailings and local till soils would be placed to create a surface capable of sustaining a vegetated cover.

The cover would slope gently toward the site perimeter to accommodate natural drainage of the runoff. Final cover slopes on the cell interior would be relatively shallow to minimize surface water runoff flow velocity and the associated erosion. Runoff that becomes channeled along the cell perimeter would be routed down-slope via rip-rapped drainage swales or plug-resistant inlet structures and piping systems. Once runoff is moved down the cell embankment, it would be routed to the flotation tailings basin pond.

Cover and Revegetation of the Building Area

After demolition of Plant Site buildings, these areas would be reclaimed and vegetated according to Minnesota Rules 6132.2700. All areas would be stabilized as required for stormwater management. Roads and parking lots would be reclaimed and vegetated according to Minnesota Rules 6132.2700. Asphalt pavement would be recycled or properly disposed.

3.1.12. Post-Closure Activities

Inspection, maintenance, and reporting activities would be required at the Mine Site and Plant Site after the closure activities are complete. For example, Mine Site process water and pore water from the Hydrometallurgical Residue Facility at the Plant Site would be treated using the existing WWTF as the primary treatment mechanism, and the constructed wetland in the East Pit as the secondary treatment mechanism. The effluent from the WWTF would be monitored on a daily and monthly basis as described in RS 52 – Mine Closure Plan Report, Tables 7-14 .6 and 7-14.7. In addition, the chemical precipitates generated from wastewater treatment operations would be characterized and disposed in an off-site, licensed solid waste disposal facility. These post-closure and reclamation activities would be expected to generate 20 to 50 jobs for many years.

3.2. PROJECT ALTERNATIVES

3.2.1. Overview of Alternatives

The MEQB statutes and rules (Minnesota Statutes 116D, sections 04 and 045; and Minnesota Rules 4410, section 0200 through 7500) require that an EIS include at least one alternative in each of the following categories, or provide an explanation as to why no alternative is provided for that category in the EIS:

3.2.1.1 Alternative sites

The CDEIS will not evaluate alternative sites to the Proposed Action. The ore deposit is found at the NorthMet site so consideration of alternative sites would not satisfy the Project purpose. Off-site subaqueous disposal of waste rock was considered; however, the proposed on-site subaqueous disposal would provide the same environmental benefit and avoid the environmental impact of transporting the waste rock off-site. Therefore, no off-site alternatives will be evaluated.

3.2.1.2 Alternative technologies

The CDEIS will not evaluate alternative technologies to the Proposed Action. During the Scoping EAW and Final SDD process, the MnDNR and USACE identified underground mining as a potential alternative to be considered based on an economic evaluation. During development of the CDEIS the underground mining alternative was determined to be economically prohibitive to the Project due to the reduced rate of production associated with underground mining relative to an open pit. The rate of ore production of an underground mine would not support the processing rate necessary to economically process the low grade ore, and therefore would not meet the purpose and need of the Project. This reduced scale of production ties into the elimination of the modified scale or magnitude alternative discussed below. Additionally, the ore deposit is shallow and broadly distributed throughout the Mine Site; which increases the safety hazards due to the risk of the mine ceiling collapse unless a sizable amount of ore was left in place and not recovered.

3.2.1.3 Modified designs or layouts

The CDEIS will evaluate one alternative design or layout for the Project: subaqueous disposal of the most reactive waste rock. This alternative is discussed in more detail in Section 3.2.2.

3.2.1.4 Modified scale or magnitude

As discussed in Section 2.2.4, multiple ore processing rates were analyzed to determine the economic feasibility of the Project at various scales. The reduced scale operations (e.g., processing ore at 18,000 tpd) offered significant environmental benefits relative to the Proposed Action but was not economically feasible and therefore did not meet the Purpose and Need for the Project. It was also determined that a lesser degree of variability around the Proposed Action would be economically feasible; however, these smaller changes to the processing rate did not offer significant environmental benefits when compared to the Proposed Action. Therefore, no alternative scale and magnitude alternatives were carried forward for further consideration.

3.2.1.5 Alternatives incorporating reasonable mitigation measures

During the EIS scoping process and CPDEIS preparation, potential mitigation measures were identified for further analysis. These measures would potentially mitigate impacts to water quality, air quality, land use, and waste from the mining operations and are discussed in more detail in Section 3.2.2.3.

3.2.2. Proposed Reasonable Alternatives

3.2.2.1 No-Action Alternative

Under the No-Action alternative, the Project would not be constructed and open pit mining operations would not occur. The Mine Site would remain at its current, undeveloped state; however, portions of the Plant Site would be reclaimed according the previous LTVSMC closure plan. This alternative would avoid the environmental impacts associated with the Project; however, the social and economic benefits from the Project would not occur. Local employment and economic revenue would not increase as a result of this alternative. This alternative would not meet the purpose and need of the Project, but may still be a reasonable alternative if the adverse impacts of the Project outweigh its benefits.

3.2.2.2 Other Alternatives

During development of the CPDEIS, the majority of the reasonable alternatives identified during the Scoping EAW and Final SDD process were revised and refined into the alternative discussed below, while others were eliminated. The revised alternative and mitigation and monitoring measures are identified in Table 3-14. For a discussion of the alternatives that have been eliminated, see Section 3.2.3, Alternatives Considered but Eliminated.

Subaqueous Disposal Alternative

The CPDEIS will evaluate one on-site disposal alternative for Category 2, 3, and 4 waste rock. This alternative would subaqueously dispose of the most-reactive waste rock (all Category 3and 4 and, to the greatest extent possible, the highest sulfur content Category 2) in the NorthMet East Pit to cover the Virginia formation instead of the least reactive waste rock (Category 1 and 2). Since Category 3 and 4 waste rock is more reactive, it would be preferable to dispose of this rock subaqueously (to prevent oxidation) and to process the Category 3 and 4 lean ore (removing sulfur) to the extent market prices will allow. Surface stockpiles would be temporarily used to store the category 2, 3, and 4 waste rock until mining of the East Pit is completed and it becomes available for waste rock disposal. To the extent that high sulfur waste rock is mined, it is beneficial to minimize the stockpile exposure time by mining as quickly as possible to accelerate the subaqueous disposal. Limestone will be added to the temporary stockpiles to neutralize acid formation. The Category 4 lean ore would be processed as it is mined and the Category 3 lean ore would be processed or disposed as it is mined. Temporary stockpiling would allow for additional waste rock processing during transfer to the East Pit, pending market conditions. The capacity of the East Pit would be 125 M tons. Therefore, this pit can accommodate all the Category 2, 3, and 4 waste rock (99.2 M tons).

3.2.2.3 Mitigation and Monitoring Measures

The CPDEIS will evaluate mitigation and monitoring measures for potential impacts from the Project. The eight broadly-applicable mitigation and monitoring measures identified during EIS scoping are described below. During development of the CPDEIS, additional resource-specific mitigation measures were identified. Refer to the resource-specific analyses in Chapter 4 and Section 5.2 for further discussion of these measures.

- Fully-Lined Tailings Basin – a fully-lined tailings basin would be constructed on top of the former 1E, 2E, and 2W tailings basins. These cells would need to be drained and the entire basin area would be lined to prevent the percolation of leachate from the new tailings into the surrounding surface and ground water. This measure would operate on a phased approach. The 2W basin would be lined and tailings would be placed in 2W for the first five years of operation. If the tailings are determined to be reactive, Cells 1E and 2E would be lined for tailings disposal for the entire life of the operation. The timing of the tailings basin dewatering may present a problem in that the east half of the existing tailings basin would need to be dewatered before the basin could be lined.
- Monitoring of Waste Rock Stockpiles and Tailings Basin - These monitoring programs would address the materials being placed in the stockpiles and tailings basin, performance of the constructed facilities (e.g.,. liners, trenches, collection systems), and water quality and quantity associated with the stockpiles and tailings basin (e.g., groundwater seepage and surface water drainage).
- Chemical Modification of the Reactive Waste Rock Stockpiles - All, or portions of all, temporary and permanent surface waste rock stockpiles would be chemically treated with limestone (in either lump or ground form) to neutralize potential ARD.
- Use Overburden in the East Pit - The EIS will consider using the overburden as a substrate to create wetlands in the East Pit and revegetate the Category 1 and 2 stockpile. This measure would serve to reduce the need for PolyMet to import substrate material for the site reclamation and also reduce the footprint of the overburden stockpile.
- Separate Reactive Residue Cell for Pure Gypsum By-Product - A task force including the Iron Range Resources (IRR), the Natural Resources Research Institute (NRRI), and Minnesota Power is investigating alternate uses for gypsum, which would qualify as a “green” product since it is recycled waste material.

- Maximize the elevation of the Category 1 and 2 stockpile – This measure would minimize the stockpile footprint, thereby decreasing the area of wetland disturbance from the project.
- Use LTVSMC taconite tailings for construction of the NorthMet tailings embankment - The LTVSMC taconite tailings provide greater stability in each tier of the tailings basin. A study was completed to optimize the design of the tailings embankment to ensure stability while maximizing storage capacity. (Barr, 2008)
- Use a native species seed mix to stabilize disturbed areas during site reclamation – The current seed mix for vegetation restoration contains a variety of invasive species. A seed mix composed of native species would more effectively restore local habitats and ecosystems during reclamation.

Table 3-14. Proposed Reasonable Alternative and Mitigation and Monitoring Measures

Table Alternative Number	Potential Alternative	Meet the Purpose and Need	Technically Feasible	Economically Feasible	Available	Potentially Offer Significant Environmental or Socioeconomic Benefits
Reasonable Alternative						
Reasonable Alternative (R) 1	Subaqueous Disposal of Category 2, 3, and 4 waste rock in NorthMet East Pit.	Yes	Yes	Yes	Yes	Yes, this alternative would place the most reactive waste rock under water to minimize oxidation and creation of ARD.
Mitigation and Monitoring (M) Measures						
M1	Fully-lined tailings basin on the former 1E, 2E, and 2W tailings basins (phased approach).	Yes	Yes, although dewatering timing may present a problem	Yes	Yes	Yes, this measure would prevent leachate from the new tailings from percolating into the surrounding surface and ground water.
M2	Monitoring waste rock stockpiles and tailings basin to monitor materials, construction performance, and water quality and quantity.	Yes	Yes	Yes	Yes	Yes, this measure would provide instantaneous water quality and quantity information
M3	Chemical modification of reactive waste rock stockpiles through application of limestone.	Yes	Yes	Yes	Yes	Yes, limestone addition would help neutralize potential ARD.
M4	Use the overburden in the East Pit to construct wetlands	Yes	Yes	Yes	Yes	Yes, this measure would reduce need for imported substrates and would reduce the overburden stockpile footprint
M5	Separate reactive residue cell for the pure gypsum by-product	Yes	Possible, alternative uses of the product are under investigation	Yes	Yes	Yes, this measure would provide a beneficial reuse of a mining by-product.
M6	Maximize the elevation of the Category 1 and 2 stockpile	Yes	Yes	Yes	Yes	Yes, this measure would reduce the stockpile footprint, thereby decreasing the wetland and vegetation disturbance.
M7	Use the LTVSMC taconite tailings to construct the NorthMet tailings embankment	Yes	Possible, pending verification of material stability	Yes	Yes	Yes, this measure would increase the volume of the tailings basin while also reducing the need to import construction materials. However, additional wetland and vegetation impact would result.
M8	Use a native species seed mix to stabilize disturbed areas during site reclamation	Yes	Yes	Yes	Yes	Yes, this measure would reduce the potential for invasive species to colonize the reclaimed areas.

3.2.3. Alternatives Considered but Eliminated

Minnesota Rules 4410.2300, subpart G states that an alternative may be excluded if "it would not meet the underlying need for or purpose of the project, it would likely not have any significant environmental benefit compared to the project as proposed, or another alternative, of any type, that will be analyzed in the CPDEIS would likely have similar environmental benefits but substantially less adverse economic, employment, or sociological impacts." In accordance with the requirements of subpart G, Table 3-15 describes the alternatives previously considered, but subsequently eliminated from detailed analysis and the rationale for their elimination.

Table 3.2-2 Alternatives Considered But Eliminated

Alternative Number	Potential Alternative	Meet the Purpose and Need	Technically Feasible	Economically Feasible	Available	Potentially Offer Significant Environmental or Socioeconomic Benefits	Rationale
Alternative Sites							
Eliminated Alternative 1 (E1)	Off-site non-reactive waste rock disposal	Yes	Yes	Yes	Yes	Unlikely	This alternative was eliminated from consideration because the on-site subaqueous disposal alternative offered all the benefits of off-site disposal without the added impacts associated with transporting the waste rock off-site (e.g., noise and emissions from the trucks).
E2	Offsite, in-pit sub-aqueous reactive waste rock (preferably Category 3 and 4) disposal in the LTVSMC Area 3 pit or other previously disturbed land (including Area 2, 2W, 2WX, 5S, 5N, 5NW, and Dunka pits)	Yes	Yes	Yes	Partially	Yes	Area 2E, 2W, and 3 pits have 216, 136, and 90 million tons of proven taconite crude ore reserves, respectively, and have been recently sold to another developer. Area 2WX pit has over 383 million tons of known mineral reserves and is optioned to Mesabi Nugget. The Dunka Pit is under contract to another developer. Therefore it is concluded that these pits are unavailable and have mineral reserves that would be lost if the pits were used for waste rock disposal. The Area 5 pits are available; however, they were eliminated from consideration because the on-site subaqueous disposal alternative offered all the benefits of off-site disposal without the impacts associated with transporting the waste rock off-site (e.g., noise and emissions from the trucks).
E3	Alternative mine pit	No	No	No	No	Uncertain	An alternative Mine Site would not meet the underlying need or purpose of the project. The mineralization of the desired elements within a geologic deposit dictates the location of the mine. Eliminated in Final Scoping Document
E4	Alternative processing plant site	Yes	Uncertain	No	Uncertain	No	An alternative processing plant site would not likely have significant environmental benefits over using existing mining industry infrastructure. Eliminated in Final Scoping Document

Alternative Number	Potential Alternative	Meet the Purpose and Need	Technically Feasible	Economically Feasible	Available	Potentially Offer Significant Environmental or Socioeconomic Benefits	Rationale
E5	Off-site sub-aqueous in-pit tailings disposal (consider LTVSMC Area 2, Area 2W, Area 2WX, Area 3, Area 5S, Area 5N, and Area 5NW)	Yes	Yes, but insufficient volume	Uncertain	Only Area 5 pits	No	Area 2E, 2W, and 3 pits have 216, 136, and 90 million tons of proven taconite crude ore reserves, respectively, and have been recently sold to another developer. Area 2WX has over 383 million tons of known mineral reserves and is optioned to Mesabi Nugget. Therefore we conclude these pits are unavailable and have mineral reserves that would be lost if the pits were used for waste rock disposal. The Area 5 pits are available; however, they were eliminated from consideration because the on-site subaqueous disposal alternative offered all the benefits of off-site disposal without the added impacts associated with transporting the waste rock off-site (e.g., noise and emissions from the trucks).
E6	Off-site subaqueous in-pit co-disposal of reactive waste rock, tailings, and/or overburden	Yes	Yes	Uncertain	Only Pits 5S and 5N	No	Area 2E, 2W, and 3 pits have 216, 136, and 90 million tons of proven taconite crude ore reserves, respectively, and have been recently sold to another developer. Area 2WX has over 383 million tons of known mineral reserves and is optioned to Mesabi Nugget. Therefore we conclude these pits are unavailable and have mineral reserves that would be lost if the pits were used for waste rock disposal. The Area 5 pits are available; however, they were eliminated from consideration because the on-site subaqueous disposal alternative offered all the benefits of off-site disposal without the added impacts associated with transporting the waste rock off-site (e.g., noise and emissions from the trucks).

Alternative Number	Potential Alternative	Meet the Purpose and Need	Technically Feasible	Economically Feasible	Available	Potentially Offer Significant Environmental or Socioeconomic Benefits	Rationale
Alternative Technologies							
E7	Underground mining	Yes	Yes	No	Yes	Possibly	Not economically viable. During development of the DEIS the underground mining alternative was determined to be economically prohibitive to the Project due to the reduced rate of production associated with underground mining relative to an open pit. The rate of ore production of an underground mine would not support the processing rate necessary to economically process the low grade ore, and therefore would not meet the purpose and need of the Project. This reduced scale of production ties into the elimination of the modified scale or magnitude alternative discussed below. Additionally, the ore deposit is shallow and broadly distributed throughout the Mine Site; which increases the safety hazards due to the risk of the mine ceiling collapse unless a sizable amount of ore was left in place and not recovered.
E8	Hydrometallurgical technologies	Yes	Yes	Uncertain	Yes	No	The Project uses a technology that does not include cyanide leach or other technologies that may have significant environmental effects. Although there are impacts that will need to be analyzed for the proposed hydrometallurgical process, other processing technologies would have no significant environmental benefit over the proposed technology. Eliminated in the Final Scoping Decision Document
E9	Concentrate-only operations mode	No	Yes	No	Yes	Possibly	PolyMet has proposed as an alternative operating scenario in limited circumstances, such as pre-hydromet startup and during maintenance and periods of high energy costs. Normal operation in concentrate only mode cannot sustain successful levels of production.
Modified Designs or Layouts							
E10	Process the Category 3 and 4 lean ore and waste rock through the processing plant	Yes	Yes	No	Yes	No	This alternative would exacerbate the current groundwater impacts to the tailings basin by increasing the tailings volume. Further, this alternative would have no significant environmental benefits to water chemistry at the mine site.

Alternative Number	Potential Alternative	Meet the Purpose and Need	Technically Feasible	Economically Feasible	Available	Potentially Offer Significant Environmental or Socioeconomic Benefits	Rationale
E11	Alternative designs and layouts for the ore processing plant.	Yes	Yes	Uncertain	Yes	No	Alternative designs and layouts of the ore processing plant would not likely provide significant environmental benefits over the Project. Eliminated in Final Scoping Document
E12	Alternative ore transportation from the mine to the processing plant (e.g., conveyor belt)	Yes	Uncertain	Uncertain	Yes	No	The Project includes using existing railroads with construction of a short railroad spur from the mine to the processing plant. Alternative designs and layouts would not likely provide significant environmental benefits over the Project. Eliminated in Final Scoping Document
E13	Alternative ore transport from pit to surface (conveyors vs. trucks)	Yes	Possibly, but may require less steep pit.	Possibly, would require a mobile in-pit crusher	Yes	Possibly would reduce mobile source air emissions and reactivity of waste rock. May also result in increased wetland and habitat impacts.	Conveying ore from pit to surface will require a mobile in-pit crusher and a likely a less steep pit, which would increase land disturbance and wetland impacts. Although using a conveyor system could allow separation of large diameter rocks, which if used for construction purposes might produce drainage that would meet water quality standards, practically these larger rocks are not useful for construction and would need to be further crushed. Air quality benefits are not believed to be significant.
E14	Co-disposal of reactive waste rock and tailings on a lined tailing basin	Yes	Possibly	Uncertain	Yes	Possibly	PLACEHOLDER – awaiting water analysis to determine if a lined tailings basin is proposed. If not, this alternative is to be removed.
E15	Pretreatment of Mine Site reactive runoff and discharge to City of Babbitt or Hoyt Lakes POTW	Yes	Yes	Uncertain	Uncertain	No	The current project description no longer proposes a surface water discharge, but rather collects this water for use at the process plant.
E16	Pretreatment of tailings basin process water and discharge to the City of Hoyt Lakes POTW	Yes	Yes	Uncertain	Uncertain	No	The current project description no longer proposes a surface water discharge, but rather collects this water for use at the process plant.

Alternative Number	Potential Alternative	Meet the Purpose and Need	Technically Feasible	Economically Feasible	Available	Potentially Offer Significant Environmental or Socioeconomic Benefits	Rationale
E17	Evaluate use of low sulfur waste rock as construction material	Yes	Yes	Yes	Uncertain due to timing issue	No	This alternative was eliminated because the construction material would be required prior to the extraction of the low-sulfur waste rock. Therefore, this material would not be available for construction purposes.
E18	Use non-contact stormwater from detention pond at Mine Site as process water to reduce withdrawals from Colby Lake and fluctuations in Whitewater Reservoir	Yes	Yes	Yes	Yes	No	MnDNR fisheries staff indicate that they would prefer maintaining the base flow in the Partridge River (to which the non-contact storm water would otherwise flow) over reducing water level fluctuations in Whitewater Reservoir
E19	Dispose of waste rock and/or tailings in West Pit	Yes	Yes	Possibly	Yes	No	There are additional mineral resources in the West Pit that would effectively be lost if the pit was used for waste rock and/or tailings disposal. This alternative does not appear to offer significant benefits over other alternatives (subaqueous disposal and processing waste rock) already under consideration that would still allow future ore recovery in West Pit
Modified Scale or Magnitude							
E20	Operating a smaller mine and ore processing facility	No	Yes	No	Yes	No	Although there may be environmental benefits from a smaller scale project, the cost of operating a smaller mine and ore processing facility for the diffuse ore body will adversely affect the feasibility of the project. An 18,000 tpd operation was determined not to be feasible. There is some smaller variability associated with the proposed 32,000 tpd scale that would still be economically feasible, but the environmental benefits associated with this smaller degree of variability would not produce significant environmental benefits. Eliminated in Final Scoping Document

4.0 Existing Conditions and Environmental Consequences

4.1. WATER RESOURCES

4.1.1 Existing Conditions

4.1.1.1 Climate

Precipitation

The NorthMet Project Site is located near the headwaters of the Partridge River and Embarrass River watersheds at approximately elevation 1,600 feet above mean sea level (feet msl). Two weather stations representative of the NorthMet Project Site include Babbitt 2SE and Hoyt Lakes 5N (see Figure 4.1-1) for locations). Table 4.1-1 shows the station name, National Climatic Data Center (NCDC) Cooperative Identification Number, elevation, period of record, latitude and longitude, and distance from the NorthMet Project Site for each of these stations (NCDC, 2002).

Table 4.1-1 Weather Stations near the PolyMet NorthMet Project Site

Station Name	CoopID No.	Elev. Above Mean Sea Level (feet)	Period of Record (Month/Year)	Lat./Long.	Distance from Site (mi)
Babbitt 2SE	210390	1,615	1920-1986	47°41'N/91°55'W	4.8
Hoyt Lakes 5N	213921	1,522	1958-1983	47°35'N/92°08'W	8.5

Babbitt (Coop ID No. 210387) and Embarrass (Coop ID No. 212576) are two other weather stations that are relatively close to the NorthMet Project Site, within 11 miles, but with periods of record dating back to 1995 only, so these two records will not be used in the present analysis.

Following the definition of climate normal by the Climate Prediction Center of the National Weather Service (NWS), thirty-year precipitation typifies the long-term monthly and annual values for a given location. The currently valid climate normal period spans from water year 1971 (begins on October 1, 1971) through water year 2000 (ends on September 30, 2001). Table 4.1-2 shows the NCDC 30-year normals (NCDC, 2002) for monthly and annual average precipitation for the two stations listed in Table 4.1-2. For the Hoyt Lakes 5N station, the period of record is 13 years from 1971 through 1983.

Table 4.1-2: Normal Monthly and Annual Average Precipitation for

Station Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Babbitt 2SE	0.83	0.65	0.97	1.49	2.82	3.96	3.61	4.14	3.44	2.9	1.92	0.92	27.65
Hoyt Lakes 5N(1)	0.95	0.81	1.46	1.49	3.01	3.98	3.84	4.38	3.17	3.06	1.21	0.78	28.15

Hoyt Lakes 5N station period of record is from 1971 through 1983 (13 yrs) only.

Table 4.1-3: Normal Monthly and Annual Average Snowfall for

Station Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Babbitt 2SE	9.3	7.6	7.6	2.8	0.0	0.0	0.0	0.0	0.0	0.9	8.8	8.3	45.3
Hoyt Lakes 5N(1)	12.6	9.1	9.3	3.0	0.2	0.0	0.0	0.0	0.1	1.3	7.4	9.6	52.6

(1)Hoyt Lakes 5N station period of record is from 1971 through 1983 (13 yrs) only.

Snowfall near the NorthMet Project Site typically occurs between October and April. Table 4.1-3 shows the NCDC 30-year normals for monthly and annual average snowfall for the two stations listed in Table 4.1-3 (13 year period of record for Hoyt Lakes 5N).

In addition to normal monthly and annual average precipitation (rain and snow), rainfall statistics from various storm events for this area were obtained from the Rainfall Frequency Atlas of the Midwest by Huff and Angel (1992). These values were used for calculation of storm runoff at the NorthMet Project Site. Table 4.1-4 shows the 24-hour design rainfall for selected recurrence intervals.

Table 4.1-4: 24-Hour Precipitation for Selected Recurrence Intervals

Recurrence Interval	Precipitation (inches)
2-Year	2.31
5-Year	3.0
10-Year	3.5
25-Year	4. 25
50-Year	4. 8
100-Year	5.20

Air Temperature

Table 4.1-5 shows the NCDC 30-year normals for monthly and annual average air temperature for the two stations listed in Table 4.1-1 except for Hoyt Lakes 5N, which has a period of record of 13 years from 1971 through 1983.

Table 4.1-5: Normal Monthly and Annual Average Air Temperature for 1971–2000 (oF)

Station Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Babbit 2 SE	6.7	14.4		40.3	54.6	62.4	66.6	64.5	54.9	43.3	26.5	12.0	39.3
Hoyt Lakes 5N[1]	3.4	8.6	21.8	37.5	52.3	58.9	64.9	61.4	51.8	41.0	25.4	8.7	36.3

(1)Hoyt Lakes 5N station period of record is from 1971 through 1983 (13 yrs) only.

The data presented in Sections 4.1.1.1 and 4.1.1.2 are from the Minnesota State Climatology Office and the NCDC of the National Oceanic and Atmospheric Administration (NOAA) (NCDC, 2002).

Evaporation and Evapotranspiration

Monthly and annual average evaporation for northern Minnesota are available from several sources and range from 18 inches (Siegel and Ericson, 1980) to 22 inches (Meyer, 1942). Pan evaporation measurements from Hoyt Lakes for the period 1966 through 1983 provide no evaporation for the winter months and determine an annual total evaporation rate of between 18.7 and 20.8 inches depending on whether a pan correction factor of 0.70 or 0.78 is used. Monthly pan evaporation data from Hoyt Lakes with a pan correction factor of 0.78 were used by Barr Engineering, Inc. (Barr) (RS73A, 2006d; RS73B, 2007d) in the Partridge River XP-SWMM modeling for the NorthMet Project Site. Baker et al. (1979) suggests a mean annual potential evapotranspiration of 21.8 inches and a mean annual actual evapotranspiration of 16 inches.

4.1.1.2 Surface Water Resources

The proposed NorthMet Project mining and processing activities are located in or may impact drainage basins that discharge to Lake Superior. Figure 4.1-1 shows the locations of the primary rivers and creeks on and near the NorthMet Project Site. This site is located between Hoyt Lakes and Babbitt. The proposed mine and process plant are located in the Partridge River watershed and the proposed tailings basin is located in the Embarrass River watershed. Seeps from the tailings basin daylight at the headwaters of Second Creek, which drains to the Partridge River. The Partridge River flows through Colby Lake near the city of Hoyt Lakes before joining the St. Louis River which discharges to Lake Superior. The Partridge River basin is bounded by the Laurentian Divide east of the NorthMet Project Site. The Partridge River and Embarrass River are both tributary to the St. Louis River.

Streamflow and water quality data availability for the various rivers and creeks in the NorthMet Project Site area are presented in the following Table 4-6. Figure 4.1-1 shows the locations of the referenced USGS stream gaging stations.

Table 4.1- 6: Summary of Surface Water Data Availability for the PartridgeRiver and Embarrass River Watersheds

River/Creek	USGS Station No.	Drainage Area (mi^2)	Streamflow Period of Record	Water Quality Data
		▪ Embarrass River Watershed		
Embarrass R.	04017000	88.3	1942 - 1964	3 sites
Trimble Ck.	None	Unknown	None	None
Spring Mine Ck.	None	Unknown	None	None
Ridge Ck.	None	Unknown	None	None
		▪ Partridge River Watershed		
Partridge R. above Colby Lake	04015475	103.4	1978-1988	6 sites
Partridge R. below Colby Lake	04016000	161	1942-1982	2 sites
Yelp Ck.	None	Unknown	None	None
Stubble Ck.	None	Unknown	None	None
South Branch Partridge R.	04015455	18.5	1977-1980	1 site
Colvin Ck.	None	Unknown	None	1 site
Wetlegs Ck.	None	Unknown	None	None
Longnose Ck.	None	Unknown	None	None
Wyman Ck.	None	Unknown	None	2 sites
Second (Knox) Ck.	04015500	29	1955-1980	2 sites

Partridge River Channel Morphology.

A Level I Rosgen Geomorphic Survey (Rosgen, 1996) was conducted for the Partridge River from its headwaters to Colby Lake, a distance of about 28 miles (Barr, RS26, 2005). A Level I Survey is a physical classification of a stream channel to determine its geomorphic characteristics based on the relationship of its physical geometry and hydraulic characteristics. This broad level characterization is performed using available topography, aerial photography, and other readily available information such as ground photographs. The purpose of a Geomorphic Survey is to evaluate the stability of a stream under existing conditions, to determine its sensitivity to change, and to indicate how restoration may be approached if a portion of the stream becomes unstable. The Partridge River watershed is a mix of upland and marshland, with very little development. The river varies from sluggish, marshy reaches to large open ponds to steep boulder rapids.

The Level I Survey on the Partridge River was performed based primarily on 2003 aerial photography, USGS 7.5 minute quadrangles with a 10-foot contour interval, available ground photographs, and two site visits. The survey results indicated that 54 percent of the Partridge River is a Type C channel, 31 percent is a Type E channel, and 13 percent is a Type B channel. Type C channels are characterized as being moderately sinuous (meandering), having a mild slope, a well-developed floodplain, and are fairly shallow relative to their width. Type E channels are similar to Type C, except that they tend to be more sinuous and deeper relative to their width. Type B channels are steeper, straighter, and have less floodplain available than Type C or E channels. Type B channels tend to be less sensitive to impact than Type C or E channels, and on the Partridge River are dominated by boulder material.

The Level I physical classification of the Partridge River indicates that it has a variety of stream types, including B, C, and E. There is no evidence of erosion problems between Station 0 and Station 131,000 (see Figures in Barr, RS26, 2005). It appears that there may be some erosion and /or channel widening from Station 131,000 to Station 147,600 (the upstream-most limits of the river). This may be due to previous Northshore Mining mine pit dewatering pumping to the river, or due to straightening of the channel adjacent to a railroad. In general, the Partridge River has excellent vegetation for nearly its entire length, and it has a very well-developed floodplain for all but the Type B reaches. The Type B reaches, as well as many shorter portions of the Type C reaches, tend to be boulder-dominated rapids. There are many beaver dams along the entire length of the Partridge River, particularly at the top of rapids sections. The dams create wide pools and in some cases large ponds behind them.

Because its steep reaches are well-armored and the flatter reaches tend to have excellent vegetation, the Partridge River is considered to be a robust stream, and should be able to withstand a moderate increase to its base flow with no significant degradation, as it has been demonstrated by previous mine pit dewatering pumping to the river.

The need for more detailed classification or monitoring of the river should be based on the level of impact to baseflow due to the loss of drainage area resulting from the NorthMet Project.

Colby Lake.

Colby Lake is currently used as a potable water source for the City of Hoyt Lakes and as a cooling water source for the Laskin Energy Center coal powered electrical plant owned by Minnesota Power. The city water intake is on the southern shore of the eastern portion of the lake. The power plant intake is towards the western end of the lake and has a fish screen. The primary discharge point from the power plant is on the other side of a long point of land, in the channel where the Partridge River exits the lake (see Figures 4.1-3 and 4.1-8). The Laskin Power wastewater discharges are authorized and regulated Plant under National Pollutant Discharge Elimination System (NPDES)/State Disposal System (SDS) Permit MN000090. Colby Lake has a surface area of approximately 539 acres, and a maximum depth of approximately 30 feet (http://www.dnr.state.mn.us/lakefind/showreport.html).

Colby Lake was used as a makeup water source by the LTV Steel Mining Company (LTVSMC) taconite plant to the north. Whitewater Reservoir and Diversion Works connecting Colby Lake and Whitewater Reservoir were constructed around 1955 to help secure sufficient supply of makeup water for its ore processing operations. Several thousand gallons per minute were pumped from Colby Lake on a continuous basis. MDNR Water Appropriation Permit 49-135 required LTVSMC that when Colby Lake water level fell below 1,439.0 feet msl due to low inflows, the withdrawal of water from Colby Lake was authorized up to rate that could be pumped from Whitewater Reservoir to replace the water withdrawn. The Diversion Works contain three 8-foot gates that can be opened to release a large flow of water from Colby Lake to Whitewater Reservoir during high flows in the Partridge River. It also contains three high-volume pumps to move water back to Colby Lake during low water levels for compliance with the Water Appropriation Permit. After closure of the LTVSMC mine and process plant, Minnesota Power purchased the Diversion Works and all of the riparian land around Whitewater Reservoir. This land currently is leased to potential homeowners as “lake-front” property. The Water Appropriation Permit was transferred from LTVSMC to Minnesota Power and Cliffs Erie LLC as co-permittees.

PolyMet has requested, and Minnesota Power has agreed (Minnesota Power, 2007) to replace Cliffs Erie on the joint Water Appropriation Permit for Colby Lake with PolyMet so that can makeup water can be obtained from Colby Lake for the process plant.

In 2004, MDNR performed hydrologic modeling of the Colby Lake/Whitewater Reservoir system without exercise of Water Appropriation Permit 49-135 in order to assess reclamation needs related to the closing of LTVSMC open pits and various options for operation of the Diversion Works by Minnesota Power (Adams, Leibfried and Herr, 2004). Results of the modeling indicated that with the existing water demands on Colby Lake by Minnesota Power and the City of Hoyt Lakes, water levels in Colby Lake could not always be maintained above 1,439.0 feet msl, even with skillful operation of the Diversion Works. The MDNR modeling by Adams, Leibfried and Herr (2004) concluded that the best option to maintain water levels in Colby Lake above 1,439.0 feet msl was to keep the Diversion Works gates closed so no water was discharged from Colby Lake to Whitewater Reservoir. Even this “best” option resulted in water levels in Colby Lake dropping below 1,439.0 feet msl during some periods of low inflows, but not below the run out elevation of 1,438.5 feet msl. This indicates that Colby Lake would still provide flow to downstream reaches of the Partridge River.

Baseline water levels in Colby Lake for the period January 2001 to December 2006 are shown on Figure 4.1-2 and represent the baseline period since LTVSMC ceased mining. Water levels in Colby Lake have had annual fluctuations averaging 2.6 feet from 2001 through 2006, which are 27 percent less than the 3.3 feet changes to Colby Lake water levels recorded from 1939 through 1980 (http://www.dnr.state.mn.us/lakefind/showreport.html). During the baseline period, the maximum water level elevation in Colby Lake was 1,442.62 feet msl; whereas, the minimum water level elevation was 1,438.78 feet msl (i.e., the water level fell below 1,439.0 feet msl).

Whitewater Reservoir.

Whitewater Reservoir was impounded in 1955 for use as a water storage reservoir for the LTVSMC taconite operation. Formerly known as Partridge Lake, this impoundment increased the size and depth of the original lake and subjected it to greater annual water level fluctuations. The inlet/outlet control structure is now owned and controlled by Minnesota Power. An overflow outlet to the St. Louis River on the southern dike is not used. Water losses due to ground water seepage can be as high as 15 cubic feet per second (cfs) or more (Barr, 1964).

Hoyt Lakes treated sewage effluent is discharged into Whitewater Reservoir under NPDES/SDS Permit MN0020206 (see Figure 4.1-3). Whitewater Reservoir has a surface area of approximately 1,210 acres, and a maximum depth of approximately 73 feet. (http://www.dnr.state.mn.us/lakefind/showreport.html).

During operation by LTVSMC, water would flow through a channel from Colby Lake to Whitewater Reservoir during the spring runoff, then be pumped back into Colby Lake when needed. This system was never used as much as expected, as 30+ foot fluctuations in the water level of Whitewater Reservoir were anticipated, but never realized. Baseline water levels in Whitewater Reservoir for the period January 2002 to December 2006 are shown on Figure 4.1-2 and represent the baseline period since LTVSMC ceased mining. Water levels in Whitewater Reservoir have had annual fluctuations averaging 3.5 feet from 2002 through 2006. During the baseline period, the maximum water level elevation in Whitewater Reservoir was 1,440.41 feet msl; whereas, the minimum water level elevation was 1,436.06 feet msl.

Wastewater - Hoyt Lakes POTW.

The City of Hoyt Lakes discharges its treated secondary effluent from its publicly-owned treatment works (POTW) wastewater treatment plant (WWTP) into Whitewater Reservoir under NPDES/SDS Permit MN0020206 (see Figure 4.1-3). Water quality of the WWTP discharges for the period April 1999 through January 2007 are given in Knight Piésold (2007a). The WWTP discharge most likely affects the water quality of Whitewater Reservoir by addition of nutrients (phosphorus and nitrogen species) and other constituents (Knight Piésold, 2007a).

4.1.1.3 Existing Mine Discharges

Several mines have discharged in the past, or currently discharge water to rivers and streams in the vicinity of the NorthMet Project Site, including the NorthShore Mining Company (NorthShore) Peter Mitchell pits and LTVSMC mines. Mining activities have impacted to different degrees the hydrologic regime of the Partridge River, Wyman Creek, Second Creek, and Embarrass River watersheds. Potential impacts on streamflows due to mining at the headwaters of these watersheds date back to 1956.

Figure 4.1-3 shows the approximate locations of past and current water appropriations from and discharges into the Partridge River, Wyman Creek, Second Creek, and Embarrass River. Although mine discharges to the watercourses listed above have occurred periodically since 1956, there are no mine pumping records available prior to 1988 (http://www.pca.state.mn.us/data/edaWater/index.cfm). The discharges to the Partridge River, Wyman Creek, Second Creek, and Embarrass River from the NorthShore and LTVSMC mining and processing facilities will continue in the future.

Partridge River watershed

In the case of the Peter Mitchell pits, discharges are neither continuous nor simultaneously directed to Second Creek, Partridge River, and Dunka River (the latter watercourse is located in the Rainy River watershed, which is not part of the Lake Superior basin; see Figure 4.1-1). When Peter Mitchell pits discharges to the Partridge River do occur, the maximum flow rate has been 34 cfs, which corresponds to the maximum permitted discharge under NPDES/SDS Permit MN0046981. The total maximum permitted discharge to the Partridge River is

36.3 cfs; other NPDES/SDS permits to discharge into the Partridge River account for 2.3 cfs. The total maximum permitted discharge to Second Creek is 62 cfs.

Streams in the Wyman Creek/Partridge River and Second Creek (Knox Creek) watersheds receive discharges under NPDES/SDS Permit MN0042536 issued to the Cliffs-Erie LLC.

Table 4-7 summarizes the NPDES/SDS discharges to the Partridge River and their tributaries (http://www.pca.state.mn.us/data/edawater). Many of these NPDES/SDS locations had no discharges during the period of record, which was typically 1999 through 2006. Details of the discharges are shown in (Knight Piésold, 2007a).

Table 4.1-7: NPDES/SDS Mining Discharges to Partridge River Watershed

NPDES Permit Number	Discharge ID	Outfall Description	Receiving Waters
MN0069078 (Mesabi Mining LLC)	**SD-001***	**Composite SD-018 to SD-021**	**Colby Lake Watershed**
	SD-004	**Pit 1 dewatering pipe**	**Unnamed creek (to Wynne L.)**
	SD-005	**Pit 9 dewatering pipe**	**First Creek**
	SD-006	**Pit 6 dewatering pipe**	**Second Creek**
	SD-007	**Pit 9S dewatering pipe**	**First Creek**
	SD-014	**Pit 2WX dewatering pipe**	**Second Cr. (via wetlands)**
	SD-015	**Pit 2WX dewatering pipe**	**Second Cr. (via wetlands)**
	SD-016	**Pit 2WX dewatering pipe**	**Second Cr. (via wetlands)**
	SD-017	**Pit 2WX dewatering pipe**	**Second Cr. (via wetlands)**
	SD-018	**Pit 2WX dewatering pipe**	**Unnamed creek (to Partridge R.)**
	SD-019	**Pit 2WX dewatering pipe**	**Unnamed creek (to Partridge R.)**
	SD-020	**Pit 2WX dewatering pipe**	**Unnamed creek (to Partridge R.)**
	SD-021	**Pit 2WX dewatering pipe**	**Unnamed creek (to Partridge R.)**
	SD-022	**Pit 9 dewatering pipe**	**Unnamed creek (to Wynne L.)**
	SD-023	**Pit 9S dewatering pipe**	**First Creek**
	SD-024	**Pit 6 dewatering pipe**	**First Creek**
MN0042536 (Cliffs Erie LLC)	**SD-008**	**Pit 2W dewatering pipe**	**Second Creek**
	SD-009	**Pit 2W dewatering pipe**	**Second Creek**
	SD-010	**Pits 2/2E/3 dewatering pipe**	**Unnamed wetland (to Wyman Cr.)**
	SD-011	**Pits 2/2E/3 dewatering pipe**	**Unnamed wetland (to Wyman Cr.)**
	SD-012	**Pit 3 overflow channel**	**Wyman Creek**
	SD-013	**Pit 2W dewatering pipe**	**Unnamed creek (to Colby L.)**
	SD-030	**Pit 5S overflow (unauthorized)**	**Wyman Creek**
	SD-033	**Rail culvert NE of Pit 5N loadout**	**Spring Mine Creek**
MN0067687 (Mesabi Nugget Delaware LLC)	**SD-001**	**Pit 1 overflow**	**Second Creek**
MN0046981 (Northshore Mining Co.)	**SD-006**	**185S pit dewatering**	**Partridge R. (via One Hundred Mile Swamp)**
	SD-007	**223S pit dewatering**	**Partridge R. (via One Hundred Mile Swamp)**
	SD-008	**258S pit dewatering**	**Partridge R. (via One Hundred Mile Swamp)**
	SD-009	**280/292S pit dewatering**	**Partridge R. (via One Hundred Mile Swamp)**
	SD-010	**360S pit dewatering**	**Partridge R. (via One Hundred Mile Swamp)**
	SD-011	**380S pit dewatering**	**Partridge R. (via One Hundred Mile Swamp)**
	SD-012	**430S pit dewatering**	**Partridge R. (via One Hundred Mile Swamp)**
	SD-013	**Crusher 2 sanitary pipe**	**Partridge R. (via One Hundred Mile Swamp)**
	SD-023	**Crusher 2 area discharge**	**Partridge R. (via One Hundred Mile Swamp)**

*Location not available

Embarrass River watershed.

The existing Cliffs Erie Hoyt Lakes Tailings Basin area discharges primarily to the Embarrass River watershed. Various types of monitoring have been conducted as part of the existing Tailings Basin area NPDES/SDS Permit MN0054089 issued to Cliffs Erie LLC for the tailings basin. The data, including both permit-required and voluntary monitoring results are provided to the MPCA in an annual report as specified in the permit. Beginning in 2001, data generated by these activities have been electronically managed and are readily available. Barr (RS64, 2006c) [GAP - - verify if Feb 8, 2008 memo should be cited] provided a tabulation of tailing basin discharge data for the period 2001 through 2005. The NPDES permit monitoring points are shown on Figure 4.1-3.

The tailings basin has remained inactive since January 2001, except for continuing reclamation work. Eight (8) ground water (GW) monitoring stations (i.e., wells GW001 through GW008 located as shown on Figure 4.1-4) are included in the Permit. GW002 is considered the background station for the tailings basin. Three (3) of the wells (GW003, GW004, and GW005) are located within tailings basin Cell 2W. The wells installed in Cell 2W were intended to monitor hornfels rock that was placed in the tailings basin and covered with tailings during 1993. The remaining four (4) wells (GW001, GW006, GW007, and GW008) are located downgradient of the toe of tailings basin dams.

Specific seeps are included in the Permit as surface discharge (SD) monitoring stations and waste stream (WS) monitoring stations. SD monitoring stations discharge external to the tailings basin system while WS monitoring stations discharge internal (e.g., to the Emergency Basin) to the tailings basin. All SD monitoring stations are seeps except for SD006. Both SD and WS seep information are presented in RS64 (Barr, 2006c). Table 4-8 summarizes measured discharges obtained during NDPES monitoring for the SD and WS monitoring stations. These data also are detailed in Knight Piésold (2007a). Table 4-8 also summarizes data for 31 additional seeps identified over the period 2002 to 2006 (see Figure 6 and Table 2 in RS55T (Barr, 2007g).

Table 4-8 includes only those seeps flowing at greater than 1 gpm, including monitoring locations which are not part of the NPDES permit system but may have impacted the surface water and ground water near the Hoyt Lakes Tailings Basin. These seeps have caused elevated levels of chemical constituents into the environment as shown by the water quality summaries in Knight Piésold (2007a).

Table 4.1-8 Summary of Seep Flow Monitoring at the Existing Tailings Basin Estimated Flows (gpm)

Seep ID	Description	May 2002	December 2002	November 2003	October 2004	October 2005	October 2006
Seep 1	Emergency Basin area seep	1	No Flow / Could Not Locate	No Data Recorded	No Data Recorded	Not Measurable	No Flow
Seep 2	Emergency Basin area seep	Not Measurable	No Flow / Could Not Locate	No Data Recorded	No Data Recorded	Not Measurable	No Flow
*Seep 3	Emergency Basin area seep	6	12	No Data Recorded	No Data Recorded	Not Measurable	No Flow
*Seep 4	Emergency Basin area seep	25-30	42	11	No Data Recorded	Not Measurable	No Flow
*Culvert (WS-011)	Combined flow of seeps in area of and including seeps 1, 2, 3, & 4 near emergency basin	Not Measurable	Not Measureable	No Data Recorded	21.8	7.2	No Flow
Seep 5	Emergency Basin area seep	0.8	No Flow / Could Not Locate	No Data Recorded	No Data Recorded	Not Measurable	Not Measurable
Seep 6	Emergency Basin area seep	1.6	No Flow / Could Not Locate	No Data Recorded	No Data Recorded	Not Measurable	Not Measurable
Seep 7	Emergency Basin area seep	1.6	0.9	No Data Recorded	No Data Recorded	Not Measurable	Not Measurable
*Seep 8	Emergency Basin area approx. 4 seeps in one small area	3.5	35	33	No Data Recorded	Not Measurable	Not Measurable
Seep 9	Emergency Basin area seep	Not Measurable	Not Measurable	No Data Recorded	No Data Recorded	Not Measurable	Not Measurable
*Weir (WS-012)	NPDES Permit Station Combined flow of area including seeps 4 thru 9	94	25	25	35	0.2	No Flow
*EB Outflow	Emergency Basin outflow	1051	568	797	928	896	554
Seep 10	West side of TB	Not Measurable	>50	No Data Recorded	No Data Recorded	Not Measurable	No Flow
Seep 11	West side of TB	Not Measurable	0.5	No Data Recorded	No Data Recorded	Not Measurable	No Flow

▪ Seep ID	▪ Description	▪ May ▪ 2002	▪ December ▪ 2002	▪ November ▪ 2003	▪ October ▪ 2004	▪ October ▪ 2005	▪ October ▪ 2006
▪ Seep 12	West side of TB	Not Measurable	0.5	No Data Recorded	No Data Recorded	Not Measurable	No Flow
▪ Seep 13	West side of TB	1 – 1.5	0.5	No Data Recorded	No Data Recorded	Not Measurable	No Flow
▪ Seep 14	West side of TB	0.8	No Flow / Could Not Locate	No Data Recorded	No Data Recorded	Not Measurable	0.47 (Seeps 14-17 Combined)
▪ Seep 15	West side of TB	Not Measurable	No Flow / Could Not Locate	No Data Recorded	No Data Recorded	Not Measurable	0.47 (Seeps 14-17 Combined)
▪ Seep 16	West side of TB	Not Measurable	No Flow / Could Not Locate	No Data Recorded	No Data Recorded	Not Measurable	0.47 (Seeps 14-17 Combined)
▪ Seep 17	West side of TB	Not Measurable	No Flow / Could Not Locate	No Data Recorded	No Data Recorded	Not Measurable	0.47 (Seeps 14-17 Combined)
▪ *Weir (West Side seep)	Combined flow of area including seeps 11 thru 17	24	25	9	3	No Flow	No Flow
▪ *SD-006	NPDES Permit Station Culvert Flow	1387	247	359	406	509	356
▪ Seep 18	West side of TB	Not Measurable	2.0	No Data Recorded	No Data Recorded	No Flow	No Flow
▪ *Seep 19	West side of TB	Not Measurable	22	No Data Recorded	No Data Recorded	No Flow	No Flow
▪ Seep 20	Northwest side of TB pipe flow	1.5 - 2.0	5.0	9	No Data Recorded	2.1	1.59
▪ Seep 21	Northwest side of TB	0.5	1.5	No Data Recorded	No Data Recorded	No Flow	No Flow
▪ Seep 22 ▪ SD-004	Northwest side of TB	1.0 - 1.5	7.0	5	5	5	1.35
▪ Seep 23	No pipe present	Not Measurable	6.0	No Data Recorded	No Data Recorded	No Flow	No Flow
▪ *Seep 24 ▪ (North Side seep)	Flow from pipe	1.0 – 1.5	20	21	3	2.7	1.08

▪ Seep ID	▪ Description	▪ May ▪ 2002	▪ December ▪ 2002	▪ November ▪ 2003	▪ October ▪ 2004	▪ October ▪ 2005	▪ October ▪ 2006
▪ *Seep 25	**Flow from pipe**	**2.5 – 3.0**	**15**	**29**	**5**	**15.5**	**21.54**
▪ Seep 26	**North Side of TB**	**1.0**	**Frozen**	**No Data Recorded**	**No Data Recorded**	**No Flow**	**No Flow**
▪ Seep 27	**Flow from pipe**	**0.25**	**Frozen**	**<1**	**No Data Recorded**	**No Flow**	**No Flow**
▪ Seep 28	**Flow from pipe**	**0.25**	**Frozen**	**No Data Recorded**	**No Data Recorded**	**No Flow**	**No Flow**
▪ *Seep 29	**Flow from pipe**	**25-30**	**12**	**5**	**0.7**	**No Flow**	**No Flow**
▪ *Seep 30	**Three seeps in one small area, no pipe present.**	**1.5 – 2.0**	**12**	**99**	**62**	**81**	**127**
▪ Seep 31	**Various seeps along northeast side of TB flowing onto the road.**	**Not Measurable**	**>60**	**No Data Recorded**	**No Data Recorded**	**Not Measurable**	**No Flow**
▪ *Seep 32	**Knox Creek Headwaters, south of TB**	**No Data Recorded**	**No Data Recorded**	**265**	**360**	**409 (Seeps 32-33 Combined)**	**199 (Seeps 32-33 Combined)**
▪ *Seep 33	**Knox Creek Headwaters, south of TB**	**No Data Recorded**	**No Data Recorded**	**114**	**89**	**See Seep 32**	**See Seep 32**
▪ *Knox Creek Headquarters	**Seeps 32 and 33 Combined**	**554**	**332**	**See Seep 32 and 33**	**See Seep 32 and 33**	**See Seep 32 and 33**	**See Seep 32 and 33**
▪ *Inflow (culvert)	**NE end of TB process water pond**	**No Data Recorded**	**No Data Recorded**	**No Data Recorded**	**42**	**67**	**151**

Indicates "significant" flows (measured flows greater than 10 gpm).
Not Measureable – Moisture observed but could not quantify flow.
No Data Recorded – Seepage was not measureable, did not exist, and/or was not recorded
No Flow – No flow observed

Although included in Table 4-8, the flows listed under EB outflow, SD-006, and Inflow (culvert) are not actually seepage flows from the basin. The EB outflow includes seepage from the basin (seeps 1-9) as well as direct precipitation less evaporation to the emergency basin and runoff from the surrounding watershed. Similarly, the SD-006 flow, which is flow through a culvert, has contributing water other than seep water. The flow listed as "Inflow (culvert)" is flow into the Tailings Basin from the surrounding upland areas to the east of the basin. The following Table 4-9 provides statistics of the seep discharges at the Hoyt Lakes Tailings Basin as measured by PolyMet during the period January 5, 2001 and November 15, 2005.

Table 4.1-9: Statistics of Measured Discharges of Seeps at the Hoyt Lakes Tailings Basin[(1)]

Statistic[(2)]	SD-004	SD-006	West Side Seep	WS-011	WS-012	WS-013
Average	0.284	4.985	0.277	0.248	0.915	0.914
Std. Dev.	0.823	5.935	0.393	0.346	0.280	0.245
Maximum	3.003	33.76	0.833	1.057	0.833	1.034
Minimum	0.001	0.237	0005	0.009	0.013	0.014
Number of Measurements	13	37	13	9	10	25

(1)Locations as shown on Figure 4.1-4.
(2)All discharges are in cubic feet per second (cfs).

4.1.1.4 Surface Water Model (XP-SWMM)

PolyMet's mining activities will alter land use characteristics within the NorthMet Project Mine Site, which will have some impact on the quantity of water that leaves the Mine Site. The quantitative assessment of the impacts of the Mine Site on the daily and storm water runoff quantities has been performed by PolyMet for this EIS using the XP-SWMM computer model (USEPA, 2007). The cumulative impacts model has been developed and calibrated using USGS gage data for the Partridge River above Colby Lake at Hoyt Lakes (USGS Station No. 04015475); for more details, see Barr (RS73A, 2006d).

The Mine Site of the NorthMet Project covers about 4.7 square miles in the headwaters of the Partridge River watershed (Figure 4.1-1). The Mine Site is larger than the actual area to be occupied by the mine facilities, which ranges from approximately 1.1 square miles at the end of Mine Year 1 to approximately 2.4 square miles by the end of Mine Year 20 when mining operations are expected to cease. The study area for quantitative hydrologic and hydraulic assessment of the potential impacts associated with the development and operation of the proposed NorthMet Project Mine Site was defined in the Scoping Decision Document (SDD) as the 103.4 mi2 catchment area of USGS gaging Station No. 04015475 (Partridge River above Colby Lake at Hoyt Lakes). The XP-SWMM model has been used to evaluate expected relative changes on the average, minimum and maximum flows for various time intervals at seven locations along the Partridge River during different stages of the mining project. The XP-SWMM model is not intended to predict instantaneous flow values, but to provide estimates of overall trends in the flow pattern as the mining project is implemented (Barr, RS73B, 2007d).

The XP-SWMM model has been calibrated using data from water year 1984-1985 at USGS gaging Station No. 04015475. This water year was selected because the ratio of the average gaged runoff to precipitation is about the same as the mean value of between 0.40 and 0.45 suggested by Baker and others (1979) for this region of Minnesota. The model calibration to the USGS gaging station has been made by comparing modeled versus recorded flows, and indirectly by comparing modeled versus estimated (see Section 4.1.1.3) watershed-averaged evapotranspiration. The calibrated model has also provided useful information pertaining groundwater recharge from the Partridge River watershed to the main channel network. Such information has been the basis for development and calibration of a separate groundwater model for the Mine Site (Barr, RS21, 2007a).

The XP-SWMM model has been validated using data from (1) USGS Station No. 04015475 for the period 1978 through 1988, and (2) USGS Station No. 04015455 (South Branch Partridge River near Babbitt), for the period 1978 through 1980 (RS73A, 2006d; RS73B, 2007d).

4.1.1.5 Surface Water Streamflows

Snowmelt, rainfall, and groundwater recharge all contribute to streamflow in the Project area streams. Table 4-10 summarizes streamflow data in the Project area and the locations of the referenced USGS gaging stations are shown on

Figure 4.1-1. Stream hydrographs indicate that high flows occur during the months of April and May and are the result of snowmelt or rain-on-snow events. Both the seasonal variations in flow and effects of regulation are illustrated in the hydrographs shown on Figure 4.1-5. These hydrographs show that streamflow is generally low in late fall and through the winter, rises sharply during spring snowmelt, and recedes during the summer, except during occasionally heavy storms.

Baseflow is small during the winter because groundwater recharge is low (Siegel and Ericson, 1980). The largest aquifer in the study area is located in the

Embarrass River watershed, but baseflow is not sustained at a very high rate, even in wet years. Table 4-10 summarizes monthly average discharges and maximum and minimum streamflows by month for the period of record at selected USGS gaging stations.

Additional statistical analyses were performed by Barr (RS73B, 2007d) to assess hydrologic alteration within ecosystems as suggested by Richter et al. (1996 and 1998). The statistical discharge variables for USGS Station No. 04015475 as well as the six other locations (SW-001, SW-002, SW-003, SW-004, SW-004a, and SW-005) on the Partridge River upstream are presented on Figure 4.1-10. Barr (RS73B, 2007d) details these discharge statistics, which are summarized in Table 4-10A.

For the Embarrass River, the low, average, and high flows used for water quality predictions in the impacts section of this EIS are summarized in Table 4.10B. These low, average and high flows were estimated by Barr (RS74B, 2008) utilizing measured flows at USGS gaging station 04017000 (Embarrass River at Embarrass)

Table 4.1-10: Monthly Statistical Flow Data for USGS Gaging Stations (1/2)

Station:	04015455 South Branch Partridge River			04015475 Partridge River Ab. Colby Lake			04015500 Second Creek Nr. Aurora		
Period of Record:	1977 - 1980			1978-1988			1955-1980		
Drainage Area:	18.5 mi^2			106 mi^2			29.0 mi^2		
Contributing Drainage Area:	18.5 mi^2			100 mi^2			22.4 mi^2		
	Monthly	Daily	Daily	Monthly	Daily	Daily	Monthly	Daily	Daily
Month	Average	Minimum	Maximum	Average	Minimum	Maximum	Average	Minimum	Maximum
October	13	1.7	74	116	14	775	24	1.2	131
Novermber	12	1.4	50	63	13	468	20	4.0	103
December	4.4	0.22	16	20	4.1	95	12	2.2	35
January	1.0	0.04	3.7	7.5	1.4	23	9.2	1.5	30
February	0.78	0.03	1.8	6.4	0.96	26	8.9	1.5	28
March	0.95	0.02	4.5	16	0.61	209	16	2.0	84
April	47	1.0	426	242	4.0	1,960	47	5.0	233
May	36	1.2	171	220	11	874	34	1.7	126
June	22	0.66	100	105	5.9	568	29	1.4	95
July	11	0.20	75	104	0.54	866	23	3.1	88
August	8.4	0.06	57	55	0.68	480	20	2.6	130
September	26	1.9	81	87	2.0	374	24	1.9	100

Table 4.1-10: Monthly Statistical Flow Data for USGS Gaging Stations (1/2) Cont.

Station:	04017000 Embarrass River Nr. Embarrass			05026000 Dunka River Nr. Babbitt			04016000 Partridge River Nr. Aurora		
Period of Record:	1942 - 1964			1951 - 1962, 1975 - 1980			1944 - 1977		
Drainage Area:	88.3 mi^2			53.4 mi^2			161 mi^2		
Contributing Drainage Area:	88.3 mi^2			49.4 mi^2			147.7 mi^2		
	Monthly	Daily	Daily	Monthly	Daily	Daily	Monthly	Daily	Daily
Month	Average	Minimum	Maximum	Average	Minimum	Maximum	Average	Minimum	Maximum
October	46	2.6	453	27	0.00	202	97	3.3	1,140
Novermber	33	4.9	166	26	0.00	142	71	4.0	308
December	14	3.4	50	11	0.00	61	34	5.7	116
January	6.7	0.90	22	3.8	0.00	12	21	2.3	61
February	5.0	0.90	14	2.5	0.00	8.3	17	2.3	41
March	22	1.4	774	7.1	0.00	90	41	3.0	1,560
April	190	2.6	1,490	120	2.5	828	271	6.5	2,580
May	194	21	1,720	95	4.8	585	333	37	3,190
June	114	5.2	1,090	66	1.8	344	210	17	2,920
July	63	3.6	790	34	0.95	360	101	11	950
August	31	1.8	284	21	0.00	150	64	5.2	459
September	50	2.2	789	47	0.00	250	81	3.2	438

Notes:
(1) Statistical data from USGS National Water Information System (http://nwis.waterdata.usgs.gov/nwis).
(2) All values in cfs unless otherwise noted.

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Table 4.1-10A Flow statistics at USGS Gaging Station #04015475 and Six Surface Water Monitoring Stations (including correction accounting for ratios of the recorded versus calibrated modeled values) for the 10-Year Period from 1978-1988

Statistic	Units	Location						
		USGS Gage	SW-005	SW-004a	SW-004	SW-003	SW-002	SW-001
Mean Annual Flow	cfs	88	83	45	19	12	11	4.7
Max 1-Day Flow	cfs	1,960	1,859	1,163	385	246	193	68
Avg. Max 1-Day Flow	cfs	748	722	474	166	107	90	32
Max 3-Day Flow	cfs	1,840	1,753	1,002	365	214	173	57
Max 7-Day Flow	cfs	1,446	1,380	759	291	171	140	42
Max 30-Day Flow	cfs	710	676	356	148	91	77	30
Max 90-Day Flow	cfs	362	344	180	75	46	39	15
Min 1-Day Flow	cfs	0.54	0.49	0.22	0.09	0.07	0.05	0.01
Avg. Min 1-Day Flow	cfs	3.6	3.3	1.6	0.62	0.42	0.32	0.06
Min 3-Day Flow	cfs	0.65	0.59	0.28	0.11	0.08	0.06	0.01
Min 7-Day Flow	cfs	0.79	0.68	0.32	0.13	0.09	0.07	0.01
Min 30-Day Flow	cfs	1.2	1.1	0.55	0.21	0.15	0.12	0.03
Min 90-Day Flow	cfs	2.2	2.1	1.15	0.52	0.34	0.29	0.11

Source: Barr (2008, RS73B, Table 2).

Table 4.10BLow, Average, and High Flows used for Water Quality Impact Prediction in the Embarrass River [(6)]

	Embarrass River Location [(2)]	
Flow (cfs) [(1)]	**PM-12**	**PM-13**
Low [(3)]	1.19	5.66
Average [(4)]	13.8	81.5
High [(5)]	144	853

1. Includes surface and ground water not originating at the TSF.
2. As shown on Figure 4.1-1.
3. Average annual 30-day minimum flow updated to reflect the changes in modeled discharges from Babbitt WWTP and Pit 5NW during low flow conditions.
4. Average annual mean flow.
5. Average annual 1-day maximum flow
6. Barr (2008, RS74B, Table 2-1 (Revised).

Because the floodplain of the Partridge River in the vicinity of the Mine Site is currently unmapped by the Federal Emergency Management Agency (FEMA), Barr calculated and delineated the 100-year and 500-year floodplain boundaries from approximately Mud Lake downstream to approximately the confluence of South Branch Partridge River (Barr, RS73B, 2007d). Figure 4.1-7 shows the

100-year and 500-year floodplain boundaries along the Partridge River in the vicinity of the Mine Site, as well as the subwatershed boundaries at the Mine Site. The gradient of the Partridge River valley between its headwaters and Dunka Road is about 0.6 percent. The 100-year flood elevations downstream of Dunka Road are more than 20 feet lower than most of the adjacent Mine Site perimeter ground surface elevations. The increase in flood elevation from the 100-year event to the 500-year event on the Partridge River is relatively minor, varying from 0.2 to 0.5 feet upstream of Dunka Road, and as much as 1.4 feet downstream of Dunka Road.

4.1.1.6 Surface Water Quality

Regulatory Information

Table 4-11 summarizes the classifications of water bodies in the project area. The two water classifications with the most stringent regulatory water-quality standards are Class 1 and Class 2 which correspond, respectively, to waters protected for domestic consumption and for aquatic life and recreation (Minn R. ch. 7050). These classifications are described in more detail below. It should be noted that the classifications extend beyond just the Class 1 and Class 2 designations listed in Table 4-11, as they also include Class 3 (industrial consumption), Class 4 (agriculture and wildlife), Class 5 (aesthetic enjoyment and navigation) and Class 6 (other uses) designations.. Unless specifically designated in Minnesota Rule as otherwise, all surface waters are by default classified as Class 2B, 3B, 4A, 4B, 5 and 6 waters.

Particular water quality standards that would be applicable to these waters also extend beyond what is listed for Class 1B, 2A, 2B and 2B in Table 4-12. Water quality standards for some parameters, for example hardness, are related to the water's Class 3 or Class 4 designation, which are in addition to the broader list of standards that are related to the Class 1B, 2A, 2B and Class 2Bd designations. The applicable water quality standards for each of these waters, therefore, would include the standards from all the water's listed classifications (Minn R. ch. 7050).

Class 1 waters are subdivided into four categories of A through D depending on (1) the type of water treatment needed so that maximum contaminant levels (MCL's) and secondary drinking water standards are achieved, (2) any exceptions to using MCL's and secondary drinking water standards as Class 1 standards, and (3) the types of aquifers or other drinking water sources that are in the class based on the degree of natural protection from contamination. Class 2 waters are subdivided into five classes: A, Bd, B, C, and D depending on (1) whether the surface water is protected as a drinking water source, and (2) the type of fish and other aquatic life and their habitats that are being protected.

In-stream surface water quality standards for the Partridge River and Embarrass River correspond to Class 2B waters, in accordance with the Minnesota Rule Chapter 7050.0222, Subpart 4. In addition, because these surface waters are part of the Lake Superior Basin watershed, additional water quality rules for certain parameters such as dissolved metals supersede the general Class 2B rules, in accordance with the Minnesota Rule Chapter 7052.0100, Subpart 5.

In the Project area, Colby Lake is designated as Class 1B and 2Bd waters because the City of Hoyt Lakes withdraws water from Colby Lake for domestic consumption, hence this water body is protected as a source of drinking water. Wyman Creek is designated as Class 1B and 2A because it is listed as a trout stream in Minnesota Rule Chapter 6264.0050, Subpart 4, and it is protected for propagation and maintenance of a healthy community of cold water sport or commercial fish and associated aquatic life, and their habitats; for aquatic recreation of all kinds, including bathing, for which the waters may be usable; and as a source of drinking water waters with a moderately high degree of natural protection and apply to these waters in the untreated state.

The remaining surface waters in the Project area are Class 2B, in accordance with the Minnesota Rule Chapter 7050.0222, Subpart 4. In addition, because these surface waters are part of the Lake Superior Basin watershed, additional water quality rules for certain parameters such as dissolved metals supersede the general Class 2B rules, in accordance with the Minnesota Rule Chapter 7052.0100, Subpart 5. Class 2B waters are protected to permit the propagation and maintenance of a healthy community of cool or warm water sport or commercial fish and associated aquatic life, and their habitats; and for aquatic recreation of all kinds, including bathing, for which the waters may be usable. This class of surface water is not protected as a source of drinking water.

In accordance with the Minnesota Rules Chapter 7050.0221, Subpart 3, Class 1B waters shall be such that with approved disinfection, such as simple chlorination or its equivalent, the treated water must meet all primary (maximum contaminant levels) and secondary USEPA drinking water standards. The USEPA primary and secondary drinking water standards are presented in Section 4.1.3.7.1.

Class 2B water quality standards are given in Table 4-12 where the water quality standards of the metals prefaced by ** are hardness dependent. The concentrations listed in Table 4.12 below are for water with a hardness of 50 mg/L.

Table 4.1-11 Summary of NorthMet Project site Water Quality Classifications by Water Body[(1)]

River/Creek/Lake	Water-Quality Classification
Embarrass R.	**2B**
Trimble Ck.	**2B**
Spring Mine Ck.	**2B**

River/Creek/Lake	Water-Quality Classification
Ridge Ck.	2B
Partridge R.	2B
Colby Lake	1B, 2Bd
Whitewater Reservoir	2B
Yelp Ck.	2B
Stubble Ck.	2B
South Branch Partridge R.	2B
Colvin Ck.	2B
Wetlegs Ck.	2B
Longnose Ck.	2B
Wyman Ck.	1B, 2A
Second (Knox) Ck.	2B

(1) Minnesota Rules Chapter 7050 as defined below.

Because the project is in the Lake Superior Basin, GLI water quality standards as detailed in Minnesota Rules Chapter 7052.0100 also are included in Table 4-12. These can be somewhat different than the WQ standards for the same parameters in Minnesota Rules Chapter 7050 (where different, the 7052 standards supercede the 7050 standards). For parameters not listed in Minnesota Rules Chapter 7052, the standards from Minnesota Rules Chapter 7050 should be used. Therefore, Table4-12 reflects a mix of water quality standards from both Rules 7052 and 7050.

Table 4.1-12: Class 2B Water Quality Standards Applicable to the Lake Superior Basin – Aquatic Life and Recreation

Constituent	Units	CS(2)	Basis(1)	MS	FAV	Basis (1)
Tot. Aluminum	µg/L	125	Tox.	1072	2145	Tox.
Antimony	µg/L	31	Tox.	90	180	Tox.
Tot. Arsenic	µg/L	53	HH	340	680	Tox.
**Tot. Cadmium	µg/L	1.4	Tox.	2.1	4.1	Tox.
**Tot. Chromium +3	µg/L	49	Tox.	1022	2044	Tox.
Tot. Chromium +6	µg/L	11	Tox.	16	32	Tox.
Cobalt	µg/L	5	Tox.	436	872	Tox.
**Tot. Copper	µg/L	5.2	Tox.	7.3	15	Tox.
**Tot. Lead	µg/L	1.3	Tox.	34	68	Tox.
**Tot. Nickel	µg/L	29	Tox.	261	522	Tox.
Selenium	µg/L	5	Tox.	20	40	Tox.
**Tot. Silver	µg/L	1	Tox.	1	1.2	Tox.
Thallium	µg/L	0.56	HH	64	128	Tox.
**Tot. Zinc	µg/L	67	Tox.	67	133	Tox.
Tot. Mercury	µg/L	0.0013	HH			-
Un-ionized Ammonia (as N)	µg/L	40	Tox.	n/a	n/a	n/a
Chloride	mg/L	230	Tox.	860	1720	Tox.
Cyanide (free)	µg/L	5.2	Tox.	22	45	Tox.
Oil	µg/L	500	n/a	5000	10,000	n/a
Turbidity	NTU	25	n/a	n/a	n/a	n/a
pH	S.U.	Between 6.0 and 9.0				-
Dissolved Oxygen	mg/L	Greater than 5.0		-	-	-

(1) Standards: CS = Chronic Standard; MS = Maximum Standard; FAV = Final Acute Value
(2) Basis: Tox. = Toxicity to aquatic life; HH = Harmful to human health from sport caught fish
** Water quality standards of the metals prefaced by ** are hardness dependent.

Table 4.1-13: Class 2B Water Quality Standards –

Total Cadmium (µg/L)	**Hardness** (1)	**50**	**100**	**200**
	CS (2)	1.4	2.5	4.2
	MS(2)	2.1	4.5	9.9
	FAV(2)	4.1	9.0	20
Total Chromium+3 (µg/L)	**Hardness**	**50**	**100**	**200**
	CS	49	86	152
	MS	1022	1803	3181
	FAV	2044	3606	6362
Total Copper (mg/L)	**Hardness**	**50**	**100**	**200**
	CS	5.2	9.3	17
	MS	7.3	14	27
	FAV	15	28	54
Total Lead (µg/L)	**Hardness**	**50**	**100**	**200**
	CS	1.3	3.2	7.7
	MS	34	82	197
	FAV	68	164	396
Total Nickel (µg/L)	**Hardness**	**50**	**100**	**200**
	CS	29	52	94
	MS	261	469	843
	FAV	522	938	1687
Total Silver (µg/L)	**Hardness**	**50**	**100**	**200**
	CS	1.0	1.0	1.0
	MS	1.0	2.0	6.7
	FAV	1.2	4.1	13
Total Zinc (µg/L)	**Hardness**	**50**	**100**	**200**
	CS	67	120	216
	MS	67	120	216
	FAV	133	240	431

(1) Hardness in mg/L as $CaCO_3$
(2) Standards: CS = Chronic Standard; MS = Maximum Standard; FAV = Final Acute Value

Class 2Bd waters must meet the same water quality standards as Class 2B waters with the exceptions shown in Table 4-14.

Class 3 and 4 water quality standards for water bodies in the Project area are summarized in the following Tables 4-15 through 4-17.

Table 4.1-14: Class 2Bd Water Quality Standards

Constituent	Units	Std. (1)	Class 2B	Class 2Bd	Basis (2)
Antimony	µg/L	CS	31	5.5	HH
Tot. Arsenic	µg/L	CS	53	2.0	HH
Cobalt	µg/L	CS	5.0	2.8	HH
Thallium	µg/L	CS	0.56	0.28	HH

(1) Standards: CS = Chronic Standard; MS = Maximum Standard; FAV = Final Acute Value

(2) Basis: Tox. = Toxicity to aquatic life; HH = Harmful to human health from sport caught fish

Table 4.1- 15: Class 3B Water Quality Standards – Industrial Consumption

Constituent	Units	Standard
Chloride	mg/L	100
Hardness	mg/L	250
pH	S.U.	Between 6.0 and 9.0

Table 4.1-16: Class 4A Water Quality Standards – Irrigation

Constituent	Units	Standard
Bicarbonate	meq/L	5
Boron	mg/L	0.5
Sodium	meq/L	60% of total cations
Specific Conductance	µmhos/cm	1000
Total Dissolved Solids	mg/L	700
pH	S.U.	Between 6.5 and 8.5

(1) Such a discharge will also need to be protective of downstream Class 1B and 2Bd waters.

Table 4.1-17: Class 4B Water Quality Standards – Wildlife and Livestock

Constituent	Units	Standard
Total Salinity	mg/L	1000
pH	S.U.	Between 6.0 and 9.0

Chemical Characteristics of Surface Water

Available surface water quality data for the project area includes both historical data dating to the 1950's (Barr, RS76) as well as recent data collected by PolyMet within the last four years.

The historical data include a compilation of surface water quality data from the eastern edge Mesabi Range of Northeastern Minnesota, specifically, surface water quality data in proximity to the Duluth Complex (Barr, 2006). The historical surface water quality data in this dataset (and in the associated tables in Knight Piésold (2007a) have been organized by location, including unique sample-specific identification numbers, their associated stream/river/lake and/or watershed locale, and their associated latitude/longitude or UTM coordinates. The locations of the stations queried are shown on Figures 4.1-1 and 4.1-6. Table 4-18 summarizes the organizations responsible, the approximate time-frame of the monitoring and a summary of the sampling station location identifications for each group.

Table 4.1- 18: Timeline of Organizations Responsible for Historic SurfaceWater Monitoring

Approximate Date Range	Responsible Organization	Common Sample Location Name
1974-1982	Amax Inc.	S-1, S-2, S-3, S-6, S-7
1976- 1981	Regional Copper-Nickel Study [(1)]	CN101 – CN129, Partridge River Locations (4016000, 4015475, South Branch 4015455)
~1994	Kennecott (Amax Site Closure)	S-1, S-2, S-3, S-6, S-7
2001-2002	Cominco	S-1, S-2, S-3, S-4, S-5, S-6, S-7
2001-2002	Lehmann Exploration Management, Inc.	L-1, L-2, L-3, L-4, L-5
2004-2007	PolyMet Mining, Inc.	PM-1 through PM-16

(1) USGS NWIS database queries returned results from as far back as 1955 (this applies to Copper-Nickel Study sample IDs). These data are included as they were "readily available".

PolyMet performed baseline surface water quality monitoring as part of its proposed mine development effort beginning in April-November 2004 and continuing in 2006 and 2007. The locations at which surface water quality samples were obtained are presented in Table 4-16 above, and are denoted with a "PM" in the sample identification

Summaries of other historical water quality data (Barr, RS76, 2006a) and the more recent baseline water quality data (Barr, RS63, 2006b) are presented in Knight Piésold (2007a). These historical and baseline water quality data were compared to Minnesota water quality standards. The constituents not meeting water quality standards for Class 1B, 2B, 3B, or 4A and 4B waters in one or more samples at one or more sites are summarized in Table 4-19. This large number of recurring water quality violations indicates that the existing surface waters in the project area have concentrations higher than existing water quality standards.

Table 4.1- 19: Summary of Constituents Not Meeting Water Quality Standards

Stream	Locations (as shown on Figures 4.1-1 and 4.1-6)	Constituents not Meeting Water Quality Standards for Class 1B, 2B, 3B, or 4A and 4B Waters
▪ **HISTORICAL**	▪	▪
Dunka River	**CN118, CN119, S6, S7, S8, L1**	**D.O., pH, Al, Fe, Hg, Pb**
Langley Creek	**S2 and S3**	**D.O., pH, Al, Cu, Fe, Hg, Pb, Ag**
Embarrass River	**CN120 and CN121**	**pH, Al, Cu, Fe, Pb**
Partridge River	**04016000, CN122, CN123, CN126, S1, S4**	**D.O., pH, Al, Co, Cu, Fe, Hg, Pb, Zn**
South Branch Partridge River	**04015455**	**Fe**
Colvin Creek	**CN124**	**D.O., pH, Al, Fe**
St. Louis River	**CN127, CN128, CN129**	**pH, Al, Fe, Pb, Ag**
▪ **RECENT BACKGROUND**	▪	▪
Langley Creek	**PM-14 and PM-15**	**Fe, Hg**
Embarrass River	**PM-12 and PM-13**	**Fe, Hg**
Partridge River	**PM-1 to 4 and PM-16**	**Al, Fe, Pb, Hg**
Trimble Creek	**PM-11**	**Hardness, Cr, Fe, Hg**
Wyman Creek	**PM-5 and PM-6**	**Al, Cr, Co, Fe, Hg**
Second (Knox) Creek)	**PM-7**	**Hardness, SC, Al, Cr, Hg**
Tailings Area Seepage	**SD001, SD002, SD004 and SD006, PM-8 to PM-10**	**Hardness, SC, Cr, Fe, Hg**
Background Wetlands	**Wetland 03, SW003**	**Hg**

Barr (2008, RS74A, Table 5-3) averaged historical Partridge River water quality data for the various locations, including 2007 data, to proide a baseline against which to model impacts from the NorthMet mine activities. These averaged Partridge River water quality baseline data are presented in Table 4-19A for the key locations of SW-002 through SW-005.

Similarly, Barr (2008, RS74B, Table 5-3) averaged historical Embarrass River water quality data for the two locations (PM12 and PM13) utilized to assess impacts. These averaged Embarrass River water quality baseline data are presented in Table 4-19B.

Table 4.1-19A Average Baseline Concentrations Measured in the Partridge River [1]

Parameter		Units	SW-002	SW-003	SW-004	SW-005	Stream Standard[3]
Ag	Silver	mg/L	0.0001	0.0001	0.0001	0.0001	0.001
Al	Aluminum	mg/L	0.0459	0.0603	0.0713	0.2754	0.125
As	Arsenic	mg/L	0.001	0.001	0.001	0.001	0.053
B	Boron	mg/L	0.0585	0.0661	0.0611	0.0372	0.5
Ba	Barium	mg/L	0.0096	0.01	0.005	0.0088	
Be	Beryllium	mg/L	0.0001	0.0001	0.0001	0.0001	
Ca	Calcium	mg/L	24.5	20.7	20.7	18.6	
Cd	Cadmium	mg/L	0.0001	0.0001	0.0001	0.0001	0.0011
Cl	Chloride	mg/L	1.8	10.5	9.1	6.2	230
Co	Cobalt	mg/L	0.0005	0.0005	0.0005	0.0008	0.005
Cu	Copper	mg/L	0.0005	0.0011	0.0021	0.0017	0.0093
F	Fluoride	mg/L	0.11	0.09	0.09	0.09	
Fe	Iron	mg/L	1.22	1.63	1.34	1.99	
Hardness		mg/L	112	101.1	92.9	82.9	500
K	Potassium	mg/L	2	2	1.6	1	
Mg	Magnesium	mg/L	7.5	9	8.3	7.5	
Mn	Manganese	mg/L	0.14	0.19	0.13	0.2	
Na	Sodium	mg/L	3.2	3.8	3.5	2.9	
Ni	Nickel	mg/L	0.0008	0.0016	0.0019	0.0021	0.052
Pb	Lead	mg/L	0.0003	0.0002	0.0002	0.0008	0.0032
Sb	Antimony	mg/L	0.0015	0.0015	0.0015	0.0015	0.031
Se	Selenium	mg/L	0.0005	0.0005	0.0005	0.0005	0.005
SO_4	Sulfate	mg/L	6.3	10.9	10	9	
Tl	Thallium	mg/L	0.0002	0.0002	0.0002	0.0002	0.00056
V	Vanadium [2]	mg/L	0.0009	0.0009	0.0009	0.0009	
Zn	Zinc	mg/L	0.0101	0.0064	0.0192	0.0167	0.106

(1) Source: Barr, RS74A, 2008. Mercury not reported.
(2) Vanadium was not monitored in the Partridge River. Value assumed from Hem (1992).
(3) For statewide waters or Lake Superior waters, whichever was more stringent.
Adjusted for a total hardness of 100 mg/L where appropriate (Barr, RS74A, 2008).
Blank means no standard has been set.

Table 4-19B: Average Baseline Concentrations Observed in the Embarrass River[1]

Parameter		Units	PM-12	PM-13	Stream Standard[2]
Ag	Silver	mg/L	0.00012	0.00012	0.001
Al	Aluminum	mg/L	0.0983	0.1916	0.125
As	Arsenic	mg/L	0.001	0.001	0.053
B	Boron	mg/L	0.0175	0.0443	0.5
Ba	Barium	mg/L	0.0155	0.0278	
Be	Beryllium	mg/L	0.0001	0.0001	
Ca	Calcium	mg/L	13.4	19.9	
Cd	Cadmium	mg/L	0.0001	0.0001	0.0011
Cl	Chloride	mg/L	4.49	6.98	230
Co	Cobalt	mg/L	0.0006	0.0005	0.005
Cu	Copper	mg/L	0.00153	0.002	0.0093
F	Fluoride	mg/L	0.1	0.39	
Fe	Iron	mg/L	1.72	1.29	
Hardness		mg/L	61.7	143.5	500
K	Potassium	mg/L	0.8	2.3	
Mg	Magnesium	mg/L	6.2	15.9	
Mn	Manganese	mg/L	0.16	0.11	
Na	Sodium	mg/L	3	12.7	
Ni	Nickel	mg/L	0.00194	0.00207	0.052
Pb	Lead	mg/L	0.00015	0.00027	0.0032
Sb	Antimony	mg/L	0.0015	0.0015	0.031
Se	Selenium	mg/L	0.0005	0.0005	0.005
SO_4	Sulfate	mg/L	4.64	36.13	
Tl	Thallium	mg/L	0.0002	0.0002	0.00056
Zn	Zinc	mg/L	0.0183	0.0123	0.106

(1) Source: Barr, RS74B, 2008.Mercury not reported
(2) For statewide waters or Lake Superior waters, whichever was more stringent. Adjusted for a total hardness of 100 mg/L where appropriate (Barr, RS74B, 2008). Blank means no standard has been set.

Water quality data are available for Colby Lake from the Regional Copper-Nickel Study and subsequent monitoring by MPCA (see Knight Piésold, 2007a). Minnesota Power's Laskin Power Plant has three permitted discharges to Colby Lake, which meet the effluent limitations in their NPDES/SDS permit. These data indicate that Colby Lake typically is mildly stratified due to the water temperature vertical profile that develops during the summer and fall months, but is generally isothermal during winter and spring.

The water column in Colby Lake shows that the following constituents do not meet MPCA water quality standards for Class 1B, 2Bd, 3B, or 4A and 4B waters: Al, Cu. Fe, and Hg. Given the average chlorophyll-a (2.56 µg/L) and total phosphorus (27 µg/L) concentrations in the Colby Lake water column, along with the average Secchi disk depth of 1.28 m (4.2 ft), the lake can be considered to be mesotrophic. This trophic status means that Colby Lake is moderately productive, with slightly green water due to algae growth in the lake. A typical mesotrophic lake has a Secchi disk depth of between 8 to 12 ft, 3 to 7 µg/L average chlorophyll-a, and 15 to 25 µg/L total phosphorus (http://plants.ifas.ufl.edu/guide/trophstate.html). The City of Hoyt Lakes water intake appears to be at the upstream end of Colby Lake; whereas the Laskin Power Plant NPDES discharge is downstream of Colby Lake. Therefore, the lake water quality data shown in Knight Piésold (2007a) do not appear to reflect water quality discharged by the Laskin Power Plant.

Water quality data are available within Whitewater Reservoir from the USEPA and MPCA and are summarized in Knight Piésold (2007a). These data indicate that Whitewater Reservoir typically is mildly stratified due to the water temperature vertical profile that develops during the summer and fall months, but is generally isothermal during winter and spring. The water column in Whitewater Reservoir did not indicate that any constituents do not meet MPCA water quality standards for Class 2B, 3B, or 4A and 4B waters, based on very limited available data. Given the average chlorophyll-a (5.48 µg/L) and total phosphorus (33 µg/L) concentrations in the Whitewater Reservoir water column, along with the average Secchi disk depth of 2.9 m (9.5 ft), the lake can be considered to be mesotrophic. This trophic status means that Whitewater Reservoir is moderately productive, with slightly green water due to algae growth in the lake.

The City of Hoyt Lakes discharges treated effluent from its Publicly Owner Treatment Works (POTW) into Whitewater Reservoir under NPDES/SDS Permit MN0020206 (SD-002) (Permit). A summary of the historical water quality under this Permit are presented in Knight Piésold (2007a). Nutrients from the City of Hoyt Lakes POTW contribute to the trophic status of Whitewater Reservoir as well as Colby Lake due to pumping from one lake to the other under the Water Appropriation Permit

4.1.1.7 Ground Water Resources

Information about the ground water resources at the NorthMet Project Site is taken from the following sources: (1) the baseline water quality assessment of Minnesota's principal aquifers (MPCA, 1999) prepared by the Ground Water Monitoring and Assessment Program (GMAP); (2) published reports concerning the geology and hydrogeology of the region including the Project area prepared by the U.S. Geological Survey (Olcott and Siegel, 1978; Olcott. et al., 1978; Siegel and Ericson, 1980; Adolphson, et al., 1981) and the Minnesota Geological Survey (Jennings and Reynolds, 2005; and Jirsa and others, 2005a, 2005b, and 2005c); (3) ground water level information publicly available from MDNR at the following website: http://www.dnr.state.mn.us/groundwater/index.html; (4) well construction and ground water level information publicly available from Minnesota Department of Health at the following website: http://mdh-agua.health.state.mn.us/cwi/cwiViewer.htm, (5) the detailed project description documents (PolyMet Mining, Inc. [PolyMet], 2006; 2007); and (6) reports prepared by Barr Engineering for the assessment of Mine Site hydrogeological conditions (Barr RS documents as referenced below).

4.1.1.8 Geological Summary

The NorthMet deposit is one of eleven copper-nickel-platinum group element deposits along the northern margin of the Duluth Complex. The deposit is located on the southern flank of the Mesabi Iron Range which hosts large taconite iron ore mines, the closest of which is about a mile north of the planned NorthMet open pits.
A cross-section illustrating the major geologic formations of the Duluth Complex in the Mine Site is shown on Figure 4.1-9. The geologic formations displayed on Figure 4.1-9 are explained on Figure 4.1-10. Igneous rock units are labeled 1 through 7 from bottom to top. Figures 4.1-11A and 4.1-11B are, respectively, bedrock and surficial geologic maps of the region surrounding the Project Area.

Major geologic units include Neoarchean granite (Giants Range Batholith), Paleoproterozoic sedimentary rocks, and Mesoproterozoic intrusive, volcanic, and sedimentary rocks. The Paleoproterozoic sedimentary rocks include the Biwabik Iron Formation, the source of taconite iron ore and the overlying Virginia Formation (Figures 4.1-9 and 4.1-10). The Mesoproterozoic intrusive rocks include the Duluth Complex, which is comprised of many sub-intrusions, the oldest of which is the Partridge River intrusion. The Partridge River intrusion, which is host to the NorthMet deposit has been extensively drilled holes within the deposit intersect the seven, layered troctolitic (plagioclase and olivine with minor pyroxene) igneous rock units shown on Figure 4.1-9. At the NorthMet Mine Site, the igneous rocks directly overlie the Paleoproterozoic Virginia Formation and do not contact iron-formation or granite.

The deposit is generally described as consisting of disseminated sulfides with minor local massive sulfides hosted in layered heterogeneous troctolitic (plagioclase and olivine with minor pyroxene) rocks forming the basal unit of the Duluth Complex. The deposit consists of seven troctolite units dipping southeast, with most economic sulfide mineralization in the lowermost unit. Igneous units are labeled 1 through 7 from bottom to top (Figures 4.1-9 and 4.1-10). The deposit is located along the contact with older rock below; all dipping to the southeast.

Bedrock Geology

Bedrock unit descriptions for the NorthMet Mine Site and Plant Site/Tailings Basin Area are given by Jirsa and others (2005c) as reproduced on Figure 4.1-11A. The units in general proximity to the project area are described (from youngest to oldest) as follows:

Mdu (Mesoproterozoic, Duluth Complex, ultramafic, oxide-rich intrusions). Coarse-grained to pegmatitic clinopyroxenite, peridotite, and dunite enriched in Fe-Ti oxide; oxide contents vary from 15 to nearly 100 percent.

Mdp (Mesoproterozoic, Duluth Complex, Partridge River intrusion).

Composed predominantly of troctolite containing inclusions of volcanic hornfels and anorthositic rocks; southeast-dipping; forms the base of the Duluth Complex. Typically medium- to coarse-grained, variably layered olivine-plagioclase cumulates. The basal contact zone is composed of olivine gabbro, augite troctolite, gabbronorite, and norite.

Mda (Mesoproterozoic, Anorthositic series subsuite of the Duluth Complex).

Composed predominantly of medium- to coarse-grained leucocratic anorthosite, troctolite, and gabbro.

Mnv (Mesoproterozoic, North Shore Volcanic Group).

A sequence of tholeiitic plateau lava flows and minor interflow sedimentary rocks. Forms the hanging wall to the Duluth Complex and occurs as isolated mafic hornfels inclusions in basal intrusions of the complex. Commonly associated with and intruded by anorthositic-series rocks (unit Mda).

Pav (Paleoproterozoic, Virginia Formation).

Interbedded carbonaceous shale, mudstone, siltstone, and fine-grained feldspathic graywacke. Zircons in a tuffaceous layer at the base of the formation yielded a U-Pb date of 1,832 ± 3 Ma, and ages of strata inferred to be broadly equivalent vary from 1,827 to 1,878 Ma (Addison and others, 2005).

Pab (Paleoproterozoic, Biwabik Iron Formation).

Contains thick-bedded granular chert, iron silicates, magnetite, and hematite, interlayered with thin-bedded iron silicates and carbonates, magnetite, and hematite. Unit was formed almost wholly as a chemical precipitate, with localized mechanical reworking of allochems. The iron-formation has historically been

subdivided into four members, based largely on iron mineral content. Mining of iron included extraction of high-grade, hematitic, "natural ore," which formed by percolation of oxidizing ground water along fractures, faults, folds, and bedding surfaces; and the more recent extraction of comparatively unoxidized, magnetic taconite. Rocks are deeply weathered locally within the oxidized zones.
Paq (Paleoproterozoic, Pokegama Quartzite).

Includes quartzite, quartz-rich siltstone, shale and localized basal conglemerate.

Agm, Agr, Agt (NeoArchean, Giants Range Batholith).

A multi-lithic batholith containing distinct intrusions and phases. None of the Neoarchean bedrock within the map area of Jirsa and others (2005c) has been precisely dated. Subunit Agm, the major unit near the Project Area, is quartz monzonite and monzodiorite, pink to dark greenish-gray, hornblende-bearing, coarse-grained and variably porphyritic.

Asv, Asb (NeoArchean, Minntac sequence and equivalent rocks)

Subunt Asv is schist of mafic to intermediate volcanic protholith. Typically fine- to medium-grained amphibolitic rocks containing locally recognizable pillows and other primary volcanic structures. Similar volcanic strata north of the Giants Range Batholith have been dated at approximately 2,722 million years ago. Subunit Asb is schist of sedimentary protolith. Biotite-plagioclase-quartz schist and lesser migmatite exposed discontinuously north and south of Giants Range Batholith.

Surficial Geology.

Geomorphically, the Project Site is part of the Superior Upland Province and is characterized by bedrock hills and ridges which are interspersed with peat bogs and wetlands (Olcott and Siegel, 1978). At the Mine Site, the bedrock surface appears to be hummocky, with a low rise parallel to deposit strike caused by the more resistant Unit 3. Much of the area is covered by peat/wetland deposits overlying rolling to undulating Wisconsin-aged Rainy Lobe drift. Rainy Lobe drift is generally a bouldery till with high clay content. In the region, it appears that only the Embarrass River and Dunka River basins, north of the Mesabi Range, have significant quantities of outwash (sand and gravel), with thicknesses greater than 100 ft (Olcott and Siegel, 1978; Jennings and Reynolds, 2005). Elsewhere in the region, including the Mine Site and Plant Site/Tailings Basin areas, the sediments form a thin cover over the bedrock.

More specifically, the surficial geology of the NorthMet Mine Site and Plant Site Tailings Basin areas has been recently described by Jennings and Reynolds (2005) as composed of various Quaternary deposits including postglacial deposits and deposits associated with the St. Louis sublobe and Rainy lobe. A narrow band of alluvium has been mapped along the Partridge River near the Mine Site. The map of the surficial deposits is reproduced on Figure 4.1-11B and include the following deposits in the Project Area.

Qa (Alluvium).

Interbedded fine-grained sand, fine-grained sandy loam, and silt loam. Streams incising till tend to have more gravel as a lag deposit. Shells, wood, and other organic debris are typically present in low-gradient, slack-water areas. Interpreted as the deposits of modern rivers during high-water stages.

bQp (Postglacial peat).

Organic material in various stages of decomposition. Some deposits include small bodies of open water. Interpreted as palustrine deposits that form as fresh-water lakes and shallow depressions of glacial origin fill with vegetation.

Ql (Postglacial lake sediment).

Predominantly silt, clay, and organic material that have settled to the bottom of modern lakes. Clay is most common in the deep, still portions of the basins. Sandier sediment is more common in nearshore and shallow areas where waves and wind keep finer-grained particles suspended.

Qla (Lacusstrine sediment).

Predominantly silt and clay but also includes sand. Occurs as massive layers or as interbedded laminae. Formed as sediment.discharged from the glacier settled through ponded meltwater. Gradational with other flacial lacustrine units. Unit has a flat, unpitted surface expression.

Qrt (Rainy Lobe till).

Chiefly sandy loam matrix texture (48 to 87 percent sand, 9 to 40 percent silt, 0 to 13 percent clay); variable color; unsorted sediment with common pebbles, cobbles, and boulders. Massive to vaguely stratified, with lenses of sorted sediment. More massive, compact layers are interpreted as having been deposited beneath moving ice, whereas layers with vague stratification, a higher density of clasts, and sorted beds were more likely deposited at the ice margin during moraine formation and retreat. In the glacial setting, till was easily reworked by meltwater, gravity, and wind owing to its non-cohesive nature (generally much less than 10 percent clay). Where subglacially deposited and therefore potentially over consolidated till, unit may temporarily maintain steep, artificial slopes.

Qrm (Rainy Lobe till, eroded).

As above, but eroded by water, producing a less rugged surface expression and possibly concentrating coarse-grained clasts as a lag at the surface.

Qrp (Rainy Lobe till, re-sedimented till and sorted sediment).

Forms distinct but discontinuous highlands aligned with other features that mark the transition from a glacial to a proglacial setting (for example ice-contact delta fronts). Recognized mainly by topographic expression. Interpreted as created by deposition of basal Rainy lobe till at the ice front (unit Qrt), followed by resedimentation by gravity and slope processes down a steep moraine front. The result is a poorly sorted diamicton to a sand and gravel. Facies are not laterally continuous. Where the ice fronted a proglacial lake, unit grades into deltaic landforms.

MPA (Mesoproterozoic, Paleoproterozoic, Eoarchaen, Undivided bedrock at or near surface).

Where buried, generally by till, the expression of the surface is controlled by the underlying bedrock.

4.1.1.9 Existing Wells

Mine Site

At the Mine Site, PolyMet completed three new monitoring wells within the surficial aquifer in 2005. The wells are MW-05-02, MW-05-05, and MW-05-08 and are located as shown on Figure 4.1-12. Boring logs and well completion diagrams are included in Appendix A to RS02 (Barr, 2006e). Borings for the wells were drilled into bedrock or until refusal and terminated at depths ranging from 13 to 28 ft below ground surface (bgs). Wells are screened within the surficial aquifer with bottom of screen depths ranging from 7 to 18 ft (bgs). Each well has been sampled twice, once in 2005 and once in 2006 (Barr, 2006e; 2006f; and 2007h).

PolyMet also completed nine new pumping and observation wells within the bedrock in 2005. The four pumping wells (P1 through P4) and five observation wells (Ob-1 through Ob-5 were completed in PreCambrian bedrock of the Duluth Complex and Virginia Formation and are located as shown on Figure 4.1-12. The wells were all sampled at least once in 2005 and 2006 (Barr, RS-10A, 2007x).

Tailings Basin

There are eight existing ground water monitoring wells (i.e., wells GW001 through GW008) at the Hoyt Lakes Tailings Basin (Figure 4.1-4) with ground water elevation and quality data available since June 2001. GW002 is considered the background station for the Tailings Basin. Three of the wells (GW003, GW004 and GW005) are located within Tailings Basin Cell 2W. The wells installed in Cell 2W were intended to monitor hornfels rock that was placed in the Tailing Basin and covered with tailings during 1993. Wells GW001, GW006, GW007, and GW008 are located laterally adjacent to and hydraulically downgradient from the Tailings Basin.

There appear to be no available boring logs or well completion diagrams that document the total thickness or character of the surficial aquifer to the depth of underlying bedrock beneath or surrounding the Tailings Basin. Specifically, the driller's log for the background well (GW002) does not indicate any lithologic information, only a total depth of 47 feet below ground surface. PolyMet and NTS were not able to provide any information concerning well GW001, at the northeast margin of the Tailings Basin; however, there is anecdotal information that the well may be a standpipe with unknown construction emplaced to an unknown depth in the surficial materials. Well completion logs for GW006, GW007, and GW008, at the northwest and southwest margins of the Tailings Basin indicate that the wells were completed at depths ranging from 12 to 14 ft below ground surface, but there is no record of the wells or borings encountering the underlying bedrock.

Ground water elevation data are available for GW0002, GW001, GW006, GW007, and GW008 from 2001 through 2006 and water levels have been relatively constant through the period of record (NTS, 2007). Well GW003 was dry during the April 2003 monitoring event and has remained dry to date. Static water elevations in GW004 and GW005 (located within Tailings Basin Cell 2W) have continued to decrease.

Local Wells Outside the Project Area

The Minnesota county well index (http://mdh-agua.health.state.mn.us/cwi/) was searched for existing wells which might be impacted by the proposed PolyMet, NorthMet Mine and Plant Site facilities. The well locations are tabulated in Table 4-20. No domestic wells are located up- or down-gradient between the Mine Site and the Partridge River. The tabulated wells in Table 4-20 are near the Plant and Tailings Basin sites and are reportedly used for domestic water supply. There are 27 known domestic wells between the Plant and TSF sites and the Embarrass River which may be impacted by the NorthMet facilities. The locations of these domestic wells are shown on Figure 4.1-4A. Recent well water levels and water quality data will be collected prior to preparation of the final EIS.

4.1.1.10 Hydrostratigraphy

Principal ground water resources in the Mine Site region are contained within various the bedrock geologic units and overlying peat/wetland and glacial till deposits. The aquifer testing and ground water modeling conducted by PolyMet follows earlier geologic studies and considers the principal hydrogeologic units as bedrock and surfical aquifers.

Mine Site

A detailed bedrock geologic map of the Mine Site based on Jirsa and others (2005c) is shown on Figure 4.1-13. The outlines of the proposed mine pits are

Table 4.1-20. Existing Wells Located Between the PolyMet Tailings Area and Embarrass River

Unique Well No.	Well Owner and Designation On Figure	Twp. N	Rng. W	Dir. From Site	Sect.	Sub Sect.	Depth (ft)	Use	Elev. (ft)	Depth Cased (ft)	SWL (ft bgs)	Casing Dia. (in)	Aquifer
476480	Paul F. Sherer (1)	60	15	NW	25	DABBDA	63	Dom.	1445	63	8	6	Qa
584595	Jim Grizzard (2)	60	14	N	27	BBBCDC	30	Dom.	1468	30	8.3	6	Qa
144818	Kenneth Alaspa (3)	60	14	N	22	CBBCDD	45	Dom.	1467	28	--	6	p€
668955	Tom Martin (4)	60	14	N	21	BDDCDA	50	Dom.	1459	50	15.3	6	Qa
658445	Dwight Light (5)	60	14	N	16	DDDCAA	83	Dom.	1436	81	-2	6	ggb - p€
693384	Clarance Flug (6)	59	15	W	10	ABBBCB	325	Dom.	1423	20	22	6	ggb - p€
151880	John Brouherd (7)	60	15	NW	25	ACCDCB	103	Dom.	1433	96	--	6	Multiple
189325	Paul Sherer (8)	60	15	NW	25	ACCABB	97	Dom.	1430	97	7	6	Qa
519773	Gerald Kiwhuneu (9)	60	15	NW	26	DDCDDC	42	Dom.	1417	42	5	6	Qa
169958	Dale Sperling (10)	60	15	NW	26	DACDCB	223	Dom.	1443	33	23	6	p€
411142	Reynold Kinnunen (11)	60	15	NW	26	DCBDAA	229	Dom.	1445	34	35	6	ggb - p€
409338	Uuno J. Alto (12)	60	15	NW	26	DCBCDD	43	Dom.	1429	43	25	6	Qa
563293	Milton Lerfald (13)	60	14	N	22	BADDBA	325	Dom.	1459	18	--	6	ggb - p€
555048	Rodger Porisch (14)	60	14	NNE	23	BCDDAA	45	Dom.	1459	29	0	6	ggb - p€
620123	Pat Chearon (15)	60	14	NNE	23	CBAAAB	65	Dom.	1461	18	8.2	6	ggb - p€
555023	Frank Kufrin (16)	60	14	NNE	23	ACCDAB	100	Dom.	1459	19	--	6	ggb - p€
716183	Richard Pierce (17)	60	14	NNE	23	DBB	325	Dom.	--	29	20.5	6	--
174550	Walter Salo (18)	60	13	NE	19	BCCCDD	60	Dom.	1445	50	8	7	p€
447031	Jennie Carson (19)	60	14	N	21	BCBBDC	86	Dom.	1451	86	15	6	Qa
701452	Patrick Norcha (20)	60	14	N	21	ACC	125	Dom.	--	40	8	6	--
735554	Anthony Licari (21)	60	14	N	21	DDD	205	Dom.	--	31	14	6	--
576439	Howard Kari (22)	60	14	NNW	20	CBBCBD	80	Dom.	1447	80	7.7	6	Qa
187853	Raymond Lund (23)	60	14	NNW	19	CAAAAC	90	Dom.	1465	90	--	6	Qa
529149	Einar Taapa (24)	60	14	NNW	19	DBBBBB	42	Dom.	1468	42	22	6	Qa
620143	Mary Jo Salo (25)	60	14	NNW	19	ACCCBC	61	Dom.	1469	61	34.4	6	Qa
409060	Clarence Miller (26)	60	14	NNW	19	CAA	100	Dom.	--	60	40	6	--
741400	Floyd Joki (27)	60	14	NNW	19	DAD	41	Dom	--	41	21	6	--

Notes: Q = Quaternary alluvium
p€ = Pre-Cambrian (undifferentiated)
ggb = Giants Range Granite - p€
Dom. = Domestic use.
Source: Minnesota County Well Index (http://mdh-agua.health.state.mn.us/cwi/)

also shown. Within the bedrock, the NorthMet mine pits will be located primarily within the Duluth Complex, with the Virginia Formation encountered in some locations along the northwest face of the East Pit.

Figure 4.1-13 also shows generalized geologic cross-sections. Underlying the Virginia Formation is the Biwabik Iron Formation. The Biwabik Iron Formation is a water source for residential and community wells in the local region outside the project area. The use of the Biwabik Iron Formation for water supply is possible due to its relatively high permeability, with the Virginia Formation and Duluth Complex being much less permeable (Siegel and Ericson, 1980). The Biwabik Iron Formation will not be encountered by the proposed mine pits.

The depth to ground water across the Mine Site is generally less than five feet below ground surface (Barr, RS02, 2006e). Investigations at the Mine Site determined that the surficial sediments ranged from very dense clay to well-sorted sand (Barr, RS02, 2006e; Golder Associates, Inc. (Golder), RS49, 2007). PolyMet advanced ten shallow borings through the surficial sediment at the Mine Site, and (nine of ten borings) encountered bedrock at depths ranging from four to 17 feet below ground surface. Fifteen test trenches were extended either to bedrock refusal or to 20 feet which was the limit of the track hoe reach. Bedrock was encountered in 13 of the 15 test trenches at depths ranging from 3.5 to 15 feet below ground surface (RS49, Golder, 2007).

In general, the surficial sediments are poorly sorted and contain numerous cobbles and boulders. The surficial sediments across the Site are heterogeneous, ranging from very dense clay to well-sorted sand. The test trenches typically encountered up to 6 inches of topsoil over primarily silty sand with boulders and cobbles (Golder, RS49, 2007). Sandy lean clay and sandy silt were encountered in two test trenches; three other trenches encountered layers of relatively clean sand. A highly compacted clay unit with numerous pebbles was encountered just above the bedrock surface in several of the borings (Barr, RS02, 2006e).

The Site exploration drilling database, drilling logs and geophysics (electrical resistivity) data were used to develop an estimated depth to bedrock isopach map (Golder, RS49, 2007). The isopach map indicates that more than 75 percent of the surficial cover is 20 feet thick or less, and 92 percent is less than or equal to 30 feet in thickness. Although the isopach contouring indicates local depressions in the bedrock where estimated surficial cover thickness reaches 50 feet, no major thicknesses of highly permeable outwash sands and gravel that might act as ground water conduits through the cover have been reported.

Tailings Basin/Plant Site area

There are no available boring logs or well completion diagrams that document the total thickness or character of the surficial aquifer to the depth of underlying bedrock. No new data detailing the composition of the surficial aquifer at the Tailings Basin area have been collected, although results of aquifer testing in uppermost part of the surficial aquifer are available.

Jennings and Reynolds (2005, see Figure 4.1-11B) map the surficial deposits beneath and around the Tailings Basin as Rainy Lobe till and modern lake sediments (i.e., the Tailings Pond) overlying till. The Tailings Basin was constructed adjacent two high exposures of bedrock, such that the east and south side of the Tailings Basin abut bedrock. The surficial aquifer therefore likely exists beneath the majority of the Tailings Basin and extends north into the Embarrass River Watershed.

South of the surface drainage divide with the Second Creek (Knox Creek) Watershed (Figure 4.1-1), Jennings and Reynolds (2005, Figure 4.1-11B) map the deposits beneath and around Second (Knox) Creek as Rainy Lobe till and modern lake sediments overlying till, similar to the surficial aquifer north of the drainage divide. Although not shown on the Jennings and Reynolds (2005) surficial geologic map, PolyMet has developed geologic cross-sections (see Figures A-6-2-1 and 2-2 in RS 13, Barr, 2007e) that map a layer of thin (0 to 50 ft thick) till extending from beneath Cell 1E and the southern part of Cell 2W in the Tailings Basin to the headwaters of Second Creek (Knox Creek). The surficial aquifer may therefore be thin but continuous beneath the Tailings Basin to the Second (Knox) Creek Watershed.

Jennings and Reynolds (2005) also map a "potential aquifer" in the area of a gravel pit near the NTS and PolyMet office complex south of the Plant Site. They defined a potential aquifer as "exposed sand and gravel features located in outcrops that could potentially be or become aquifers". No other information about the aquifer, particularly its lateral and vertical extent, is available. There are no other mapped potential aquifers in the project area, either at the Mine Site or the Tailings Basin/Plant Site areas.

4.1.1.11 Aquifier Hydraulic Characteristics

Aquifer tests were conducted at the Mine Site to determine aquifer properties of the Surficial Aquifer, and the Duluth Complex and Virginia Formation bedrock aquifers. The Virginia Formation directly underlies the seven Duluth Complex units which will be mined at the Site as shown on Figures 4.1-13. The aquifer testing did not include completing a well in the underlying Biwabik Iron Formation. However, PolyMet has developed a ground water model that incorporates the more permeable Biwabik Iron Formation as a distinct unit, and the ground water model can be used to evaluate possible project impacts to this aquifer.

Polymet did not perform aquifer testing in the bedrock aquifer in the Tailings Basin area. A ground water model that was developed for the Tailings Basin area was calibrated to head and flux targets, which provides a good approximation for the aquifer characteristics of the surficial deposits. However, the groundwater model does not incorporate underlying bedrock. These potential data gap for bedrock aquifer hydraulic parameters at the Trailings Basin will be addressed if it is determined that these are necessary in order to issue permits for compliance groundwater monitoring wells; as described in the monitoring and mitigation sections of this EIS (Section 5), installation of new groundwater monitoring wells for the Tailings Basin area will be recommended.

Surficial Sediments

PolyMet advanced ten shallow borings through the surficial sediment at the Mine Site (nine of ten encountered bedrock) using Rotosonic drilling techniques in order to visually inspect core, collect high quality samples for geotechnical testing, and conduct single-well aquifer tests (Barr, RS02, 2006e). The ability of the surficial sediment to transmit water was found to be highly variable depending upon location and thickness of the sediments, as recognized in other studies (Adams, et al., 2004; Siegel and Ericson, 1980). Lab permeability tests on the silty sand found the hydraulic conductivity to be 0.00043 to 0.0081 ft/day, while field testing (single-well tests) of the various unconsolidated deposits found a range in hydraulic conductivities of 0.012 ft/day to 31 ft/day. No data is known about the storage parameters for the surficial deposits.

At the Tailings Basin area, PolyMet performed single well “slug tests” in standpipe piezometers in the surficial glacial till where a volume of water was displaced and the depth to water recorded over a measured period of time until equilibrium was reached (Barr, 2008x). The average permeability determined was 0.031 ft/day within a range of 0.00026 to 0.2 ft /day.

Duluth Complex

PolyMet conducted single-well aquifer tests on ten exploration borings completed in the Duluth Complex. The hydraulic conductivity values measured in the Duluth Complex boreholes ranged from 2.6 x 10-4 ft/day to 4.09 x 10-2 ft/day, with a geometric mean of 2.3 x 10-3 ft/day (Barr, RS02, 2006e). As a comparison, the average hydraulic conductivity determined from earlier specific capacity tests conducted in the underlying Biwabik Iron-Formation wells was 0.9 ft/day (Siegel and Ericson, 1980).

Virginia Formation

A second hydrogeologic investigation conducted by PolyMet focused on determining the hydraulic properties of the Virginia Formation (Barr, RS10, 2006f). Four 6-inch diameter pumping wells and five 2-inch diameter observation wells were installed near the contact between the Virginia Formation and the Duluth Complex, near the northern boundary of the proposed NorthMet Mine open pits. A pumping test was conducted at each pumping well, three 36 hour tests and one 96 hour test. Prior to, during, and following the tests, water levels in the pumping well and observation wells were recorded to determine hydraulic parameters over a larger area than is sampled in single-well tests. These data were analyzed using conventional analytical methods to determine hydraulic properties of the Virginia Formation. Hydraulic conductivities calculated from the measured water level data ranged from 0.0024 to 1.0 ft/day. The geometric mean was 0.17 ft/day. As part of the analysis of the multiple well aquifer tests discussed above, a range of specific storage values for the bedrock of 2.3×10^{-5} to 5.5×10^{-7} ft^{-1} was determined from time-drawdown data at observation wells. The limited amount of data on the aquifer storage parameters makes estimating pit dewatering flow volumes more difficult; however, uncertainty is accounted for by using a range of possible storage parameters in the groundwater modeling that was conducted for the project.

A third hydrogeologic investigation was conducted by PolyMet to perform additional specific capacity (single-well) tests on wells completed in the Virginia Formation (Barr, RS10A, 2007h). The specific capacity tests conducted in two wells indicated that the upper portion of the Virginia Formation is more permeable than the lower portion. This is attributed to the increased amount of secondary porosity features such as fractures and joints in the bedrock closer to the surface. Analysis of the test results yielded a hydraulic conductivity value of 0.047 feet per day for the Virginia Formation, consistent with previous test results.

Connection Between Bedrock and Surficial Aquifer

The third hydrogeologic investigation conducted by PolyMet also evaluated the possible effects of mine dewatering on the wetland areas in the vicinity of the Mine Site. In order to test the connectivity between the bedrock, overlying surficial deposits, and overlying wetlands, a multiple well pumping test that consisted of a pumping well in the bedrock together with observation points in the adjacent bedrock and the overlying surficial/wetland sediments was conducted. Pumping of the bedrock well resulted in slight (< 1 ft), drawdown observed in the nearest deep piezometer completed in the surficial aquifer, but there was no detectable drawdown in an adjacent shallow wetlands piezometer, or in more distant deep surfical aquifer piezometers or shallow water table wetland piezometers. However, the amount of drawdown in the bedrock at the more distant locations was not established. Thus the results of the testing were generally inconclusive and the potential for widspread drawdown of the water table within the surfical and wetlands deposits cannot be evaluated from the available study.

4.1.1.12 Ground Water Movement

Saturated conditions exist within the unconsolidated deposits at the Mine Site and Plant Site/Tailings Basin in bedrock underlying surficial deposits (Figure 4.1-14). Because of the shallow water table and thin nature of the surficial aquifer, flow paths within the surficial deposits are generally thought to be short, with the recharge areas being very near the discharge areas. Ground water divides generally coincide with surface water divides. However, ground water flow is interrupted by bedrock outcrops, which force deviations in the ground water flow field (Siegel and Ericson, 1980).

Recharge to the bedrock aquifers is by infiltration of precipitation in outcrop areas and leakage from the overlying surficial aquifers (Siegel and Ericson, 1980). Ground water flow within the bedrock units is thought to be primarily through fractures and other secondary porosity features because the rocks have low primary hydraulic conductivity. Near the surface, ground water in the bedrock is thought to be hydraulically connected with the overlying surficial aquifers, resulting in similar flow directions (Barr, RS22, 2007f).

PolyMet developed a regional water table map (Figure 4.1-14) for the Project Area. The map is based on modeling results (Barr 2007e, 2007f), elevation data for surface water features, and data presented in Siegel and Ericson (1980). The water table is primarily located within the surficial aquifer materials but is likely located within the bedrock in areas of local bedrock highs.

At the Plant Site, ground water flow is to the south towards Second (Knox) Creek. From the Tailings Basin, the majority of ground water flow is to the north towards the Embarrass River. At the southern end of the Tailings Basin, there is some flow to the south, from existing Cell 1E to the headwaters of Second Creek. This ground water divide between flow going north to the Embarrass Rivr and flow going south to Second (Knox) Creek is attributable to the pre-existing divide over which the Tailings Basin was constructed.

As the Tailings Basin was built up over time, a ground water mound formed beneath the basin due to seepage from the various basins. Seeps have been identified on the south, west, and north sides of the Tailings Basin (Figure 4.1-4 and Table 4-8). The east side of the Tailings Basin is bounded by low-permeability bedrock uplands and there is likely little or no water that seeps out in this direction. In addition to the visible seeps, ground water likely flows out from beneath the tailing basin into the surrounding glacial till to the south, west, and north of the basin.

At the Mine Site, PolyMet has developed sufficient data to map ground water elevations within the surficial deposits and the bedrock units as shown on Figures 4.1-15 and 4.1-16. Figure 4.1-15 shows water levels measured in the wetland piezometers installed at the Mine Site (PolyMet Mining, Inc., 2006). The bedrock potentiometric surface contours are based on water levels collected from bedrock monitoring wells and exploratory boreholes during December 2006 (Figure 4.1-16). Local incision of the Partridge River north of the site captures some surface water and ground water flow, and develops a local ground water divide at the northern margin of the Mine Site.

In general, however, ground water at the Mine Site flows to the south with the major component from the north-northwest direction to south-southeast, perpendicular to the strike of the bedrock geologic formations. Ground water flow from the Mine Site is to the Partridge River, the major discharge point for the area.

4.1.1.13 Ground Water Flow Models (MODFLOW)

Ground water flow within fractured bedrock, such as at the Mine Site, can be simulated using conventional porous media modeling codes if the model scale is sufficiently large and bedrock fractures are sufficiently interconnected that the fractured rock medium behaves similar to a porous medium. By assuming that the aquifer acts as an equivalent porous medium at the scale of the problem, it is possible to use the standard porous media modeling code MODFLOW (McDonald and Harbaugh, 1988; Harbaugh, et al., 2000). Overlying glacial drift can be simulated with MODFLOW, although here the greatest difficulty is representing the heterogeneous nature of the sediments. Again, a MODFLOW model is useful if the scale of the heterogeneities is small relative to the features of interest, such as the Mine Site or Tailings Basin facilities.

PolyMet has prepared detailed reports describing two MODFLOW models, one developed for both the Mine Site (RS22, Barr, 2007f) and the other for the Tailings Basin (RS13, Barr, 2007e). ,PolyMet states that these models were constructed chiefly to assess operational conditions, specifically dewatering of the proposed mine pits and additional mounding, seepage simulations for the Tailings Basin. Because the models were calibrated to present-day conditions, they are also useful for assessing and describing existing ground water conditions. However, there are some fundamental limitations of the numerical flow models for predicting impacts at both major facilities that will also be described.

It should be noted that model results are necessarily generalized outside the areas where there are model calibration targets. This means that simulated potentiometric surfaces (presented below, excepting Figure 4.1-14, above), outside the calibration areas, should not be considered as necessarily accurate indications of the ground water levels. Additional uncertainty in the model predictions is due to the fact that they do not incorporate possible future operations at other existing adjacent mines. The Peter Mitchell Pit, located north of the Mine Site, has historically been dewatered periodically, and the future operation of the pit cannot be anticipated or simulated. .

4.1.1.14 Regional Model

A single-layer model of the regional area surrounding the Mine Site and Tailings Basins was constructed. The purpose of the model was to provide the boundary conditions for a smaller, local-scale model for the Mine Site area embedded in the regional model. This approach for linking regional and local scale models is called Telescopic Mesh Refinement (TMR) (Ward, et al., 1987).

The regional model consisted of a single model layer covering approximately 1,000 square miles (Barr, 2007f, RS22, Appendix B). The model boundaries extend about 15 miles further south, 5 miles north, and 10 miles east and west of the mapped area shown on Figure 4.1-14, sufficiently far from the Mine Site so that the no-flow boundaries would not affect ground water flow predictions at the Mine Site. The character of bedrock was determined spatially by geologic map outcroppings of the various bedrock units. The bottom elevation of the model was set below the maximum depth of the proposed open pits at an elevation of 640 feet above mean sea level (MSL). A uniform grid with a spacing of 500 meters (1,640 feet) was used.

Hydraulic Conductivity Distribution

Hydraulic conductivity distribution was based on the bedrock geology of the area (Jirsa and others, 2005c). Four zones were used, with a single zone representing each of the four major bedrock formations: the Biwabik Iron Formation, Giants Range Formation, the Duluth Complex, and the Virginia Formation. Hydraulic conductivity values for the Biwabik Iron Formation and the Giants Range batholith are from Siegel and Erickson (1980). The hydraulic conductivities of the Duluth Complex and the Virginia Formation were set as the geometric mean of values determined in the aquifer test studies for the EIS. Hydraulic conductivity values used in the Regional Model are shown in Table 4.1-21.

Calibration and Results

The regional model for bedrock was calibrated to 25 head values measured in wetlands piezometers in the central, Mine Site area of the model (Figure 4.1-15).

The calibration to steady-state conditions used the automated calibration capabilities of MODFLOW-2000 (Hill, et al., 2000) with the value of recharge allowed to vary within expected upper and lower ranges. The final calibrated valued for recharge was 0.001 inches/year.

The near zero recharge value is consistent with regional hydrologic water budgets described by Siegel and Ericson (1980), who state that underflow (i.e. ground water flow within bedrock moving to a discharge zone outside the regional domain) can be considered to be zero in this terrain. With near zero recharge, ground water in the model bedrock must come from or go to surface water features, and heads are established independently of recharge. The allows the TMR model to have fixed heads at the periphery and to be further calibrated with positive recharge over a smaller domain independent of the regional model.

The purpose of the regional model was to provide the head values at the periphery of the local-scale TMR model, and the difference in head values between bedrock and surfical aquifers in the center of the model is not critical. The model calibration residual errors were approximately 10 to 15 percent difference in head (observed minus calibrated) relative to the total range of ground water levels in center of the model. The regional model calibration was considered to be acceptable for use with the local-scale TMR model. However, the calibrated potentiometric surface was not considered by PolyMet to be realistic outside the Mine Site area, and was therefore not presented. PolyMet has provided Figure 4.1-14 as the determination of the regional-scale potentiometric surface.

Table 4 .1-21 Hydraulic Conductivity Values used in the MODFLOW Models

Model	Hydrogeologic Unit	Hydraulic Conductivity(ft/day) Horizontal (Kx, Ky)	Hydraulic Conductivity(ft/day) Vertical (Kz)
Regional	Duluth Complex (Regional Model)	0.0014	1 Layer Model
	Virginia Formation (Regional Model)	0.33	
	Biwabik Iron Formation (Regional Model)	0.72	
	Giants Range Batholith	0.029	
Local Scale (Site)	Wetland Deposits	9.3	0.0000033
	Glacial Drift	2.6	0.0000033
	Duluth Complex (Local Model)	0.0024	0.0024
	Virginia Formation – Upper Portion	0.34	0.34
	Virginia Formation – Lower Portion	0.085	0.085
	Biwabik Iron Formation (Local Model)	0.98	0.98
	Giants Range Batholith	0.029	0.029
TSF	LTV Coarse Tailing	0.14	0.14
	LTV Fine Tailing	0.028	0.028
	Native Drift	80	8
	Bedrock	0.000024	0.000024

4.1.1.15 Local Scale Model for the Mine Site

A grid covering an area of approximately 100 square miles was extracted from the Regional Model and used for the Local-Scale Model (Figure 4.1-17). The model grid was further discritized at the Mine Site with the final grid coarser (cells of approximately 100 to 200 meters on a side) outside of the area of interest and more refined at the Mine Site (cell size of 10 to 30 meters).

In anticipation of mine pit development, the Local-Scale Model was vertically discritized into eight layers; seven layers simulating the various bedrock units and one layer simulating the surficial deposits (Table 4.1-22). The use of a single surficial layer does not allow wetlands to be simulated as potentially perched overlying the surficial glacial deposits which is not consistent with the design of the pumping test with shallow and deep piezometers described in "Connection Between Bedrock and Surficial Aquifer", above. Thus the MODFLOW model for the Mine Site cannot be calibrated to simulate potential impacts to wetlands separately from surficial glacial till.

In the bedrock, vertical descritization was needed to accurately simulate the footwall and headwall geology of the pit at various stages of pit development. The bottom of Layer 1 was set equal to the bedrock-surface elevation as defined in RS49 (Golder, 2007). The bottom elevations were modified slightly in some locations to prevent portions of the layer from going dry during model simulations. Bottom elevations for Layers 2 through 7 were set to correspond to the elevations of major benches in the mine pits and pit bottom elevations at various stages of development. The bottom elevation for Layer 8 was set at -65 feet MSL, which corresponds roughly to the estimated bottom elevation of the Biwabik Iron Formation at the Mine Site. Model layer bottom elevations are shown in Table 4.1-22

Table 4.1-22: Local-scale (Mine Site) MODFLOW Model Bottom Elevations

(ft MSL)
Layer 1:1400 – 1585
Layer 2: 1,350
Layer 3: 1,270
Layer 4: 1,050
Layer 5: 890
Layer 6: 700
Layer 7: 330
Layer 8: -65

Boundary Conditions

The lateral model boundaries were extracted from the regional model as constant head cells as shown in Figure 4.1-17. The starting head values correspond to the regional model's simulated values at these locations. Additional boundaries, such as constant head cells simulating the water levels in the Peter Mitchell Pit, were added during the calibration process. Figure 4.1-17 shows the final boundary conditions in Layer 1 of the model.

Hydraulic Conductivity Distribution

Five hydraulic conductivity zones were used to simulate the bedrock units in the local-scale model: one zone for the Duluth Complex, two zones for the Virginia Formation, one zone for the BIF, and one zone for the Giants Range batholith

(Table 4.1-21). The upper portion of the Virginia Formation is approximately twice as permeable as the lower portion. A three-dimensional picture of the dipping formation contacts developed by PolyMet (Barr, RS78, 2007i) was used to assign hydraulic conductivity zones that defined the extent of dipping formations in each horizontal model layer.

The single surficial aquifer Layer 1 was attributed with two hydraulic conductivity zones: one zone with the properties of wetland deposits and one zone for glacial deposits. Boundaries of the wetland deposits were based on the wetland delineation presented in RS14 (Barr, 2006g). For these two zones, hydraulic conductivity was assumed to be laterally isotropic and vertically anisotropic. The hydraulic conductivity of the two zones was calibrated, and Table 4.1-21 shows the final hydraulic conductivity values used in the Local-scale Model. The calibrated vertical hydraulic conductivity of the wetland and glacial materials is identical (which is unrealistic but likely a consequence of putting both types of deposits adjacent in a single layer) and low, corresponding to 1×10^{-9} cm/sec. This may have the effect of limiting recharge into the model, and may also limit simulated interchange between the bedrock and surfical aquifers.

Recharge Distribution

The same two zones that were used to represent the hydraulic conductivity of the surficial deposits were used to represent recharge in the Local-Scale Model. Recharge was applied to the upper-most active layer. Recharge values were allowed to vary during model calibration. The final recharge values used in the Local-Scale Model are as follows:

- Recharge to wetland deposits = 0.3 inches per year
- Recharge to the glacial deposits = 1.5 inches per year

These recharge rates are consistent with the ground water recharge rate that was predicted by the XP-SWMM model of the Mine Site area, which was calibrated to stream flow data in the Partridge River (Barr, RS73A, 2006d)). This model used an average recharge rate of 0.84 inches per year.

Calibration and Results

The Local-scale Model was calibrated to steady-state using a combination of traditional trial-and-error methods and automated calibration methods. Automated calibration was conducted using MODFLOW-2000 (Hill, et al., 2000). The calibrated local scale model generally matches the head calibraton targets and general flow directions in both the unconsolidated deposits and the bedrock. The predicted baseflow in the Partridge River at monitoring station SW004 was 1.49 cfs, compared to the target baseflow of 1.43 cfs. Overall, the calibration was determined to be acceptable given the modeling objectives.

The steady-state Local-scale MODFLOW model for the Mine Site area was converted to a transient predictive model to assess project dewatering and impacts, as described in Section 4.1.3. However, no transient calibration was performed.

4.1.1.16 Tailings Basin

The MODFLOW model for the Tailings Basin covers approximately 18 square miles and is described in detail in RS 13 (Barr, 2007e). The model domain extends from the Embarrass River in the north and west to the south and east of the historic LTV mine pits (i.e., south of LTV Pits 1, 2, 3 and 2WX and east of LTV Pits 5S and 5N) . The lateral extent of the model area is sufficiently large and distant from the area of interest that the model boundaries do not meaningfully affect the model results at the Tailings Basin. However, as described the below, use of internal boundary conditions further restricts the effective area of model simulation to the Tailings Basin facilities alone.

The calibration model simulating current conditions has two layers: Layer 1 representing the LTVSMC tailings basin and Layer 2 representing the underlying native material. The bottom elevation for Layer 2 was defined as the top of bedrock. Topographic information from the Minnesota Geological Survey was used to define the elevations of the pre-mining and bedrock surfaces. The exception to this was in the area of the Embarrass Mountains, where the water table is likely located within the bedrock hills. In this area, the bottom of Layer 2 is lowered and the bedrock is simulated as a zone of low hydraulic conductivity. This was necessary to prevent dry cells in Layer 2.

Hydraulic Conductivity Distribution

Six hydraulic conductivity zones were used in the model to simulate the varying geologic material and tailings (Table 4.1-21). In the baseline calibration model, two zones were used to represent the LTVSMC tailings—one for the fine tailings and one for the coarse tailings, one zone was used to represent the native unconsolidated material, and one zone was used to represent the bedrock hills, as discussed above. Table 4.1-21 also summarizes the hydraulic conductivities used for each material in the calibration ground water model. The LTVSMC tailings and the bedrock were assumed to be isotropic (i.e. Kx = Ky = Kz). The glacial drift was assumed to have a vertical anisotropy ratio (Kx/Kz) of 10.

Hydraulic conductivity values for the LTVSMC tailings were taken from the SEEP/W modeling described in RS39/40 (Barr, 2007j). Hydraulic conductivity values for the native materials, the drift and bedrock, were allowed to vary during model calibration within expected ranges.

Boundary Conditions

Internal boundaries were used to represent surface-water features within the model domain. Streams and rivers were simulated with elevations obtained from USGS 7.5' quadrangle maps. The River Package in MODFLOW was used to simulate area wetlands as head-dependent boundaries Wetland areas were based on the USGS's countywide lake shapefile. This means that the effective area for model simulation is restricted to the perimeter of the tailings, particularly on the north side and west sides of the facility where the MODFLOW river cells are located at the toes of the tailings embankments

The pools of water in Cells 1E and 2E were simulated as constant head boundaries. For the steady state calibration, the heads were set based on water levels reported in the East Range Hydrology Study (Adams, et al., 2004). The Recharge Package for MODFLOW was used to simulate the infiltration of precipitation within the model domain. Recharge was applied to the uppermost active layer and was allowed to vary during the calibration process. Zones of high recharge were used above Cell 2W in order to reproduce the ground water mound within the basin.

Calibration and Results

Calibration of the ground water flow model was accomplished using traditional trial-and-error methods. The steady-state model was calibrated to hydraulic head (water level) targets measured on or around February 2002. The target locations are throughout the model domain with targets in Layers 1 and 2. The model calibration was complicated by the fact that the system is not actually at steady-state. The calibration period of February 2002 represents the period shortly after LTVSMC operations at the tailing basin ceased, which coincides with the period that was simulated as part of the East Range Hydrology Project (Adams et al., 2004). After Cell 2W dried up (prior to 2002), the water-table mound beneath the basin started to dissipate and was still dropping in 2002. This mound is artificially simulated in the model using zones of high recharge.

The calibration focused on matching the general head distribution within the basin and surrounding drift and did not attempt to match every individual target. The total range in head targets was 302 ft. In addition to matching measured heads, model calibration focused on matching seepage rates at the seeps south of Cell 1E (seeps 32 and 33 and Knox Creek Headquarters as described in Table 4.8). A flow rate of 554 gpm was measured at this location in May, 2002. Model simulated flow at for these seeps was 570 gpm.

The steady-state calibration MODFLOW model for the Tailings Basin area was converted to a transient model to assess project operations and impacts, as described in Section 4.1.3

4.1.1.17 Ground Water Quality

Regulatory Information

In Minnesota underground waters are protected for just one use: an actual or potential source of drinking water. All ground water in PolyMet's NorthMet Project area is, therefore, designated as Class 1 waters, with the applicable water quality standards being, with minor exception, the USEPA primary and secondary drinking water standards.

It is noted that Minnesota Rules Chapter 7060.0600 also has a provision that states

> *"The groundwater may in its natural state have some characteristics or properties exceeding the standards for potable water supplies. 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 ground water quality standards that the project will be required to meet and the compliance locations will be established during the permitting process. Ground water quality standards are published in Minnesota Rules 4717.7500 Table of Health Risk Limits (HRLs). The Minnesota water quality standards for ground water constituents being evaluated as part of this EIS are given Table 4.1-23.

When the USEPA primary or secondary drinking water standard concentrations are greater than the Minnesota standard for a given class water, the Minnesota standard will apply. This may occur for chloride, mercury, sulfate, as well as other constituents shown in Table 4.1-23.

Table 4.1-23: Minnesota Ground Water Standards Applicable to the Project for EIS Evaluation

		EPA	MDH	EPA
		MCL	**HRL**	**sMCL**
Antimony	ug/L	6	6	--
Arsenic	ug/L	10	--	--
Barium	ug/L	2,000	2,000	--
Beryllium	ug/L	4	0.08	--
Boron	ug/L	--	600	--
Cadmium	ug/L	5	4	--
Calcium		--	--	--
Chromium, total	ug/L	100	--	--
Chromium Hexavalent	ug/L	--	100	--
Chromium Trivalent	ug/L	--	20,000	--
Cobalt	ug/L	--	--	--
Copper	ug/L	1,300	--	1,000

		EPA MCL	MDH HRL	EPA sMCL
Iron	ug/L	--	--	300
Lead (TT)	ug/L	15	--	--
Magnesium		--	--	--
Manganese	ug/L	--	*100**	50
Mercury	ug/L	2	--	--
Nickel	ug/L	--	100	--
Selenium	ug/L	50	30	--
Silver	ug/L	--	30	100
Thallium	ug/L	2	0.6	--
Tin	ug/L	--	4,000	--
Vanadium	ug/L	--	50	--
Zinc	ug/L	--	2,000	5,000
Other parameters				
Sulfate	ug/L	--	--	250,000
Alkalinity		--	--	--
Chloride	ug/L	--	--	250,000
Fluoride	ug/L	4,000	--	2,000
Hardness		--	--	--
Potassium		--	--	--
Sodium		--	--	--
Nitrogen as nitrate	ug/L	10,000	10,000	--
Nitrogen as ammonia		--	--	--
Aluminum	ug/L		--	50 to 200
Molybdenum	ug/L	--	--	--
Groundwater Criteria:				
sMCL - Secondary MCLs (40 CFR 143) based on aesthetics.				
MCL - Maximum Contaminant Levels (40 CFR 141)				

HRLs - Health Risk Limits - (MN Rules 4717.7500)
* While a HRL was promulgated for this chemical, due to research that has become available since the HRLs were promulgated, the MDH no longer recommends the HRL value.

Recent (2005 – 2007) ground water samples collected by PolyMet from the Mine Site and Tailings Basin areas data are compared to the Minnesota surface water and ground water water quality standards (Tables 4.1-12 and 4.1.23) and the results summarized in the following table (Table 4.1-24). The purpose of the comparison table is to both make a comparison to ground water standards and also to illustrate that there are presently background concentrations of a number trace metals in ground water that are high with respect to surface water standards. As discussed under *Ground Water Movement* (above), due to the shallow water table it may be important to know that ground water from the surficial aquifer reporting to wetlands might exceed surface water quality standards as well as ground water quality standards. The exceedances noted in Table 4.1-24 are described in detail for the surficial and bedrock aquifers in sections below.

Chemical Characteristics of Ground Water

At the Mine Site ground water samples have been collected from wells and boreholes recently completed in the surficial aquifer, the Virginia Formation and the Duluth Complex at the Mine Site (RS02, RS10, RS10A, respectively, Barr, 2006e; 2006f; and 2007h), At the Tailings Basin area, historical data are available from several sources as compiled in Knight Piésold (2007a). Recent data for ground water samples from the surficial aquifer are ground water samples from the surficial aquifer are also available for wells in the Tailings Basin area (RS64, Barr, 2006c;RS74, Barr, 2008x). Sampling locations are shown on Figures 4.1-4 and 4.1-12. .

Table 4.1-24: Summary of Constituents Not Meeting Water Quality Standards in PolyMet 2005 to 2007 Baseline Ground Water Samples

Aquifer	Locations (as shown on Figures 4.1-4 and 4.1-12)[(1)]	Constituents not Meeting Class 2B Surface Water Standards (Table 4.1-12)	Constituents not Meeting Minnesota Ground Water Standards (Table 4.1-23)
Tailings Basin			
Surficial Background	**GW002**	**Al, Co, Cu, Ni, Pb, Hg**	**Al, Fe, Mn**
Surficial Downgradient	**GW001, GW006, GW007, GW008**	**NH_3, Al, Cu, Pb, Hg**	**F, Al, Fe, SO_4, Mn**
Mine Site			
Surficial	**MW0502, MW0508, MW0509**	**NH_3, pH, Al, Cr, Co, Cu, Ni, Pb, Hg**	**pH, Al, Be, Fe, Mn**
Duluth	**OB1, OB2**	**Hg**	**pH, Fe**
Virginia	**OB3, OB4, OB5, P-3, P-4**	**NH_3, pH, Al, Hg, Ni**	**pH, Al, Fe, Mn**
Duluth + Virginia	**P-1, P-2**	**NH_3, Zn**	**Be, SO_4 , Fe, Mn**

(1)Not all parameters exceed at each location.

Surficial Aquifer Water Quality.

At the Mine Site three monitoring wells are completed within the surficial aquifer. Each well has been sampled twice, once in 2005 and once in 2006. Surficial aquifer water quality sampling results are given in Table 3 of the PolyMet hydrogeologic investigation (RS10A, Barr, 2007h).

The mine area ground water within the surficial aquifer has elevated (i.e., at or higher than the Minnesota ground water standards in Table 4.1-23) of total aluminum (31.6 – 27100 µg/L) and dissolved aluminum (<25 – 910 µg/L); total beryllium (<0.2 – 0.7 μg/L), total iron (54.3 – 29800 μg/L) and total manganese (<30 - 584 μg/L). There were detected concentrations of total and dissolved chromium (<1 – 55 μg/L), total cobalt (<1 – 8.8 μg/L), total copper (2.4 – 99.6 μg/L), total lead (<1 – 6.1 μg/L), total mercury (<0.002 – 0.0288 μg/L) and total nickel (<2 – 40.2 μg/L). The above metals described as detected were at concentrations below ground water standards but, in some cases, were above surface water standards (Tables 4.1-12, 4.1-24). Methyl mercury was detected in two samples at concentrations of 0.043 - 0.13 nanograms per liter. Ammonia nitrogen was detected in two samples at concentrations of <100 to 420 2 μg/L. The pH of water samples generally varied from 6.5 to 7.7 with a value of 10 in one sample.

The metals exceeding surface water standards in the surficial aquifer (chromium, cobalt, copper, lead, mercury, and nickel) can be considered as background constituents. Whether or not these present-day background metals are entirely due to natural process or represent an impact from previous activities cannot be determined. The natural presence of some of these constituents is consistent with the findings presented in the U.S. Geological Survey Copper-Nickel Study Region report (see Table 6 in Siegel and Ericson, 1980), which found elevated concentratons (i.e., at or higher than the Minnesota ground water standards and/or surface water standards, respectively in Tables 4.1-23 and 4.1-12) of cadmium (up to 8.4 ug/L), cobalt (up to 46 ug/L), copper (up to 190 ug/L), lead (up to 6.4 ug/L), nickel (up to 120 ug/L) and zinc (up to 170 ug/L) in groundwater samples collected from the surficial material (glacial till) overlying the Duluth Complex. The study also found elevated concentrations of iron (up to 3.1 mg/L), aluminum (up to 200 ug/L), and manganese (up to 7.1 mg/L) in the surfical/till aquifers (see Table 6 in Siegel and Ericson, 1980). Siegel and Ericson (1980) noted that higher concentrations correlated with proximity to the mineralized contact zone between the Duluth Complex and older rocks, and is probably related to the oxidation of sulfide ores at the contact zone.

At the Tailings Basin five monitoring wells are completed in the surficial aquifer, and historical monitoring of indicator constituents such as specific conductance, total dissolved solids, and sulfate at these wells indicates that surficial ground water in the vicinity of the Tailings Basin has concentrations greater than water quality standards. The historical monitoring is summarized in Knight Piésold (Appendix A, 2007a). The areal extent of this historical impact is unknown due to the lack of other down gradient monitoring wells and because no additional monitoring wells have been installed.

Additional sampling at the five monitoring wells for all project-specified constituents was also completed in 2007 (RS74B, Barr, 2008x). At background well GW002, ground water within the surficial aquifer had elevated (i.e., at or higher than the Minnesota ground water standards in Table 4.1-23) total aluminum (9800 – 16000 μg/L), total iron (12000 – 18000 μg/L), and total manganese (230 – 340 μg/L). There were detected concentrations of total cobalt (4.2 – 7.9 μg/L), total copper (17 – 32 μg/L), total lead (2.6 – 4 μg/L), total mercury (one sample with 0.008 μg/L) and total nickel (15 – 32 μg/L). The above metals described as detected were at concentrations below ground water standards but, in some cases, were above surface water standards (Tables 4.1-12, 4.1-24).

The four downgradient ground water monitoring wells at the Tailings Basin (GW001, GW006, GW007 and GW008) were generally similar to the background well in terms of elevated metals concentrations, with the addition of elevated (i.e., at or higher than the Minnesota ground water standards in Table 4.1-23) sulfate (220 – 430 mg/L) and fluoride (1.7 – 2.6 mg/L) at GW006, and also detected ammonia nitrogen (130 – 150 μg/L) and total cadmium (0.98 μg/L) at GW001. Methyl mercury was not detected in any of the Tailings Basin groundwater monitoring well samples at a reporting limit concentration of 0.05 nanograms per liter.

A separate report (NTS, 2007) concluded that ground water has been impacted by the Tailings Basin based on comparison of GW006 and GW007 monitoring results to those of GW002 (the background well). All comparisons are done with respect to limits established in NPDES/SDS Permit MN0054089. Ground water monitoring data and analyte concentration trends are presented graphically as Figures 2A through 2H in NTS (2007). Included on the graphs are the ground water instantaneous maximum limits and instantaneous maximum intervention limits established within the Permit for ground water monitoring stations. Instantaneous maximum intervention limits have been routinely exceeded for boron, fluoride, manganese, and molybdenum at wells GW006 and GW007. In addition, instantaneous maximum limits have been routinely exceeded for manganese, molybdenum, and Total Dissolved Solids (TDS) at wells GW006 and GW007.

NTS (2007) further noted that, although limits had been exceeded within ground water, there does not appear to be an overall trend (i.e., either increasing or decreasing) in concentration of constituents monitored. The exception was TDS and sulfate which appear to be decreasing in GW006.

Bedrock Aquifer Water Quality

No bedrock ground water samples are available from the Tailings Basin or Plant Site facilities areas. Ground water samples have been collected from nine bedrock monitoring wells, one water supply well and two exploratory boreholes at the Mine Site. Samples were analyzed for general chemistry and total and dissolved metals. Bedrock aquifer water quality sampling results are summarized in Table 3 of the PolyMet hydrogeologic investigation (RS10A, Barr, 2007h). .

Ground water samples were also collected from two exploratory boreholes and a water supply well at the Mine Site. The exploratory boreholes contained large quantities of drilling fluid and were developed to the extent possible by overpumping prior to sampling. High total and dissolved metal concentrations in the exploratory boreholes suggest that these boreholes may have had drilling fluid or rock powder from drilling remaining in the water. As such, these samples are not included in the discussion of background bedrock water quality.

The water quality in the bedrock at the Mine Site is generally has elevated(i.e., at or higher than the Minnesota ground water standards in Table 4.1-23) total aluminum (<25 – 368 μg/L), total beryllium (<0.2 – 0.2 μg/L), total iron (<50 – 7040 μg/L), total manganese (<10 – 380 μg/L), total nickel (<2 – 128 μg/L) and dissolved nickel (<2 – 100 μg/L). There were detected concentrations of total mercury (up to 0.0016 – 0.005 μg/L), total zinc (<25 – 125 μg/L) and dissolved zinc (<25 – 134 μg/L). The above metals described as detected were at concentrations below ground water standards but, in some cases, were above surface water standards (Table 4.1-12, 4.1-24). The pH of the bedrock water samples ranged from 5.7 to 9.8. Wells/piezometers sampling the Virginia Formation in some cases had relatively low pH (e.g., 5.7 – 6.1) and in one case had high sulfate (1,200 mg/L).

Table 4.1-24 finds similar constituents exceeding ground water and/or surface water standards in the surficial aquifer and the combined units of the underlying bedrock aquifer. This suggests that constituents from the surficial aquifer (e.g. mecury, ammonia, beryllium) were introduced into the bedrock aquifer naturally due to downward seepage. The presence of ammonia in the deep boreholes may indicate that the water in the borehole came from the shallow surficial deposits. Ammonia is not typically found in deep bedrock systems but is common in wetland environments. Isotope analysis results of groundwater samples from a bedrock well indicate the presence of tritium (concentrations expressed as tritium units [TU]) in the samples (2.77-3.82 TU), which suggests that at least a portion of the water sampled is post-1952 water (Barr, RS10A, 2007h).

Ground Water – Surface Water Interconnection

Barr (2007h) attempted to measure the impact of bedrock aquifer pumping on the surficial aquifer. The field testing of ground water – surface water interaction was conducted at the Mine Site and utilized an existing pumping well in the Virginia formation and wetland observations wells. The results of the testing were generally inconclusive, but did show a response in a deep wetland piezometer closest to the pumping well, but not in adjacent and more distant shallow wetland piezometers. It is reasonable to expect that dewatering of the proposed mine pits will increase the vertical gradient through the surficial and wetland deposits at the Mine Site, but the the potential for drawdown of the water table within these deposits cannot be evaluated from the available study. The need for additional testing and/or modeling to justify this conclusion will be addressed in the monitoring and mitigations sections of this EIS.

Water Rights and Appropriation

A water use (appropriation) permit from MDNR Waters is required for all users withdrawing more than 10,000 gallons of water per day or 1 million gallons per year. PolyMet has requested, and Minnesota Power has agreed (Minnesota Power, 2007) to transfer, upon completion of the EIS, the Water Appropriation Permit No 49-135 for Colby Lake to PolyMet to obtain process water from Colby Lake. This Permit has a stipulation that water levels in Colby Lake always be maintained at an elevation of 1,439.0 feet msl. The permit is for 12,000 gpm although PolyMet has indicated that, on average, it will pump between 2,500 and 5,000 gpm for process makeup water for the ore processing facilities and other uses.

In order to safeguard water availability for natural environments and downstream higher priority users, Minnesota law requires the MDNR to limit consumptive appropriations of surface water under certain low flow conditions. Should conditions warrant, MDNR Waters may suspend surface water appropriation permits as determined by its Surface Water Appropriation Permit Issuance and Suspension Procedures (http://www.dnr.state.mn.us/waters/watermgmt_section/appropriations/).

4.1.2 Impact Criteria

In general, impact criteria for purposes of water resources will be defined as changes in the baseline physical-chemical-biological environment, focusing on over-all stream health. Water resources impact criteria will include a comparison of proposed hydrologic changes with historic hydrologic alteration from permitted mining practices, an assessment of present and predicted channel stability, and review of any appropriate physical or biological stream data. Hydrologic alteration may be quantified as percent change in any of several defined flow parameters, minimum lake or ground water levels, or water quality concentrations or other water quality numeric or narrative standards.

Impact criteria which will be used for stream flows in the Partridge and Embarrass River basins and changes in lake, reservoir, or ground water levels in the project area are those developed by Richter and others (1996; 1998) related to alteration of hydrology. Impact criteria for water quality impacts will rely on

Minnesota water quality classifications as described in the "Surface Water Quality, Regulatory Information" and "Ground Water Quality, Regulatory Information" sections of this water resources chapter. Additionally, surface water and wetlands water quality impact criteria will rely on narrative standards as defined later in this section. For mercury in surface water and wetlands, as well as ground water, the Minnesota fish consumption advisory and the U.S. EPA drinking water standards will be utilized for defining impact criteria. These are further defined below for mercury and methyl mercury.

4.1.2.1 Hydrologic Alteration of Streams, Lakes and Aquifers Impact Criteria

Certain hydrologic alterations due to construction, operation, closure, and post closure of the NorthMet Project may affect biotic composition, structure, and function of aquatic, wetland, and riparian systems. The methodology of using percent change in stream flow to guide evaluation of impacts on aquatic habitat is known as "The Indicators of Hydrologic Alteration" (Richter, et al., 1996; 1998). These indicators will be used to guide the hydrologic alteration assessment and help determine if significant impacts may occur. This EIS utilizes 19 parameters organized into five groups to statistically characterize hydrologic variation over a specified period of discharge record. The main parameters recommended for this "range of variability" approach by Richter, et al. (1996; 1998) 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; that is, 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; that is, 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; that is, the number of days per year with mean flows above the 75th percentile of all simulated daily mean flows.
- Duration of Low Pulses; that is, the number of days per year with mean flows below the 25th percentile of all simulated daily mean flows.
- Mean Duration of High Pulses; that is, the ratio of Duration of High Pulses to Number of High Pulses.
- Mean Duration of Low Pulses; that is, the ratio of Duration of Low Pulses to Number of Low Pulses.
- Annual Mean, Maximum and Minimum Lake Level Changes
- Annual Change in Ground Water Levels

Richter, et al. (1996; 1998) also recommended using these statistics to evaluate potential flow and stream morphology impacts. The discussion of the XP-SWMM results (Barr, RS73B, 2007d) is centered on the Richter, et al. (1996; 1998) stream flow parameters at seven locations in the Partridge River, as described in Section 4.1.1. The impacts also will include annual mean, maximum, and minimum lake level changes in Colby Lake and Whitewater Reservoir, and annual change in ground water levels due to mine dewatering and/or seepage from the TSF facilities. The deviation from baseline, based on modeling, in the mean values of the hydrologic parameters will be used to help determine the degree of impact to stream ecology.

For this EIS, the percent alteration in the mean values of the 19 flow parameters will establish a base for helping assess impacts to over-all stream health. Other, important information will include historic flow alterations from other permitted mining activities, channel stability data, and related biologic, chemical, and physical data.

There are currently no impact criteria for change in ground water levels. For the purposes of this EIS, an assessment of predicted change in ground water levels can be made at the Mine Site area using numerical ground water (MODFLOW) modeling by Barr (RS22, 2007f). It is recognized that ground water drawdown surrounding the Mine Site in the Partridge River watershed, and ground water level increase north of the Tailings Basin in the Embarrass River watershed, may potentially cause impacts to wetlands. Therefore, a threshold of 1- foot of simulated water level change will be used when evaluating numerical model results. Where possible, baseline values for fluctuations in ground water levels will be established.

4.1.2.2 Water Quality Impact Criteria

The baseline data show that some surface water and ground water quality constituents have concentrations greater than the numeric standards set by the State of Minnesota. Those water quality constituents were identified in Section 4.1.1 for existing surface water and ground water resources in and near the project site. The reason that baseline surface and ground waters are impacted is because the area has been actively mined for many years and/or the concentrations of selected water quality constituents are naturally greater than statewide water quality standards.

The approach used in this EIS for assessing water quality impacts to surface and ground water is a two tiered approach which takes into account the baseline data. Two comparisons of impacts will be made for both surface and ground water quality as follows:

Predicted impacts to the environment from the project will be compared to (1) appropriate Minnesota surface or ground water quality standards; and (2) the baseline as determined by both historical and more recent baseline water quality data collected by PolyMet. The percentage difference in concentration (positive or negative) between the predicted project impacts and either the water quality standard or the baseline concentration will be presented. Judgments will be made as to the significance of the impacts based on this two-tiered approach.

If numeric standards are not available for selected water quality constituents, for example sulfate in surface waters and wetlands, a narrative standard would be utilized. Minn R. ch. 7050.0150 subp. 3 presents:

> ***Narrative Standards.*** *For all Class 2 waters the aquatic habitat, which includes the waters of the state and stream bed, shall not be degraded in any material manner, there shall be no material increase in undesirable slime growths or aquatic plants, including algae, nor shall there be any significant increase in harmful pesticide or other residues in the waters, sediments, and aquatic flora and fauna; the normal fishery and lower aquatic biota upon which it is dependent and the use thereof shall not be seriously impaired or endangered, the species composition shall not be altered materially, and the propagation or migration of the fish and other biota normally present shall not be prevented or hindered by the discharge of any sewage, industrial waste, or other wastes to the waters.*

Also, 7050.0210 subp. 2 has the following:

> **General Standard for Waters of the State:** *Nuisance conditions prohibited. No sewage, industrial waste, or other wastes shall be discharged from either point or nonpoint sources into any waters of the state so as to cause any nuisance conditions, such as the presence of significant amounts of floating solids, scum, visible oil film, excessive suspended solids, material discoloration, obnoxious odors, gas ebullition, deleterious sludge deposits, undesirable slimes or fungus growths, aquatic habitat degradation, excessive growths of aquatic plants, or other offensive or harmful effects.*

Regarding wetlands, 7050.0186 subp. 1 contains the following language:

> **Policy and Wetland Beneficial Uses.** *It is the policy of the state to protect wetlands and prevent significant adverse*

> *impacts on wetland beneficial uses caused by chemical, physical, biological, or radiological changes. The quality of wetlands shall be maintained to permit the propagation and maintenance of a healthy community of aquatic and terrestrial species indigenous to wetlands, preserve wildlife habitat, and support biological diversity of the landscape.*

4.1.2.3 Mercury Impact Criteria

For purposes of this EIS, a mercury numeric standard, a fish consumption advisory, and a narrative standard will be utilized to describe the impact criteria of mercury in the environment. Each of these three mercury impact criteria are presented below (MPCA, 2007).

Mercury Numeric Water Quality Standard.

Mercury numeric standards are based on total (particulate plus dissolved) concentrations. For the Lake Superior basin, of which the NorthMet Mine project is a part, the numeric chronic standard protective of aquatic organisms and recreation is 0.0013 μg/L (1.3 nanograms per liter). Concentrations higher than this numeric standard or increases in mercury concentrations if the baseline concentration is higher than this standard will be deemed a large impact. Additionally, because there is a relationship, as yet poorly known, between sulfate concentration and the conversion of inorganic mercury by sulfate reducing bacteria into methyl mercury, most likely a sulfate standard for surface water may occur in the future. Currently, neither a methyl mercury nor sulfate numeric water quality standard for surface water exists in Minnesota. Until a surface-water sulfate and/or methyl mercury standard is implemented, Minnesota is utilizing fish consumption advisories and/or narrative standards for mercury.

Fish Consumption Advisory.

The Minnesota Department of Health (MDH) has issued guidelines for consumption of fish for young children and women of child-bearing age. This consumption advisory is based on a methyl mercury concentration of 0.2 mg/kg in fish tissue based on U.S. EPA studies (MDH, 2004). The concentrations of mercury in fish tissue determine the level of advise from “unlimited consumption” to “do not eat” as shown by the Minnesota Fish Consumption Advisory (MFCA) in Table 4-25.

Table 4.1-25: Fish Tissue Mercury Concentration for

Mercury Concentration in Fish (ppm)				
▪ **MFCA for Mercury**	<0.05	0.05 – 0.2	>0.2 – 1.0	>1.0
▪ **Consumption Advice (1)**	Unlimited	1 meal/week	1 meal /month	Do not Eat

Consumption advice for young children and women of child-bearing age.

Narrative Standards – Basis for Assessment of Fish Contaminants.

The basis for assessing the contaminant in fish tissue is the narrative water quality standards and assessment factors in Sub-paragraph 7 of the Minn. R. pt. 7050.0150. This sub-paragraph is for impairment of water relating to fish for human consumption and states: “In evaluating whether the narrative standards in subpart 3, which prevent harmful pesticide or other residues in aquatic flora or fauna, are being met, the commissioner will use the residue levels in fish muscle tissue established by the Minnesota Department of Health to identify surface waters supporting fish for which the Minnesota Department of Health recommends a reduced frequency of fish consumption for the protection of public health. A water body will be considered impaired when the recommended consumption frequency is less than one meal per week, such as one meal per month, for any member of the population. That is, a water body will not be considered impaired if the recommended consumption frequency is one meal per week, or any less restrictive recommendation such as two meals per week, for all members of the population. The impaired condition must be supported with measured data on the contaminant levels in the indigenous fish.”

Surface water quality standards are ‘in-stream’ standards applicable at the surface water in question. At the mine site, surface waters include the Partridge River and adjacent wetlands. At the plant site, surface waters include the Embarrass River, tributaries to the Embarrass River and adjacent wetlands. For the purposes of describing potential water quality impacts to surface waters in this EIS, in-stream sites in the Partridge and Embarrass Rivers, respectively, as shown on Figure 4.1-10 and Figure 4.1-6 will be utilized.

Ground water quality standards are U.S. EPA primary and secondary drinking water standards and apply to ‘in-situ’ ground water. For the purposes of describing potential water quality impacts to ground water in this EIS, the project property boundary (as shown in Figure 4.1-17) or the point where ground water discharges to surface water (such as into the Partridge River at the mine site), whichever occurs closest to the proposed project, will be utilized. It is important to note that ultimate ground water quality ‘compliance points’ will be determined during project permitting using, in part, information from the EIS; and, therefore, these compliance points may be different than the 'evaluation points' utilized in the EIS for describing potential impacts. Additionally, it is recognized that shallow ground water typically immediately discharges to adjacent wetlands and surface water, thus application of ground water standards versus surface water standards becomes somewhat more complicated. This interaction of ground and surface waters will be taken into account in the overall water quality impact assessment.

4.1.3 Environmental Consequences to Water Resources

The primary issues related to water resources are that mining and milling operations and related transportation and storage activities may cause changes to the quantity and quality of surface water and wetlands or ground water in the NorthMet Mine Project Area and within the Embarrass River and Partridge River watershed areas.

Other potential impacts to wetland areas are discussed in section 4.2 of this EIS. Potential impacts from the transportation, storage and use of hazardous substances are addressed in the Hazardous Materials section of this EIS (section 4.12).

4.1.3.1 Proposed Action Environmental Consequences

PolyMet Mining, Inc. (PolyMet) plans to use the existing (formerly Cliffs Erie LLC [CE] and prior to that formerly LTV Steel Mining Company [LTVSMC]) tailings basin for disposal of tailings from the processing of low-grade polymetallic, disseminated, magmatic-sulfide NorthMet-deposit ore. LTVSMC operated the existing basin for taconite tailings deposition from 1957 to January of 2001. Through the EIS process, geotechnical concerns were raised regarding the proposed design.

The initial design of the NorthMet tailing facility for the proposed action did not provide for adequate slope stability with an acceptable factor of safety. The design may result in the construction of a facility subject to large scale slope failure and uncontrolled release of impounded flotation tailings and process water. Stability analysis results presented to date do not adequately demonstrate that the design will perform as intended under static or post-liquefaction loading conditions. As a result of the geotechnical concerns with that design, a new design was prepared by PolyMet, referred to as the Proposed Action Mitigation Design.

- **Hydromet Residue**

In evaluating the proposed design of the hydrometallurgical residue cells as detailed in RS28T, a number of key areas were identified as discussed below. The proposed design comprises four rectangular cells constructed in a cut-to-fill fashion, lined with a prepared subgrade and geomembrane, and fitted with two strip underdrains.

Generally, the storage efficiency of rectangular basins is less than that for square or circular cells and pond control is more difficult. The hydromet cells are designed with a flat (constant elevation) bottom so that if there is more settlement at the center of the cell as is likely, a “birdbath” will develop such that some portion of the cell volume will not drain to collection points in the corners of the cell.

RS28T Appendix K provides only a minimal indication that the stability of the cell embankments has been evaluated and found to be adequate especially given the foundation comprising LTV tailings.

Sizing of the hydromet residue cells is dependent upon the in-place density of the materials and the tonnage produced over the life of the facility. The hydromet residue cells were sized based on an in-place dry density of 73 pounds per cubic foot (pcf) taken from Bateman METSIM modeling. However, based on correspondence with other METSIM users and the authors of the software, “METSIM does not predict the final tailings density.” The in place density is an input to METSIM to be provided by the geotechnical consultant on a project from the design of the waste storage facility; it is not an output from METSIM to be provided to the geotechnical consultant on a project for use in the design of the waste storage facility.

The proposed drain system design comprises two geonet strip drains along the long axis of each cell that is to be activated upon closure of each cell, which is not consistent with best management practices. A full blanket drain comprising a herringbone pattern of perforated drain pipes in a sand and gravel envelope should be considered. Worldwide industry standards minimize flow through liners by use of a leachate collection and recovery system (LCRS) and/or by minimizing the head acting on the liner. Planned operation of the hydromet residue cells does not activate the drainage system until after deposition is complete. It would be more typical for the drainage system to be active during deposition, which (1) minimizes hydraulic head above the underlying liner system thus greatly reducing potential leakage through the liner, (2) improves water recovery and (3) enhances residue consolidation (double versus single drainage). Enhanced consolidation improves storage efficiency by increasing the in-place density of the stored material and expedites closure of the cell by minimizing the amount of consolidation settlement and seepage remaining at the end of deposition. In some cases, it develops a surface on the tailing that is trafficable at closure.

4.1.3.1.1 Environmental Consequences to Water Quantity

4.1.3.1.1.1 Ground Water Flow to Open Pits

Inflows to the mine pits will include direct precipitation, runoff and ground water. Ground water contributes the largest expected volume of inflow of water to the pits. Ground water inflows from surficial deposits, the Duluth Complex, and the Virginia Formation were predicted using the industry standard finite difference groundwater modeling code MODFLOW (McDonald and Harbaugh, 1988). A summary of the ground water modeling and calibration to baseline (existing) conditions is provided in Section 4.1.1.13 and the complete model report is in Appendix B of RS22 (Barr, 2008). There were transient MODFLOW simulations of the pits in stages of development (i.e. Years 1, 5, 10, 15 and 20) based on the proposed mine plan. Groundwater inflow rates to the pits were predicted as shown in Table 4.1-26.

Combined ground water inflows into the East and West Pits will increase from 200 to 1,080 gpm during Years 1 through 11 as the pits expand wider and deeper. Thereafter, the West Pit will continue to expand until Year 20 with concurrent increase in dewatering inflows. Starting in Year 12, backfill of the East Pit with rock and water will begin and active dewatering will cease. By Year 20, the East Pit is predicted to lose more water to the groundwater system that it receives. The combined project pit dewatering rates plateau at 1,000 to 1,100 gpm from Years 12 to 15, and then decline to 850 gpm at Year 20.

Table 4.1-26 Predicted Groundwater Flow Rates during Mine Operations and Closure

	East Pit		**Central Pit**		**West Pit**	
	GW Inflow	**GW Outflow**	**GW Inflow**	**GW Outflow**	**GW Inflow**	**GW Outflow**
	gpm	**gpm**	**gpm**	**gpm**	**gpm**	**gpm**
Year 1	180	0	--	--	20	0
Year 5	820	0	--	--	80	0
Year 10	880	0	--	--	160	0
Year 11	930	0	--	--	140	0
Year 12	870	0	--	--	150	0
Year 15	750	0	70	0	320	0
Year 20	20	130	20	10	810	0

		East Pit		Central Pit		West Pit	
		GW Inflow	GW Outflow	GW Inflow	GW Outflow	GW Inflow	GW Outflow
		gpm	gpm	gpm	gpm	gpm	gpm
Post-Closure	Surficial			30[a]	10	80	20
	Bedrock			20	<5	30	<5
Notes:	[a]Combined flow merged East and Central Pits						

Notes: aCombined flow merged East and Central Pits
Source: Modified from Tables 4-1 and 4-2 in RS22 Appendix B Draft-03 (Barr, 2008).

The Central Pit, which will eventually become part of the East Pit, will be mined from Year 12 to Year 13. Starting in Year 14, the pit will be filled with rock and water and dewatering ceases. Similar to the East Pit, the Central pit is predicted to have both groundwater inflow and outflow by Year 20. In Year 20, the East and Central Pits are one combined pit. This merged pit has a predicted net loss of water to the ground water system. This is mainly due to the dewatering of the West Pit, which creates a cone of depression that extends to the East and Central Pits and beyond.

4.1.3.1.1.2 Ground Water Levels

Changes to ground water levels in the surficial deposits and bedrock (i.e., the Duluth Complex, and the Virginia Formation) were predicted using the industry standard finite difference groundwater modeling code MODFLOW (McDonald and Harbaugh, 1988). As described in Section 4.1.1.13 of this EIS, PolyMet has prepared reports describing two MODFLOW models, one developed for both the Mine Site (see RS22 [Barr, 2007] and update to Appendix B of RS22[Barr, 2008]) and the other for the Tailings Basin (see Attachment A-6 in RS13, Barr, 2007). In these reports, PolyMet has stated that these models were constructed to assess operational conditions, specifically dewatering of the proposed mine pits and seepage simulations for the internal portions of the tailings facility. Some fundamental limitations of the MODFLOW models for predicting water level impacts surrounding both major facilities are as follows:

- The use of a single surficial layer does not allow wetlands to be simulated as potentially perched overlying the surficial glacial deposits; the MODFLOW models cannot be calibrated to simulate potential impacts to wetlands separately from surficial glacial till.

- As described below, for the bedrock aquifer at the Mine Site, the model domain is too small to accurately simulate drawdown because of boundary effects.

At the Tailings Basin, the effective area for model simulation is restricted to the interior region of the tailings facility because MODFLOW boundary cells are located at the toes of the tailings embankments.

4.1.3.1.1.2.1 Mine Site

For this impact analysis at the proposed Mine Site, surrounding areas that are predicted to experience significant decreases in ground water elevation (drawdown of one foot or more, see *Impact Criteria* in Section 4.1.2.1 of this EIS) are designated as the areas of interest concerning impacts to ground water resources. Drawdown is determined with the calibrated MODFLOW model results described in Section 4.1.1.15 of this EIS, Figure 4.1-17, and Appendix B of RS22 (Barr, 2008).

For the surficial aquifer, drawdown maps indicating the area that is predicted to undergo 1 foot or more of drawdown have been prepared by PolyMet. This is less than natural ground water level variations (about 3 to 10 feet according to few available DNR well records) observed in wells completed in glacial till in the Hoyt Lakes area; however a water level change of one foot is considered potentially significant in an area with wetlands. For bedrock, there are no long-term hydrographs available for water levels in bedrock wells at the mine site area, and the designated area of interest is somewhat arbitrarily restricted to model-predicted areas with five feet or greater water level change, based on drawdown maps prepared by PolyMet.

4.1.3.1.1.2.1.1 Operational Years 1 to 20

<u>Drawdown</u>

Model simulated water level changes in project Years 11 and 20 in the surficial and bedrock aquifers are shown in Figures 4.1-19 through 4.1-22. Year 11 represents the time of maximum dewatering inflows from the East Pit and Year 20 is time of maximum dewatering at the West Pit (Table 4.1-26). It is noted that the one-foot drawdown contours depicted on Figure 4.1-19 and Figure 4.1-21 are adjusted from the actual MODFLOW model output because the surficial aquifer thins against bedrock north of the Mine Site, and the model is not calibrated to measurements outside the area shown.

The surficial aquifer by Year 11 is predicted to undergo greater than ten feet of drawdown, and/or to be dewatered (i.e., model cells go dry during simulation), in areas within about 2,000 feet of both East and West Pits, with the outermost one-foot drawdown contour within the property boundary (Figure 4.1-19).

By Year 20, due to cessation of dewatering at the East Pit, ground water levels recover such that the ten-foot drawdown contour is restricted to the rim of the East Pit (Figure 4.1-21). Continued dewatering at the West Pit is predicted to expand the ten-foot drawdown contour slightly (relative to Year 11) to about the Dunka Road south of the West Pit, but still within the property boundary. By Year 20, the limit of drawdown as determined by the one-foot drawdown contour is predicted to generally remain within the property boundary, except it extends about one-half mile south of the property boundary at the Dunka Road due to West Pit dewatering.

The bedrock aquifer is predicted to undergo greater than 50 feet of drawdown in a narrow area surrounding both Mine Pits. By Year 11, the center of major drawdown is located at the East Pit and to the north, such that the 50-foot drawdown contour extends well north of the property boundary to locations under the Partridge River (Figure 4.1-20). By Year 20 the center of drawdown shifts from the East Pit to the West Pit, and the 50-foot drawdown contour retreats southwards to be entirely within the property boundary (Figure 4.1-22). In both simulations, drawdown immediately south of the property boundary is predicted to reach 30 to 40 feet.

Although the ground water model predicts drawdown in both the bedrock and glacial sediment aquifers at the Mine Site, there is uncertainty as to what magnitude and extent. There is also uncertainty as to what, if any, impact such drawdown would have on adjacent wetlands and surface waters. Empirical observations at taconite surface mining operations in the region (including the Peter Mitchell Mine to the north of the proposed Mine Site) show little indirect impacts to adjacent wetlands from mine dewatering. Ground water model drawdown predictions may be useful to plan the geographic extent for monitoring and mitigation, as appropriate,

Baseflow to Partridge River

The transient MODFLOW model was also used for prediction of impacts to Partridge River baseflow during mine operations. Predicted baseflow reductions at three locations (SW-002, 003, and 004), as shown on Figure 4.1-6, are summarized in Table 4.1-27. Baseflow impacts to the Partridge River increase at all locations as mining progresses and the pit dewatering increases, reaching 10 to 20 percent by Year 20. In absolute amounts, the calculated amount of flow reductions at Year 20 ranges from 0.12 to 0.15 cfs at the stations shown in **Table 4.1-27** (see also Table 2-1 in RS74A, Barr, 2008).

Table 4.1-27 Predicted Percent Reduction in Partridge River Baseflow

	Location		
	SW002	**SW003**	**SW004**
Year 1	3.7%	2.9%	1.0%
Year 5	7.7%	5.7%	3.6%
Year 10	12.6%	9.1%	6.3%
Year 15	13.9%	8.7%	5.4%
Year 20	21.8%	15.4%	10.4%
During West Pit Filling (Closure)	21.8%	15.4%	10.4%
After West Pit Filling (Post-closure)	20.1%	12.5%	7.6%

Source: Table 2-1, RS74A, Barr, 2008.

4.1.3.3.1.2.1.2 Closure and Post-Closure

Upon completion of mining operations at the end of Year 20 and after pit dewatering systems are removed, the West Pit will begin to fill naturally with water from groundwater inflows, precipitation and stormwater runoff from the tributary watershed. These sources would fill the West Pit approximately 53 years after dewatering ceases. The East Pit will also fill naturally and begin overflowing into the West Pit in approximately Year 21, as described in **Section 3.1.11** of this EIS and in the closure plan report (RS52, Barr, 2007).

The actual steady-state water levels in the East and West Pits after Year 20 will be established by outlet structures that will be used to route surface overflows from the East Pit into the West Pit, and from the West Pit to a final discharge location in the wetlands west of the site and north of the Partridge River.

A constructed wetland will be built within the area of the former East Pit to provide additional treatment for drainage water from the stockpiles to the east. The constructed wetland treatment system will be a passive system, with an inflow area along the eastern boundary and an outflow structure to the West Pit along the western boundary. The wetland will be constructed above the waste rock fill in the East Pit and will be separated from the waste rock by a barrier layer constructed of compacted glacial till overburden.

The invert of the outlet structure connecting the East Pit to the West Pit will be at an elevation of 1,592 ft-MSL. The water level in the East Pit was designed to provide an adequate buffer between the overflow to the West Pit (1,592 ft-MSL) and the natural overflow elevation of 1,596 ft-MSL. The West Pit was designed to stabilize at an elevation of 1,581 ft-MSL, which is the natural overflow elevation of the West Pit.

MODFLOW simulations were performed to predict final ground water conditions in Post-closure, i.e., once the West Pit has filled. **Figures 4.1-23** and **4.1-24**, respectively, depict model simulated ground water drawdown contours in the surficial and bedrock aquifers, and **Figures 4.1-25 and 4.1-26** illustrate the corresponding ground water elevation contours in the surficial and bedrock aquifers. The West Pit lake is simulated using a head set at the outlet elevation of 1,581 ft-MSL (**Figure 4.1-25**). The portion of the East Pit that is backfilled with waste rock and the constructed wetland above the waste rock was simulated using a head set equal to the East Pit outlet elevation of 1,592 ft-MSL.

Drawdown

The extent of drawdown after project completion, as measured by the one-foot ground water contour in the surficial aquifer, is somewhat smaller than during mine operations and completely within the property boundary (**Figure 4.1-23**). This long-term change in surficial aquifer ground water levels (i.e., permanent drawdown) is due to the closure-management of the hydrologic system by fixing head boundaries to lower surface water levels controlled by outlet structures. The drawdown reaches maxima of about 10 to 20 feet at the West Pit lake and 10 feet at the area of the East Pit (**Figure 4.1-23**).

In the bedrock aquifer (**Figure 4.1-24**), the model predicts nearly complete recovery of ground water elevations, within the five-foot drawdown resolution. The exception is at the West Pit lake where the long-term bedrock ground water elevation is also predicted to be about 10 to 20 feet lower than previously due to the lowered head boundary at the lake.

Baseflow to the Partridge River

Impacts to baseflow in the Partridge River during Closure and Post-closure are shown in **Table 4.1-27**. Closure is defined as the time-period for filling of the West Pit Lake, which is calculated as approximately 40 to 57 years, extending from Mine Year 21 to between Year 60 to Year 77. Post-closure is an unspecified time period thereafter, ranging from Mine Year 60-77 to hundreds of years in the future, or to steady-state. **Table 4.1-27** and **Figure 4.1-23** illustrate that the realignment of the hydrologic system for water management purposes produces long-term drawdown in the surficial aquifer that re-directs ground water flow to the former pit areas. Post-closure, this permanently reduces ground water flow (baseflow) to the surrounding Partridge River by calculated amounts ranging from 8 to 20 percent.

4.1.3.1.1.2.2 Tailings Basin

Although PolyMet developed a ground water flow model for the Tailings Basin area, it is not suitable for determining impacts to ground water elevations outside the tailings embankments. As described in **Section 4.1.1.16** of this EIS, the surrounding wetlands were used as head boundaries to the model, so the ground water elevations in the wetlands are by definition fixed in the model. This is reasonable to simulate internal flow in the Tailings Basin based on examination of the (limited to 2001 to 2006) ground water elevation data at monitoring wells GW007, GW006 and GW001 in the wetlands north and north west of the Tailings Basin. As described in **Section 4.1.1.9** of this EIS, there are limited variations in water levels at these wells (i.e., three to five feet maximum, but generally less than one to two feet). The trends are flat compared to declining head trends at wells within the Tailings Basin. This suggests that ground water elevations outside the basin are controlled by contact with relatively stable water levels in the adjacent wetlands.

Drawdown/Mounding

Although wetland hydrology is a function of many factors, all of which are quantitatively unknown due to the absence of a definitive study, the potential wetland impacts resulting from future changes in the Tailings Basin can be considered likely to be proportional to changes in recharge to the area.

PolyMet (Barr, 2008 [“Lined Tailings Basin Alternative – EIS Data Request”", Memo from Greg Williams et al to Project File, April 8, 2008]) estimated future impacts to the hydrology of the Tailings Basin area using predicted changes in net recharge. The results are shown in **Table 4.1-28**. The methodology considers the portion of Cells 2E and 1E that contribute seepage to the Embarrass River watershed (1,050 acres) relative to an evaluation area extending from the toe of the impoundment north to the Embarrass River (3,900 acres), about 64 percent of which is wetlands. The methodology ratios calculable changes in recharge at the cells to the areas of the cells and evaluation area (1:4). It is predicted that the current recharge rate is about six percent greater than the pre-Tailings Basin condition.

This is validated by a review of historical aerial photographs. Although not directly convertible to estimates of changes in wetland water levels, the photographs are interpreted to document recent historical (1940 to present) changes in water levels of a few feet. Historical impacts are interpreted to have been limited to the wetlands immediately north of the Tailings Basin embankment and to have diminished such that there was no historical change interpretable from the photographs further north towards the Embarrass River.

The impact of the proposed action is qualitatively estimated to have a recharge rate the same or greater than current conditions, which would presumably correspond to water levels ranging from present-day conditions to some unspecified increase in water levels. This does not allow quantitative prediction of future potential impacts to wetlands, which could include possible inundation, from the predicted project-related increase in water levels. Given an unspecified increase in water levels predicted to progressively diminish to the North, there is a lack of baseline data collection and establishment of monitoring points in the wetlands north of the tailings basin.

Table 4.1-28 Summary of Potential Hydrologic Impacts of the Existing Tailings Basin, Proposed Project

Condition	Cell 2E Annual Net Recharge (inch/yr)	Area of Interest Net Recharge (inch/yr)	Equivalent Recharge Rate (gpm)	Rate relative to pre-Cell 2E/1E conditions (% change)	Rate relative to existing conditions (% change)	Steady state seepage rate for Cell 2E/1E (gpm)
Pre-tailings basin condition	--	9.9	2,530	--	- 6%	--
Existing condition of Cell 2E/1E	12.9	10.5	2,700	+ 6%	--	700
Future condition with now new activity in Cell 2E/1E (range)	1.8 to 9.2	8.2 to 9.2	2,100 to 2,500	- 1% to -17%	- 7% to -22%	100 to 500
Future condition of Cell 2E/1E (proposed action)	> 12.9	> 10.5	> 2,750	> + 6%	> + 0%	> 700[a]

aThe unrecovered seepage from Cell 2E/1E will reach a maximum seepage rate of 2,680 gpm in Year 20.
bThe liner reduces groundwater seepage to zero. Water discharging to surface seeps will be collected and recycled to Cell 2E/1E.
Source: Barr, 2008 [“Lined Tailings Basin Alternative – EIS Data Request”", Memo from Greg Williams et al to Project File, April 8, 2008

Baseflow to the Embarrass River

Potential changes to baseflow to the Embarrass River are discussed under hydrologic alteration results in Section 4.1.3.3.1.4.2 of this EIS.

4.1.3.1.1.3 Watershed Area Disturbance

RS73A and B (Barr, 2008) indicates that the maximum amount of watershed disturbance in the Partridge River basin related to the proposed mine area (4.7 mi^2) is approximately 2.4 mi^2, of which most of this disturbance is new; although a small amount (existing roads and the railroad) is existing disturbance from previous mining activity. This disturbance of 2.4 mi^2 is less than 2 percent of the Colby Lake-Whitewater Reservoir hydrologic system, with a catchment area of 127.8 mi^2.

In the Tailings Basin area the new disturbance will be negligible as all the existing Tailings Basin area was formerly disturbed by LTVSMC during taconite milling and tailing disposal. This existing disturbed area is approximately 5.6 mi^2, all of which is in the Second (Knox) Creek (235 acres or 0.37 mi^2) and Embarrass River (3,296 acres or 5.2 mi^2) catchments (RS36, Barr, 2006; RS13, Barr, 2007).

The locations of potentially impacted watersheds and their relationship to the NorthMet Mine Project area is shown on **Figure 4.1-27**. The watershed area disturbances are small (less than 2 percent) compared to the total watershed areas.

<u>4.1.3.1.1.4 Runoff Changes</u>

Hydrologic Alteration. Hydrologic alteration due to construction, operation and post closure of PolyMet's NorthMet Mine may impact biotic composition, structure, and function of aquatic, wetland, and riparian systems. A methodology known as "The Indicators of Hydrologic Alteration" (Richter et al., 1996; 1998) utilizes 19 parameters organized into five groups to statistically characterize hydrologic variation over a specified period of discharge record. The summary statistics produced by Barr Engineering, Inc.'s XP-SWMM model (Barr, RS73A and B, 2008) correspond to the parameters recommended in the "Range of Variability Approach" by Richter et al. (1998), and include:

- Group 1: Monthly Magnitude.
    - Mean flow for each calendar month.
- Group 2: Magnitude and duration of annual extremes.
    - Annual maximum 1-day, 3-day, 7-day, 30-day and 90-day mean flows.
    - Annual minimum 1-day, 3-day, 7-day, 30-day and 90-day mean flows.
- Group 3: Timing of annual extremes.
    - Julian date of each annual 1-day maximum flow.
    - Julian date of each annual 1-day minimum flow.
- Group 4: Frequency and duration of high and low pulses.

  - Number of high pulses each year; that is, the number of times per year the mean daily flow increases above the 75th-percentile of all observed/simulated mean daily flows.
  - Number of low pulses each year; that is, the number of times per year the mean daily flow falls below the 25th-percentile of all observed/simulated mean daily flows.
  - Mean duration of high pulses; that is, the number of days per year with mean flows above the 75th-percentile of all observed/simulated mean daily flows.
  - Mean duration of low pulses; that is, the number of days per year with mean flows below the 25th-percentile of all observed/simulated mean daily flows.

- Group 5: Rate and Frequency of change in conditions.
  - Means of all positive differences between consecutive daily values.
  - Means of all negative differences between consecutive daily values.
  - Number of flow reversals.

Richter and others (1996; 1998) also recommended using these statistics to evaluate flow and stream morphology impacts. The deviation from baseline, based on modeling, in the mean values of the parameters will be used to judge the degree of impact.

Runoff changes refers to mean (average) monthly discharges in the Partridge River at various locations downstream from the NorthMet mine and Tailings Basin at various times during the mine life as defined by Group 1 above. Runoff changes also refer to other hydrologic variables defined by Groups 2 through 5 above having to do with discharges which shape the stream channel, scour or deposit sediment, or correspond to the timing of biological processes within the stream. Because runoff impacts to the Embarrass River and Second Creek from the Tailings Basin site are so small as to be non-quantifiable (Barr, RS74B, 2008), the runoff changes discussed herein are for the Partridge River. The impacts were calculated using a baseline data period of 10 water years from 1978 through 1987 at the USGS Gage (Barr, RS73A and B, 2008). A similar 10-year period was utilized to calculate impacts based on daily streamflow data in the Partridge River.

4.1.3.3.1.4.1 Partridge River

Partridge River Impact Prediction Sites. Six surface water monitoring stations and one USGS gage station (seven sites) were used in the XP-SWMM model. The flow results from the modeling with XP-SWMM were corrected to incorporate the MODFLOW model predictions of the effects of mine pit dewatering on Partridge River flows (Barr, RS73A and B, 2008). The locations of the seven sites are shown in **Figure 4.1-28**, and the stations have the following characteristics:

- Station SW-001. This location on the north branch of the Partridge River is upstream of all Mine Site facilities (but downstream of the Peter Mitchell Pit discharge), and its catchment area is 6.2 square miles. Because of its location upstream of all Mine Site facilities only baseline modeling was preformed for SW-001.

- Station SW-002. This location on the north branch of the Partridge River is northeast of the Mine Site, and its catchment area is 13.3 square miles.

- Station SW-003. This location on the north branch of the Partridge River is east of the Mine Site, and its catchment area is 15.2 square miles.

- Station SW-004. This location on the north branch of the Partridge River is immediately upstream of the confluence with the south branch, downstream of 64 percent of the proposed Mine Site facilities by the end of Year 20, and its catchment area is 23.0 square miles.

- Station SW-004a. This location on the Partridge River is immediately downstream of the confluence of the north and south branches, downstream of 99 percent of the proposed Mine Site facilities by the end of Year 20, and its catchment area is 54.1 square miles.

- Station SW-005. This location on the Partridge River is at the railway crossing, downstream of 100 percent of the proposed Mine Site facilities by the end of Year 20, and its catchment area is 98.7 square miles. The Mine Site (4.7 square miles) represents less than 5 percent of this watershed.

- USGS Gaging Station #04015475. This location on the Partridge River is upstream of Colby Lake, and its catchment area is approximately 103.4 square miles.

Stations SW-001 through SW-005, and perhaps the USGS gage will be used as monitoring points in the Partridge River during and after mining. Barr (RS73A and B, 2008) predicted the discharges and other hydrologic alteration parameters at various times during mining, including Mine Years 1, 5, 10, 15, and 20, as well as after mining (Mine Facilities Off, During West Pit Filling, and After West Pit Filling). The after West Pit filling temporal scenario is interpreted as post-reclamation, long-term impacts.

Hydrologic Alteration Results. Because the disturbed area for the NorthMet Mine project impacting the Embarrass River and Second Creek is small, there will be no alteration of hydrology in these two streams (Barr, RS74B, 2008).

The hydrologic alteration analyses included both the impacts of reduced drainage area from mining activities, as well as impacts to the Partridge River during mining from dewatering activities (Barr, RS73A and B, 2008). The results of the runoff hydrologic alterations suggest that below the confluence of the north and south branches of the Partridge River, the deviation from baseline tends to be minimal. The greatest deviation from baseline spatially is typically seen in the Partridge River at or near SW-004, with the exception of annual 1-day minimum extreme flow, which is greatest at SW-002 (-14 percent change from baseline), as shown in Figure **4.1-29** (percent deviation graphs for mine year 15) and -20 percent change from baseline as shown in **Figure 4.1-30** (after West Pit Filling).

The greatest overall impact on Partridge River flows during mining is expected in Mine Year 15, with the greatest change (decrease) in monthly magnitude and annual extreme flows, -9.6 percent in January and -9.6 percent (1-day maximum), respectively, being seen at SW-004. According to Barr (RS73A and B, 2008), these mine years are when the footprint of the mine facilities is near the maximum area covered by the NorthMet Project, and the reclamation of the stockpiles is still underway in the case of Year 15. Modern stream gaging techniques are most likely accurate to ±10 to 15 percent.

Barr (RS73A and B, 2008) also notes that the larger impact on the Partridge River monthly magnitude and annual extreme flows is at the surface water monitoring station SW-004, which is located just upstream of the confluence with the South Branch of the Partridge River and downstream of 64 percent of the projected Mine Site facilities by the end of Year 20. Surface water monitoring station SW-004a is located immediately downstream of the confluence of the Partridge north and south branches and it covers 99 percent of the Mine Site. Impacts at this location could be expected to be the greatest, but the unaffected south branch reduces impacts at SW-004a and at Partridge River surface water monitoring stations further downstream.

The predicted change in minimum annual extreme (1-day, 3-day, 7-day, 30-day and 90-day) flows throughout the temporal scenarios modeled (Mine Years 1, 5, 10, 15, 20, Pit Filling, and After West Pit Filling) was more noticeable, with a -20 percent change in minimum annual extreme flow at SW-002 by After West Pit Filling (**Figure 4.1-30**). Barr (RS73A and B, 2008) notes that this is likely due to the West Pit reaching its deepest elevation, in addition to the factors previously mentioned for monthly magnitude and maximum annual extreme flows.

Again, downstream of the Partridge River confluence with the South Branch of the Partridge River, a smaller deviation from baseline with respect to minimum annual extreme flows is seen. The predicted change in minimum annual extreme flow ranges from -20 percent at SW-002 north of the Mine Site to -2.6 percent at SW-005, and -2.5 percent at the USGS gage After West Pit Filling.

For the hypothetical high-impact scenario, Mine Facilities Off, the predicted decrease in minimum annual extremes, monthly means, and maximum annual extremes are similar to those for After West Pit Filling.

In addition to the five project stages that were modeled (Mine Year 1 through Mine Year 20), XP-SWMM model runs were performed for two additional time periods: During West Pit Filling and After West Pit Filling (post-mining impact) (Barr, RS73A and B, 2008). The predicted change in minimum annual extreme, monthly magnitude and maximum annual extreme flows During West Pit Filling is similar to those for Mine Year 20. The greatest change in minimum annual extreme flow and monthly magnitude flow is predicted to occur at SW-002 and is -20 percent and -16 percent (January), respectively. The greatest change in maximum annual extreme flow is predicted to occur at SW-004 and ranges from -6.6 percent for the 90-day maximum to -9.0 percent for the 1-day maximum. Modern stream gaging techniques are probably accurate to within ±10 to 15 percent.

The results of the post-mining hydrologic alteration analysis for the predicted flows After West Pit Filling (see **Figure 4.1-30**) show that the deviation from pre-impact conditions is typically lowest downstream, near Colby Lake, at SW-005 and the USGS Gage. After West Pit Filling the predicted change in average monthly mean flow is +1.5 percent at SW-005 (ranging from -0.9 in December to +8.0 in August) and +1.2 percent at the USGS gage. The predicted change in 1-day minimum extreme at SW-005 is -2.6 percent. The predicted deviation in 1-day maximum extreme flow at SW-005 is -1.0 percent, and for the 7-day maximum it is approximately the same. The 90-day maximum flow change from baseline at SW-005 is nearly zero. At the USGS gage, these same minimum and maximum flows are approximately the same as for SW-005. These changes most likely are not measureable using modern stream gaging techniques.

The largest predicted deviations from pre-mining conditions are seen further upstream for the After West Pit Fill model. SW-002 sees the largest predicted change in average monthly magnitude at -5.0 percent. SW-002 (**Figure 4.1-30**) also has the largest predicted change in 1-day minimum extreme, at -20 percent. SW-004 (**Figure 4.1-30**) has the largest predicted change in maximum extreme flows, ranging from -4.9 percent for 90-day maximum to -6.6 percent for 1-day maximum.

Indicators of hydrologic alteration summary tables for SW-002 through SW-005 and the USGS gage for all development and high-impact scenarios including post-mining can be found in Barr (RS73A and B, 2008).

Summary of Hydrologic Alteration in the Partridge River. In summary, the largest during-mining changes in Partridge River flows occur in Year 15 in the winter months (January through March) and range from -8.3 to -9.6 percent. During-mining impacts on maximum flows are larger percentagewise than minimum flows. After mining and reclamation (long-term impacts), changes in flows in the Partridge River are less than during mining, but tend to result in less water in the stream during low flows, and altered high flow regimes as a result of the watershed changes (increased flows due to open pit discharges and stockpile runoff).

A comparison of the pre-mining (baseline) and post-mining (long-term) changes in selected (mean April flow in cfs, maximum 1-day flow in cfs, mean high pulse duration in days, and mean rate of flow increase in cfs/day) Partridge River flow statistics at Stations SW-002, SW004, and the USGS Gage are shown on F**igures 4.1-31, 4.1-32, and 4.1-33** respectively. These comparison statistics were selected based on the largest alterations percentagewise in the Partridge River from baseline into the future. These percentages, on average, range from -0.4 to -16 percent for all four statistics at the three stations. These alterations are not significant, although a reduction in the maximum pulse duration (days) of -16 percent could lead to sediment accumulation at some locations within the Partridge River streambed. The exact locations or the degree of sediment accumulation cannot be predicted. Nearly all of the predicted flow changes, due to their small magnitudes will be difficult to measure using modern stream gaging techniques.

4.1.3.3.1.4.2 Embarrass River

Embarrass River Impact Prediction Sites. Two surface water monitoring stations were used in the mass-balance model (Barr, RS74B, 2008). The locations of the two sites are shown in **Figure 4.1-34** and the stations have the following characteristics:

- Station PM-12. This location on the Embarrass River (18.9 square mile drainage area) is downstream from Babbitt, MN and is upstream from Plant Site, existing Open Pit and Tailings Basin impacts, but does receive effluent from the Babbitt WWTP

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- Station PM-13. This location on the Embarrass River (111.8 square mile drainage area) is downstream from all Plant site, existing Open Pit and Tailings Basin facilities

These two stations were utilized to assess the potential impacts to Embarrass River water quality as a result of discharges from the tailing management facility (Cells 1E and 2E), potential discharges from Pit 5, and potential seepage from Cell 1W and the hydrometallurgical cells as shown in Figure 4-25. Locations PM-12 and PM-13 were selected because background water quality data were available (see Barr, RS63 and RS76, 2006). The locations and their designations are stations used by PolyMet for baseline monitoring in 2004, 2006 and 2007. The potential impacts to water quality in the Embarrass River are discussed below in the "Water Quality Impacts on Rivers" section.

Hydrologic Alteration Results. As noted above, the disturbed area for the NorthMet Mine project impacting the Embarrass River and Second Creek is small, there will be no alteration of hydrology in these two streams due to changes in drainage area (Barr, RS74B, 2008).

However, there will be alterations to flows in the Embarrass River due to uncontrolled (and unmeasured) seepage from the Tailings Basin both during Operation and Post closure. The baseline condition of uncontrolled and unmeasured seepage from the LTVSMC Tailings Basin (Adams and others, 2004) indicates that up to 920 gpm (2.05 cfs) of the flow in the Embarrass River could be from Tailings Basin cells 1E and 2E. Potentially large changes in this flow may occur in the large wetlands between the existing Tailings Basins and the River. The net, long-term impact on hydrologic alteration of the Embarrass River flows is unknown, but most likely small. At low flow, the alteration is anticipated to be approximately a 20 percent increase in flow. At high flow, the alteration will be unmeasurable.

During operation it is estimated (Barr, 2008, RS74B) that uncontrolled and unmeasured flows from the Tailings Basin cells 1E and 2E would vary from 1,430 to 2,680 gpm (up to approximately 6 cfs). This uncontrolled seepage may not be seen in the Embarrass River as a sustained flow due to the wetlands, but could increase the water level in the wetlands slightly. Williams and others (2008) discuss the potential impacts to wetlands due to the increased seepage from the Tailings Basin, but do no discuss alteration of flows in the Embarrass River.

At closure and post-closure, Barr (2008, RS74B) indicates that the steady-state seepage from the Tailings Basin cells 1E and 2E will be approximately 1,100 gpm (2.45 cfs). This long-term steady state seepage is approximately 20 percent higher than the LTVSMC uncontrolled seepage. The conclusion presented in Barr (2008, RS74B) and Barr, 2008 ["Lined Tailings Basin Alternative – EIS Data Request"", Memo from Greg Williams et al to Project File, April 8, 2008] is that minimal changes in wetland hydrology is expected beyond the historical impacts due to uncontrolled seepage from the LTVSMC Tailing Basin.

4.1.3.1.1.5 Water-level Changes in Colby Lake and Whitewater Reservoir

The RS73A and B report (Barr, 2008) presents the results of water balance modeling to determine the effects of the NorthMet Project on the water levels in Colby Lake and Whitewater Reservoir. A total of nine scenarios in four major categories were evaluated to determine which scenario was best suited to meet the following criteria. The four final scenarios included the following: (1) maintaining the level of Colby Lake above 1438.5 feet at all times to insure discharge to the Partridge River; (2) meeting the criteria for operation of the diversion works from Colby Lake to Whitewater Reservoir; (3) minimizing water level fluctuations in Colby Lake and Whitewater Reservoir; and (4) providing makeup water to the NorthMet Project during mining operations. Under certain conditions, the model allowed for transfer of water from Whitewater Reservoir to Colby Lake to maintain the water level in Colby Lake. Based on the modeling, the report concluded that Scenario 2b (average flow conditions in the Partridge River, with Colby Lake water level above 1,439.50 feet above mean sea level for water to be diverted to Whitewater Reservoir via 2 sluice gates) was most effective at meeting the above criteria (Barr, RS73A and B 2008).

The modeling presents the daily water levels in both lakes for three cases for the period from October 1, 2001 to September 30, 2005, a total of 1461 days. This time period was judged to be representative of the baseline condition of no mining or water use by LTVSMC for taconite production. This baseline period also was requested by MDNR. The base case water balance modeling assumes zero withdrawals for NorthMet Mine makeup water. The second case allows for 3,500 gpm to be withdrawn from Colby Lake to provide makeup water for NorthMet mining operations. This is the expected average annual make-up water demand during operations. The third case allows for 5,000 gpm to be withdrawn, which is the demand rate that is expected to be exceeded, on average once every ten years.

The water-level change results for the second case (3,500 gpm of makeup water withdrawal) are shown in **Table 4.1-29**. These results show that the average water level difference between the base case (0 gpm withdrawal) and 3,500 gpm withdrawal is 0.03 feet for Colby Lake and 0.39 feet for Whitewater Reservoir. The percent of the days that the Colby Lake water level was below elevation 1,489.0 was 9.0 percent (approximately 132 days).

The water-level change results for the third case (5,000 gpm of makeup water withdrawal) are shown in **Table 4.1-30**. The results show that the average water level difference between the base case (0 gpm withdrawal) and 5,000 gpm withdrawal is 0.01 feet for Colby Lake and 1.00 feet for Whitewater Reservoir. The percent of the days that the Colby Lake water level was below elevation 1,489.0 was 0.5 percent (approximately 7 days). This smaller percentage for a larger withdrawal (5,000 gpm) from Colby Lake comes as the expense of larger water-level changes in Whitewater Reservoir.

The results show that under the expected average demand rate of 3,500 gpm, the average water level in Whitewater Reservoir will be lower than the base case (0.39 feet). The minimum water levels for the annual average 3,500 gallons per minute-demand under average flow conditions indicates that the Whitewater Reservoir shoreline retreat is less than 10 feet except in two short, localized reaches where the shoreline retreat can be approximately 75 feet; this shoreline retreat will be evident during less than 10 percent of the period April-October. For the higher demand rate of 5,000 gpm, this effect will occur more frequently and will be more pronounced. Figures in Appendix B of RS73B (Barr, 2008) show that a drop in the water level of 1 foot may cause the shoreline to retreat up to 25 feet along some parts of Whitewater Reservoir, with maximum retreat values of several hundred feet.

Table 4.1-29 Water Level Results for 3,500 gpm Makeup Water Withdrawal

Description	Colby Lake	Whitewater Reservoir
Average Water Level for Base Case	1439.45 ft	1439.33 ft
Average Water Level for 3,500 gpm case	1439.42 ft	1438.94 ft
Average Water Level difference from base case	0.03 ft	0.39 ft
Percent of days with W.L. below 1,439.0	9.0	N/A
Maximum W.L. fluctuation	3.63 ft	4.27 ft

Table 4.1-30 Water Level Results for 5,000 gpm Makeup Water Withdrawal

Description	Colby Lake	Whitewater Reservoir
Average Water Level for Base Case	1439.45 ft	1439.33 ft
Average Water Level for 5,000 gpm case	1439.44	1438.33
Average Water Level difference from base case	0.01	1.00
Percent of days with W.L. below 1,439.0	0.5	N/A
Maximum W.L. fluctuation	3.61	6.89

It is judged that the maximum water-level changes in Whitewater Reservoir for a demand of 3,500 gpm makeup withdrawal are most likely acceptable to homeowners living or who will be living on the shore of the reservoir. However, if a makeup demand of 5,000 gpm is utilized, a significant impact could occur to those living in shoreline areas where the shoreline retreat is greater than 25 feet. Over six feet of water level change in Whitewater Reservoir may result in visual and esthetic impacts during high water demand periods. Based on the analyses summarized in Tables **4.1-29 and 4.1-30** above, Colby Lake water levels will not be significantly impacted under either of the proposed makeup water demands.

4.1.3.1.1.6 Water Rights and Water Uses

There are two ways in which water rights to streams could be affected: by reducing streamflow and thus restricting quantity of water delivered to a right holder or by impacting water quality in a manner that would preclude the beneficial uses for which the right is granted. The water rights in the Project Area that would have the potential to be impacted are granted for domestic and industrial uses and irrigation, typically on a point-to-point basis in a given stream reach.

4.1.3.1.2 Environmental Consequences to Water Quality

The assessment of consequences to water quality follow from the discussion of Impact Criteria (**Section 4.1.2 of this EIS**), specifically:

"Predicted impacts to the environment from the project will be compared to (1) appropriate Minnesota surface or ground water quality standards; and (2) the baseline as determined by both historical and more recent baseline water quality data collected by Polymet."

"For the purposes of describing potential water quality impacts to ground water in this EIS, the project property boundary (as shown in Figure 4.1-17) or the point where ground water discharges to surface water (such as into the Partridge River at the mine site), whichever occurs closest to the proposed project, will be utilized."

4.1.3.1.2.1 Effects on Ground Water Quality under Proposed Action

Ground water quality was estimated using two distinct modeling techniques:

- "Deterministic" simulations (i.e., using a single set of parameter values to produce results that do not indicate uncertainty), which were conducted for a complete set of analytes and for long-term forecast periods; and

- "Probabilistic" simulations" (i.e., using ranges for model parameters to produce results with ranges than indicate uncertainty), which where conducted for a limited number of solutes (those most likely to exceed water quality standards) and for a limited time period (typically select periods during and shortly after mining).

These results yield two methods to broadly assess total uncertainty in predicted groundwater concentrations: 1) from the range in concentrations estimated by the probabilistic simulations, and 2) from the difference between deterministic and the probabilistic results, where both methods were used to predict concentrations of the same constituent at the same point in space and time.

The project proponent's technical studies were conducted with the intent of producing deerministic predictions that were conservative. However, the deterministic predictions for groundwater constituent concentration ranged from far above to far below the median values in the parallel probabilistic simulations. Maximum deterministic values are expected to be far above the probabilistic results. However, the presence of some "conservative case" values below the middle of the uncertainty range suggests strongly that 1) actual uncertainty is larger than indicated by the probabilistic simulations, and 2) concentrations predicted in the deterministic simulations are not always "conservative" or "upper limits" for at least some of the constituents.

As an example, uncertainty indicated by the probabilistic simulations, based on the difference between the 5th and 95th percentile (i.e., the 90% confidence interval) typically ranged by a factor of 2 up to as high as 10. Given the discrepancy between deterministic and probabilistic models, actual uncertainty is larger than indicated by the probabilistic simulations.

4.1.3.1.2.1.1 Mine Site

Effects on ground water on the Mine Site would arise primarily from effluent released by the pit lakes or waste rock facilities. As described in detail in the introduction to this section (see Impact Criteria immediately under Section 4.1.3.1.2 above) predicted impacts to the environment from the project at the Mine Site will be compared to appropriate Minnesota ground water quality standards, and/or the baseline, at the project propertyboundry (Figure 4.1-17) and the Partride River. Because of the variability and limited number of baseline ground water sample data available, only the comparison to the standard approach will be used for describing potentially significant impacts in this section of the EIS. However, predicted concentration changes with respect to baseline water quality samples collected by PolyMet can be evaluated from the information presented in Section 6.3 of RX74A (Barr (2008). Briefly, screening models (introduced below and also in Section 4.1.5.5, of the EIS) presented in Tables 6-6 through 6-23 in RS74A (Barr 2008), show predicted changes in concentrations to ground water for all modeled constituents regardless of whether calculated concentrations exceeded ground water standard evaluation criteria

As described in Section 4.1.5.5, the effects of the Proposed Action on ground water were evaluated from predicted concentrations along six flow paths that extended from the source areas (waste rock and mine pits) to the following evaluation points:

- Dunka Road (closest to the mine facilities).
- PolyMet property boundary (between the source areas and the Partridge River).
- Partridge River (i.e., where groundwater discharges to surface waters).

The effect of waste rock on groundwater quality considered a range for leakage rates from the piles (i.e., high, average, and low leakage, based in part on different leakage for uncovered and covered waste rock and the duration over which some waste was uncovered.) High, average, and low estimates of liner leakage rates (i.e., the amount of water that escapes the liner system and flows to ground water, see Table 4.1-31C) were obtained by analyzing data from test stockpiles in northeast Minnesota and combined with best professional judgment from MDNR and PolyMet and it's consultants about potential infiltration into stockpiles based on the type of cover material and the main components of the liner system.

These selected groundwater evaluation points are shown on Figures 4.1-35 and 4.1-36 where concentrations are reported for the points where cross-sectional model transects (shown as black lines) cross Dunka Road (white line), the mine property boundary (yellow line), or Partridge River (blue line). The methodology for solute transport modeling is described in Section 4.1.5.5, below. Briefly, "screening level models" were prepared to determine what the dissolved constituents of concern were for the six flow paths. In the screening level model, the most conservative simplifying assumptions were made. If the dissolved constituents being evaluated were not predicted to exceed ground water evaluation criteria under these assumptions, those constituents were not carried forward to the next phase of modeling. More detailed transient modeling was conducted for those constituents that showed potential exceedances of ground water evaluation criteria using the screening level model. Because of the heightened concern regarding sulfate concentration as it relates to mercury, sulfate was carried forward to the next phase of modeling regardless of whether the screening level model predicted ground water concentrations in excess of criteria.

The detailed deterministic model predictions for the six flow paths are summarized below in Tables 4.1-31A and 4.1-31B. Key impacts on Mine Site ground water under the Proposed Action are as follows:

- Category 1 and Overburden Stockpile (Flow Path #1, Table 4.1-31A):
  - Physical conditions: Facility remains as surface pile after closure.
  - Constituents above MCL near the source (models without sorption): arsenic, antimony, and sulfate.
  - Constituents above MCL at Property Boundary evaluation point: sulfate (only under high liner leakage rate).

- West Pit (Flow Path #2, Table 4.1-31A):
  - Physical conditions: No outflow to groundwater until pit is full at Years 60 to 76 (i.e., 40 to 56 years after mining).
  - Constituents above MCL near the source (models without sorption): arsenic and antimony.
  - Constituents above MCL at Property Boundary evaluation point: none.

- Lean Ore Surge Pile (Flow Path #3, Table 4.1-31B):
  - Physical conditions: Removed in closure.
  - Constituents above MCL near the source (models without sorption): iron, manganese, and nickel.
  - Constituents above MCL at Partridge River evaluation point: iron (only under high liner leakage rate) and manganese (only under high liner leakage rate) possible for temporary period.

- East Pit and Category 4 Waste Rock Stockpile (Flow Path #4, Table 4.1-31B):
  - Physical conditions: Facility remains as surface pile after closure.
  - Constituents above MCL near the source (models without sorption): antimony, nickel, iron, and manganese.

  - Constituents above MCL at Partridge River evaluation point: iron and manganese.

- East Pit and Category 3 Stockpile (Flow Path #5, Table 4.1-31A):
  - Physical conditions: Facility remains as surface pile after closure.
  - Constituents above MCL near the source (models without sorption): antimony, arsenic, copper, iron, manganese, and nickel and sulfate.
  - Constituents above MCL at Partridge River evaluation point: iron, manganese, nickel (only under high liner leakage rate), and sulfate (only under high liner leakage rate).

- Category 3 Lean Ore Stockpile (Flow Path #6, Table 4.1-31B):
  - Physical conditions: Facility remains as surface pile after closure.
  - Constituents above MCL near the source (models without sorption): iron, manganese, and nickel.
  - Constituents above MCL at Partridge River evaluation point: iron, manganese, and nickel.

Table 4.1-31A: Summary of Maximum Concentrations Predicted Using Transient Solute Transport Models for Mine Site - Proposed Action, Flow Paths #1, #2, #5, All Liner Yields

	Project Operations and Closure		Post-closure		
	Years 1-76 (L), 1-66 (A), 1-60 (H)		Years 61 to 77-2000		
	Ground Water Evaluation Criteria	**Model Maximum Conc.**	**Model Liner**	**Model Maximum Conc.**	**Model Final Conc.**
	(mg/L)	**(mg/L)**	**(L, A, H)**	**(mg/L)**	**(mg/L)**
Category 1/2 & Overburden Stockpile (FP #1, Property Bndry. Eval. Point)					
Arsenic					
No Sorption	0.01	**0.019**	L, A, H	**0.14**	**0.14**
With Sorption	0.01	0.0028	L, A, H	0.0028	0.0028
Antimony					
No Sorption	0.006	0.0027	L, A, H	**0.016**	**0.016**
With Sorption	0.006	0.0015	L, A, H	0.0015	0.0015
Sulfate					
No Sorption	250	64	L	**460**	**460**
West Pit (Flow Path #2, Property Boundary Evaluation Point)					
Arsenic					
No Sorption	0.01	---	H	**0.082**	**0.082**
With Sorption	0.01	---	H	0.0028	0.0021
Antimony					
No Sorption	0.006	---	L	**0.049**	**0.049**
With Sorption	0.006	---	L	0.0015	0.0015
Sulfate					
No Sorption	250	---	L	110	110
Category 3 Stockpile (Flow Path #5, Partridge River Evaluation Point)					
Arsenic					
No Sorption	0.01	0.0092	H	**0.046**	**0.025**
With Sorption	0.01	0.0021	H	0.0023	0.0023
Copper					
No Sorption	1	**1.6**	H	**3.2**	**3.2**
With Sorption	1	0.0068	H	0.10	0.10
Iron					
No Sorption	0.3	**1.6**	H	**4.2**	**4.2**
Manganese					
No Sorption	0.05	**0.42**	H	**0.90**	**0.86**
Nickel					
No Sorption	0.1	**5.1**	H	**12.0**	**12.0**
With Sorption	0.1	0.001	H	**1.0**	**1.0**
Antimony					
No Sorption	0.006	0.0023	L	**0.041**	**0.018**
With Sorption	0.006	0.0015	L	0.0016	0.0016
Sulfate					
No Sorption	250	97	H	**280**	210
NOTES:					

Project Operations and Closure		Post-closure
Years 1-76 (L), 1-66 (A), 1-60 (H)		**Years 61 to 77-2000**
Conc. = concentration; Eval. = evaluation; FP = Flow Path; Bndry. = boundary		
0.014	**Bold** indicates exceeds evaluation criteria.	
L, A, H:	Low (L), Average (A), or High (L) liner leakage model.	
Model Liner:	For post-closure, liner leakage model with maximum.	

NOTES: (1) Maximum concentrations are from deterministic predictions; for some constituents, these ranged from far above to far below median values in parallel probabalistic simulations (see text for further explanation).
(2) Solute transport modeling used adsorption values from other studies based on data from other sites (Table 4.1-42); NorthMet site-specific sample values are not available (see text for further explanation).Source: modified from Tables 6-30, 6-31, 6-32, RS74A (Barr, 2008).

Table 4.1-31B: Summary of Maximum Concentrations Predicted Using Transient Solute Transport Models for Mine Site - Proposed Action, Flow Paths #3, #4, #6, All Liner Yields

Project Operations and Closure			Post-closure		
Years 1-76 (L), 1-66 (A), 1-60 (H)			**Years 61 to 77-2000**		
	Ground Water Evaluation Criteria	**Model Maximum Conc.**	**Model Liner**	**Model Maximum Conc.**	**Model Final Conc.**
	(mg/L)	**(mg/L)**	**(L, A, H)**	**(mg/L)**	**(mg/L)**
Lean Ore Surge Pile (Flow Path #3, Partridge River Evaluation Point)					
Iron					
No Sorption	0.3	**0.47**	H	**0.47**	0.20
Manganese					
No Sorption	0.05	**0.065**	H	**0.066**	0.039
Nickel					
No Sorption	0.1	**0.140**	H	**0.150**	0.001
With Sorption	0.1	0.001	H	0.001	0.001
Sulfate					
No Sorption	250	23	H	23	14
East Pit & Category 4 Stockpile (Flow Path #4, Partridge River Eval. Point)					
Iron					
No Sorption	0.3	**0.50**	H	**0.47**	**0.40**
Manganese					
No Sorption	0.05	**0.075**	H	**0.110**	**0.082**
Nickel					
No Sorption	0.1	**0.25**	H	**0.29**	**0.29**
With Sorption	0.1	0.0010	H	0.0037	0.0037
Antimony					
No Sorption	0.006	0.0019	L	**0.015**	0.0059
With Sorption	0.006	0.0015	L	0.0015	0.0015
Sulfate					
No Sorption	250	24	L, A	68	41
Category 3 Lean Ore Stockpile (Flow Path #6, Partridge River Eval. Point)					

Project Operations and Closure			Post-closure		
Years 1-76 (L), 1-66 (A), 1-60 (H)			Years 61 to 77-2000		
Copper					
No Sorption	1	0.92	H	0.92	0.91
With Sorption	1	0.0068	H	0.043	0.043
Iron					
No Sorption	0.3	**1.2**	H	**1.3**	**1.3**
Manganese					
No Sorption	0.05	**0.25**	H	**0.25**	**0.25**
Nickel					
No Sorption	0.1	**3.3**	H	**3.4**	**3.4**
With Sorption	0.1	0.001	H	**0.65**	**0.65**
Sulfate					
No Sorption	250	58	H	58	56
NOTES:					
Conc. = concentration; Eval. = evaluation					
0.014	**Bold** indicates exceeds evaluation criteria.				
L, A, H:	Low (L), Average (A), or High (L) liner leakage model.				
Model Liner:	For post-closure, liner leakage model with maximum.				

NOTES: (1) Maximum concentrations are from deterministic predictions; for some constituents, these ranged from far above to far below median values in parallel probabalistic simulations (see text for further explanation).
(2) Solute transport modeling used adsorption values from other studies based on data from other sites (Table 4.1-42); NorthMet site-specific sample values are not available (see text for further explanation).
Source: modified from Tables 6-30, 6-31, 6-32, RS74A (Barr, 2008).

Table 4.1-31C. Stockpile Liner Leakage Rates under Proposed Action

Stockpile	Low Liner Leakage Rate under Proposed Action (gpm)						
	Year 1	Year 5	Year 10	Year 15	Year 20	Closure	Post-Closure
Category 1/2 Waste Rock	43.9	120.3	132.0	116.2	116.2	116.2	116.2
Category 1/2 (Overburden Areas)	16.2	31.0	24.2	20.5	20.5	20.5	20.5
Category 3 Waste Rock	0.001223	0.004980	0.008771	0.012574	0.006628	0.006628	0.006628
Category 3 Lean Ore	0.001352	0.002301	0.003203	0.004570	0.002773	0.002773	0.002773
Category 4 Waste Rock	0.000171	0.001371	0.001570	0.001422	0.000131	0.000131	0.000131
Lean Ore Surge Pile	0.002085	0.002085	0.002085	0.002085	0.002085	0	0

Stockpile	Average Liner Leakage Rate under Proposed Action (gpm)						
	Year 1	Year 5	Year 10	Year 15	Year 20	Closure	Post-Closure
Category 1/2 Waste Rock	50.9	142.3	163.3	159.7	159.7	159.7	159.7
Category 1/2 (Overburden Areas)	18.6	36.6	30.2	28.1	28.1	28.1	28.1
Category 3 Waste Rock	0.002011	0.008371	0.014869	0.021733	0.013148	0.013148	0.013148
Category 3 Lean Ore	0.002211	0.003842	0.005454	0.008010	0.005460	0.005460	0.005460
Category 4 Waste Rock	0.000280	0.002237	0.002536	0.002289	0.000131	0.000131	0.000131
Lean Ore Surge Pile	0.003409	0.003409	0.003409	0.003409	0.003409	0	0

Stockpile	High Liner Leakage Rate under Proposed Action (gpm)						
	Year 1	Year 5	Year 10	Year 15	Year 20	Closure	Post-Closure
Category 1/2 Waste Rock	172.5	469.5	506.4	425.9	425.9	425.9	425.9
Category 1/2 (Overburden Areas)	64.1	121.2	92.3	75.1	75.1	75.1	75.1
Category 3 Waste Rock	0.010453	0.043517	0.077379	0.113243	0.070709	0.070709	0.070709
Category 3 Lean Ore	0.062496	0.108580	0.154510	0.227554	0.158460	0.158460	0.158460
Category 4 Waste Rock	0.007901	0.063674	0.074159	0.067621	0.010373	0.010373	0.010373
Lean Ore Surge Pile	0.096353	0.096348	0.096353	0.096348	0.096353	0	0

A complete listing of predicted elevation point concentrations in groundwater for the proposed action is presented in Section 6.4 of RS74A (Barr 2008) and Tables 6-30 through 6-32 therein. Screening models described in Section 6.3 of RS74A and Tables 6-6 through 6-23 present predicted changes in concentrations to ground water for all modeled constituents regardless of whether calculated concentrations exceeded evaluation criteria.

Wetland Treatment Efficiency and Effective Life

The Proposed Action assumes that effluent from the East Pit will be treated indefinitely in a passive wetland built on the surface of the backfilled East Pit. However, a technical justification for treatment efficiency and duration of effective treatment has not been provided.

Waste Rock

The Category 1 waste rock (i.e., least reactive) was found to leach copper to effluent at concentrations above regulatory thresholds, and thus not be suitable as unamended surface construction material (Table 8-3 in RS 53/42 [SRK 2007]).

Within the waste rock facilities containing Category 2, 3, and 4 rock, oxidation is expected to release solute to percolating water, so that “All chemistry predictions indicate that drainage from the waste rock and lean ore stockpiles will exceed water quality discharge limits for several parameters including sulfate, nickel, and copper.” (RS 53/42 [SRK 2007]). Thus there will be some mixing zone in the aquifer below the storage facility where solute concentrations will exceed drinking water standards.

For the Category 1/2 waste rock, model uncertainty analysis indicated that of the eight key analytes included in probabilistic simulation, the deterministic model may have underestimated the release to groundwater of cobalt (slight underestimate), copper (moderate underestimate), and fluoride (large underestimate). As an indication of uncertainty, the 90% confidence intervals ranged by a factor of ~5x for cobalt, ~2x for fluoride, and 6x for copper (Barr 2008, Memo from Peter Hink and Miguel Wong, Document UA02A). Model results indicate a reasonable chance for sulfate to exceed the secondary MCL criteria at the property boundary (i.e., exceeds the MCL only under the high linear leakage scenario). Arsenic and antimony are likely to exceed the MCL for some distance down-gradient of the Category 1/2 stockpile, but will probably be below their MCLs (i.e., incorporation of reasonable attenuation in the groundwater model reduced predicted concentrations to below the MCLs; RS74A, Tables 6-30 to 6-32).

For the Category 3 waste rock stockpile, concentrations of arsenic, copper, iron, manganese, nickel and antimony are likely to exceed the ground water evaluation criteria or secondary MCL criteria in a zone downgradient of the facility (**Table 4.31A**). There is a reasonable chance (i.e., under high liner leakage scenario) that nickel and, for some years, sulfate, will exceed their MCLs where this ground water discharges to the Partridge River (**Figure 4.1-37**).

The predicted nickel concentrations in groundwater downgradient from the Category 3 waste rock stockpile (**Figure 4.1-37**) illustrate two important characteristics of potential effects on groundwater quality:

- Natural attenuation (adsorption of nickel to the shallow aquifer material in this case) is a very important mechanism for reducing the concentrations of metals loaded to groundwater from waste rock, with a 50- to 500-fold reduction required to reduce concentrations in receiving groundwater to below regulated thresholds.

- Surface deposited Category 3 and 4 waste rock have the potential to leach solutes to groundwater for long periods (i.e., continue for greater than a thousand years).

Although the solute transport modeling used adsorption values from other studies, the PolyMet modeling is not supported by site-specific values for nickel adsorption to mine-site materials. The potential for a long-term groundwater impacts increases the “significance” of nickel contamination. In light of this, site-specific information on metal attenuation in the shallow aquifer around the PolyMet project would greatly reduce uncertainty in predicted groundwater impacts.

Uncertainty analysis for the Category 3, Lean Ore, and Category 4 waste rock indicated that solute load rates from the waste facility were above the median values for the set of representative analytes selected (i.e., antimony, arsenic, cobalt, copper, fluoride, nickel, sulfate and vanadium) (Barr 2008, Memo from Peter Hink and Miguel Wong, Document UA02A).

For Category 3 Lean Ore Stockpile (**Table 4.1-31B**), there will probably be a groundwater zone where iron, manganese, and nickel exceed their respective MCLs. There is a moderate probability (i.e., under high liner-leakage conditions, or if attenuation is very low) that nickel will exceed its MCL at the Partridge River (RS74A, Barr 2008, Tables 6-30 to 6-32).

The Lean Ore Surge Pile behaves similarly (**Table 4.1-31B**). It will almost certainly produce a groundwater plume that exceeds MCLs for iron, manganese, and nickel; and there is some chance (i.e., under high liner leakage condition) that the zone of groundwater that exceeds the MCLs for these three constituents will become large enough to discharge to the Partridge River. (RS74A, Barr 2008, Tables 6-30-6-32)

Pit Lakes

The uncertainty in the pit lake water quality was estimated by conducting probabilistic simulation of the pit infilling, and water quality when full, for the Proposed Action West Pit; chemical constituents that were agreed upon for this study are antimony, arsenic, cobalt, copper, fluoride, nickel, sulfate, and vanadium. (Barr 2008, Memorandum from Peter Hinck and Miguel Wong, Document UA02D Draft-02). The accuracy of the more extensive deterministic model results can then be assessed by comparing deterministic results to probabilistic results for the limited cases where both models estimated the same results.

Comparison of probabilistic model results for West-Pit water quality when it initially fills (Barr 2008, UA02D Draft-02) to the deterministic model results of the same condition (RS74A, Barr, 2008) provide the following guidance for assessing the reliability of the deterministic results:

- Actual concentrations of antimony, arsenic, and vanadium will probably be lower than predicted (i.e., predicted concentrations in the deterministic model were several times higher than the median value of the uncertainty range).

- Actual concentrations of cobalt, copper, nickel, and sulfate will probably be higher than predicted (i.e., predicted concentrations in the deterministic model were lower than the median value of the uncertainty range).

The reason that the deterministic model underestimates solute concentrations in the west lake is attributed variously to the following assumptions in the probabilistic modeling:

- Solute release rates from wall rock may be constant (rather than an exponential decay over time).

- Concentration “caps” (i.e., maximum solubility levels that limit solute concentration in rock leachate) may not apply.

- Precipitation and adsorption reaction in the lake may not significantly reduce solutes.

Collectively, the range in concentrations between the various models suggests that true uncertainty in predicted trace-element concentrations in mine effluent is probably larger than is indicated - even by the probabilistic models. For arsenic (**Figure 4.1-38)**, the "worst case" concentration (0.198 mg/l) was almost 10 times higher than then median value from the probabilistic model (0.029), and the probabilistic model indicated a 2-times factor for the 90% confidence interval (from 0.018 to 0.039 mg/l).

For nickel (**Figure 4.1-39**) the "worst case" concentration (0.0715 mg/l) was over 3 times lower than the median value (0.242 mg/l), and there is a 7-times factor across the 90% confidence interval (0.11 to 0.77 mg/l). These ranges are approximately consistent with the discrepancy between observed and predicted solute concentration in existing mine pit lakes, which typically differ by factors of 5 to 10

For the West Pit, results predict that there will probably be a downgradient zone of ground water that exceeds the MCLs for arsenic and antimony. However, when modeling included reasonable attenuation of these elements due to their adsorption on to aquifer solids, all constituents are likely to remain below their MCL at the property boundary but perhaps not at the Dunka Road. (RS74A, Barr 2008, Figures 6-8 to 6-11).

For the East Pit (and combined effect from Category 4 Stockpile), there will be some zone of groundwater that exceeds the MCLs for nickel and antimony. However, with reasonable values for attenuation by adsorption to aquifer materials, concentrations of all solutes are expected to be below their MCLs at the Partridge River (RS74A, Barr 2008, Tables 6-30-6-32). In considering effects, the East Pit closure design includes some wall rock in the acid-generating Virginia Formation. Although closure plan include covering this low-permeability material, the long-term water quality in the East Pit requires that this cover remain perpetually sound.

4.1.3.1.2.1.2 Tailings Basin Area

As described in Section 4.1.5.5, below, the analysis of potential water-quality impacts from the Proposed Action tailings impoundment did not use solute transport models as was done for the Mine Site. The deterministic assessment of effects on ground water considered only the seepage that could flow north from Cell 2E. Results are presented by PolyMet as predicted concentrations of constituents over time at the toe of the LTVSMC Cell 2E embankment (Table 4.1-32 and Figure 4.1-40).

For comparability of operational and closure calculations, only the "Total Water" illustrated on Figure 4.1-40 calculation is used for this EIS. Using the "Total Water" calculation, Table 4-2 in RS74B (Barr, 2008) provides the water chemistry of seepage to ground water from Cells 1E and 2E for selected operational years together with Closure and Post-closure years for the Proposed Action. It is noted that these are the same data used for the surface water modeling for the Tailings Basin – Proposed Action, except that the surface water modeling additionally considered the load associated with seepage escaping from Cell 2W, which includes the relatively small volume liner leakage from the Hydrometallurgical Residue Cells; these are not included in PolyMet's calculations of discharges to ground water at the Tailings Basin.

Table 4.1-32: Water Chemistry of Cells 1E and 2E Seepage to Groundwater under Tailings Basin – Proposed Action

	GW Eval. Crit.	Units	Year 1	Year 5	Year 9	Year 15	Year 20	Closure	Post-Closure
Ag	0.03	mg/L	0.001	0.0009	0.0009	0.0012	0.0012	0.001	0.001
Al	0.05	mg/L	0.01	**0.0961**	**0.1068**	**0.4434**	**0.3735**	**0.6373**	**0.6373**
As	0.01	mg/L	0.0059	0.0068	0.0076	**0.0155**	**0.0144**	**0.0124**	**0.0124**
B	0.6	mg/L	0.139	0.1354	0.1451	0.1732	0.1741	0.1988	0.1988
Ba	2	mg/L	0.0529	0.0503	0.0505	0.0635	0.066	0.0481	0.0481
Be	0.00008	mg/L	**0.0003**	**0.0005**	**0.0006**	**0.0014**	**0.0013**	**0.0008**	**0.0008**
Ca	--	mg/L	45.8	55.6	75.5	95.4	76.4	59.9	59.9
Cd	0.004	mg/L	0.0001	0.0002	0.0004	0.0007	0.0005	0.0002	0.0002
Cl	250	mg/L	18.9	10.7	5.9	7.6	7.7	6.3	6.3
Co	--	mg/L	0.0012	0.002	0.0025	0.0087	0.0079	0.0014	0.0014
Cu	1	mg/L	0.0059	0.0078	0.0086	0.0208	0.0202	0.0182	0.0182
F	2	mg/L	**4.5714**	**2.247**	0.6911	0.8265	0.7704	0.0182	0.0182
Fe	0.3	mg/L	0.004	0.0596	0.0591	0.0982	0.0872	**0.6747**	**0.6747**
Hardness	--	mg/L	315	261.3	255.7	319.8	270.8	227.4	227.4
K	--	mg/L	9.2	7.7	7	14.6	13.4	13.4	13.4
Mg	--	mg/L	48.7	29.8	16.3	19.8	19.4	18.9	18.9
Mn	0.05	mg/L	**0.2895**	**0.3101**	**0.2887**	**0.4324**	**0.4504**	**0.2764**	**0.2764**
Na	--	mg/L	66.1	34.8	22.1	22.5	19.4	12.2	12.2
Ni	0.1	mg/L	0.0095	0.0298	0.0412	**0.1537**	**0.1418**	0.0151	0.0151
Pb	0.015	mg/L	0.0006	0.0008	0.0017	0.0024	0.0018	0.0011	0.0011
Sb	0.006	mg/L	0.0048	**0.0065**	**0.0088**	**0.0113**	**0.0102**	0.0054	0.0054
Se	0.03	mg/L	0.001	0.0012	0.0014	0.0025	0.0023	0.0015	0.0015
SO_4	250	mg/L	142.8	140.4	166.6	241.9	212	110.3	110.3
Tl	0.0006	mg/L	**0.001**	**0.0009**	**0.001**	**0.0012**	**0.0011**	**0.0009**	**0.0009**
Zn	2	mg/L	0.0098	0.0176	0.0397	0.0812	0.0611	0.0202	0.0202

NOTES: Concentrations highlighted in bold exceed the ground water evaluation criteria.
Source: Modified from Table 4-2, RS74B, Barr (2008).

Because the Proposed Action Mitigation Design appeared to be a more likely design for the tailings facility, the uncertainty assessment was restricted to two parameters in the deterministic predictions for the Proposed Action: (1) seepage rate of water from the pond into the tailings, and (2) the efficiency of horizontal drains used to capture seepage near the tailings dam. Higher seepage from the relatively good-quality pond increases dilution of contaminants and thus improves ground water quality; and the drains preferentially capture more contaminated tailings-dam water, so more effective capture by the drains improves the quality of the receiving groundwater. Constituent loads from the beaches and embankment were held constant, neglecting a potentially large source of uncertainty. Details of the plan to estimate uncertainty in groundwater impacts from the Proposed Action Tailings Facility, along with the more extensive list of model parameters and associated ranges for each that could be used for a more complete uncertainty analysis, are presented in the Model Evaluation Plan (MDNR 2008).

The key impacts on Tailings Basin area ground water under the Proposed Action are as follows:

- The deterministic modeling indicated that the horizontal drains would preferentially capture the high-sulfate water from the coarse tailing (Figure 4.1-40), and thereby maintain sulfate below the 250 mg/l MCL. However, the probabilistic simulations of groundwater quality at the same point (i.e., below Proposed Action TSF Cell 2E) indicates that there is an approximately 50% probability that the sulfate concentration would actually exceed the 250 mg/l MCL [Figure 4.1-41]).

- Deterministic modeling of the TSF indicates that during operations, seepage from the toe of the Proposed Action TSF Cell 2E would cause ground water to exceed the MCLs for arsenic, antimony, and nickel, starting ~5 to 15 years after mining, with concentrations then decreasing beyond ~Year 20 as the proposed liners decreased water flow through the reactive tailings (Figure 4.1-41, Table 4.1-32). In addition, concentrations of aluminum, iron, and manganese would also exceed secondary MCLs. However, it is considered that a more thorough uncertainty analysis is likely to indicate that solute concentrations could range between several times higher and several times lower than these predicted values.

4.2.3.1.2.2 Effects on Surface Water Quality under Proposed Action

4.2.3.1.2.2.1 Sediment in Runoff

No baseline sediment concentration data were available in the Mine area rivers and creeks. During mining, sediment ponds will be constructed to minimize sediment discharges from disturbed haul road and other areas and waste rock stockpiles. With proper reclamation of the waste rock stockpiles, long-term increases in sediment in runoff in the Partridge River or Embarrass River are not anticipated.

4.2.3.1.2.2.2 Water Quality Impacts on Rivers and Lakes

Historic taconite mining throughout northeastern Minnesota has impacted and continues to impact, surface water quality by contributing various PCOC's, primarily iron and perhaps mercury. Impacts of the proposed action, and its alternatives, were predicted based on computer models. RS74A and B (Barr, 2008) describes the models used and the quality of runoff from various mine and residuals locations at the Project site. This EIS section also includes the impacts on rivers and streams from up-gradient ground water which may transport contaminants from various mine and Tailings Basin facilities. These water-quality impacts are anticipated to come from stormwater runoff from rainfall and snowmelt, waste rock stockpile liner leakage, open pit mine overflows, hydrometallurgical waste storage area seepage, and TSF seepage.

Water-quality impacts of the proposed NorthMet Mine and Tailings Basin facilities were addressed by RS74A and RS74B, respectively, (Barr, 2008). For the mine facilities, water-quality impacts were calculated at the seven Partridge River station locations (**Figure 4.1-28**) used to address streamflow impacts (SW-001, 002, 003, 004, 004a, 005, and the USGS Gage). For the Tailings Basin facilities, water-quality impacts were calculated in the Embarrass River at a site upstream (PM-12 on **Figure 4.1-34**) and a site downstream (PM-13 on **Figure 4.1-34**) from the NorthMet Mine Site.

Partridge River

Water-quality impacts in the Partridge River included existing inputs from Northshore Mining Company's Peter Mitchell Pit and the City of Hoyt Lakes WWTP. The water quality model developed and calibrated for the Partridge River watershed (RS74A, Barr 2008) was used to predict the chemistry of the River for seven time periods from Year 1 of mining through Post Closure. Each of these seven time periods was evaluated for characteristic conditions of low flow, average flow and high flow.

Modeling results included predicted concentrations for silver, aluminum, arsenic, boron, barium, beryllium, calcium, cadmium, chloride, cobalt, copper, fluoride, iron, hardness, potassium, magnesium, manganese, sodium, nickel, lead, antimony, selenium, sulfate, thallium, vanadium, and zinc. No predictions for mercury are presented because predicted concentrations for mercury were not available for the liner leakage of the stockpiles (RS53/RS42, SRK, 2007a) and groundwater recharge from the East Pit and West Pit (RS31, SRK, 2007b).

Deterministic water quality predictions were computed using the best available flow and chemistry data for the various components included in the mass-balance model. When necessary, conservative assumptions were made (e.g., all the liner leakage/seepage from the Mine Site facilities will reach the Partridge River as groundwater). In addition, the mass-balance model does not account for possible reductions in chemical mass resulting from the transport of the chemical to and within the Partridge River.

The reuse/recycle strategy adopted by PolyMet (see RS21, Barr 2007a) has resulted in no planned point discharge of process water from the Mine Site to the Partridge River. However, unrecoverable leakage from Category 1/2 Waste Rock, Category 3 Waste Rock, Category 3 Lean Ore and Category 4 Waste Rock Stockpiles and Category 4 Lean Ore Surge Pile represents a potential pathway for water quality impacts to the Partridge River and Colby Lake, in particular during the period of mining operations prior to the complete closure of waste rock stockpiles. In addition, as a result of the closure plan (RS52, Barr, 2007) for the East Pit and West Pit, groundwater recharge to the Partridge River can be expected from these pits, which represents a second potential pathway for water quality impacts to the Partridge River.

The results indicate that the Year 20 scenario under low flow conditions depicts the case in which the impact of the NorthMet Project on the water quality of the Partridge River and Colby Lake would be the greatest. This is due to the high concentrations that were predicted for most trace metals in the stockpile leachate (RS53/RS42, SRK, 2007a) and in water accumulated in the flooded East Pit (RS31, SRK, 2007b) precisely at the time when the liner leakage from Category 3 Waste Rock, Category 3 Lean Ore and Category 4 Waste Rock Stockpiles flows south/southwest via groundwater to the Partridge River and groundwater recharge from the East Pit to the Partridge River begins to take place, while flows in the Partridge River correspond to only baseflow.

Notwithstanding the critical (conservative) combination of factors depicted in the Year 20 scenario under low flow conditions, the highest predicted concentrations for the main water quality variables of interest (antimony, arsenic, cobalt, copper, nickel, and sulfate) are less than the corresponding applicable Minnesota water quality standards:

- **Antimony.** The highest deterministic water quality prediction of antimony is 0.0069 mg/L at SW-004a in Post-Closure during average flow conditions under Mine Site-Proposed Action. This value is one-fourth of the Minnesota surface water quality standard of 0.031 mg/L. The average concentration from surface water quality monitoring in 2004, 2006 and 2007 at SW-004 is 0.0015 mg/L and at SW-005 is 0.0015 mg/L.

- **Arsenic.** The highest deterministic water quality prediction of arsenic is 0.0083 mg/L at

- SW-004a in Post-Closure during low flow conditions under Mine Site-Proposed Action. This value is one order of magnitude smaller than the Minnesota surface water quality standard of 0.053 mg/L. The average concentration from surface water quality monitoring in 2004, 2006 and 2007 at SW-004 is 0.0010 mg/L and at SW-005 is 0.0010 mg/L.

- **Cobalt.** The highest deterministic water quality prediction of cobalt is 0.00207 mg/L at SW-004 in Year 15 during low flow conditions under Mine Site-Proposed Action. This value is less than one-half the Minnesota surface water quality standard of 0.005 mg/L. The average concentration from surface water quality monitoring in 2004, 2006 and 2007 at SW-004 is 0.00050 mg/L and at SW-005 is 0.00060 mg/L.

- **Copper.** The highest deterministic water quality prediction of copper is 0.00697 mg/L at SW-004 in Year 15 during low flow conditions under Mine Site-Proposed Action. This value is 84 percent of the Minnesota surface water quality standard of 0.00830 mg/L, based on a predicted hardness of 87.3 mg/L. The average concentration from surface water quality monitoring in 2004, 2006 and 2007 at SW-004 is 0.00209 mg/L and at SW-005 is 0.00174 mg/L.

- **Nickel.** The highest deterministic water quality prediction of nickel is 0.02565 mg/L at SW-004 in Year 15 during low flow conditions under Mine Site-Proposed Action. This value is approximately one-half the Minnesota surface water quality standard of 0.0465 mg/L, based on a predicted hardness of 87.3 mg/L. The average concentration from surface water quality monitoring in 2004, 2006 and 2007 at SW-004 is 0.00190 mg/L and at SW-005 is 0.00207 mg/L.

- **Sulfate**. The highest deterministic water quality prediction of sulfate is 31.7 mg/L at SW-004a in Post-Closure during low flow conditions under Mine Site-Proposed Action.There is no Minnesota water quality standard for sulfate applicable to the use classification of the Partridge River. The average concentration from surface water quality monitoring in 2004, 2006 and 2007 at SW-004 is 10.0 mg/L and at SW-005 is 9.0 mg/L.

All constituents meet minimum in-stream Minnesota water quality standards at all locations in the Partridge River during low, average and high flow conditions for all modeled scenarios under the Mine Site-Proposed Action. In most cases, the deterministic water quality predictions are well below the Minnesota surface water quality standards.

Colby Lake

Water-quality impacts in the Colby Lake portion of the Partridge River included existing inputs from Northshore Mining Company's Peter Mitchell Pit and the City of Hoyt Lakes WWTP. The water quality model developed and calibrated for the Partridge River watershed (RS74A, Barr 2008) was used to predict the chemistry of

Colby Lake for the seven time periods corresponding to different stages of the Mine Site development, closure and post closure. Each of these seven time periods was evaluated for characteristic conditions of low flow, average flow and high flow.

Notwithstanding the critical (conservative) combination of factors depicted in the Year 20 scenario under low flow conditions, the highest predicted concentrations for the main water quality variables of interest (antimony, arsenic, cobalt, copper, nickel, and sulfate) are less than the corresponding applicable Minnesota water quality standards:

- Antimony. The highest deterministic water quality prediction of antimony is 0.00395 mg/L in Colby Lake in Post-Closure during low flow conditions under Mine Site-Proposed Action. This value is 70 percent of the Minnesota surface water quality standard of 0.0055 mg/L.

- Arsenic. The highest deterministic water quality prediction of arsenic is 0.00515 mg/L in Colby Lake in Post-Closure during high flow conditions under Mine Site-Proposed Action. This value is one-half the Minnesota surface water quality standard of 0.01 mg/L.

- Cobalt. The highest deterministic water quality prediction of cobalt is 0.00081 mg/L in Colby Lake in Post-Closure during low flow conditions under Mine Site-Proposed Action. This value is one-fourth the Minnesota surface water quality standard of 0.0028 mg/L.

- Copper. The highest deterministic water quality prediction of copper is 0.00253 mg/L in Colby Lake in Year 15 during high flow conditions under Mine Site-Proposed Action. This value is one-fourth the Minnesota surface water quality standard of 0.0093 mg/L based on an estimated hardness of 100 mg/L.

- Nickel. The highest deterministic water quality prediction of nickel is 0.00506 mg/L in Colby Lake in Post-Closure during low flow conditions under Mine Site-Proposed Action. This value is one order of magnitude lower than the Minnesota surface water quality standard of 0.052 mg/L based on a predicted hardness of 100 mg/L.

- Sulfate. The highest deterministic water quality prediction of sulfate is 15.3 mg/L in Colby Lake in Post-Closure during low flow conditions under Mine Site-Proposed Action. This value is 6 percent of the Minnesota surface water quality standard of 250 mg/L.

All constituents meet minimum Minnesota surface water quality standards in Colby Lake during low, average and high flow conditions for all modeled time periods under the Mine Site-Proposed Action except for iron and thallium (see Tables 5-25 to 5-27 in RS74A, Barr, 2008). This result is not attributable to the NorthMet Project, but rather it is related to the detection limit of the groundwater and to the existing levels in the surface water quality monitoring of the Partridge River. The Class 1B Minnesota water quality standard for iron is a secondary MCL of 0.3 mg/L, which is applicable for Colby Lake. There is no Minnesota water quality standard for iron in the Partridge River. The average concentration of iron from surface water quality monitoring in 2004, 2006 and 2007 at SW-004 is 1.99 mg/L and at SW-005 is 1.34 mg/L at SW-004. The average concentration of iron from groundwater quality monitoring in 2004, 2006 and 2007 at SW-004 is 2.84 mg/L. Therefore, the Minnesota water quality standard for iron would be exceeded even without NorthMet Project.

The deterministic water quality predictions for thallium in the Partridge River did not exceed Minnesota water quality standards under Mine Site-Proposed Action. However, thallium standards are stricter for Class 2Bd waters (0.00028 mg/L) to which Colby Lake must adhere than for Class 2B waters (0.00056 mg/L) which is applicable for the Partridge River. Thallium was only detected once in the Partridge River at PM-1 in August 2004; all the other reported values were below the detection limit of 0.00040 mg/L. By using half the detection limit as the target in the model calibration and an

estimated concentration in groundwater that is basically negligible (0.000004 mg/L), an artificially high concentration in surface runoff was obtained. This high concentration dominates the predictions in Colby Lake. Further testing of thallium using a lower detection limit in the Partridge River would be necessary to determine predicted concentrations with a higher certainty.

Embarrass River

Water-quality impacts in the Embarrass River included existing inputs from the City of Babbitt WWTP upstream. The Embarrass River water quality model (RS74B, Barr, 2008) was used to predict water chemistry in the Embarrass River during various stages of mine operation and closure. Deterministic water quality predictions of each constituent of analysis during Years 1, 5, 8, 9, 15, 20, Closure, and Post-Closure at surface water monitoring location PM-12 for low, average and high flows under Tailings Basin-Proposed Action. PM-12 is located upstream of all mining related inputs to the Embarrass River model. Therefore, no changes in water quality are observed between model predictive time periods (RS74B, Barr, 2008).

Modeling results included predicted concentrations for silver, aluminum, arsenic, boron, barium, beryllium, calcium, cadmium, chloride, cobalt, copper, fluoride, iron, hardness, potassium, magnesium, manganese, sodium, nickel, lead, antimony, selenium, sulfate, thallium, vanadium and zinc. The maximum deterministic water quality predictions of some key water quality parameters are summarized below:

- **Antimony**. The highest deterministic water quality prediction of antimony is 0.00150 mg/L at PM-12 during low flow conditions under Tailings Basin-Proposed Action. This value is one order of magnitude smaller than the Minnesota surface water quality standard of 0.031 mg/L. The average concentration from surface water quality monitoring in 2004, 2006 and 2007 at PM-12 is 0.00150 mg/L.

- **Arsenic**. The highest deterministic water quality prediction of arsenic is 0.00273 mg/L at PM-12 during low flow conditions under Tailings Basin-Proposed Action. This value is one order of magnitude smaller than the Minnesota surface water quality standard of 0.053 mg/L. The average concentration from surface water quality monitoring in 2004, 2006 and 2007 at PM-12 is 0.00100 mg/L.

- **Cobalt**. The highest deterministic water quality prediction of cobalt is 0.00110 mg/L at PM-12 during low flow conditions under Tailings Basin-Proposed Action. This value is about one-fifth the Minnesota surface water quality standard of 0.005 mg/L. The average concentration from surface water quality monitoring in 2004, 2006 and 2007 at PM-12 is 0.00058 mg/L.

- **Copper.** The highest deterministic water quality prediction of copper is 0.00400 mg/L at PM-12 during low flow conditions under Tailings Basin-Proposed Action. This value is about one-half the Minnesota surface water quality standard of 0.00832 mg/L, based on a hardness of 87.5 mg/L. The average concentration from surface water quality monitoring in 2004, 2006 and 2007 at PM-12 is 0.00153 mg/L.

- **Nickel.** The highest deterministic water quality prediction of nickel is 0.00700 mg/L at PM-12 during low flow conditions under Tailings Basin-Proposed Action. This value is one order of magnitude smaller than the Minnesota surface water quality standard of 0.04659 mg/L based on a hardness of 87.5 mg/L. The average concentration from surface water quality monitoring in 2004, 2006 and 2007 at PM-12 is 0.00194 mg/L.

- **Sulfate.** The highest deterministic water quality prediction of sulfate is 8.5 mg/L at PM-12 during low flow conditions under Tailings Basin-Proposed Action. There is no Minnesota surface water quality standard for sulfate applicable to the Use Classification of the Embarrass River. The average concentration from surface water quality monitoring in 2004, 2006 and 2007 at PM-12 is 4.6 mg/L.

All modeled parameters meet minimum in-stream Minnesota water quality standards at

PM-12 during low, average and high flows for all modeled scenarios under Tailings Basin-Proposed Action. In most cases, the deterministic water quality predictions are well below the Minnesota surface water quality standards.

Deterministic Water Quality Predictions at PM-13 for each constituent of analysis during Years 1, 5, 8, 9, 15, 20, Closure, and Post-Closure at surface water monitoring location PM-13 are presented for low, average and high flows under Tailings Basin-Proposed Action. PM-13 is located downstream of the Tailings Basin. The maximum deterministic water quality predictions of some key water quality parameters are summarized below:

- **Antimony.** The highest deterministic water quality prediction of antimony is 0.00209 mg/L at PM-13 in Year 20 during low flow conditions under Tailings Basin-Proposed Action. This value is one order of magnitude smaller than the Minnesota surface water quality standard of 0.031 mg/L. The average concentration from surface water quality monitoring in 2004, 2006 and 2007 at PM-13 is 0.00150 mg/L.

- **Arsenic**. The highest deterministic water quality prediction of arsenic is 0.00393 mg/L at PM-13 in Post-Closure during low flow conditions under Tailings Basin-Proposed Action. This value is one order of magnitude smaller than the Minnesota surface water quality standard of 0.053 mg/L. The average concentration from surface water quality monitoring in 2004, 2006 and 2007 at PM-13 is 0.00100 mg/L.

- **Cobal**t. The highest deterministic water quality prediction of cobalt is 0.00172 mg/L at PM-13 in Year 20 during low flow conditions under Tailings Basin-Proposed Action. This value is about one-third the Minnesota surface water quality standard of 0.005 mg/L. The average concentration from surface water quality monitoring in 2004, 2006 and 2007 at PM-13 is 0.00050 mg/L.

- **Copper**. The highest deterministic water quality prediction of copper is 0.00579 mg/L at PM-13 in Post-Closure during low flow conditions under Tailings Basin-Proposed Action. This value is less than one-half the Minnesota surface water quality standard of 0.0116 mg/L, based on a hardness of 130.7 mg/L. The average concentration from surface water quality monitoring in 2004, 2006 and 2007 at PM-13 is 0.00200 mg/L.

- **Nickel**. The highest deterministic water quality prediction of nickel is 0.01829 mg/L at PM-13 in Year 20 during low flow conditions under Tailings Basin-

Proposed Action. This value is about one-fifth the Minnesota surface water quality standard of 0.0804 mg/L based on a hardness of 166.7 mg/L. The average concentration from surface water quality monitoring in 2004, 2006 and 2007 at PM-13 is 0.00207 mg/L.

- **Sulfate**. The highest deterministic water quality prediction of sulfate is 63.4 mg/L at PM-13 in Year 20 during low flow conditions under Tailings Basin-Proposed Action. There is no Minnesota surface water quality standard for sulfate applicable to the Use Classification of the Embarrass River. The average concentration from surface water quality monitoring in 2004, 2006 and 2007 at PM-13 is 36.1 mg/L.

All constituents meet minimum in-stream Minnesota water quality standards at PM-13 during low, average and high flow conditions for all modeled scenarios under the Tailings Basin-Proposed Action except for aluminum. In most cases, the deterministic water quality predictions are well below the Minnesota surface water quality standards. The water quality standard for aluminum of 0.125 mg/L is exceeded at PM-13 for all scenarios of Plant Site development and closure for low and average flow conditions. The maximum deterministic water quality prediction for aluminum is 0.24649 mg/L under low flow conditions and 0.23718 mg/L under average flow conditions. The exceedances are in part explained by the fact that the average monitored concentration of aluminum in the Embarrass River at PM-13 in 2004, 2006 and 2007 (0.1916 mg/L) also exceeds the Minnesota surface water quality standard. The maximum deterministic water quality prediction of aluminum is an increase of 29 percent over existing conditions.

The deterministic model predicts sulfate concentrations at PM-13 that are above the average measured concentration of 36.1 mg/L. This is in part due to the difficulties of the sulfate calibration. The high concentrations of sulfate in the Pit 5NW discharge (1,046 mg/L) result in a significant load to the Embarrass River, as the deterministic model assumes conservation of mass. Including the load from the Pit 5NW discharge, the model calibration resulted in predicted sulfate concentrations (51 mg/L for average flow conditions) higher than the average measured concentration even without any additional mining inputs. Therefore, while the model-predicted sulfate concentrations for average flows are higher than the average measured concentration, the increase relative to model calibration (i.e., pre-PolyMet) is smaller than might be considered when comparing to the average measured sulfate concentration of 36.1 mg/L at PM-13. This is apparent in the culpability analysis for sulfate (see Barr, RS74B, 2008), where Pit 5NW appears as the primary source for average flow conditions. This situation does not occur during low flows, for which the discharge from the Pit 5NW is assumed to be zero.

4.2.3.1.2.2.2 Other Pollutants

Accidental releases of materials associated with mining such as oils and chemicals represent potential impacts to surface water quality during the life of the mining activity. Potential hydrocarbon-related effects to water quality would be minimized through non-structural BMPs in the SWPPP and secondary containment and other procedures in PolyMet's Spill Prevention Control Countermeasures (SPCC) Plans for the plant and mine sites (PolyMet Mining, 2006; 2007). Vehicle accidents, which would presumably be rare, could also release fuel, oil, or other substances to the road drainage network. In the event of any such releases, standard response and cleanup practices would occur, but there could be some short-term effects on water quality and biotic stream components if spilled materials reached nearby streams. The potential for such spills to occur would be low and the potential for stream impact even less so. These impacts are considered to be negligible to minor, site-specific, and short-term (See Section 4.1.12 Hazardous Materials).

4.2.3.1.2.2.3 Geotechnical Evaluation of the Proposed Action, Waste Dumps

In evaluating the proposed design of the waste rock stockpiles as detailed in

RS23T and RS49, a number of key areas and potential impacts were identified as discussed below. The proposed design comprises stockpiles to store four different types of mine waste rock from Category 1 to 4 in increasing levels of reactivity with liners designed for each waste rock type.

Liner System

Minnesota regulations indicate that the design of the waste rock stockpiles must "provide for collection and disposal of any remaining waters that drain from the mine waste." The proposed Category 1/2 stockpile liner system does not appear to provide adequate containment. A soil liner subject to small flows (i.e., flux rates less than the saturated hydraulic conductivity of the liner) will pass essentially all of that flow because the predominant hydraulic gradient (driven by gravity) is vertical downward. For a significant portion of the flow to be diverted into a drain system overlying the soil liner, the flow rates in question must exceed the saturated hydraulic conductivity of the liner, and even then, a portion of the total flow equal to or greater than the saturated hydraulic conductivity of the liner (depending upon the magnitude of the hydraulic head allowed to develop above the liner) will pass through the soil liner. Since expected infiltration rates are generally less than 500 gallons per day per acre (gpd/acre) and the proposed liner at 5×10-7 centimeters per second (cm/sec) will pass 462 gpd/acre under a unit hydraulic gradient, most if not all of the infiltration will pass through the soil liner with little or no flow collected by the drain layer.

Facility Capacity

The RS reports state that waste rock stockpile capacities were developed using a dry density of 1.7 tons per cubic yard, i.e., 125.9 pounds per cubic foot (pcf), but in other places in the reports, they states that capacities were based on a waste rock porosity of 30 percent, which equates to a dry density of 115.6 pcf assuming a specific gravity of 2.65. The relevant density value needs to be clarified and the resultant capacities confirmed. Failure to address the in place density of the waste rock may result in undersized stockpiles that would need to be expanded.

Slope Stability

To date, a rigorous slope stability assessment of the stockpiles has not been conducted. This needs to be completed to include site specific shears strength testing of the mine waste rock and foundation materials (e.g., triaxial shear strength testing) and the underlying liner (i.e., liner interface direct shear strength testing if a composite liner system is incorporated into the design) and limit equilibrium slope stability analyses.

Failure to address this area of concern could result in large scale slope instability with movement of the waste rock off of the lined area, potential release of contaminants, and significant mitigation work to return the stockpiles to an operable configuration. However, it should be noted that the proposed heights and slopes of the stockpiles are within typical ranges for similar facilities.

4.1.3.2 No-Action Alternative Environmental Consequences

4.1.3.2.1 Environmental Consequences to Water Quantity

Under the No Action alternative, water quantities at the Mine and Tailings Basin sites (Partridge and Embarrass rivers) would not change from those documented in the Existing Conditions section (4.1.1.) of this EIS.

4.1.3.2.2 Environmental Consequences to Water Quality

4.1.3.2.2.1 Effects on Groundwater Quality under No Action Alternative

Under the No Action alternative, impacts to ground water at the Mine Site and Tailings Basin would not change beyond those caused by the exiting LTVSMC mine wastes as documented in the Existing Conditions section (4.1.1) of this EIS. Natural dissolution, mobilization, and transport of PCOC's would still occur at current rates due to past mining and milling activities.

4.2.3.2.2.2 Effects on Surface Water Quality under No Action Alternative

Under the No Action alternative, impacts to surface water at the Mine Site and Tailings Basin sites (respectively the Partridge and Embarrass rivers) would not change beyond those caused by the exiting LTVSMC mine wastes as documented in the Existing Conditions section (4.1.1) of this EIS. Natural dissolution, mobilization, and transport of PCOC's would still occur at current rates due to past mining and milling activities.

4.1.3.3 Proposed Action Mitigation Design Environmental Consequences

4.1.3.3.1 Proposed Action Mitigated Design for Tailings Facility

There is one proposed mitigation for the Tailings Basin design which is as follows: (1) embankments will be constructed out of LTVSMC bulk/coarse tailings instead of out of PolyMet coarse tailings, (2) the PolyMet tailings particle size will result in the tailings being deposited as bulk tailings in the tailings pond and on the beaches from subaerial spigotting, (3) the footprint of the Tailings Basin has changed in order to minimize dam construction, to allow for recovery of more LTVSMC coarse tailings, and to increase the watershed contributing to the Tailings Basin pond at closure, (4) there will be no horizontal drains in the LTVSMC north embankment of Cell 2E, and (5) a pond above the tailings will be maintained during closure.

Sufficient data, information and analyses are not presented to support the Proposed Action Mitigation Design. Some of the data presented appears to be conflicting and the analyses incorrect. Additionally, the Proposed Action Mitigation Design is not consistent with what is believed to be the standard approach to upstream method dams. ***Given the above, there are significant concerns about the viability of the mitigation design.*** A summary of a few of the key points that lead to this conclusion are presented below.

1. As stated in the Evaluation, Flotation Tailing Basin Report, (Barr May 2008), "A preliminary geotechnical site exploration was conducted in 2005 to provide updated information on the stratigraphy the tailings in the central portion of Cell 2W (previously identified area for possible tailings storage) and the southern portion of Cell 1E. Since closure in 2000, the basin has undergone significant changes due to non-use, dewatering, and consolidation that leads to strength gain."

This statement is appropriate and lends credence to the suggestion that additional investigations need to be conducted in Cells 2E and 1E where disposal of flotation tailings is planned since they have significant water pools. It also indicates that the parameters used for the analysis presented in this report reflect higher strength than the materials in Cells 2E and 1E since the materials in Cell 2W have "undergone significant changes due to non-use, dewatering, and consolidation that lead to strength gain." Thus the soil parameters used in the analysis are judged to be non-conservative and the resulting analyses are not conservative.

2. The seepage modeling was apparently conducted using permeabilities representative of materials under low effective stresses. There is likely a significant reduction in permeability in the deeper seated materials with increased effective confining stress and density. The end result is that relatively large flows may enter the tailings from the water pond. At depth, as the permeability decreases, flow in the vertical direction is limited by the decreasing permeability and thus flow to the perimeter is increased such that it is likely that the actual phreatic surface may be higher than modeled. This would lower the factor of safety and increase the risk of flows exiting the dam face thus increasing the potential for piping of the materials comprising the embankment.

3. In Section 3.3.4 of Recommended Design Alternative Report, (Barr May 2008) the following statement is made: "The USSA liquefied strength condition constrained the design. The buttress was sized to maintain a minimum factor of safety of 1.05 for the liquefied condition." The apparent reported minimum factor of safety for the USSA liquefied strength condition on the unnumbered figures attached as Appendix B is 1.01, which is below the stated desired minimum and well below commonly accepted minimum values. Polous, Castro, and France (1985) indicate that if the soil characteristics are well defined a minimum post liquefaction factor of safety of 1.1 can be considered safe. Substantially higher factors of safety should be required for less well defined soil characteristics. The Proposed Action Mitigation Design does not meet the stated minimum factor of safety of 1.05 stated in the May 2008 Report as the minimum desirable value and is well below the minimum commonly accepted factor of safety of 1.1 used when soil parameters are well defined. Given the lack of definition of the soil parameters and that they are primarily from Cell 2W and thus believed to be stronger than the soils in Cells 1E and 2E, a minimum factor of safety substantially in excess of 1.1 should be selected as the minimum acceptable.

4. Despite the stated requirement that the LTVSMC bulk tailings must have a minimum friction angle of 33 degrees in the liquefied strength condition, it is unlikely that said material will realize such a high shear strength following the occurrence of static liquefaction.

5. In Section 3.3 Slope Stability Analysis (Barr, May 2008) the statement is made that "Each strength case was analyzed for a circular slip surface failure and for a wedge failure. A wedge failure would occur if the fill materials mobilized along the contact plane between the native materials (peat and till) and the tailings." No trial wedge

failure analyses are discussed in the summary presented in Section 3.3.4 Recommended Design Alternative, nor are any presented in the figures in Appendix B. On Figure 18 there is a layer of LTVSMC slimes in the existing tailings extending under the raise intended to store PolyMet tailings and toward the downstream face of the existing LTVSMC embankment. In Section 2.2.3.5 LTVSMC Slimes, the statement is made that “The LTVSMC slimes were characterized by an approximate drained friction angle of 20 degrees (Figure 8).” In Section 2.2.3.8 PolyMet Bulk Tailings, the following statement is made “The PolyMet bulk tailings is characterized by an approximate drained friction angle of 19 degrees (Figure 14).” Given the low drained strength of both the slimes and PolyMet bulk tailings (and the possibility for either or both of those materials to statically liquefy), it would seem prudent to evaluate a potential wedge failure surface extending through the horizontal slimes layer into the PolyMet bulk tailings.

6. From an experience based standpoint most upstream method tailings dams with tailings similar to the PolyMet bulk tailings are operated with the water pond 800 to 1000 feet or more behind the dam crest to maintain low phreatic levels within the tailings. The Proposed Action Mitigation Design would operate with a water pond 400 feet upstream of the crest of the dam. This is judged to not be conservative for a major tailings storage facility with a height approaching 260 feet. A further discussion of the disadvantages of maintaining a large water pool on the surface of the tailings facility is included below under Closure. Also with the water pool close to the crest, installation of drains at the crest would be exceedingly difficult once the facility was in operation.

7. It appears an exhaustive study has been completed on potential methods to enhance the stability and the methods are either not effective, too costly or significantly reduce the storage volume. The concern here is that the Proposed Action Mitigation Design does not meet the minimum factor of safety criteria as it is currently proposed, the permeabilities of the materials are apparently not well known and subject to variation thus the suggestion that drains could be installed to enhance the stability may not be a viable option to enhance stability if the phreatic surface is higher than envisioned as a basis for this report.

8. The planned deposition method does not allow for normal hydraulic material segregation. The design calls for the placement of PolyMet bulk tailings behind a zone of relatively low permeability LTVSMC bulk tailings. Since the permeability of the LTVSMC bulk tailings is equal to or lower than the PolyMet bulk tailings it is hard to envision how the LTVSMC bulk tailings will serve as a drain. Indeed they may act to retard the flow and increase pore pressure along the contact.

Impact

Failure to complete these analyses and address the concerns discussed above may result in the construction of a facility without adequate slope stability or seepage control that may fail with a corresponding release of the impounded PolyMet flotation tailings and process water.

Closure

As detailed in RS-39/40T, the anticipated deposition pattern will leave a pond up to 50 feet deep in the center of the basin at the end of operations without a stated means of filling or regrading the top of the facility.

From a geotechnical perspective, developing a closure scheme that eliminates the water pond on the top of the tailings facility and minimizes infiltration into the tailings facility greatly reduces the potential for slope failures since one of the primary factors that leads to slope instability, namely water, is reduced or removed as the tailings facility drains.

Water is the cause of many of the problems associated with wet tailings disposal. This is well demonstrated by a review of the recent paper “Tailings Dam Safety in Sweden” by Annika Benckert in the proceedings of the “International Symposium on Major Challenges in Tailings Dams” presented at the International Commission on Large Dams (ICOLD) Congress, Montreal, Canada, June 15, 2003.

Failure to provide a closure plan addressing this issue will result in a tailings facility that will impound water in the basin in perpetuity and the resultant driving head will continue to promote flow through the tailings and then into the underlying foundation; some of which will move laterally, bypass the facility perimeter drains and escape into the environment. Additionally, design of a wet closure scheme keeps portions of the embankments saturated, which develops slopes with lower stability and higher failure potential than a relatively dry closure. Additionally, the long term functioning of any drains needs to be addressed including the longevity of pipes, if they are included in the drains, and the potential for drain plugging through chemical or biological activity.

4.1.3.3.2 Proposed Action Mitigation Design for Waste Rock and Pit Lakes

There is one Proposed Action Mitigation Design (Mine Site Alternative 1) for the mine area which include (1) the type of waste rock or lean ore material to be contained in a stockpile at a given stage of the Mine Site development or closure, (2) total and reclaimed (versus active) footprint areas of the different waste rock and lean ore stockpiles during different stages of the Mine Site development or closure, (3) type of waste rock or lean ore material to be used for backfilling of East Pit, (4) the location of

Sumps S-9 and S-10 of the Category 3 Lean Ore Stockpile are located on the north side of the stockpile rather than along Dunka Road to allow gravity drainage to the East Pit after closure, and (5) the length of time and amount of active treatment expected to be required.

4.1.3.3.3 Environmental Consequences to Water Quantity under Proposed Action Mitigation Design and Alternative

- Proposed Action Mitigation Design for Tailings Facility

The Tailings Facility Proposed Action Mitigation Design will not change impacts to water quantity in the Embarrass River already discussed for the preferred alternative.

- Proposed Action Mitigation Design for Waste Rock and Pit Lakes

The mining Proposed Action Mitigation Design will not change impacts to water quantity in the Partridge River or ground water levels already discussed for the preferred alternative.

4.1.3.3.4 Environmental Consequences to Water Quality under Proposed Action Mitigation Design

<u>4.1.3.3.4.1 Effects on Groundwater Quality under Proposed Action Mitigation Design</u>

4.1.3.3.4.1.1 Groundwater Impacts under the Proposed Action Mitigation Design (Plant Site and Tailings Basin)

As described in the introduction to this Proposed Action Mitigation Design section, the design for the Tailings Basin seeks to reduce the effects on groundwater and surface water by constructing the tailings dam out of residue from the existing LTVSMC tailings, then placing most of the PolyMet tailings in subaqueous zones to prevent oxidation and associated release of solutes. The final configuration of the Proposed Action Mitigation Design facility is shown in **Figure 4.1-42.**

Deterministic Water Quality Predictions at the Toe of the Tailings Embankment

Deterministic water quality predictions for the water leaving the toe of the LTVSMC embankment flowing north are shown in Table 8-8 and on Figures 8-16 through 8-23 in RS74B (Barr, 2008). As with the “Total Water” quality predictions summarized in Section 4.1.3.2.1.2 of this EIS for the Proposed Action, Table 4-5 in RS74B (Barr, 2008) provides the comparable water chemistry of seepage to ground water from Cells 1E and 2E for selected operational years together with Closure and Post-closure years for the Proposed Action Mitigation Design.

The predicted concentrations in Table 4-5 in RS74B are provided in **Table 4.1-33** together with a comparison to ground water evaluation criteria. It is noted that these are the same data used for the surface water modeling for the Tailings Basin – Proposed Action Mitigation Design, except that the surface water modeling additionally considered the load associated with seepage escaping from Cell 2W, which includes the relatively small volume liner leakage from the Hydrometallurgical Residue Cells; these are not included in PolyMet's calculations of discharges to ground water at the Tailings Basin.

Table 4.1-33: Water Chemistry of Cells 1E and 2E Seepage to Groundwater under Tailings Basin – Mitigation Design

	GW Eval. Crit.	Units	Year 1	Year 5	Year 10	Year 15	Year 20	Closure	P
Ag	0.03	mg/L	0.0009	0.0009	0.0008	0.0009	0.0009	0.0012	
Al	0.05	mg/L	0.0100	0.0100	**0.1251**	**0.0874**	**0.0688**	**0.6149**	
As	0.01	mg/L	0.0068	0.0068	0.0094	0.0078	0.0075	**0.0279**	
B	0.6	mg/L	0.1378	0.1378	0.1500	0.1535	0.1587	0.1506	
Ba	2	mg/L	0.0505	0.0505	0.0492	0.0500	0.0540	0.0195	
Be	0.00008	mg/L	**0.0004**	**0.0004**	**0.0006**	**0.0005**	**0.0005**	**0.0013**	
Ca	--	mg/L	77.3	77.3	107.3	81.6	65.2	68.7	
Cd	0.004	mg/L	0.0003	0.0003	0.0006	0.0006	0.0005	0.0012	
Cl	250	mg/L	15.2	15.2	5.1	5.7	5.9	4.0	
Co	--	mg/L	0.0015	0.0015	0.0016	0.0019	0.0022	0.0027	
Cu	1	mg/L	0.0068	0.0068	0.0070	0.0091	0.0114	0.0141	
F	2	mg/L	**2.9034**	**2.9034**	0.5070	0.5631	0.5994	1.1369	
Fe	0.3	mg/L	0.0040	0.0040	0.0397	0.0386	0.0217	0.0994	
Hardness	--	mg/L	374.3	374.3	310.8	254.7	218.2	402.1	
K	--	mg/L	9.3	9.3	8.0	6.7	6.2	21.3	
Mg	--	mg/L	44.0	44.0	10.4	12.4	13.4	56.0	
Mn	0.05	mg/L	**0.2403**	**0.2403**	**0.1585**	**0.1938**	**0.2308**	**0.1435**	
Na	--	mg/L	52.9	52.9	31.4	26.0	22.2	26.6	
Ni	0.1	mg/L	0.0191	0.0191	0.0248	0.0222	0.0236	0.0055	
Pb	0.015	mg/L	0.0009	0.0009	0.0030	0.0027	0.0023	0.0010	
Sb	0.006	mg/L	**0.0080**	**0.0080**	**0.0117**	**0.0093**	**0.0088**	0.0012	
Se	0.03	mg/L	0.0011	0.0011	0.0016	0.0015	0.0014	0.0033	
SO_4	250	mg/L	190.0	190.0	223.1	183.9	163.3	176.5	
Tl	0.0006	mg/L	**0.0009**	**0.0009**	**0.0010**	**0.0010**	**0.0010**	**0.0001**	
Zn	2	mg/L	0.0182	0.0182	0.0636	0.0666	0.0587	0.0128	

NOTES: Concentrations highlighted in bold exceed the ground water evaluation criteria.
Source: Modified from Table 4-5, RS74B, Barr (2008).

Key results of deterministic modeling indicates the following characteristics of groundwater quality at the toe of the tailings facility (c.f. **Table 4.1-32** with **Table 4.1-33** and see **Figure 4.1-43**):

- Sulfate (SO4) remains below the groundwater MCL of 250 mg/l (peak at 245 mg/l in year 11, then decreases thereafter, including Closure and Post-closure, Figure 4.1-43),
- Arsenic (As) exceeds the MCL (0.01 mg/l) by only ~20% during operations, and for only ~2 years around year 11, after which it remains below the MCL; however, in Closure and Post-closure arsenic concentrations increase to ~twice the MCL, and
- Antimony (Sb) is between ~0.008 and 0.012, slightly above the MCL (0.006 mg/L) during operations, and decreases to below the MCL in Closure and Post-Closure

The temporal trend in ground water sulfate at the toe of the Proposed Action Mitigation Design illustrates the effect of facility construction, which produces a slug of sulfate associated with oxidation products, then a decrease in sulfate as the oxidation rate slows in response to isolation of the Polymet tailings in subaqueous zones.

However, the temporal trend for arsenic with nearly two-fold increase relative to the Proposed Action in Closure and Post-closure is believed to reflect the increased presence and/or reactivity of the LTVSMC tails.

Solute Transport Modeling of Impacts to Ground Water

PolyMet performed additional solute transport modeling using the same cross-sectional methodology presented for the Mine Site – Proposed Action (Section 4.1.3.1.2.1.1, above). This new modeling [Barr, 2008 “Plant Site Groundwater Impacts Predictions", Memo from Jere Mohr, Tina Pint, and Don Richard (Barr Engineering) to Stuart Arkley (MDNR), November 12, 2008], was in response to an Agency request for modeling directly comparable to the Mine Site and also to correct technical flaws in the Closure modeling in RS74B, particularly Sections 8.3 and 8.4 therein, together with Figures 8-24 through 8-37.

The same general modeling approach is used for the evaluation of the potential Tailings Basin ground water impacts predictions as was used for the Mine Site (RS74A) and summarized in **Section 4.1.5.5, below**. A “screening level model” was prepared to determine what the dissolved constituents of concern were for the

Plant Site. In the screening level model, the most conservative simplifying assumptions were made. If the dissolved constituents being evaluated were not predicted to exceed groundwater evaluation criteria under these assumptions, those constituents were not carried forward to the next phase of modeling. More detailed modeling was conducted for those constituents that showed potential exceedances of groundwater evaluation criteria using the screening level model. Because of the heightened concern regarding sulfate concentration as it relates to mercury, sulfate was carried forward to the next phase of modeling regardless of whether the screening level model predicted ground water concentrations in excess of criteria.

At the Tailings Basin, predicted groundwater concentrations were evaluated at four points along the flow path as shown on **Figure 4.1-44**. The four evaluation points are, respectively, a point midway between the toe of the Tailings Basin and the property boundary, the property boundary, the closest domestic well downgradient of the Tailings Basin, and the Embarrass River. The four evaluation locations are approximately 575 meters, 1150 meters, 2575 meters, and 4725 meters from the toe of the Tailings Basin, respectively.

The model dispersion coefficients, domain and discritization, and hydraulic conductivity values are summarized, respectively, in **Tables 4.1-39, 4.1-40, and 4.1-41 of Section 4.1.5.5, below**. For the transient models, sorption was allowed using Kd parameters summarized in **Table 4.1-42**, except the Kd value for arsenic was required to be increased from 25 in the base case model to values of about 400 to 6,000 in order to demonstrate that ground water concentrations below the MCL for arsenic of 0.01 mg/L could be achieved with attenuation by sorption.

Concentrations of seepage from the Tailings Basin – Proposed Action Mitigated Design were presented in Table 8-8 of RS74B (**Table 4.1-33** shows selected years). Predicted concentrations of Tailings Basin seepage were applied to the upgradient specified flux boundary of the cross-sectional model. For the screening level model, the highest predicted concentrations for each constituent were used. For the more detailed transient model, time-varying source area concentrations were incorporated as shown in Table 5-2 in [BARR, 2008 "Plant Site Groundwater Impacts Predictions", Memo from Jere Mohr, Tina Pint, and Don Richard (Barr Engineering) to Stuart Arkley (MDNR), November 12, 2008].

Deterministic Water Quality Predictions for Ground Water North of the Tailings Facility

Results from the transient models are presented in Table 5-4 of [BARR, 2008 "Plant Site Groundwater Impacts Predictions", Memo from Jere Mohr, Tina Pint, and Don Richard (Barr Engineering) to Stuart Arkley (MDNR), November 12, 2008]. The results for two of the evaluation points are summarized in **Table 4.1-34**:

Table 4.1-34: Summary of Maximum Concentrations Predicted Using Transient Solute Transport Models for Tailings Basin - Mitigation Design, Property Boundary and Residential Well Evaluation Locations

	Project Operations		**Closure and Post-closure**		
	Years 1-20		**Years 21-2000**		
	Ground Water Evaluation Criteria	**Model Maximum Conc.**	**Model Kd**	**Model Maximum Conc.**	**Model Final Conc.**
	(mg/L)	**(mg/L)**	**(L/kg)**	**(mg/L)**	**(mg/L)**
Tailings Basin Northern Flow Path - Property Boundary Evaluation Location					
Arsenic					
No Sorption	0.01	**0.010**	--	**0.027**	**0.026**
With Sorption	0.01	0.003	25	**0.026**	**0.026**
With Sorption[1]	--	--	433	0.0045	0.0042
Aluminum					
No Sorption	0.05	**0.20**	--	**0.58**	**0.58**
Fluoride					
No Sorption	2	**2.76**	--	1.08	1.07
Manganese					
No Sorption	0.05	**0.23**	--	**0.22**	**0.14**
Antimony					
No Sorption	0.006	**0.0113**	--	**0.0085**	0.0012
With Sorption	0.006	0.0015	45	0.0025	0.0012
Sulfate					
No Sorption	250	217	--	167	166
Tailings Basin Northern Flow Path - Residential Well Evaluation Location					
Arsenic					
No Sorption	0.01	0.009	--	**0.025**	**0.025**
With Sorption	0.01	0.003	25	**0.025**	**0.025**
With Sorption[1]	--	--	433	0.0045	0.0042
Aluminum					
No Sorption	0.05	**0.16**	--	**0.54**	**0.54**
Fluoride					
No Sorption	2	1.74	--	1.00	1.00
Manganese					
No Sorption	0.05	**0.19**	--	**0.20**	**0.13**
Antimony					
No Sorption	0.006	**0.0098**	--	**0.0085**	0.0012
With Sorption	0.006	0.0015	45	0.0021	0.0012
Sulfate					
No Sorption	250	188	--	166	155

NOTES:
Conc. Concentration, 0.014 Bold indicates exceeds evaluation criteria.
1 Equivalent Kd from Barr PHREEQC geochemical model,
Todd DeJournett, personal communication, 11/26/08.NOTES: (1) Maximum concentrations are from deterministic predictions; for some constituents, these ranged from far above to far below median values in parallel probabalistic simulations (see text for further explanation).

(2) Solute transport modeling used adsorption values from other studies based on data from other sites (Table 4.1-42); NorthMet site-specific sample values are not available (see text for further explanation).
Source: modified from Table 5-4 in BARR, 2008 "Plant Site Groundwater Impacts Predictions", Memo from Jere Mohr, Tina Pint, and Don Richard (Barr Engineering) to Stuart Arkley (MDNR), November 12, 2008

Evaluation determines the following impacts to ground water in the surficial aquifer north of the Tailings Basin:

- **Arsenic**: The concentration of arsenic in ground water is predicted to be above the evaluation criterion (0.01 mg/L) with and without the inclusion of sorption at all four of the evaluation locations.

- **Antimony**: The concentration of antimony in ground water is predicted to be below the evaluation criterion (0.006 mg/L) with the inclusion of sorption at all four of the evaluation locations. When sorption is not simulated, the concentration of antimony in ground water is predicted to be above the criterion for a period during operations and closure (less than 50 years).

- **Aluminum:** The concentration of aluminum in groundwater is predicted to be above the ground water evaluation criterion (0.05 mg/L) at all four of the evaluation locations throughout operations and closure.

- **Fluoride**: The concentration of fluoride in groundwater is predicted to be below the ground water evaluation criterion (2 mg/L) at the residential well and Embarrass River evaluation locations during operations. The concentrations are predicted to be temporarily above the secondary MCL at the property boundary (second evaluation location) and the first evaluation location during operations but not during closure.

- **Manganese:** The concentration of manganese in groundwater is predicted to be above the ground water evaluation criterion (0.05 mg/L) at all four of the evaluation locations during operations and closure.

- **Sulfate**: The concentration of sulfate in groundwater is predicted to be below the evaluation criterion (250 mg/L) at all four of the evaluation locations during operations and closure.

The transient groundwater transport models thus predict potential exceedances of antimony, arsenic, aluminum, fluoride and manganese. The potential arsenic exceedance is further addressed below. Fluoride is predicted to exceed the secondary MCL at the first evaluation and second locations (i.e., the property boundary) during operations. The possibility of high fluoride concentrations discharging from the Tailings Basin are considered by PolyMet to be a likely consequence of flushing from previous LTCSMC operations as discussed in Section 8.2 of RS74B.

It is also noted by PolyMet [BARR, 2008 “Plant Site Groundwater Impacts Predictions", Memo from Jere Mohr, Tina Pint, and Don Richard (Barr Engineering) to Stuart Arkley (MDNR), November 12, 2008] that while aluminum concentrations are predicted to reach a maximum concentration of 0.6 mg/L at the first evaluation location and 0.54 mg/L at the residential well evaluation location (third evaluation location), that these concentrations are well below the existing aluminum concentrations measured at several of the wells surrounding the Tailings Basin.

For example, well GW-001 (**Figure 4.1-44)**, which is located at the toe of the Tailings Basin, very near the cross-section being modeled, has an average aluminum concentration of 12.9 mg/L. The maximum predicted concentration for seepage leaving the PolyMet Tailings Basin is 0.62 mg/L. A similar condition exists for manganese: Tailings Basin seepage is predicted to have a maximum manganese concentration of 0.24 mg/L while well GW-001 reported an average manganese concentration of 2.35 mg/L.

Thus the background concentrations in surficial aquifer described by PolyMet appear to be both above the evaluation criteria and to reflect the history of seepage from the LTVSMC tailings. However, PolyMet did not acquire sufficient ground water chemistry data or install new monitoring wells North from the tailings impoundment to develop background concentrations so as to use the elevated background in the ground water impact models described above.

The question of arsenic attenuation was further addressed by PolyMet [BARR, 2008 “Plant Site Groundwater Impacts Predictions", Memo from Jere Mohr, Tina Pint, and Don Richard (Barr Engineering) to Stuart Arkley (MDNR), November 12, 2008] using geochemical modeling based on measured total iron concentrations in Mine Site surficial aquifer materials as a proxy for sorption onto amorphous iron hydroxide (ferrihydrite) in the Tailings Basin surficial aquifer. However, the Agency contractor (Knight Piésold) has questioned the appropriateness of the geochemical modeling given the lack of site specific sediment samples, constraining geochemical data (e.g., site specific redox measurements), or site specific sorption data (e.g., development of a sorption isotherm for the area in question.

Given the short time-frame for Agency comment and response, and in lieu of the above geochemical modeling, the Agency contractor requested PolyMet to determine the effective Kd for arsenic consistent with the results of the geochemical modeling. Briefly, the results of the additional modeling were the attenuation of arsenic seepage (i.e., discharging at 0.028 mg/L during Closure and Post-closure) throughout 2,000 year transient models to concentrations ranging from the recharge/background (i.e., about 0.003 mg/L), up to about 0.005 mg/L (i.e., one-half the MCL of 0.01 mg/L) at all the evaluation points. As shown in Table 4.1-42, these effective Kds for arsenic ranged from about 400 to 6,000 L/kg. As also shown in Table 4.1-42, these effective Kd values are substantially greater than EPA recommended values referred to by PolyMet, but well within the range of Kds for arsenic used in other studies.

Comparison of Mitigation Design to Proposed Action

Given the lack of impact predictions for the Proposed Action, the best comparison between likely impacts for the Tailings Basin - Proposed Action Mitigation Design to the Proposed Action lies in comparison of the deterministic predictions for the Cells 1E and 2E seepage to ground water at the toe of the tailings facility, for which key results for arsenic, antimony and sulfate were summarized above. Further comparison of **Table 4.1-32** – Proposed Action with **Table 4.1-33** – Proposed Action Mitigation Design finds that the alternative has substantially lower concentrations of nickel, particularly in Closure; somewhat lower concentrations of iron, manganese, antimony, and sulfate in all time periods; but substantially higher arsenic concentrations in Closure.

The Mitigation Design thus appears to be an improvement to the Proposed Action in terms of impacts to ground water quality for most constituents except arsenic, but this could be a matter of perspective depending upon the relative importance attached to substantially higher (modeled) arsenic concentrations compared to credence attached to the geochemical modeling of arsenic attenuation during transport. In any case, similar to the conclusions from the limited uncertainty analysis for the Proposed Action, it is considered that a thorough uncertainty analysis for the Mitigation Design is likely to indicate that solute concentrations could range between several times higher and several times lower than these predicted values.

Unresolved Components in Tailings Basin Solute Transport Models

- Resolution of the PolyMet modeling currently presented in RS74B in response to Agency comments about technical flaws in the Closure modeling, particularly Sections 8.3 and 8.4 therein, together with Figures 8-24 through 8-37.

- Development of formal Agency comments with possible response from PolyMet concerning the geochemical modeling of arsenic attenuation due to sorption onto total iron in surficial aquifer sediment [BARR, 2008 “Plant Site

Groundwater Impacts Predictions", Memo from Jere Mohr, Tina Pint, and Don Richard (Barr Engineering) to Stuart Arkley (MDNR), November 12, 2008].

4.1.3.3.4.1.2 Groundwater Impacts under Reasonable Alternative 1 (Subaqueous Disposal Alternative, Mine Site)

RA1 (described in Chapter 3) is designed to reduce effects on groundwater and surface water by: 1) minimizing the duration over which sulfide-bearing rock is allowed to oxidize in surface facilities, 2) virtually eliminate long-term sulfide oxidation and associated solute release by backfilling and then submerging Category 2, 3, and 4 rock in the East pit, and 3) capturing and treating leachate from the backfilled East Pit as it floods.

Modeling to estimate the effect of waste rock and mine pits on groundwater under RA1 used the same general approach as the evaluation of the Mine Site under the Proposed Action: A “Screening Level” model was used first to assess transport all analytes under “high,” “medium,” and “low” rates of leakage through waste-rock liners, then refined modeling (i.e., incorporating attenuation by adsorption to the aquifer matrix) was applied only to constituents with a reasonable chance of exceeding standards. Because final stockpile footprints and groundwater flow conditions under RA1 would be similar to the Proposed Action, the same cross-sectional groundwater solute transport models were used for both scenarios.

Constituents predicted to exceed their respective MCLs in groundwater before considering attenuation are listed below in Table 8-20 of RS74B (Barr, 2008).

The modeling indicates that RA1 has a lower potential to effect groundwater quality than the proposed action. The results of the transient modeling are summarized in **Table 4.1-35.**

Following is a summary of groundwater effects under RA1 for in each area of the Mine Site (RS74A, Barr 2008). These include a description of how the proposed physical construction of each area differs from the Proposed Action, a list of constituents expected to exceed groundwater MCLs near the facility (i.e., those constituents predicted to exceed MCLs in the screening model, and that thus will produce at least a small plume of groundwater that exceeds the MCLs), and a list of the constituents expected to be above MCLs at exposure points (i.e., predicted to exceed in MCLs at evaluation points in the detailed transient models).

Effects on Mine Site groundwater under RA1:

- Category 1 and Overburden Stockpile (Flow Path #1, **Table 4.1-35**):
    - Physical conditions: Facility remains as surface pile after closure.
    - Constituents above MCL near the source (models without sorption): arsenic, antimony, nickel and sulfate.
    - Constituents above MCL at Property Boundary evaluation point: Sulfate could exceed MCL (only exceeds under assumed high liner leakage rate).
- West Pit (Flow Path #2, **Table 4.1-35**):
    - Physical conditions: No outflow to groundwater until pit is full at Years 60 to 76 (i.e., 40 to 56 years after mining):
    - Constituents above MCL near the source (models without sorption): arsenic and antimony.
    - Constituents above MCL at Property Boundary evaluation points: none.

- East Pit and Category 4 Waste Rock Stockpile. (Flow Path #4, **Table 4.1-35**):
    - Physical conditions: Pit excavated for 12 years, then backfilled with Category 2, 3, and 4 waste rock as it fills, then outflow to groundwater starting at mine closure at 20 years after closure; Category 4 waste rock removed form surface storage before closure.
    - Constituents above MCL near the source (model without sorption): iron.
    - Constituents above MCL at Partridge River evaluation point: none.

- Category 2/3 Waste Rock Stockpile (Flow Path #6, Table 4.1-35):
    - Physical conditions: Re-excavated and placed in the pit before mine closure, surface storage replaced with Category 1 waste rock by mine closure.
    - Constituents above MCL near the source (models without sorption): arsenic, antimony, iron, and manganese.
    - Constituents above MCL at Partridge River evaluation points: none.

- Category 3 Lean Ore Stockpile (Flow Path #5, **Table 4.1-35**):
    - Physical conditions: Excavated and replaced with Category 1 waste rock by year 15 of mining.
    - Constituents above MCL near the source (models without sorption): none
    - Constituents above MCL at Partridge River evaluation point: none.

- Lean Ore Surge Pile (Flow Path #3**, Table 4.1-35**):
    - Physical conditions: Removed after closure.

- Constituents above MCL near the source (models without sorption): iron, manganese.
- Constituents above MCL at Partridge River evaluation points: iron and manganese possible (only under high liner leakage rate)

Table 4-1-35: Summary of Maximum Concentrations Predicted Using Transient Solute Transport Models for Mine Site - RA1, Flow Paths #1, #2, #3, #4, #5, and #6, All Liner Yields

	Project Operations and Closure		Post-closure		
	Years 1-76 (L), 1-66 (A), 1-60 (H)		Years 61 to 77-2000		
	Ground Water Evaluation Criteria	Model Maximum Conc.	Model Liner	Model Maximum Conc.	Model Final Conc.
	(mg/L)	(mg/L)	(L, A. H)	(mg/L)	(mg/L)
Category 1 - Overburden Stockpile (Flow Path #1, Property Bndry. Eval. Point)					
Arsenic					
No Sorption	0.01	0.0033	H	**0.099**	**0.099**
With Sorption	0.01	0.0028	H	0.0028	0.0028
Nickel					
No Sorption	0.1	0.013	H	**0.110**	**0.110**
With Sorption	0.1	0.0057	H	0.0057	0.0057
Antimony					
No Sorption	0.006	0.0015	H	**0.016**	**0.016**
With Sorption	0.006	0.0015	H	0.0015	0.0015
Sulfate					
No Sorption	250	45	H	**408**	**408**
West Pit (Flow Path #2, Property Boundary Evaluation Point)					
Arsenic					
No Sorption	0.01	---	H	**0.079**	**0.079**
With Sorption	0.01	---	H	0.0028	0.0028
Antimony					
No Sorption	0.006	---	L	**0.046**	**0.046**
With Sorption	0.006	---	L	0.0015	0.0015
Sulfate					
No Sorption	250	---	L	120	120
Category 2/3 Stockpile (Flow Path #5, Partridge River Evaluation Point)					
Arsenic					
No Sorption	0.01	**0.011**	H	**0.022**	**0.022**
With Sorption	0.01	0.0021	H	0.0024	0.0024
Iron					
No Sorption	0.3	0.21	H	**0.60**	**0.60**
Manganese					
No Sorption	0.05	0.048	H	**0.077**	**0.077**
Antimony					
No Sorption	0.006	0.0025	L	**0.0086**	**0.0086**
With Sorption	0.006	0.0015	L	0.0015	0.0015
Sulfate					
No Sorption	250	42	L	213	213
Lean Ore Surge Pile (Flow Path #3, Partridge River Evaluation Point)					
Iron					
No Sorption	0.3	**0.65**	H	**0.65**	0.20
Manganese					
No Sorption	0.05	**0.080**	H	**0.081**	0.039

	Project Operations and Closure		Post-closure		
	Years 1-76 (L), 1-66 (A), 1-60 (H)		Years 61 to 77-2000		
	Ground Water Evaluation Criteria	Model Maximum Conc.	Model Liner	Model Maximum Conc.	Model Final Conc.
	(mg/L)	(mg/L)	(L, A. H)	(mg/L)	(mg/L)
Sulfate					
No Sorption	250	29	H	30	14
East Pit and Category 4 Stockpile (Flow Path #4, Partridge River Eval. Point)					
Iron					
No Sorption	0.3	0.27	H	0.27	0.24
Sulfate					
No Sorption	250	18	L, A	46	30
Category 3 Lean Ore Stockpile (Flow Path #6, Partridge River Evaluation Point)					
Sulfate					
No Sorption	250	27	H	27	27
NOTES:					
Conc. = concentration; Eval. = evaluation; Bndry. = boundary					
0.022	Bold indicates exceeds evaluation criteria.				
L, A, H	Low (L), Average (A), or High (L) liner leakage.				

NOTES: (1) Maximum concentrations are from deterministic predictions; for some constituents, these ranged from far above to far below median values in parallel probabalistic simulations (see text for further explanation).
(2) Solute transport modeling used adsorption values from other studies based on data from other sites (Table 4.1-42); NorthMet site-specific sample values are not available (see text for further explanation).
Source: Modified from Tables 8-24, 8-25, 8-26, RS74B (Barr, 2008).

A complete listing of predicted evaluation point concentrations in groundwater for RA1 is presented in RS74A (Barr 2008), Tables 8-24 through 8-26.

Comparison of Reasonable Alternative 1 to Proposed Action

The modeling indicates that Reasonable Alternative 1 has a lower potential to effect ground water quality than the Proposed Action. In addition to the parameters discussed below, both the Proposed Action and Reasonable Alternative 1 are predicted to have several exceedances of iron, manganese and aluminum secondary MCL criteria. The predicted concentrations of key dissolved constituents are discussed below:

- Antimony. For the Proposed Action, potential exceedances were identified using the screening level models for the Category 1/2 – Overburden Stockpile and the West Pit; the detailed models for these flow paths showed that no exceedances are predicted when sorption is considered. For the RA1, potential exceedances were identified using the screening level models for the Category 1 Stockpile and the West Pit; the detailed models for these flow paths showed that no exceedances are predicted when sorption is considered.

- Arsenic. For the Proposed Action, potential exceedances were identified using the screening level models for the Category 1/2 – Overburden Stockpile, the West Pit and the Category 3 Waste Rock Stockpile; the detailed models for these flow paths showed that no exceedances are predicted when sorption is considered. For the RA1, potential exceedances were identified using the screening level models for the Category 1 Stockpile, the West Pit and the Category 2/3 Waste Rock Stockpile. The detailed models for these flow paths showed that no exceedances are predicted when sorption is considered.

- Copper. For the Proposed Action, a potential exceedance was identified using the screening level model for the Category 3 Waste Rock Stockpile. The detailed model for this flow path showed that no exceedances are predicted when sorption is considered. For the RA1, no potential exceedances were identified using the screening level models.

- Nickel. For the Proposed Action, potential exceedances were identified using the screening level models for the East Pit and Category 4 Waste Rock Stockpile, the Category 3 Waste Rock Stockpile, the Category 3 Lean Ore Stockpile and the Lean Ore Surge Pile; the detailed models for these flowpaths showed that when sorption is considered, the groundwater evaluation criteria for nickel along the Category 3 Waste Rock Stockpile and the Category 3 Lean Ore Stockpile flowpaths under high liner leakage conditions may be exceeded, but exceedances are not expected for the low or average linear leakage conditions along either flow path. For the RA1, a potential exceedance was identified using the screening level model for the Category 1 Stockpile; the detailed model for this flowpath showed that no exceedances are predicted.

- Sulfate. For the Proposed Action, potential exceedances were identified using the screening level models for the Category 1/2 – Overburden Stockpile and the Category 3 Waste Rock Stockpile; the detailed model for the for the Category 1/2 – Overburden Stockpile flow path showed that the secondary MCL criteria for sulfate under high liner leakage conditions may be exceeded, but not for the low or average linear leakage conditions; the detailed model for the for the Category 3 Waste Rock stockpile flowpath showed no exceedance for sulfate. For the RA1, a potential exceedance was identified using the screening level model for the Category 1 Stockpile; the detailed model for this flowpath showed that the secondary MCL criteria for sulfate along the Category 1 Stockpile flow path under high liner leakage conditions may be exceeded, but exceedances are not expected for the low or average linear leakage conditions.

Unresolved Components in Mine Site Solute Transport Models

- RA1 assumes that effluent from the East Pit will be treated perpetually in a passive wetland built on the surface of the backfilled East Pit. However, a technical justification for treatment efficiency and duration of effective treatment has not been provided.

- Cooperating Agencies have requested steady-state screening level evaluations at the five flow paths crossing the Dunka Road because these are likely ground waster monitoring points; only transient models with the Dunka Road evaluation points have been provided.

4.2.3.3.4.2 Effects on Surface Water Quality under Proposed Action Mitigation Designs

Proposed Action Mitigation Design for Tailings Facility

PM-12 is located upstream of all mining related inputs to the Embarrass River model. Therefore, the maximum deterministic water quality predictions presented for the Tailings Basin-Proposed Action are the same as for the Tailings Basin-Proposed Action Mitigation Design.

PM-13 is located downstream of the Tailings Basin. The maximum deterministic water quality predictions of selected water quality parameters are summarized below for Tailings Basin-Proposed Action and Tailings Basin-Proposed Action Mitigation Design:

- **Antimony.** The highest deterministic water quality prediction of antimony is 0.00217 mg/L at PM-13 in Year 10 during low flow conditions under Tailings Basin-Proposed Action Mitigation Design. This value is slightly greater than the highest deterministic water quality prediction for antimony of 0.00209 mg/L at PM-13 in Year 20 during low flow conditions under Tailings Basin-Proposed Action. In both cases, however, the maximum predicted values are one order of magnitude smaller than the Minnesota surface water quality standard of 0.031 mg/L.

- **Arsenic.** The highest deterministic water quality prediction of arsenic is 0.00545 mg/L at PM-13 in Post-Closure during low flow conditions under Tailings Basin-Proposed Action Mitigation Design. This value is 39 percent greater than the highest deterministic water quality prediction for arsenic of 0.00393 mg/L in Post-Closure and during low flow conditions under Tailings Basin-Proposed Action. In both cases, however, the maximum predicted values are one order of magnitude smaller than the Minnesota surface water quality standard of 0.053 mg/L.

- **Cobalt.** The highest deterministic water quality prediction of cobalt is 0.00172 mg/L at PM-13 in Year 20 during low flow conditions under Tailings Basin-Proposed Action. This value is 31 greater than the highest deterministic water quality prediction for cobalt of 0.00131 mg/L under Tailings Basin-Proposed Action Mitigation Design. In both cases, however, the maximum predicted values are no greater than one-third the Minnesota surface water quality standards of 0.005 mg/L.

- **Copper**. The highest deterministic water quality prediction of copper is 0.00579 mg/L at PM-13 in Post-Closure during low flow conditions under Tailings Basin-Proposed Action. This value is 13 percent greater than the highest deterministic water quality prediction for copper of 0.00513 mg/L at PM-13 in Post-Closure during low flow conditions under Tailings Basin-Proposed Action Mitigation Design. The Minnesota surface water quality standard for copper is hardness-depending, being 0.0116 mg/L for the Tailings Basin-Proposed Action estimated hardness and 0.0128 mg/L for the Tailings Basin-Proposed Action Mitigation Design estimated hardness. The maximum predicted values are no greater than one-half the corresponding Minnesota surface water quality standard.

- **Nickel**. The highest deterministic water quality prediction of nickel is 0.01829 mg/L at PM-13 in Year 20 during low flow conditions under Tailings Basin-Proposed Action. This value is 110 percent greater than the highest deterministic water quality prediction for nickel of 0.00868 mg/L at PM-13 in Year 20 during low flow conditions under Tailings Basin- Proposed Action Mitigation Design The Minnesota surface water quality standard for nickel is hardness-depending, being 0.0804 mg/L for the Tailings Basin-Proposed Action estimated hardness and 0.0783 mg/L for the Tailings Basin-Proposed Action Mitigation Design estimated hardness. The maximum predicted values are no greater than one-fourth the corresponding Minnesota surface water quality standards.

- **Sulfate.** The highest deterministic water quality prediction of sulfate is 63.4 mg/L at PM-13 in Year 20 during low flow conditions under Tailings Basin-Proposed Action. This value is slightly greater than the highest deterministic water quality prediction for sulfate of 61.6 mg/L at PM-13 in Year 10 during low flow conditions under Tailings Basin-Proposed Action Mitigation Design. There is no Minnesota surface water quality standard for sulfate applicable to the Use Classification of the Embarrass River. The average concentration from surface water quality monitoring in 2004, 2006 and 2007 at PM-13 is 36.1 mg/L.

All parameters meet minimum in stream Minnesota water quality standards at PM-13 during low, average and high flow conditions for all modeled scenarios except aluminum whose exceedances were explained above for both Tailings Basin-Proposed Action and Tailings Basin-Proposed Action Mitigation Design.

Proposed Action Mitigation Design for the Mine Site (Waste Rock and Pit Lakes)

The location of the different inputs to the water quality model of the Partridge River watershed for different stages of the Mine Site development and closure under the Mine Site Alternative 1 is presented in Barr (RS74A, 2008). In addition, the footprint areas of the waste rock and lean ore stockpiles for the different stages of the Mine Site development and closure under the Mine Site Alternative 1 are presented in Barr (RS74A, 2008). Impacts to the Partridge River and Colby Lake as a result of Mine Site Alternative 1 are considered quantitatively below.

- Partridge River

Deterministic water quality predictions of each constituent of analysis during Years 1, 5, 10, 12, 15, 20, Closure, and Post-Closure in Partridge River are presented in Barr (RS74A, 2008) for low, average and high flows in the Partridge River under Mine Site Alternative 1. The maximum deterministic water quality predictions of some key water quality parameters are summarized below:

- **Antimony**. The highest deterministic water quality prediction of antimony is 0.00633 mg/L at SW-004a in Post-Closure during average flow conditions under Mine Site Alternative 1. This value is one-fifth of the Minnesota surface water quality standard of 0.031 mg/L. The average concentration from surface water quality monitoring in 2004, 2006 and 2007 at SW-004 is 0.0015 mg/L and at SW-005 is 0.0015 mg/L.

- **Arsenic.** The highest deterministic water quality prediction of arsenic is 0.00756 mg/L at SW-004a in Post-Closure during low flow conditions under Mine Site Alternative 1. This value is one-seventh of the Minnesota surface water quality standard of 0.053 mg/L. The average concentration from surface water quality monitoring in 2004, 2006 and 2007 at SW-004 is 0.0010 mg/L and at SW-005 is 0.0010 mg/L.

- **Cobalt.** The highest deterministic water quality prediction of cobalt is 0.00161 mg/L at the USGS Gage in Post-Closure during low flow conditions under Mine Site-RA1. This value is one-third the Minnesota surface water quality standard of 0.005 mg/L. The average concentration from surface water quality monitoring in 2004, 2006 and 2007 at SW-004 is 0.00050 mg/L and at SW-005 is 0.00060 mg/L.

- **Copper**. The highest deterministic water quality prediction of copper is 0.00339 mg/L at SW-004a in Year 5 during low flow conditions under Mine Site Alternative 1. This value is less than half the Minnesota surface water quality standard of 0.00758 mg/L based on a predicted hardness of 78.4 mg/L. The average concentration from surface water quality monitoring in 2004, 2006 and 2007 at SW-004 is 0.00209 mg/L and at SW-005 is 0.00174 mg/L.

- **Nickel.** The highest deterministic water quality prediction of nickel is 0.01522 mg/L at the USGS Gage in Post-Closure during low flow conditions under Mine Site Alternative 1. This value is one-third the Minnesota surface water quality standard of 0.04450 mg/L based on a predicted hardness of 82.9 mg/L. The average concentration from surface water quality monitoring in 2004, 2006 and 2007 at SW-004 is 0.00190 mg/L and at SW-005 is 0.00207 mg/L.

- **Sulfate.** The highest deterministic water quality prediction of sulfate is 33.1 mg/L at SW-004a in Post-Closure during low flow conditions under Mine Site Alternative 1. There is no Minnesota water quality standard for sulfate applicable to the use classification of the Partridge River. The average concentration from surface water quality monitoring in 2004, 2006 and 2007 at SW-004 is 10.0 mg/L and at SW-005 is 9.0 mg/L.

All constituents meet minimum in-stream Minnesota water quality standards at all locations in the Partridge River during low, average and high flow conditions for all modeled scenarios under the Mine Site Alternative 1. In most cases, the deterministic water quality predictions are well below the Minnesota surface water quality standards.

- Colby Lake

Colby Lake must conform to different Minnesota water quality standards than the Partridge River. Deterministic water quality predictions of each constituent of analysis during Years 1, 5, 10, 12, 15, 20, Closure, and Post-Closure in Colby Lake are presented in Barr (RS74A, 2008) for low, average and high flows under Mine Site Alternative 1. The maximum deterministic water quality predictions of some key water quality parameters are summarized below:

- **Antimony.** The highest deterministic water quality prediction of antimony is 0.00373 mg/L in Colby Lake in Post-Closure during low flow conditions under Mine Site Alternative 1. This value is two-thirds the Minnesota surface water quality standard of 0.0055 mg/L.

- **Arsenic**. The highest deterministically water quality prediction of arsenic is 0.00493 mg/L in Colby Lake in Post-Closure during high flow conditions under Mine Site Alternative 1. This value is one-half the Minnesota surface water quality standard of 0.01 mg/L.

- **Cobalt**. The highest deterministic water quality prediction of cobalt is 0.00077 mg/L in Colby Lake in Post-Closure during low flow conditions under Mine Site Alternative 1. This value is one-fourth the Minnesota surface water quality standard of 0.0028 mg/L.

- **Copper**. The highest deterministic water quality prediction of copper is 0.00207 mg/L in Colby Lake in Post-Closure during low flow conditions under Mine Site Alternative 1 This value is one-fourth the Minnesota surface water quality standard of 0.0093 mg/L based on an estimated hardness of 100 mg/L.

- **Nickel**. The highest deterministic water quality prediction of nickel is 0.00455 mg/L in Colby Lake in Post-Closure during low flow conditions under Mine Site Alternative 1. This value is one order of magnitude smaller than the Minnesota surface water quality standard of 0.052 mg/L based on an estimated hardness of 100 mg/L.

- **Sulfate**. The highest deterministic water quality prediction of sulfate is 15.8 mg/L in Colby Lake in Post-Closure during low flow conditions under Mine Site Alternative 1. This value is one order of magnitude smaller than the Minnesota surface water quality standard of 250 mg/L.

All constituents meet minimum Minnesota water quality standards for Colby Lake during low, average and high flow conditions for all modeled scenarios of the Mine Site development and closure under the Mine Site Alternative 1 except for iron and thallium (see Tables 7-22 to 7-24 in Barr, RS74A, 2008). Similar to the Mine Site-Proposed Action, these concentration exceedances are related to the detection limit of the groundwater and to the existing concentration levels in the surface water quality monitoring of the Partridge River as discussed above.

4.1.4 Cumulative Effects on Water Resources

4.1.4.1 Proposed Action (Cumulative Effects)

4.1.4.1.1 Water Quantity Cumulative effects under Proposed Action

Mine Site: Partridge River
Processing site: Embarrass River

4.1.4.1.2 Water Quality Cumulative effects under Proposed Action

4.1.4.1.2.1 Groundwater quality cumulative effects under Proposed Action

Mine Site
Processing site

4.1.4.1.2.2 Surface water quality cumulative effects under Proposed Action

Mine Site: Partridge River
Processing site: Embarrass River

4.1.4.2 Proposed Action Mitigation Design for Tailings Facility (Cumulative effects)

4.1.4.2.1 Water Quantity Cumulative effects under Proposed Action Mitigation Design

Mine Site: Partridge River
Processing site: Embarrass River

4.1.4.2.2 Water Quality Cumulative effects under Proposed Action Mitigation Design

4.1.4.2.2.1 Groundwater quality cumulative effects under Proposed Action Mitigation Design

Mine Site
Processing site

4.1.4.2.2.2 Surface water quality cumulative effects under Proposed Action Mitigation Design

Mine Site: Partridge River

Processing site: Embarrass River

4.1.4.3 Subaqueous Disposal Alternative for Waste Rock (Cumulative effects)

4.1.4.3.1 Water Quantity Cumulative effects under Subaqueous Disposal Alternative

Mine Site: Partridge River
Processing site: Embarrass River

- **4.1.4.3.2 Water Quality Cumulative effects under Subaqueous Disposal Alternative**

<u>4.1.4.3.2.1 Groundwater quality cumulative effects under Subaqueous Disposal Alternative</u>

Mine Site
Processing site

<u>4.1.4.3.2.2 Surface water quality cumulative effects under Subaqueous Alternative</u>

Mine Site: Partridge River
Processing site: Embarrass River

4.1.4.4 Models Used to Estimate Contaminant Release from Mine Facilities

The estimates of water quality impacts in the DEIS are based largely on computational models of water and solute release from the proposed mine facilities that were developed by consultants contracted by PolyMet. These studies measured the chemical and physical properties of mine-site materials, then incorporated these parameters into established equations of water flow and chemical reactions to produce estimates for the rates that water and dissolved constituents would discharge from the facilities to groundwater and surface water. Individual models were developed to estimate water and solute release from the existing impoundment at the Tailings Basin, the proposed expansion of the Tailings Basin, the proposed development of waste rock stockpiles at the Mine Site, and the development of open pits during mining and after they fill with water.

4.1.5.1 Evaluation Criteria for Models of Contaminant Release

As the lead agency writing the DEIS, the Minnesota Department of Natural Resources (DNR) reviewed the predictive modeling studies to determine their reliability and appropriateness for estimating potential water quality impacts from the NorthMet Project. To guide the review and evaluation of the predictive models, the DNR team developed a "Model Evaluation Plan"—a framework that identified the principle model components to evaluate, and listed specific ranges for key parameters.

This model evaluation plan for MDNR drew primarily on two sources:

The National Environmental Policy Act (NEPA) and associated guidance (Council on Environmental Quality, 1978), which established reporting requirements for an EIS, and

The National Research Council (NRC) report "Models in Environmental Regulatory Decision Making "(National Research Council, 2007), which is the most current U.S. Government guidance on the development and use of predictive environmental models.

In broad terms, NEPA guidance identifies the type of information to predict, and the NRC report identifies methods that will establish the reliability of predictions.

Under NEPA, the DEIS is required to identify "any adverse environmental effects which cannot be avoided should the proposal be implemented," where "effects" are defined specifically to include:

Direct effects, which are caused by the action and occur at the same time and place.

Indirect effects, which are caused by the action and are later in time or farther removed in distance, but are still reasonably foreseeable (Council on Environmental Quality, 1978a).

Because the potential effects from the NorthMet project include short- and long-term degradation of water quality caused by solutes leaching from mine waste, the assessments of effects described in this EIS rely heavily on predictive computer modeling. Where such quantitative predictions are part of the EIS, NEPA guidance requires the EIS preparer to evaluate the computations and describe these methods, i.e., as described under "Methodology and scientific accuracy:"

> Agencies shall insure the professional integrity, including scientific integrity, of the discussions and analyses in environmental impact statements. They shall identify any methodologies used and shall make explicit reference by footnote to the scientific and other sources relied upon for conclusions in

> the statement. An agency may place discussion of methodology in an appendix. (Council on Environmental Quality 1978b).

The NRC 2007 report on environmental modeling led to selection of three specific components to evaluate in the models supplied by PolyMet to estimate effects on water quality from the NorthMet project:

A clear conceptual model, which describes in words the processes and assumptions by which mine activities can cause the release and transport of chemicals of concern to receiving groundwater or surface water.

Independent calculations of major model results, which in this case means a check on chemical mass balance or modeled reaction rates, and

An assessment of uncertainty in model predictions, which generally do not provide confident bounds on uncertainty, but that do provide some indication of prediction reliability.

The technical review of PolyMet's water quality predictive modeling proceeded in three steps that paralleled the NRC Model Report guidelines listed above. First, a conceptual model of each model study was distilled form the technical reports. Ambiguities in concepts or assumptions were resolved through meetings or correspondence with technical preparers until the DNR was convinced that the conceptual approaches were consistent with the contemporary understanding of mine waste behavior in the environment. Second, quantitative checks on model predictions were established. These included mass-balance comparison or independent "spot checks" on model calculations (i.e., independent calculations to determine how closely the mass of a specific element lost from mine waste material matches the mass of the chemical in effluent), and bench-mark tests (i.e., comparison of the chemical reaction rate in a model to the rate predicted using an independent calculation).

Third, a plan for estimating uncertainty in model predictions was developed for each model. The NorthMet project water-quality models were "deterministic" (i.e., used single values for parameters to produce a single set of results, in contrast to using ranges for parameters to produce ranges for results). These deterministic simulations were reported to have used "conservative" values for key parameters (i.e., values that tended to produce higher than expected concentrations of solutes in water). However, initial review of the water quality models found that several of the parameters did not meet this definition of "conservative," and that some models may underestimate solute concentrations in mine effluent and associated effect on water quality.

The uncertainty plan was implemented through discussions among the technical team evaluating water-quality (PolyMet's modeling consultants and DNR's technical reviewers) to:

Select the most critical parameters for each model,

Identify a reasonable range for each parameter (typically based on a combination of ranges in measured values and professional judgment), and

Establishing probability distribution types (e.g., bell curve, triangle distribution, etc.) for each parameter.

The water quality models were then run in a probabilistic mode, so that predictions (e.g., solute concentrations and flow rates for mine-waste effluent) are provided as ranges rather than discreet values. The Model Evaluation Plan is a component of the Technical Appendix to this DEIS (Minnesota Department of Natural Resources, 2008), where the specific evaluation criteria (mass balance requirements, bench marks, and ranges and distribution types for specific for parameters) are summarized in tables. Details of the uncertainty analysis are presented in technical reports associated with each mine facility.

The uncertainty analysis provides two functions. First, it allows experts to "agree to disagree." When experts disagree on appropriate values for model parameters, they can instead select ranges for the parameters, allowing a group with disparate experience and opinions to support a single model. Second, reporting uncertainty is good science. The NRC report on environmental modeling emphasis the value of assessing uncertainty, e.g.,: "Effective decision making will require providing policy makers with more than a single probability distribution for a model result (and certainly more than just a single number, such as the expected net benefit, with no indication of uncertainty)" (National Research Council 2007). Presented with ranges for values, the decision on what effect constitutes an "impact" then become a decision for the managing State or Federal agency.

The water quality models provided by PolyMet's consultants are described in the following sections, and include summaries of conceptual and computational models, the general environmental behavior of source materials, and results of the DNR's evaluation. Possible Environmental Effects are then described in a later section. The model uncertainty warrants careful consideration when assessing impacts. A water quality "impact" typically means that water quality at an exposure point exceeds a water quality criteria, but model uncertainty analysis provides a range in water quality, meaning results are given as a probability of exceeding a standard.

A final caveat: confidence intervals in water quality predictions probably don't represent the full range of uncertainty. Modeling guidance documents generally emphasize that environmental models, even when formulated using sound science, incorporate many imperfectly know parameters and require many subjective decisions. Models are not "truth telling machines" (National Research Council 2007); and complex models invariably omit some sources of uncertainty, so that even with rigorous error propagation, predictions have a strong tendency to systematically overestimate accuracy (Morgan and Henrion, 1990). Uncertainty ranges are thus presented as an indication of reliability, but are not presented as definitive boundaries on concentrations in receiving waters.

4.1.5.2 Waste Rock Model: Contaminant Release from Runoff and Seepage

4.1.5.2.1 Conceptual Model of Solute Release from Waste Rock

The conceptual model of environmental behavior in NorthMet Project waste rock facilities describes the processes and assumptions that lead to water quality effects. These concepts are the foundation of the computational model used to estimate specific water-quality impacts.

The mechanism most responsible for the release of soluble chemicals of concern from waste rock is of oxidation sulfide minerals, which at the NorthMet site is primarily the mineral pyrrhotite (FeS). Blasting and excavation dramatically increases the oxidation rate by increasing the surface area and porosity of the rock, which allows rapid introduction of atmospheric oxygen and flushing of solutes by water.

Oxidation releases soluble metals (e.g., cobalt, copper, iron, and nickel), and sulfuric acid. At very low sulfur (S) content (e.g., ~0.1% S), the acid is neutralized by reaction with host silicate minerals; but at higher sulfide content, the acid production exceeds neutralization, producing acidic drainage. Sulfide oxidation rates will decrease in zones with low pore-gas oxygen, but studies find that pore gas deep in sulfide waste rock facilities can often be near atmospheric oxygen, depending on rates of gas flow and chemical reactions. Formation of acidic conditions is problematic because this increase metal solubility and can increase oxidation rates driven by bacteria. Metals of concern (e.g., cobalt, copper, and nickel) are bound as sulfides in the rock, so sulfide oxidation is also associated with release of soluble metals. Metal mobility can be reduced under neutral conditions as metals are removed from solution by adsorption or co-precipitation, but these may be later leached if conditions become more acidic over with time. The only method considered for stopping sulfide oxidation in NorthMet Project waste is subaqueous (underwater) disposal, or, in the case of the

Proposed Action Mitigation Design for the Tailings Basin, storage in unsaturated form but below a permanent pond. Both of these methods which reduce oxygen transport, and thus oxidation, to insignificant rates.

The portion of meteoric water (rain and melting snow) that is not lost to evaporation or runoff will percolate into the waste rock before and after the surface is capped with a vegetated soil layer. Percolating water will flush metals and other products of oxidation from the rock, though this flow through unsaturated rock will take limited flow paths that may vary with flux rate and particle-size distribution. Solutes that are out of water flow paths may remain stored in the facility for many years, while solutes in these flow paths will be flushed out, seeping either down to groundwater or out as toe seepage on a liner.

4.1.5.2.2 Environmental Characteristics of Rock (Overburden, Waste Rock, Ore)

This section provides a review of the waste characterization studies that provided the supporting data on solute release from waste rock. Leaching of metals from waste-rock (surface disposal and backfill to the East Pit) was based on the waste rock characterization report (RS 53/42 and RS53/46; SRK 2007). These results apply to the models of waste rock and also the pit lake water quality.

Extensive environmental testing has been conducted on samples of potential waste-rock from within and around the proposed NorthMet project

Following is a listing of laboratory and field-scale kinetic tests measuring rates of sulfide oxidation and solute release (description from RS53/42, SRK 2007).

AMAX Shaft Test Piles: Six roughly 1000-ton test piles were constructed from rock removed from a test shaft sunk into the Babbitt Deposit in 1977 (Lapakko 1993a; Lapakko et al. 2002; Minnesota Department of Natural Resources, 2004) by AMAX. The rock contained sulfur concentrations varying from 0.64% to 1.41%, copper concentration of 0.3% to 0.4%, and nickel concentrations of 0.08% to 0.09%. The copper and nickel content was comparable to ore at NorthMet but sulfur concentrations were higher than will be expected for most waste rock at NorthMet. The piles were constructed on lined pads, and the rock surfaces of some were reclaimed with soils, glacial tills and some were vegetated. Drainage from the piles was monitored from 1977 to 1994 after which the piles were dismantled and the rock encapsulated in concrete (RS53/42).

AMAX Drill-core tests. In a parallel experiment to the AMAX test piles, twenty-four 75-g samples crushed to -100+270 mesh containing sulfur concentrations between 0.47% and 2.57% were tested in MDNR's kinetic reactor (Lapakko 1993a; 1994). The data were provided to SRK (Engstrom 2006a-c). The tests were operated for 30 to 49 weeks.

AMAX particle Size Experiment. A study by the MDNR evaluated weathering of six particle sizes (from -0.75+0.25" to -270 mesh) of rock obtained from the pile containing 0.79% sulfur (Lapakko 1994). Resulting values for effluent pH over a 10-year period were provided to PolyMet.

Dunka Pit Stockpiles. Beginning in the 1960's, Duluth Complex rock was removed to access underlying iron formation at the Dunka Pit (Minnesota Department of Natural Resources 1994, 1996). Eight stockpiles varying in quantity from 0.1 to 21 million tons were constructed of which five contained mixed iron formation and Duluth Complex and three contained mainly Duluth Complex rock. Sulfur, nickel and copper concentrations were determined on the rock. Treatment of the drainage from the stockpiles using wetlands has been investigated (Eger and Lapakko 1980, 1988; Eger et al. 2000). Although monitoring of the site has produced a detailed long term record of stockpile drainage chemistry, uncertainty in rock composition and drainage pathways led to elimination of this drainage chemistry as an analogue for stockpiles proposed at NorthMet.

Dunka Blast Hole Samples.

In 1989 and 1990, MDNR began testing of 20 samples of Duluth Complex and Virginia Formation rock obtained from blast holes at the Dunka Pit in MDNR-style reactors (Table 3-2) (Lapakko1988a,b; 1993a) for comparison with drainage from the site stockpiles. All but one sample was initially tested in duplicate. The database of leachate chemistry was provided by MDNR (Engstrom 2006a-c). Leachate were analyzed frequently for pH and specific conductivity and sporadically for alkalinity, acidity, sulfate, silicon, calcium, magnesium, sodium, potassium, iron, aluminum, cobalt, copper, nickel and zinc.

> *Although there are essentially no acid-neutralizing carbonate minerals in the NorthMet project rocks, some of the acid produced by sulfide mineral oxidation is neutralized by silicate minerals, which delays acid onset in waste rock, and can prevent acid production in low-sulfide rock (e.g., rock with sulfide less than ~0.4% sulfide S).*

Comparison of the lowest pH measured in kinetic tests on rock from the proposed NorthMet Project vs. initial total sulfide sulfur in the rock (**Figure 4.1-45**) illustrates that acid effluent from kinetic tests on rock from the NorthMet Project area generally is not produced when sulfide is below ~0.4%. Eighteen years of kinetic testing on rock samples containing less than or equal to 0.41% sulfur did not produce acidic leachate despite the presence of sulfide minerals and minimal carbonate content, leading to a general conclusion that "Acidic effluent generally does not occur in samples containing <0.4% sulfur, and is assumed to never occur in rock with <0.12% sulfur." (RS 53/42, 2007).

Sulfide-bearing rock from the NorthMet Project may oxidize for several years before producing acidic leachate.

Multi-year oxidative weathering tests in NorthMet rock indicates that sulfide rock generally have a relatively stable reaction rate for several years, during with there may be a delay in pH decrease (**Figure 4.1-46**). As the sulfide S is depleted, the oxidation rate decreases and pH rebounds (**Figure 4.1-47**)

The rate of sulfide mineral oxidation in excavated NorthMet waste rock is approximately proportional to the total sulfur content of the material.

The broad correlation between sulfide S and oxidation rates applied across rock types (**Figure 4.1-48**). Other variables, such as rock type and position in intrusive stratigraphy, appear to play a less important role that sulfide S in predicting oxidation rate.

The rate of sulfide oxidation and associated production of sulfate and soluble metals decreases dramatically as particle size increases.

Figure 4.1-49 illustrates how solute release rates increase ~10x as rock fragment size decreases from 6.4 mm (labeled "¼ + 10" on the X-axis) -- the size used in kinetic weathering tests) to <0.149 mm (labeled as "-100" of the x-axis).

Metal leach rates are only roughly proportional to total metal concentration.

The release of soluble metals in response to oxidation of NorthMet rock is typically correlated to total metal concentration (particularly for copper), but also to total sulfur (particularly for nickel) [**Figure 4.1-50]**.

Mercury release from NorthMet waste rock does not appear to be above background levels, and mercury in rainfall may actually be attenuated by contact with mine waste rock.

Mercury is of particular interest because of its potential to methylate and strongly bio-concentrate in aquatic environments. Ultra low-level mercury analyses (detection limit 2 mg/l) on a 93-sample subset of humidity cell effluents over a range of material types found average mercury concentrations between 5 and 7 mg/L, with mercury concentrations unrelated to rock type or sulfur content.

Mercury in regional rainfall is ~10 mg/L, which is above the Lake Superior basin water quality standard of 1.3 mg/L. But tests using rainfall found that contact with Duluth Complex rock decreased mercury (from 12 mg/L to between 1.9 and 3.2 mg/L; RS 53/42 [SRK 2007]).

The concentration of metal cations, including nickel and copper, can increase dramatically when the pH decreases.

Under oxidative weathering, the pH of effluent from sulfide rock tends to decrease for the first few years as acid production exceeds acid neutralization (**Figure 4.1-51**). The decrease in pH is often associated with an increase in metal concentration (**Figure 4.1-52**, which is typically attributed to the fact that the solubilities of most metals increase under acidic conditions. Where sulfide minerals oxidize for a period under neutral conditions, metals dissolved from sulfide minerals may accumulate in the sample, and then be flushed out when acidic conditions eventually arise.

Metal concentrations in neutral effluent appear to have a "cap" concentration, or approximate maximum value that probably reflects the solubility limit.

In this example, copper concentration in waste rock effluent tends to remain below ~0.01 mg/l when the pH of effluent is above ~ 8.0 (**Figure 4.1-53**)

The environmental characteristics of waste rock described above are the basis for estimating acid production and metal release from wall rock and waste rock in the models of water quality evolution in the proposed mine pit lake and waste rock effluent.

For environmental management purposes, waste rock and lean ore are grouped into 3 categories, based on their initial concentration of sulfide S (Section 3 this report, and RS53/42 [SRK, 2007x] :

- Category 1/2: S < 0.12% (will not generate acid leachate)
- Category 3: 0.12 % < S< 0.31% (may generate acid leachate, but not before 1 year of exposure to atmospheric oxygen)
- Category 4: S > 0.31%. (may generate acid leachate immediately upon exposure to atmospheric oxygen)

4.1.5.2.3 Computational Model of Waste Rock Solute Release

The computation model used to estimate seepage from NorthMet Project waste rock, ore, and lean ore is a quantitative implementation of the processes described in the conceptual model. The prediction methods drew on a waste characterization program (see RS53/42 [SRK 2007]), using in most cases an "empirical approach," where results from laboratory and small-scale field weathering tests were scaled to estimate solute release from full-size facilities. Final predictions were then subject to several constraints, primarily mineral solubility limits and results from analog mine sites, to avoid unrealistically high estimates for solute concentrations.

To estimate solute release, modeling assumes that the entire mass of waste rock in the facility is oxygenated, and thus is capable of reacting at the rate observed in laboratory oxidation tests. Estimated field oxidation rates were then scaled down by factors to represent the effect of scaling from small scale lab test to run-of mine rock under field conditions. Specific factors in the scaling include temperature (oxidation is slower at lower temperatures on site), size of fragments (only rock < ~6.4 mm was assumed to be reactive), and the fraction of rock flushed by percolating water. Additional corrections accounted separately for solute release rates from three rock categories (non-acid generating, delayed-onset acid-generating, and rapid-onset acid generating); and to avoid predictions of excessive concentration, upper-thresholds were applied to some solutes to avoid predictions of unrealistic aqueous concentration. (Values for these critical scaling parameters are listed below, and were used to assess model uncertainty). Finally, all solute-release was assumed to be constant and perpetual. Metals and sulfate leaching will eventually be leached out, but full depletion of most components of interest would take centuries—far beyond the period of prediction.

Chemical Reaction rates and solute release from waste rock:

The rates of solute release from various rocks were estimated directly from laboratory and small-scale field kinetic tests. Specifically, average solute release rates were determined from each humidity cell (mg/kg/wk), based on the period when sulfate release had stabilized after the initial solution flush. The test materials were assigned to one of 12 waste-classification, where the groups represent classification expected to produce more than 1 million tons of rock [i.e., the numeric geological units (numbered 1 to 6, sedimentary hornfels and Virginia Formation), major rock types (anorthositic, troctolite and ultramafic), and waste rock category (1/2, 3, 4)]. Solute release rates from category 3 and 4 waste (i.e., acid-generating materials) were scaled up to account for the faster rates expected under acidic conditions. Modeling used the 95th percentile rate for each classification.

The base rate for solute release rate from waste rock is provided below (**Table 4.1-36).**

Table 4.1-36: Weighted Averages of 95th Percentile Rates Indicated by Humidity Cells (mg/kg/week)

Category	2	3 (*non-acidic*)	4 (*non-acidic*)	4 (*Virginia, acidic*)	Ore
Acidity (pH=8.3)	1.3	1.4	1.4	24	1.4
Alkalinity	7.9	9.5	15	0.88	5.2
F	0.027	0.024	0.03	0.034	0.041
Cl	0.11	0.14	0.11	0.11	0.11
SO_4	2.3	11	11	50	23
Al	0.087	0.052	0.063	0.37	0.017
As	0.0044	0.0068	0.0044	0.00071	0.0014
Ba	0.0088	0.0081	0.0075	0.0052	0.0059
B	0.0039	0.0054	0.016	0.021	0.011
Cd	0.00002	0.000028	0.000021	0.0032	0.000022
Ca	2.2	4.7	3.4	3.5	7.3
Cr	0.00011	0.00011	0.00013	0.00012	0.0001
Co	0.000053	0.0059	0.000086	0.039	0.0028
Cu	0.00085	0.0084	0.00078	0.0048	0.0053
Fe	0.015	0.011	0.03	9.5	0.0074
Pb	0.000063	0.000069	0.000059	0.0011	0.000076
Mg	0.44	0.82	0.31	3.9	1.5
Mn	0.00096	0.023	0.0033	0.12	0.022
Mo	0.000027	0.000043	0.00014	0.000026	0.000034
Ni	0.00024	0.07	0.0009	0.56	0.057
Se	0.00011	0.0002	0.00042	0.0006	0.00012
Ag	0.000025	0.000031	0.000096	0.000029	0.000025
Tl	0.00001	0.00001	0.00001	0.000012	0.00001
Zn	0.0013	0.0040	0.00069	0.60	0.0021

Source: Modified from: RS 53/42, Table 8-2

Nitrate concentration in waste rock effluent is typically elevated relative to background from dissolution of nitrate-bearing blast residue. Average nitrate in PolyMet waste rock was estimated to be 10 mg N/L, based on concentrations observed nitrate concentrations in Ekati Diamond Mine in the Northwest

Territories, Canada (SRK 2008 [Memorandum subject: NorthMet Project Geochemical Uncertainty Analysis for Proposed Action – DRAFT, October 10, 2008).

Hydraulic flushing of waste rock

All solutes produced in waste rock were assumed to be flushed out in seepage each year. Total water flow is estimated as the infiltration rate into the waste rock surface (e.g., m/yr) multiplied by the area of the facility top (m2) to yield volumetric flow (m3/yr). Seepage concentrations (mg/l) were estimated as the annual solute release (mg/yr) divided by the annual flow (l/yr). Under the assumed uniform solute production throughout the rock, seepage concentrations increase in proportion to the height of the waste rock facility.

Annual average infiltration into waste rock was calculated by PolyMet in RS21, for Years 1, 5, 10, 15 and 20. Inflow calculations account for progressive reclamation efforts including the placement of evapo-transpiration covers. PolyMet provided two flow scenarios (“low” and “high”). Because water quality impacts will be determined by concentrations, all modeling was performed using the lower-boundary for the range in seepage, which results in the highest concentrations.

Predicted effluent concentrations in full scale waste rock stockpiles used the annual quantities of each rock type applied to each facility and associated change in facility footprint, as indicated by the mine schedule of the stockpiles. Effluent concentrations were estimated for each year based on the mass of each rock type and volume of water passing through each facility.

Scaling factors

The use of small-scale laboratory kinetic tests to estimate acid production and solute from full-scale mine waste rock facilities requires the application of “scaling” factors. Draft analysis by PolyMet’s consultants applied the following factors:

- Temperature correction:
  - 0.3 for Category 1/2 rock (reduces rates measured at ~20ºC to assumed wall rock temperature of ~2.4ºC--average air temperature at Hoyt Lakes)
  - for Category 3 and 4 rock (assumes heat from oxidation may keep these close to 20ºC)

- Particle size factor 0.2 (estimates the reactive fraction, based on assumption that material larger ¼ inch, the size in humidity cell tests, makes insignificant contribution to solutes).

- Contact factor: 0.5. (fraction of rock flushed by meteoric water each year)

- Upper limits on constituent solubility from mineral saturation: Solubility limits were estimated from review of the water chemistry database to identify maximum observed concentrations for a given pH

- Timing of acid onset (Category 3 and 4 only):
  - Category 3: Acid onset at 5 years after exposure (based on the AMAX stock pile data).
  - Category 4: immediate acid onset assumed.

- Maximum concentration "Caps" on waste rock effluent. To avoid unrealistically high concentrations of solutes, waste rock seepage modeling applied upper-limit concentrations in waste rock effluent. The specific limits were based on maximum concentrations observed among all kinetic tests that produced neutral and acidic effluent. These limits are presented below (**Table 4.1-37**).

Table 4.1-37: Maximum Concentration Indicated at Characteristic pHs and Possible Controlling Minerals

			Maximum Concentrations			
Parameter	Unit	Possible Controlling Minerals	At pH 8	Source	At pH 3.5	Source
Alkalinity	Mg/L	Calcium and magnesium carbonates	72.5	NorthMet MDNR Reactor	0	By definition
SO_4	Mg/L	Gypsum	2150	AMAX Pile	9600	AMAX Pile
Al	Mg/L	Kaolinite, gibbsite	1.68	NorthMet MDNR Reactor	83	AMAX Pile
Sb	Mg/L	Fe oxides	0.003	NorthMet MDNR Reactor	0.00001	NorthMet MDNR Reactor
As	Mg/L	Fe oxides	0.71	NorthMet HCT	0.71	NorthMet HCT
Ba	Mg/L	Barite	0.19	NorthMet MDNR Reactor	0.19	NorthMet MDNR Reactor
Be	Mg/L	Fe oxides	0.0002	NorthMet MDNR Reactors and HCTs	0.0023	NorthMet HCT
B	Mg/L	Unknown	0.76	NorthMet HCT	0.76	NorthMet HCT
Cd	Mg/L	Fe oxides	0.00018	NorthMet HCT	0.0149	NorthMet

			Maximum Concentrations			
Parameter	Unit	Possible Controlling Minerals	At pH 8	Source	At pH 3.5	Source
						HCT
Cr	Mg/L	Fe oxides	0.0015	NorthMet HCT	0.0015	
Co	Mg/L	Fe oxides, cobalt silicates	0.052	AMAX Pile	44	AMAX Pile
Cu	Mg/L	Tenorite, matachite	0.092	AMAX Pile	202	AMAX Pile
Fe	Mg/L	Fe oxides	0.81	NorthMet HCT	235	NorthMet HCT
Pb	Mg/L	Fe oxides	0.0528	NorthMet HCT	0.0528	NorthMet HCT
Mn	Mg/L	Mn Oxides	0.75	AMAX Pile	47	AMAX Pile
Hg	Mg/L	Fe oxides	6	Low Level Analyses	6	Low Level Analyses
Mo	Mg/L	Fe oxides	0.0051	NorthMet HCT	0.0051	NorthMet HCT
Ni	Mg/L	Nickel silicates	0.86	AMAX Pile	762	AMAX Pile
Se	Mg/L	Fe oxides	0.0029	NorthMet HCT	0.0029	NorthMet HCT
Ag	Mg/L	Fe oxides	0.0007	NorthMet HCT	0.0007	NorthMet HCT
Ti	Mg/L	Fe oxides	0.00002	NorthMet HCT	0.00006	NorthMet HCT
Zn	Mg/L	Zinc silicates	0.09	AMAX Pile	26	AMAX Pile

Source: Table 7-2 in RS 53/42 (SRK 2007)

These upper-limits are most reasonable for neutral effluent, where trace-metal concentrations are typically limited by precipitation or adsorption reactions. However, in acidic effluent, these limits may be artifacts of the test procedure, and may cause full-scale modeling to underestimate effluent concentrations.

4.1.5.2.4 Evaluation of Waste Rock Computational Model

Conceptual Model (Evaluation)

The conceptual model used to estimate waste rock effluent water quality (described above in this EIS) is based on sound reasoning and is consistent with the current understanding of environmental behavior at hard rock mines.

Mass Balance/Benchmark (Evaluation)

In accordance with the MDNR's Model Evaluation Plan (DNR 2008) PolyMet's consultants provided an example calculation demonstrating how the total release of soluble sulfate, nickel, and copper to ground water were determined for a Category 2 and Category 4 waste rock facility at Year 20 (SRK 2008 [Memorandum subject: NorthMet Project Geochemical Uncertainty Analysis for Proposed Action – DRAFT, October 10, 2008)

Uncertainty analysis (Evaluation)

In accordance with the Model Evaluation Plan developed by MDNR and PolyMet (MDNR 2008), uncertainty in predicted water quality in waste-rock effluent was provided by PolyMet's consultants (Barr 2008, Memo from Peter Hink and Miguel Wong, DocumentUA02A). This included Monte Carlo simulations of water from two facilities:

- Category 1/2 Waste Rock Stockpile (largest stockpile, with greatest liner leakage rate, and a significant source of chemical load to the West Pit during operations and closure), and

- Category 3 Lean Ore Stockpile (largest of the stockpiles with a geomembrane liner at the base, with potential for generating acid drainage, and a significant source of chemical load to the Partridge River during operations and closure).

Further, the simulations targeted the duration expected to produce the highest effluent concentrations: years 10 and 15 for Category 1/2 Waste Rock Stockpile (Year 15 represents closure conditions because the stockpile will be fully reclaimed by that time), and years 15 and 25 for Category 3 Lean Ore Stockpile (Year 25 is Post-closure, when concentrations for some constituents can be greater than at closure at Year 20.)

Model parameters included in the probabilistic simulations (i.e., the parameters assumed to be most important for predicted effluent load rate that were thus assumed to have a range of values) included:

- Rate of production of the various constituents from the stockpile rock.

- Composite scale-up factor (estimated from the difference between field scale effluent observed at Dunka Road Stockpile and laboratory kinetic-test effluent on samples form this pile, Lapakko 2008)—a multiplier common to all constituents released from mine waste which incorporates the combined effect of uncertainty in particle size, temperature, and contact factors.

- Maximum concentrations "caps" allowed for select constituents in rock effluent (i.e., chemical limits to the concentration).

- Water flux into the waste rock (i.e., "liner yield," which his the amount of water percolating through the waste rock surface and reaching the lower liner at the bottom of the stockpile—differs for the active (open) and reclaimed (closed) facilities).

- Water seepage out the bottom of the waste rock facility (i.e., the fraction of the water seeping into the waste rock facility [liner yield] that then seeps out to groundwater through flaws in the liner beneath the waste rock facility).

This level of assessment of uncertainty complied with the Model Evaluation Plan, as requested by the MDNR.

Unresolved Components of Waste-rock Model

The mass-balance confirmation on the waste-rock modeling requested in the Model Evaluation Plan (Minnesota Department of Natural Resources 2008) has not been received by MDNR

4.1.5.3 Pit lake water quality model—contaminant release to lake and discharge

This section describes the methods and results of modeling conducted to estimate quality of water pumped from the NorthMet Project open pits during mining and the lakes that will eventually form in the pits during and after mining. This work is described in greater detail in RS31 (SRK 2007). Pit water quality predictions rely on application of the waste rock, lean ore and ore characterization tests (see RS53/42 [SKR 2007]). The issues associated with pit water quality are comparable to waste rock leachate predictions; primarily water quality degradation caused by ARD and leaching of heavy metals, particularly nickel, copper, and cobalt.

The mine pit water quality predictions are based on a two-pit configuration (East and West Pit) with the East Pit consisting of two sub-pits (East and Central—henceforth East Pit refers to the combined East and Central subpits) [**Figure 4.1-54].** The East and West Pits will be developed concurrently, with the East Pit completed after 11 years, the Central Pit complete after 14 years, and the West pit complete in Year 20. Category 2 waste rock produced in Years 12 to 20 from the West Pit will be backfilled into the East Pit (both sub-pits) as the East Pit is also filled with water using West Pit dewatering water and some treated Mine Site water from the Waste Water Treatment Facility (WWTF). Following completion of mining, the West Pit will be allowed to flood using natural inflow from groundwater, direct precipitation inputs, runoff from the reclaimed Category 2 stockpile, overflow from the East Pit and its wetland, water from the Tailings Basin ponds, and seepage water from the Tailings Basin.

4.1.5.3.1 Conceptual Model of Pit Lake Water Quality Evolution

Most broadly, soluble chemicals enter mine pit lakes primarily as 1) dissolved constituents that are present naturally in inflowing groundwater, 2) leachate that is released from mine wall rock as it is flushed by rain or snowmelt, and 3) leachate that is released from waste rock backfilled as it is flooded by the pit lake. Solutes are removed from the lake either as dissolved constituents in outflow (to groundwater or surface water) or as chemical precipitates that settle to the lake bottom. The movement of chemicals is discussed here in terms of "load rate," which is the rate that a mass of a specific constituent is added or removed. Thus for inflows, load rate [mg/month] = flow rate [l/month] × concentration [mg/l]. Because the environmental impacts related to pit lake water (e.g., human or ecological risk from the lake water, and effect on surface or groundwater receiving pit outflow) are based on constituent concentrations, estimates of mass in the lake are converted to lake concentration [mg/l] by dividing total mass in the lake [mg] by lake volume [l].

The environmental behavior of NorthMet mine rock (summarized previously in the discussion of waste rock) demonstrated that the probable elements of concern for water quality (nickel, copper, cadmium, arsenic, antimony, sulfate, and acidity) are released from waste rock and wall-rock primarily by the oxidation of sulfide minerals. The estimate of pit lake water quality thus focuses on sulfide-mineral oxidation in rock that is leached to the lake. In wall rock, blasting produces fractures, particularly in horizontal pit benches, where blast holes are typically drilled to ~2-m below the bench top. Observation in pit mines also show frequent formation of talus cones on benches from physical weathering of the steeper walls. The result is a permeable rind in the pit walls with enhanced oxygen diffusion (and thus sulfide mineral oxidation), and greater hydraulic permeability (which facilitates flushing of solutes by percolating rain and snowmelt). Some solutes may remain in the pit walls, held in fractures out of seepage flow paths; but most are assumed to eventually flush out when the rock is inundated by the lake. During mining, solutes leached from wall rock are captured in sumps and treated or used as process water. After inundation, wall-rock oxidation essentially stops due to the solubility of oxygen being low (~10 mg/l) and the diffusion rate of oxygen in water slow (i.e., ~1/10,000th as fast as in air), so submerged wall rock may be essentially inert.

Waste rock backfilled to the pit lake has a chemical effect similar to wall rock, with waste rock above the lake surface oxidizing and leaching some solutes to the lake. However, when inundated by the lake, leaching stops and the submerged rock is essentially inert fill that primarily acts to reduce the lake volume.

Finally, solutes can be lost from the pit lake by two mechanisms: direct advection, as dissolved constituents in outflow (e.g., pit water that discharges to groundwater, flows out the lip of the pit, or is pumped out); and chemical precipitation, such as when acidic water is neutralized in the pit.

4.1.5.3.2 Environmental Characteristics of Pit Rock

The material in the pit wall rock and pit backfill are subset of the materials studied for the environmental assessment of waste rock. These environmental characteristics of rock that will affect pit lake water quality (i.e., sulfide content, rates of sulfide oxidation and solute release, etc.) are summarized in the discussion of waste rock and presented in detail in RS53/42 [SRK 2007]).

4.1.5.3.3 Computational Model of Pit-lake Water Quality

The pit water-quality models couple modeling and predictions from: 1) rock composition (block modeling, mine planning), 2) physical water inflows (hydrological and hydrogeological modeling), 3) oxidation in and solute release from wall rocks, 4) geochemical predictions of effluent quality from the waste rock and tailings facilities, and 5) the waste water treatment facility effluent quality.

In overview, modeling considers the overall load reporting to the pit lake at any time to be the sum of chemical load from inflowing water (groundwater, tailings seepage, waste rock seepage, runoff, and treated water), seepage from aerated wall rock backfilled waste rock that are leached by precipitation, and flushing of stored oxidation products from wall rock and backfill as it floods. After the pit lakes reaches a static water elevation, the long-term water chemistry is controlled by the continued leaching of solutes from pit highwalls that remain above the lake and the load lost in outflow.

Solute loading to the pit from wall rock was estimated using an empirical scale-up of solute-release rates measured in small-scale kinetic test data. Most broadly, the composition of pit water, either pumped out during mining or present in the pit lake, was based on dividing the solute load into the pit (wall rock leachate, groundwater in flow, etc.) by the volume of receiving water. Upper limits on concentrations of specific metals were superimposed on this simple mixing to reflect the effect of chemical precipitation or adsorption reactions.

Sources for critical parameters for the pit lake models include:

- Geologic block models and wall-rock composition, (RS67, PolyMet 2007).

- Mine planning and excavation schedule (RS9, Golder Associates 2006; RS18, Barr 2006).

- Physical water inflows (hydrological and hydrogeological modeling; (RS22, RS10A, Barr 2007).

- Predictions of geochemical performance of wall rocks (RS53/42, SRK 2007), geochemical predictions of other related facilities (RS53/42, SRK 2007).

- Tailings water composition (RS46, SRK 2007).

- Waste water treatment plant operational parameters (RS29T, Barr 2007).

- Net precipitation (precipitation less evaporation), described in RS73 (Barr 2006).

Additional external loads to the lakes included in the computational model included:

- Groundwater (based on average from monitoring wells).

- Storm water runoff from undisturbed soil (East Pit, during closure; used Partridge R. water quality).

- Storm water runoff from the reclaimed surfaces of the waste rock stockpiles and others areas (West Pit, during closure; (RS24 and RS52, both by Barr Engineering, 2007x).

- East Pit wetland overflow (RS29T).

- Leakage from stockpile liners (RS42).

- Tailings seepage and process pond (chemistry from RS52/46).

Lake volumes are critical parameters for planning water management, dilution effects, and closure planning. Water-quality modeling used the elevation: volume relationships for proposed action pit lakes (**Figure 4.1-55)**.

<u>Mine pit excavation and filling schedule</u>

Mining planning includes the following schedule for excavation and closure of the NorthMet Project's East and West pits (where the East Pit includes the sub-basin Central Pit; **Figure 4.1-54**):

Year 1 to 12:

The East and West Pits will be started concurrently in year 1 and mined continuously until year 12, at which time the East Pit ore will be exhausted. Water produced form the pits during this period is expected to exceed surface-water quality standards, and thus will be pumped to the Waste Water Treatment Facility (WWTF) prior to discharge.

Year 12 to 20:

West Pit:

Mining continues in West pit from year 12 to exhaustion of the West Pit ore in year 20. Category 1/2 waste rock is used as backfill to the East Pit, and water produced by the West Pit excavation will be treated in the WWTF then discharged to the East Pit.

East Pit:

The East Pit will be backfilled with Category 1/2 waste rock as it is excavated from the West Pit and flooded. (Sulfide minerals oxidation was assumed to continue at a rate controlled by intrinsic reaction kinetics and oxygen availability until the rock is submerged, after which it was assumed to be perpetually stable (MEND 2001.) The waste will be emplaced in flat layers in the East Pit and rapidly flooded (i.e., cover waste layers within 1 year) with West Pit water to minimize oxidation in and associated solute release from the backfill. Water from the west pit will be first pumped through the WWTF. Backfill will be placed up to the approximately the final anticipated water level of the East pit spillway, and wetland water treatment system will be developed on the final surface of the backfill as a final water treatment step. Water balance calculations provided in RS22 (Barr 2007b) indicate that by pumping water from the WWTF (which includes some West Pit water, waste rock and tailings seepage), the East Pit will reach its final flood level by Year 20 of the mine so that overflow from the East Pit will begin when mining is complete. To reduce acid and solute release from wall rock, plans include lime addition to the acid-generating Virginia Formation wall rock while the backfill is being placed, then placement of overburden and a low permeability cover against the portion of the East Pit highwall comprised of acid-generating Virginia Formation rock. This cover will reduce water flow and oxidation in exposed wall rock.

Beyond year 20 (post-closure):

West Pit:

The West Pit will receive the overflow from the East Pit (including a wetland constructed on the backfill). During the early stages of flooding, the process water in the pond and seepage collected in the horizontal drains from the tailings facility will be pumped to the West Pit. Thereafter, filling of the West Pit will occur by inflows of direct precipitation, stormwater (including from the surfaces of the Waste Rock Stockpiles), and groundwater. The groundwater component will also include leakage from the Category 1/2 stockpile liner. Water balance calculations (RS10A, Barr (2007b)) indicated that the West Pit will take about 40 years after mining ceases to fill, after which it will overflow toward the Partridge River. The North highwall of the West Pit will contain some acid-generating rock (residual ore), which will remain exposed after flooding. No formal mitigation of the acid-generating West Pit highwall is planned, but pit water quality modeling indicates that solutes released by West Pit highwall will be diluted to below discharge standards by other inflows to the West Pit Lake.

East Pit:

Overflow from the East Pit will perpetually discharge to the West Pit. For a period of approximately 10 years after closure, water collected by the Tailings Basin seepage management system would also be pumped to the Mine Site WWTF and then pumped to the East Pit. A highwall that includes acid-generating Virginia Formation rock will remain perpetually above the backfill, but plans include covering this with overburden and a low permeability cover to reduce long-term oxidation.

The pit "walls" consists of steeply dipping sections and nearly flat benches. For modeling, solute loads from pit wall runoff were calculated by assuming that the walls behave like a 2-m thick veneer of waste rock.

Mercury Loading to the Pit Lakes

Mercury is of particular interest because of its ability to strongly bio concentrate in some aquatic environments, including mine pit lakes. Ultra low-level mercury analyses (detection limit 2 mg/l) were conducted on a 93-sample subset of humidity cell effluents over a range of material types. Results found average mercury concentrations between 5 and 7 mg/L, with no correlation to rock type or sulfur. It is present in regional rainfall (~10 mg/L, which is above the Lake Superior basin water quality standard of 1.3 mg/L); but tests using rainfall found that contact with Duluth Complex rock decreased mercury (from 12 mg/L to between 1.9 and 3.2 mg/L). (RS 53/42, SRK 2007x). Thus mercury appears to not leach from pit wall rock, and percolation through pit wall may actually reduce mercury in rain and snowmelt.

Pit wall rock loading.

Pit-wall geology suggests that wall rock will probably be am important source of metals and sulfate to the pit lake. Wall rock composition (i.e., areal extend of rock of Category 1/2, 3, 4, and ore) were estimated from the geologic block model. Acid generating rocks (ore, and Category 3 and 4 waste rock) comprise ~65 % of the wall rock in both the East and West Pits (**Figure 4.1-56**). And the acid generating wall rock extends to the rim of the pits, indicating that some acid-generating wall rock will remain exposed and subject to long-term oxidation even when the lakes reach their final elevation (**Figure 4.1-57**.

Polynomials used in modeling to relate parameters that change over space and time (lake volumes and wall rock areas vs. elevation, and backfill elevation vs. time) are summarized in Table 6-2 of RS 31 [SRK 2007x].

Oxidation rate in pit wall (mg SO_4/kg-week) and associated release of sulfate and associated constituents were based on average rates measured in kinetic tests for each category of rock, scaled to correct for laboratory-to-field conditions (see scaling factors below). Oxidation rates through waste rock are assumed to be proportional to the oxidation rate in humidity cell. The wall rock was assumed to contain oxygen at ambient atmospheric conditions through the 2-m reactive zone. Release rates (e.g., mg solute/kg rock/week) for all parameters are presented in Table 6-3 in RS31, SRK 2007x.

<u>Correction factors:</u>

The following "factors" are multiplied by the chemical release rates measured in kinetic tests to scale rates from laboratory to field conditions:

- Temperature correction: 0.3 (reduces rates measured values at ~20 C to assumed wall rock temperature of ~2.4 C--average air temperature at Hoyt Lakes).

- Particle size (Reactive fraction): 0.1 (estimate of fraction of wall rock that is smaller than the ¼ inch material in humidity cells)

- Thickness of wall rock reactive rind: 2 m (based on 2-m overdrilling of blast holes).

- Contact factor (fraction of rock flushed by meteoric water each year)

    - 0.5 for backfill (then flushed to the lake when inundated)

    - for pit surface during operations, (i.e., all solute produced in pit wall is added to the lake during operation)

    - 0.5 for pit surfaces after closure (i.e. 50% of solutes produced in pit wall leaks to the lake)

- Delay of acid onset: Solutes released in wall rock but that were assumed to be physically inaccessible for leaching—these are assumed to be loaded into the lake as soon as the rock is flooded by the lake.

Uncertainty in these scaling factors, along with other model parameters, were incorporated into the prediction uncertainty analysis (see next section).

Critical assumptions in the pit lake model:

- Upper limits on solute concentrations in wall-rock leachate: To avoid unrealistically high concentrations of solutes, waste rock seepage modeling applied upper-limit concentrations in waste rock effluent, based on maximum concentrations observed among all kinetic tests that produced neutral and acidic effluent (Table 7-2 in RS 53/42 [SRK 2007].

- Solute release rates from wall rock decay exponentially: The decrease in solute release from wall rock expected over time as sulfide minerals are depleted by oxidation in the reactive rind was estimated using exponential decay rates fit to MDNR's long-term (~17 year) kinetic reactors (Tests described in RS-42; date presented in Appendix B of RS 53/42). Each constituent was fit independently (SO4, Cu, and Ni), and analog curves were used for constituents if they were not analyzed by MNDNR

- There is an upper limits on solute concentration in the pit lakes: Removal of solutes by chemical precipitation in the lake (expected primarily when lime is added to neutralize acidic drainage) was implemented in the model by comparing the lake concentrations to the upper-concentration limit for each constituent under neutral pH. Solutes above the upper-limit concentration were set in the model to be present at the concentration limit. The lost mass was assumed to settle from the water column into lake sediments as precipitated minerals.

Finally, to reduce the potential for long-term leaching of sulfuric acid and dissolved metals to the East Pit, the proposed action includes constructing and perpetually maintaining layers of overburden and a low-permeability synthetic cover over the acid-generating Virginia Formation highwall rock. This layering is assumed to reduce long-term oxidation and solute leaching from wall rock, though examples of successful application of this technology to inhibit wall-rock acid production and solute release have not been demonstrated.

Limnology of Future Pit-lakes

Water quality modeling of the West Pit Lake assumed that the lakes remain completely mixed, with no consideration given to seasonal changes in stratification of density or nutrients. A study commissioned to estimate whether the West Pit Lake would experience "meromixis" (i.e., be permanently stratified with little mixing between a more saline deep layer and a less saline surface layer) is essentially inconclusive:

> " . . calculations based on the available data suggest that weak meromixis will
>
> occur in West pit-lake. However, there is considerable uncertainty in our estimates of the effective ice thickness, the net salinity of the inflow, the rate of deepening of the surface layer in spring and summer, and the reduction in stability during the cooling period. Therefore, the likelihood of meromixis should be reassessed if, and when, more accurate estimates of these critical factors become available." (Greg Lawrence and Associates, 2008)

However, permanent (or long-term) stratification in the West Pit would be caused by isolation of a denser saline layer at depth that is overlain by a less-dense low-salinity surface layer. Because the West Pit discharges from the surface, the quality of discharge from a stratified lake would be better than the quality from a completely mixed lake. As a result, if the West Pit Lake does turn out to be meromictic, the predicted discharge water quality will be better than predicted currently under the assumption of complete lake mixing (RS31, SRK 2007).

<u>4.1.5.3.1 Evaluation of Pit-lake Computational Model</u>

The Model Evaluation Plan is a component of the Technical Appendix to this DEIS (Minnesota Department of Natural Resources, 2008), and includes the specific evaluation criteria (mass balance requirements, bench marks, and ranges and distribution types for specific for parameters).

Conceptual Model (Evaluation)

The conceptual model used to estimate pit-lake water quality (described above in this EIS) is based on sound reasoning and is consistent with the current understanding of environmental behavior at hard rock mines.

Mass Balance/Benchmark (Evaluation)

A mass balance calculation was performed to demonstrate that the pit-lake water quality model was reliably accounting for the load of solutes released from wall rock and groundwater inflow as an increase in mass in the lake (Memo from SRK, Oct. 10, 2008, "NorthMet Project Geochemical Uncertainty Analysis for Proposed Action – DRAFT").

UNRESOLVED: The DNR team was unable to demonstrate complete consistency between the mass balance calculations cited above and the previous pit-lake water-quality model results--a request to PolyMet's consultant for clarification to link the mass balance check to the previous lake model is an outstanding request.

Uncertainty Analysis (Evaluation)

An analysis of uncertainty in predicted water quality was provided by PolyMet's consultants (Barr memo, from Peter Hink and Miguel Wong; to: PolyMet and MDNR; Subject: Uncertainty Analysis Workplan Tab 4b Monte Carlo Simulation – Pit Flooding Geochemistry Doc ID UA02D Draft-02, Date = Sept. 30, 2008.) evaluated uncertainty in predicted water quality in the East and West pit lakes due to uncertainty in the following parameters:

- Temperature of wall rock,
- Particle size in pit wall rock,
- Upper-limit "caps" on concentrations of selected elements,
- Rate of decrease in solute release from wall rock over time,
- Thickness of the veneer of reactive pit wall rock,
- Rate of solute loading from leaking liners under the Cat1/2 waste rock,
- Rate of pollutant generation (based on range in kinetic tests),
- Rate of pit filling with water,
- Efficiency of the wetland in the East Pit (placed on top of backfilled waste rock in the east pit to treat effluent before it discharges to the West Pit).

In addition, the ongoing rate of sulfide mineral oxidation in subaqueous backfill in the east pit was discussed qualitatively. This complied with the request from the DNR The accuracy of pit lake water quality predictions has not been assessed in the peer-reviewed studies. Reliable estimates of pit-water quality will not be available until sump water from wall runoff during mining is available for testing.

Unresolved Components in Pit-lake Model

- The efficiency and long-term effectiveness of the wetland proposed for installation in the East Pit at closure to treat discharge to the West Pit has is not supported with tests or references to published studies. The wetland will presumably require perpetual maintenance to ensure its effectiveness. The MDNR has submitted to PolyMet a request for information to support the assumptions about wetland treatment effectiveness.

- The DNR team was unable to demonstrate complete consistency between the mass balance calculations cited above and the previous pit-lake water-quality model results--a request to PolyMet's consultant for clarification to link the mass balance check to the previous lake model is an outstanding request

4.1.5.4 Tailing Basin Facility model—Contaminant Release by Seepage to Ground Water

Potential water quality impacts from the Proposed Action tailings facility are based on combined simulations of geochemical reaction and water flow presented by SRK and Barr Engineering on behalf of PolyMet (SRK 2007 [RS 54/46]). At the time of writing this PDEIS, the project track indicates that the Proposed Action Tailings Facility considered in this EIS) will probably be replaced with the Proposed Action Mitigation Design. The assessment of water quality from the Proposed Action tailings facility was subjected to detailed water-quality modeling by PolyMet's consultants (RS 54/46, SRK 2007), and this model is described here in some detail. The conceptual model, in particular, may be helpful in considering effects from alternative TSF designs. However, the evaluation of the Proposed Action TSF model, as described in the Model Evaluation Plan (Minnesota Department of Natural Resources, 2008) and responses to the Model Evaluation Plan (Barr 20008 [UA02B]; SRK 2008) is minimal in order to avoid unnecessary evaluation of eliminated design.

4.1.5.4.1 Conceptual Model of Solute Release from Tailings Facility

This conceptual model provides a general description of the expected environmental behavior of the Proposed Action tailings storage facility (TSF) design presented in Chapter 3. This conceptual description is based on information gleaned form technical reports on the Proposed Action TSF model (RS54/46, SRK 2007) and in direct meetings between MDNR team and PolyMet's consultants, and provides a basis for understanding how quantitative estimates of water quality effects were made.

TSF Construction Design:

PolyMet tailings are constructed on top of existing LTV tailings, covering the existing facility. PolyMet tailings will be emplaced as a slurry from a moving spigot. Tailings will be discharged from the top of the dam, producing a zone grading from coarse to fine tailings with increasing distance from the spigot. The spigot will rotate so as to disperse tailings in a 75 degree triangle. The TSF will be constructed by overlapping discharge zones, producing lifts of ~15 ft tall.

The expected distribution of tailing material is:

- Coarse tails from the spigot to ~400 ft down slope toward the pond.

- Fine tailings from 400 ft to 700 ft from spigot.

- Beyond the fine tailings will be ponded water, which will be underlain by fine tailings and “slimes.”

Each 15-ft lift of the coarse tailings dam is to be covered with a synthetic layers to reduce the potential for water quality degradation by oxidation and flushing:

> “The embankments will be raised in lifts of about 15 ft. However, only the exterior embankments along the north edge of Cell 2E and south and southeastern edge of Cell 1E will be constructed of coarse tailings (note – the reference to Cell 2E and 1E is only to indicate locations within the single large pond). As each embankment is completed, construction of the next lift commences. The exterior embankments constructed of coarse tailings will be capped with a synthetic membrane to reduce oxidation and limit infiltration to the embankment.” (RS 54/46, SRK 2007, Pg. 68) “After operations cease, the coarse tailings beach adjacent to the exterior embankments will be capped with a synthetic membrane to limit both infiltration and restrict oxidation of the coarser tailings.” (SRK 2007, Pg. 69).

Horizontal drains will be placed in the existing LTV tailings. Water seeping down through the PolyMet tailings will pass through the underlying LTV tailings, where it will either seep directly to ground water (where it may have an effect on water quality) or be capture by the drain for treatment or recirculation.

Solutes can be released from tailings by direct dissolution of minerals, but solutes of concern are released primary 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. Further, because the diffusion of oxygen is faster in air than water (i.e. ~10,000 times faster in air), the rate of oxidation and associated solute release will depend strongly on tailings moisture content, with slower oxidation in wetter material. Thus the coarse tailings in the dam and medium-size beach is expected to have the fastest oxidation rate, the fine tailings will have slower oxidation, and the saturated tailings below the pond will be essentially unreactive. (This review focuses on the coarse tailings--these will have the highest air-filled porosity, and thus the highest oxidation rates.) Finally, proposed placement of an impermeable geomembrane between each layer in the dam and over the coarse tailings in the dam face will dramatically reduce oxidation in the dam.

Solutes released by oxidation (primarily sulfate and regulated metals) will be flushed from the tailings by percolating water. The rate of percolation will depend on the surface type and climate—high precipitation on coarse, permeable layers will produce high infiltration; the dam surfaces covered with liners will virtually eliminate water infiltration and flushing of solutes; and seepage from the pond will depend largely on the permeability of the finest tailings under the pond. (The average flux of meteoric water infiltrating the tailings is expected to be 7.7 inches/yr on tailings material, and 0.23 inches/yr through the lined surface.) The seepage in the tailings will mix with water that seeps through the bottom of the pond, so the average effluent will depend on the composition of the pond water, the rate of oxidation in the unsaturated tailings, and the rates of water flow through each material.

Finally, the seepage from the PolyMet tailings will pass through the underlying LTV tailings (remnants of previous taconite mining). These underlying tailings may attenuate metals or acidity leached from the PolyMet tailings, and/or may contribute additional solutes to seepage.

4.1.5.4.2 Environmental Characteristics of Tailings

The environmental behavior of tailings are based primarily on a series kinetic oxidation tests (humidity cells) that conducted on various size fractions of representative PolyMet tailings material (RS 54/46, SRK 2007). Bulk tailings samples were screened to produce three size fractions to represent the zones in the tailings facility:

- Dam material [>0.152 mm], (+100 mesh),
- Beach [>0.152 mm - 0.076], (-100+200 mesh) and
- Fine sands [<0.076 mm], (-200 mesh).

In practice, the tailings emplacement method will produce mixtures of these sizes (e.g., the coarse tailings will contain some material finer than 100 mesh entrained during settling), so the differences in leaching behavior between the ideal fractions will be less apparent under field conditions. Kinetic tests measured the production of sulfate and metals in leachate during oxidative weathering over an 80 week period. The behavior observed in these laboratory tests was the basis for predictive modeling of solute release from the TSF. Following are summaries of the important environmental characteristics of the PolyMet tailings, with supporting figures of descriptions for each.
Total sulfide S concentration in the PolyMet Tailings is expected to be ~0.12 % S.

A tailings pilot-plant test using a configuration that represents the expected final plant design indicated that average sulfur concentration in PolyMet tailings is expected to be ~ 0.12% S (range 0.10% to 0.13%; RS54/46, SRK 2006, Table 5-1).
The rate of sulfide oxidation is the primary factor affecting pore-water pH and the concentration of sulfate and metals in the pore water.

This conclusion follows directly from previous studies of waste rock from the PolyMet Mine region:

> "The MDNR's waste rock testwork showed that sulfur content is the primary variable controlling pH of leachate, delay to onset of acidic leachate, oxidation rates, and metal release rates (Lapakko 1993; Lapakko and Antonson 2006)." (RS 54/46, SRK 2007, Pg. 6)

Sulfide mineral oxidation rates in tailings remain relatively stable for almost 2 years of testing.

After an initial period of flushing residual sulfate in humidity cell tests (~20 weeks) sulfate production from PolyMet tailings is relatively stable through week 80, producing between ~5 and 20 mg SO4/kg-rock/week (**Figure 4.1-58 top** [Source: Graph C.1.8, RS54/46 Appendix C, SRK 2007).

Pore water metal concentrations can increase dramatically if pH decreases.

Kinetic tests on tailings samples indicated that metal release rates also tended to settle to a relatively stable value after ~20 weeks (e.g., nickel production settled at ~0.001 to 0.005 mg Ni/kg-rock/week, RS54/46, SRK 2007).

However, in a few samples the concentrations of metals increased with time in the kinetic test (see nickel behavior, **Figure 4.1-58 bottom** [Source: Graph C.1.27, RS 54/46, SRK 2007). This increase in metal concentration generally correlated to a small decrease in pH (e.g., a change of <0.5 pH unit), and illustrates the potential for dramatic increases in pore-water metal concentrations if the pH decreases under field conditions:

> The effect of lower pHs is to increase the solubility of metals and in particular nickel. The testwork indicates that as pH decreases below 7, nickel stored in weathering products at higher pHs is leached resulting in a spike in nickel release lasting possibly 2 years. Coarse tailings (+100, -100+200 mesh) appear to be susceptible to moderate pH decrease below 7 resulting in enhanced leaching of nickel and cobalt. (RS 54/46, SRK 2007, pg. 53)

A prolonged dry period could produce this effect, allowing faster oxidation and lower pH when tailings are dryer, then flushing of higher concentration water during a wet period.

Acid neutralization by silicate minerals does not appear to be keeping up with acid production in the coarse tailings.

The silicate minerals in the tailings do appear to be buffering the pH, preventing the water from becoming acidic (e.g., pH below ~4.5) during the 80-week test period. However, there is a general trend towards decreasing pH in the humidity cell effluents that continues through week 80, indicating that acid production in oxygenated tailings may eventually exceed acid buffering (**Figure 4.1-59 top**).

The alkalinity in tailings pore water can be nearly exhausted within ~ 1 year.

Alkalinity, a direct measure of excess acid-neutralizing potential in the pore water, is a direct measure of buffering potential. As with pH, alkalinity decreases through week 80 in the kinetic tests on PolyMet tailings. At the very low alkalinity values (below 5 mg/l), slight additional acidity could produce dramatic decrease in pH and an associated increase in metal concentrations (**Figure 4.1-59 bottom**).

Longer-term (4 year) kinetic tests on similar sulfide tailings (from the Cominco Babbitt deposit, sulfide S ~0.2%) indicate that it may take 8 to 12 years for sulfide minerals to completely oxidize in just the surface layer:

> "In 2002, Cominco Ltd. produced tailings from processing of ore from the Babbitt Deposit (MDNR 2004b) . . .The MDNR has tested tailings produced by pilot plant run on ore grade rock from the Babbitt Deposit. This testwork is ongoing and showed that tailings

> containing 0.2% sulfur did not generate acidic leachate after four years. SRK calculated that 29%, 38% and 55% of sulfur, were depleted from the ASTM, no lid and lid tests, respectively after four years of testing." (RS 54/46, SRK 2007).

This longer-term study supports the contention that the PolyMet tailings will not ever produce acidic leachate.

The existing "LTVSMC" tailings that would underlie the proposed PolyMet tailings facility would contribute alkalinity and some arsenic to effluent.

Because the existing tailings at the NorthMet site ("LTVSMC" tailings--remnants from earlier taconite mining) will underlie the proposed PolyMet tailings facility cells 2E and 2W, water seeping down through the PolyMet tailings will pass through the LTV tailings before discharging to groundwater or horizontal drains. The effect of LTVSMC tailings on effluent water quality was estimated using sequential column tests in which water that passed through PolyMet tailings was then passed through LTVSMC tailings material (RS 54/46, Appendix C.3). Results indicated that effluent from LTV tailings will be alkaline, with a pH typically above 8 (**Figure 4.1-**60). The LTVSMC tailings attenuate some of the nickel leached from NorthMet tailings, but they also add appreciable alkalinity (e.g., ~500 mg/l maximum, and maintaining alkalinity above 300 mg/l for over 7 pore volumes) and arsenic (peaking at over 0.12 mg/l after 1 pore volume, then decreased to 0.02 after ~ 7 pore volumes).

4.1.5.4.3 Computational Model of Solute Release form Tailings Facility

This description follows from the modeling report on water quality in the PolyMet tailings (RS 54/46), and from explanations given in meetings between PolyMet's consultant (SRK) and the DNR technical team. This was then revised and superseded in 2008 slightly simpler model that produced the current assessment of the Proposed Action tailings facility (RS74B, Barr 2008).

The algorithm used to determine the water quality of seepage from the tailings proceeded in steps to estimate the following parameters:

- Maximum rate of sulfide mineral oxidation and associated metal release in oxygenated tailings (values obtained from laboratory kinetic tests on tailings).

- Average moisture content of the coarse and fine tailings (this is a critical parameter for estimating oxygen diffusion, and was calculated from water infiltration rates obtained using EPA HELP model, moisture flow and content using HYDRUS model, and estimated moisture-retention properties of the various tailings; RS13, Barr 2008).

- Oxygen diffusivity in tailings (i.e., the ability of the tailings to transmit oxygen gas, a parameter related to porosity and moisture content),

- Rate of sulfide oxidation and solute release under field conditions (this produced solute release over time in vertical columns through the various tailings, and was calculated using a numerical model developed by SKR that incorporates the rate of oxygen consumption by reaction with tailings and the limits on oxygen diffusion into the tailings).

- Concentration of solutes in tailings porewater (calculated for coarse and fine tailings by dividing solute production rate by the volumetric water flow rate)

- Concentrations of solutes in effluent from the TSF (calculated by combining water and solute concentrations from various sources—coarse tailings, fine tailings, pond seepage-- during deposition, as determined from the TSF construction plan.

- Apportionment of discharge between groundwater and seep (i.e., infiltration through the PolyMet tailings will enter the underlying LTVSMC, and hydraulic flow estimates divide the various flow between groundwater recharge and capture by horizontal drains in the LTV tailings).

The sulfide S in tails (as the mineral pyrrhotite, FeS is 0.11 % in coarse, and 0.12% in fine, and oxidation rates in oxygenated coarse tailing (i.e., the primary source solutes) was 5.1 mg/kg/wk. Metals of concern (nickel and cobalt in particular) in effluent from kinetic leaching tests on PolyMet tailings appear to be related to sulfide oxidation, so modeled metal concentrations in effluent were based on a linear relationship to sulfate production (**Table 4.1-38**.)

The molar ratios of solute release presented in RS 53/46 (SRK 2007) have been updated with more current humidity cell results for the current model results (RS74B, Barr 2008), but these ratios have not been re-released.

Vertical saturated conductivity in the tailings was estimated to be $1.2x10^{-3}$ cm/s in coarse tailings (located 0 to 400 ft from spigot) and $2.5x10^{-5}$ cm/s in fine tailings (located between 400 and 700 ft from spigot), with porosity= 0.5 in both (Values from tests conducted by Barr Engineering, RS39/40 Apx. H). The tailings slimes have even lower conductivity, and will remain saturated, which virtually eliminates oxygen entry and thus reduces oxidation rates essentially to zero.

Infiltration rates through the tailings surface were estimated to be 25 in/yr during construction (i.e., when spigotting water onto tails), 7.7 in/yr from meteoric water on the unvegetated tailings surface (HELP model), and 0.23 in/yr under synthetic liners placed on the tailings dam. At the 7.7 in/yr flow, the water saturation is estimated to be 38% and 89% in coarse and fine tailings, respectively. The distributions of moisture in the coarse and fine tailings (and thus the oxidation rate within the tailings) are predicted to develop after ~ 120 days of surface infiltration.

Table 4.1-38: Molar Metal to Sulfate Release Ratios Calculated from Humidity Cell Test

Ratio	Coarse Tailings	Fine Tailings
Sb/SO_4	$4.0x10^{-5}$	$4.0\ x10^{-5}$
As/SO_4	$2.0\ x10^{-4}$	$4.2\ x10^{-4}$
Cu/SO_4	$1.5\ x10^{-4}$	$1.4\ x10^{-4}$
Ni/SO_4	$6.6\ x10^{-4}$	$6.5\ x10^{-5}$
Zn/SO_4	$1.2\ x10^{-3}$	$6.4\ x10^{-4}$
Co/SO_4	$3.9\ x10^{-5}$	$1.3\ x10^{-5}$
Ca/SO_4	$1.8\ x10^{-1}$	$4.1\ x10^{-2}$
Mg/SO_4	$3.8\ x10^{-1}$	$4.5\ x10^{-1}$
Na/SO_4	$1.1\ x10^{-1}$	$2.3\ x10^{-1}$
K/SO_4	$3.3\ x10^{-1}$	$2.8\ x10^{-1}$
Ag/SO_4	$2.99\ x10^{-6}$	$2.7\ x10^{-6}$
B/SO_4	$5.97\ x10^{-4}$	$8.5\ x10^{-4}$
Be/SO_4	$1.43\ x10^{-4}$	$1.3\ x10^{-4}$
Cd/SO_4	$2.30\ x10^{-6}$	$2.1\ x10^{-6}$
Pb/SO_4	$1.56\ x10^{-6}$	$1.4\ x10^{-6}$
Se/SO_4	$1.63\ x10^{-5}$	$1.5\ x10^{-5}$
Tl/SO_4	$6.31\ x10^{-7}$	$5.8\ x10^{-7}$

Source: RS 54/46, Table 7-13

Correction factors applied to scale from laboratory to field conditions include:

- Temp correction = 0.3 (based on lower temperature under field conditions and well established relation between temperature and chemical reaction rates).

- Frozen ground & snow cover = 0.75 (i.e., assumes that the ground is frozen 25% of the time; however, lower diffusion in frozen ground surface was not supported by MDNR's literature review).

The oxidation model predicted that coarse tailings would be actively oxidizing from the surface to the 20-m depth in the first year, and react to over 30-m depth after only 5 years. (Where the dam is to be capped with an HDPE layer, modeling assumed that oxidation would continue, but the load essentially stops because flow decreases from 7.7 in/yr to 0.23 in/yr.)

Predicted water-quality effects from the tailings are particularly sensitive to the hydraulic model parameters. In apportioning solutes discharge (from the tailings dam, coarse beaches, and fine beaches), modeling indicated that pond water would primarily seep to groundwater along deeper flow path, whereas more of the solutes released by oxidation in the tails dam and coarse & fine beaches would be captured by horizontal drains. However, drain capture efficiency (fraction of vertical flow through area with drains) was only assumed to be 10%. In addition, seepage from the tailings pond water is an important source for dilution for oxidation products; so reducing the sulfate concentrations in pond water was a big factor in reducing sulfate in seepage from the tailings pond. The pond water quality was estimated to be 234 mg during operations (200 mg/l process water discharge plus runoff adds 34 mg/l). After closure, process water addition ceases, and coarse tails are covered with a liner, so long-term pond water is assumed to contain only ~34 mg/l sulfate, reflecting runoff quality.

Finally model predictions reflect the mixing of water flow rate through the various media. The uncovered coarse tailings (i.e., the primary source of oxidation products) are predicted to be flushed from the TSF after ~2 to 10 years. The water residence times in fine tailings are closer to 80 years; and water trapped in the dam beneath the synthetic caps (0.23 in/yr seepage) may take hundreds to thousands of years to be flushed out.

4.1.5.4.1 Evaluation of Tailings Facility Solute Release Model

Conceptual model (Evaluation)

The conceptual model used to estimate effluent water quality from the proposed action tailings facility (described above in this EIS) is based on sound reasoning and is consistent with the current understanding of environmental behavior at hard rock mines.

Mass Balance/Benchmark (Evaluation)

A mass balance calculation was proposed in the Model Evaluation Plan to determine how well the mass of solute lost from the coarse beach in the Proposed Action tailings facility water quality model matched the solute load in the facility effluent (drains and groundwater; see Model Evaluation Plan, Minnesota Department of Natural Resources 2008). However, in response to development of the Proposed Action Mitigation Design for the TSF, the MDNR agreed to forego mass-balance testing on the Proposed Action TSF Model.

The benchmark tests compared to the oxidation rates predicted in RS 54/46 (i.e., using SRK's proprietary model; SKR 2007) to rates estimated using a published numerical model ("Pyr0x", Wunderly and Blowes, 1995). Like the SRK model, Pyrox was calibrated to measured oxidation rates in oxygenated tailings, then used to estimate the cumulative oxidation for the top 30-m down into the tailings column where reaction rate was limited by oxygen diffusion. The use of a well-demonstrated model that uses slightly different assumptions provides a useful comparison to SRK's model by providing an independent check on gross model accuracy and the range of uncertainty that may be due to model assumptions. Both models predicted similar oxygen distributions down into the coarse tailings (i.e., oxygen in a 30 m column after 5 to 10 years); but Pyrox predicted 2 to 3 times greater sulfide oxidation rate during the first 10 to 20 years in a 30-m column of tailings.

Uncertainty Analysis (Evaluation)

An analysis of uncertainty in predicted TSF effluent water provided in two memos (Barr, 2008, document UA02B; and SRK 2008 memo from John Chapman) responded adequately to the Model Evaluation Plan request from MDNR (Minnesota Department of Natural Resources, 2008).

In consideration of the Proposed Action Mitigation Design currently under evaluation, the Model Evaluation Plan (Minnesota Department of Natural Resources, 2008) requested that a quantitative estimate of prediction uncertainty (i.e., flow rate and quality of water discharging from the PolyMet TSF) be evaluated only for uncertainty in:

- Capture efficiency of horizontal drains.
- Seepage rate of water from the TSF pond (a reflection of uncertainty in the vertical conductivity of the tailings slimes that will underlie the TSF pond).

The above two parameters are thought to be the primary sources of uncertainty. This was achieved in a Monte Carlo analysis that predicted ranges in concentrations of arsenic, nickel, and sulfate in water discharging from the completed TSF.

A separate memo (SRK 2008, memo from John Chapman) provided qualitative assessment of uncertainty in model predictions expected:

- Temperature.
- Surface freezing.
- Reaction rate of tailings.
- Ratio of metals to sulfate released by oxidation.
- Pond water quality.
- Water content of coarse tailings.
- Water content of fine tailings.

The sensitivity of results to these parameters are recorded in the Model Evaluation Plan (MDNR 2008).

4.1.5.5 Models used to Calculate Solute Transport

This section summarizes the solute transport modeling methodology used to predict potential ground water impacts downgradient of major facilities. It is noted that PolyMet did not perform solute transport modeling for the Tailings Basin- Proposed Action, because "MDNR has decided that the Tailings Basin- Proposed Action has sufficient geotechnical uncertainty to determine that the Proposed Action should not be pursued further, PolyMet decided to not further refine models and develop mitigations that could be modeled so as to demonstrate no exceedances of standards" (p. 61, RS74B, Barr, 2008s). However, PolyMet did perform solute transport modeling for the Tailings Basin – Mitigation Design that is similar to the methodology described here for the Mine Site. Therefore, this section describes detailes about solute transport modeling for the Mine Site (mine pit lakes and waste rock stockpiles) – Proposed Action, that is essentially the same as the solute transport modeling methodology for the Tailings Basin - Mitigation Design.

The same basic components used to evaluate the adequacy of the models used to estimate solute release from source areas (i.e., clear conceptual model, accurate mass balance, and assessment of uncertainty), was applied to the transport simulations. However, the transport models required a less rigorous independent framework than was used for the solute release simulations (i.e., from tailings, waste rock, and pit lakes). The conceptual models for solute transport were generally clear, with cross-sectional images of the model domain presented for each transport pathway. And the simulations were conducted with well established public-domain U.S. government models (e.g., MODFLOW), which include mass balance evaluations for each simulation. Finally, the uncertainty in the solute transport was assessed semi-quantitatively using uncertainty in: 1) source concentrations (i.e., the uncertainty analysis performed for the waste rock, pit lake, and tailings facility models), 2) flow rates (typically liner leakages), and 3) solute attenuation (typically adsorption), which tends to be the dominant factor on transport. In this EIS, uncertainty in estimated solute concentrations in groundwater and surface water is incorporate by providing ranges (or in some cases upper-end estimates) for solute concentrations at selected evaluation points.

Solute transport modeling was completed with two numerical models: (1) cross-sectional groundwater flow models along representative flow paths were constructed using MODFLOW, the industry standard finite difference groundwater modeling code (McDonald and Harbaugh, 1988, Harbaugh et al., 2000); and (2) the groundwater flow-fields from the MODFLOW models were input to the finite-difference solute transport model MT3DMS (Zheng and Wang, 1999), which is a program designed to work with MODFLOW.

Modeling of solute transport and evaluation of results for impacts analysis was done in a two step process described in detail by PolyMet in RS74A (Barr, 2008x). Briefly, the solute transport modeling and evaluation proceeded as follows:

1. A “screening model” was prepared to determine dissolved Constituents of Potential Concern (COPCs) for each source being evaluated; the screening models used a steady-state MODFLOW and MT3DMS cross-sectional transport model to determine factors of dilution by recharge and ambient background for project sources along a simulated flow path; at specific “evaluation points” along each flow path, these dilution factors were used with chemical concentrations in a spreadsheet mass-loading calculation to determine “worst case” chemical concentration for all constituents evaluated for the project for each flow-path scenario.

2. For those constituents that showed potential exceedances of screening level criteria by the above calculations (i.e., identified COPCs), transient flow and

transport modeling with MODFLOW and MT3DMS was conducted to determine chemical concentrations at time scales ranging from shorter-term project operations to long-term closure.

Screening Model Steady-state Dilution Factors. The dilution from recharge and distinct ambient background (if applicable) attributable to source area(s) was determined by completing a steady-state MODFLOW/MT3DMS model run with the concentration of a generic source component set equal to 100 and the concentration of all other components set to zero. The percentage of initial source concentration that reached an evaluation point was calculated to express the diluted concentrations as proportional amounts of source, recharge, and ±ambient background. An example is given in detail below, for the Mine Site.

The "screening level models" were prepared using the following relationship to predict concentrations of individual constituents:

$$C = p_s C_s + p_r C_r + (1 - p_s - p_r) C_b$$

where:

C = concentration of constituent of interest

p_s = proportional contribution from source area(s)

C_s = concentration of constituent of interest in source area(s) inflow

p_r = proportional contribution from recharge

C_r = concentration of constituent of interest in recharge inflow

C_b = background concentration of constituent of interest

The above formula is for situations at the Mine Site where a background concentration around a source area is different from natural recharge (e.g. the groundwater surrounding a mine pit lake). Where the background concentration can be assumed to be the same as natural recharge, the formula reduces to:

$$C = p_s C_s + p_r C_r$$

Evaluation Points. For each major source area, one or more groundwater flow paths originating at the source and ending at the Partridge River was selected for evaluation of potential groundwater impacts. At the Mine Site, predicted groundwater concentrations were evaluated at the property boundary, at the Dunka Road, and at the Partridge River, as illustrated on **Figure 4.1-35.**

Screening Chemical Concentration Criteria. As described in **Section 4.1.1.17**, the screening level chemical concentrations are the primary and secondary drinking USEPA drinking water standards together with Minnesota Health Risk Limits (HRLs) provided in **Table 4.1-23**. Where there were two standards, the lower was selected as the screening level groundwater concentration. In the screening level models, conservative, simplifying assumptions were made as will be described below. If the dissolved constituents being evaluated were not predicted to exceed the criteria, they were not carried forward to the next phase of modeling.

Sources Evaluated. The individual cross-section solute transport model are located on **Figure 4.1-36** for the Mine Site. Sources of potential ground water impacts evaluated were as follows:

- groundwater outflow from the East/Central and West Pits; potential impacts could occur in both the surficial aquifer and the bedrock aquifers;

- leakage through stockpiles liners from the Category 1/2 Overburden Stockpile, Category 3 Waste Rock Stockpile, Category 3 Lean Ore Stockpile, Category 4 Waste Rock Stockpile, and the Lean Ore Surge Pile Stockpile; potential impacts to the surficial aquifer were evaluated.

Table 4.1-39. Key to Solute Transport Models and Dispersion Coefficients

Model	Flow Path	Dispersion Coefficients	
		D_x (m)	D_z (m)
NA	Tailings Basin	19.2	0.96
1	Mine Site – Category 1/2 - Overburden Stockpile	17.3	0.865
2	Mine Site - West Pit	13.2	0.66
3	Mine Site - East Pit and Category 4 Waste Rock Stockpile	14.3	0.715
4	Mine Site – Category 3 Waste Rock Stockpile	12.5	0.625
5	Mine Site – Category 3 Lean Ore Stockpile	12.2	0.61
6	Mine Site - Lean Ore Surge Pile	13.4	0.67

Notes: NA = Not applicable - Tailings Basin model is for mitigation design only. Model number # as shown on Figure 4.1-35
Source: Modified from Table 6-4 in RS74A (Barr, 2008).

Source Flow Inputs. The MODFLOW/MT3DMS cross-sectional models use the hydraulic head distribution at mine closure as predicted in the calibrated Mine Site MODFLOW model. The actual head values used are arbitrary and were selected to match the predicted hydraulic gradient. Where one of the mine pits was a source, the ambient flow gradients in the cross-sectional models control flow from the pits.

For the stockpile sources in the screening level models, the maximum predicted liner leakage rates presented in Table 4-6 of RS74A (Barr, 2008x) were input for the MODFLOW recharge rate in the footprint of the stockpile area. Time-varying liner leakage rates in the Table 4-6 of RS74A (Barr, 2008) were used for the transient modeling. Recharge from precipitation (i.e. outside source areas) was set equal to the recharge value of 1.5 inches per year used in the calibrated Mine Site groundwater model.

Source Concentrations. Predicted concentrations of liner leakage/seepage calculated for high, average, and low liner flow conditions were used as source area concentrations for each of the flow path models. For the screening models, the highest predicted concentration for each constituent for each source was used. These maximum combined source concentrations together with maximum source leakage rates build conservatism into the screening models because they are input into steady-state models. For the transient models, time-varying concentrations associated with time-varying recharge rates were used over the footprint area of the source. The predicted liner leakage concentrations are presented in Tables 6-26 through 6-28 in RS74A (Barr, 2008x).

Background Concentrations. Background ground water concentrations were obtained using data collected from spatially appropriate monitoring wells located at the Mine Site (data are summarized in RS74, Barr, 2008). It was also assumed that background groundwater concentrations are representative of atmospheric recharge concentrations outside source areas. Where there was not background data available for a parameter, a concentration of zero was used. Background concentrations are given in detail in **Section 4.1.5.5** of this EIS.

Model Domain and Discretization. The x-axis is oriented along a groundwater flow path, with the origin located at the upgradient edge of the seepage/leakage source area. Model cell dimensions were set to minimize numerical dispersion and computation time. The cell dimensions were used for the simulations are summarized in **Table 4.1-40.**

Table 4.1-40. Solute Transport Model Cell Dimensions

Δx	25 meters
Δy	10 meters
Δz, surficial deposits	1 meter
Δz, bedrock	20 meters

Source: Table 6-2 in RS74A (Barr, 2008x)

Hydraulic Conductivity Values. Hydraulic conductivity values were based on those used for the Mine Site ground water model (RS22, Barr, 2007) described in this EIS in **Sections 4.1.1.13 through 4.1.1.16**. The highest hydraulic conductivity value for the surficial deposits was used to evaluate a worst-case scenario (in a transient model a higher hydraulic conductivity value results in a greater Darcy flux and less mixing with recharge prior to reaching a given evaluation location, resulting in a higher predicted concentration). The hydraulic conductivity of the Duluth Complex used in the regional model described in **Section 4.1.1.14** was used for the bedrock hydraulic conductivity. **Table 4.1-41** summarizes the hydraulic conductivity values used in the cross-sectional solute transport models.

Table 4.1-41. Solute Transport Model Hydraulic Conductivity Values

	Tailings Basin Model[1]	Mine Site Models	Mine Site Models
$K_x = K_y = K_z$, surficial deposits	20 m/d	2.83 m/d	9.3 ft/day
$K_x = K_y = K_z$, bedrock	NA	7.32×10^{-4} m/d	0.0024 ft/day

NOTES: 1Tailings Basin Model is for Mitigation Design Only
Source: Modified from Table 6-3 in RS74A (Barr, 2008)

Dispersion. After the flow field was calculated using the MODFLOW model, MT3DMS was used to predict solute fate and transport and concentrations at the evaluation locations. MT3DMS requires values for the dispersion coefficients Dx, Dy, and Dz. Because the cross-sectional model method assumes no flow in the y direction (i.e., transverse to the flow path), a value for Dy was not required. Dispersion coefficients were calculated for each flowpath as described in the PolyMet modeling report for the Mine Site (RS74A, Barr, 2008x). The dispersion coefficients are summarized in **Table 4.1-39.**

Sorption. In order to better understand a possible range for ground water impacts, the transient cross-sectional models were run both with and without sorption. Linear sorption is modeled with a partition coefficient (Kd) to relate the concentration of a sorbed constituent to the concentration of the constituent in solution. According to PolyMet, U,S.Environmental Protection Agency (USEPA) guidance says that general Kd values can be used in screening-level/risk assessment analysis to determine the impact of heavy metals on groundwater in the absence of site-specific geochemical or isotherm data (U,S.Environmental Protection Agency, 1996). The USEPA published a 2005 report titled Partition Coefficients for Metals in Surface Water, Soil, and Waste (U,S.Environmental Protection Agency, 2005). The report summarized a search of published documents on the topic of partition coefficients. Also presented in the publication are the values recommended by the USEPA for use in developing risk-based soil screening levels for contaminants in soils (U,S.Environmental Protection Agency, 1996). **Table 4.1-42** summarizes the Kd values presented in the USEPA reports and the values that were used in the modeling for the Mine Site and Tailings Basin.

For the modeling presented here, the USEPA recommended values were used as these values fall within the lower range of the values presented from the literature study. In addition to Kd values, the inclusion of sorption in the transport simulation requires a bulk density for the soil. An average bulk density of 1.27 tons/yd^3 (1.5 kg/L) was used. This value represents the average bulk density for the soils at the Mine Site as reported in the U.S. Department of Agriculture's St. Louis County Soil Survey Geographic Database. Sorption was only simulated in the surficial aquifer. In the bedrock, it was assumed there would be no sorption. Also, sorption was only used in the transient models for constituents that showed potential exceedences of screening level criteria; the steady-state screening models were "worst case" and did not use sorption.

Table 4.1-42. Solute Transport Model K_d Parameters from EPA References

Constituent	Results from Literature Study (U.S. EPA, 2005) Minimum K_d (L/kg)	Maximum K_d (L/kg)	Mean K_d (L/kg)	EPA Recommended Values (U.S. EPA, 1996b) (L/kg)	Values Used in Cross-Section Models (L/kg)
Arsenic	2	20,000	16,000	25-31	25, (444 to 6,102)[a]
Copper	1.3	4,000	320	--	22
Nickel	10	6,300	800	16-1900	16
Antimony	1.3	500	200	45	45

Note: a(indicated range is that required to achieve concentrations below 0.005 mg/L in downgradient groundwater in the Tailings Basin Model – Mitigation Design only).

Sources: Modified from Table 6-4 in RS74A (Barr, 2008). Tailings Basin Kd values from Barr (Todd DeJournett, personal communication, Nov. 26, 2008).

4.1.5.5.1 Solute Transport Model and Calculation of Ground Water Chemical Concentrations at the Mine Site

In this section two of the solute transport models for the Mine Site area described in detail to illustrate the methodologies and assumptions used in solute transport models to evaluate impacts to ground water for this EIS. **Figure 4.1-35** shows the locations of the sources and flow paths that were evaluated at the Mine Site. **Figure 4.1-36** illustrates the design of each of the six flow path models for the Mine Site. For each of the above sources, a groundwater flow path originating at the source and ending at the Partridge River was selected for evaluation of potential groundwater impacts. At the Mine Site, predicted groundwater concentrations were evaluated at the property boundary, at the Dunka Road, and at the Partridge River.

4.1.5.2.1.1 West Pit (Flow Path #2)

Steady-State Screening Model Results. Input concentrations and results for the West Pit flow path screening model are shown in the table depicted on **Figure 4.1-61**. The dilution factors for the two evaluation points obtained by running the steady-state MODFLOW/MT3DMS model are indicated in the inset table "source proportional contribution".

The multi-layer MODFLOW screening level model shows that the predicted concentrations in the upper portion of the bedrock aquifer are very similar to the predicted concentrations in the surficial aquifer. With depth, the concentrations in the bedrock are closer to the background concentrations. In order to be conservative, all bedrock aquifer concentrations used are those predicted for the upper portion of the aquifer. Potential exceedances of standards are highlighted for the West Pit flow path, together with the other Mine Site flow paths, in **Table 4.1-43**.

Table 4.1-43. Summary of Potential Ground Water Criteria Exceedances in either Bedrock or Surficial Aquifer using Screening Level Models for Mine Site-Proposed Action

Model	Potential Groundwater Exceedances	Additional Constituents for Transient Model
#1 - Category 1/2 – Overburden Stockpile	**As**, **Sb**, <u>*Al*</u>, <u>*Fe*</u>, <u>*Mn*</u>, <u>*Be*</u>, <u>*Tl*</u>	SO_4

#2 - West Pit	**As**, **Sb**, *Al*, *Fe*, *Mn*, *Be*, *Tl*	SO_4
#4 - East Pit and Category 4 Waste Rock Stockpile	**Fe**, **Mn**, **Ni**, Sb, *Al*, *Be*, *Tl*	SO_4
#5 - Category 3 Waste Rock Stockpile	**As**, **Cu**, **Fe**, **Mn**, **Ni**, **Sb, SO_4**, *Al*, *Be*, *Tl*	--
#6 - Category 3 Lean Ore Stockpile	**Cu**, **Fe**, **Mn**, **Ni**, *Al*, *Be*, *Tl*	SO_4
#3 - Lean Ore Surge Pile	**Fe**, **Mn**, **Ni**, *Al*, *Be*, *Tl*	SO_4

Notes: Constituents in bold or underlined italics exceeded ground water evaluation criteria. Constituents in underlined italics not carried forward to transient modeling.
Source: Modified from Table 6-24 in RS74A (Barr, 2008)

In all of the models, beryllium and thallium exceeded the screening criteria (**Figure 4.1-61**). However, this is due to the high background concentrations used in the models that exceed the ground water screening criteria, which is not considered a modeled exceedance attributable to the project, and these constituents were not carried forward into the next phase of transient modeling. It is noted that the true impacts of beryllium and thallium (and for similar reasons, likely mercury) therefore have not been modeled.

Similarly, the background concentrations of aluminum, iron and manganese (**Figure 4.1-61**) exceeded the ground water evaluation criteria so these parameters were not carried forward into the next phase of transient modeling for the West Pit flow path. Most constituents have been shown to be below screening level criteria using the conservative mass loading models and can be eliminated from further consideration. The constituents shown in **Table 4.1-43** were carried forward to the next phase of modeling along their respective flowpaths, and sulfate was carried forward in all models at the request of the cooperating agencies.

Detailed Transient Modeling. The second phase of groundwater modeling was to evaluate in detail the COPCs identified through use of the screening level models. The steady-state models were converted to transient models allowing for the source terms to vary. As shown in **Table 4.1-44** and RS74A (Barr, 2008) there are time-varying predictions of stockpile leachate concentrations at Year 1, Year 5, Year 10, Year 15, Year 20, Closure and Post-closure. In addition, stockpile leakage rates will change during operations as new portions of the stockpiles are created and other portions are progressively closed. Six stress periods were used in the transient models.

Table 4.1-44. Transient Model Stress Period Set-Up

Stress Period	Duration (days)	Period Simulated	Stockpile Leakage/Concentration Data Used

1		1825	Year 0 – Year 5	Year 5
2		1825	Year 6 – Year 10	Year 10
3		1825	Year 11 – Year 15	Year 15
4		1825	Year 16 – Year 20	Year 20
Low Linear Leakage	5	20440	Year 21 – Year 76	Closure Data
	6	702260	Year 77 – Year 2000	Post-closure Data
Ave. Linear Leakage	5	16790	Year 21 – Year 66	Closure Data
	6	705910	Year 67 – Year 2000	Post-closure Data
High Linear Leakage	5	14600	Year 21 – Year 60	Closure Data
	6	708100	Year 61 – Year 2000	Post-closure Data

Source: Table 6-25 in RS74A (Barr, 2008x)

While all of the cross-section models were set up in this general manner, each model had special considerations which were addressed by eliminating some time-steps and varying boundary conditions (flow and concentration inputs). For example, because the West Pit will be dewatered during Years 1 through 20, and during closure the pit will be filling with water, it is not expected to lose water to ground water. As such, only post-closure conditions were simulated with the West Pit model. As indicated in **Table 4.1-43**, this model was used to simulate antimony, arsenic and sulfate transport.

Results from the transient models are presented in RS74A (see Figures 6-5 through 6-48 and Tables 6-30 through 6-32 in RS74A, Barr,2008). The summary table for the West Pit flow path (**Table 4.1-31A**) shows the prediction at the property boundary. Results from the screening level model (**Figure 4.1-61**) showed that concentrations in the bedrock are very similar to, if not slightly less than, concentrations in the surficial deposits. As such, only concentrations in the surficial aquifer are shown in the summary table.

At the West Pit flow path, concentrations of arsenic and antimony are predicted to be above the groundwater evaluation criteria at the property boundary if sorption is not considered. With sorption, arsenic and antimony concentrations are predicted to be under the evaluation criteria at the property boundary for the entire 2,000 year period simulated.

Predictions are also made for concentrations at the Dunka Road for flow paths that cross the Dunka Road prior to the nearest other evaluation point; this includes the West Pit. The Dunka Road evaluation location is closer to the source and has higher modeled concentrations (see Figures 6-8 and 6-10 in RS74A, Barr, 2008x); arsenic and antimony reach maximum concentrations of about 0.14 and 0.08 mg/L without sorption, and with sorption eventually increase to concentrations above the criteria in long-term post-closure (Years 1,000 to 1,800). Sulfate concentrations are predicted to be below 200 mg/L at the Dunka Road and 125 mg/L at the property boundary evaluation locations under all three stockpile leakage rates.

4.1.5.2.1.2 Category 3 Stockpile (Flow Path #4)

Steady-State Screening Model Results. Input concentrations and results for the Category 3 Stockpile flow path screening model are shown in the table depicted on **Figure 4.1-62**. Potential exceedences of standards are highlighted for the Category 3 Stockpile flow path, together with the other Mine Site flow paths, in **Table 4.1-42**.

As with the West Pit flow path model, beryllium and thallium exceeded the screening criteria (**Figure 4.1-62**), which is not considered a modeled exceedance attributable to the project, and these constituents were not carried forward into the next phase of transient modeling. Similar to the West Pit flow path, the background concentration of aluminum exceeded the ground water evaluation criteria so aluminum was not carried forward into the next phase of transient modeling; by contrast, the background concentrations of iron and manganese were below the screening criteria, while the calculated project-related concentrations were above, so these constituents were carried forward. In this screening model, sulfate was calculated to exceed the secondary MCL of 250 mg/L at the downgradient evaluation point. Arsenic, antimony, copper, iron, manganese, nickel and sulfate (i.e., the constituents shown in **Table 4.1-31B)** also exceeded screening criteria and were carried forward to the next phase of transient modeling.

Detailed Transient Modeling.

The East Pit will be dewatered during Years 1 through 12 and then will be backfilled with waste rock and water. During this period, groundwater will be flowing into the pit. It is only during Closure and Post-closure that the East Pit is predicted to lose water to groundwater. To simulate this, the constant head cells representing the East Pit in the model are assigned background groundwater concentrations during stress periods 1 through 4. Closure concentrations are used in stress period 5 and Post-closure concentrations in stress period 6. In this way, leachate from the Category 4 Lean Ore Stockpile is simulated as mixed with background groundwater during operations and with water from the East Pit during Closure and Post-closure. Concentrations used for each model stress period are shown on Tables 6-26 through 6-28 of RS74A (Barr, 2008).

As summarized in **Table 4.1-31B**, concentrations of arsenic, copper, iron, manganese, nickel and antimony are predicted to be over the groundwater evaluation criteria at the Partridge River evaluation location for one or more of the leakage rate cases with no sorption simulated. Of these, nickel under the high linear leakage case exceeds evaluation criteria when sorption is considered. In the high liner leakage rate model, sulfate is predicted to reach a peak of 280 mg/L at the Partridge River in about Year 180, exceeding the secondary MCL for sulfate, and then to ultimately decline to a long term maximum concentration of 210 mg/L.

4.1.5.5.2.1 Modeling Methodology for the Tailings Basin

The methodology used at the Tailings Basin is based on a combination of ground water/solute-transport modeling within Cell 2E of the Tailings Basin combined with a spreadsheet model to predict the concentrations of dissolved constituents. The methodology was updated in response to Agency comments on earlier modeling in both RS13 and RS54/46. The revised modeling was formally released with RS74B and RS13Bon September 12, 2008.

Travel times through the basin were computed using MODFLOW-SURFACT (SURFACT), which is a fully integrated flow and transport code that is based on MODFLOW. SURFACT includes the ability to simulate unsaturated flow, which is why it was chosen for this application. For the Tailings Basin-Proposed Action, the model considered the following source areas (see Figures 6-1 through 6-4 in RS74B, Barr, 2008):

- Embankments (both capped and uncapped).
- The coarse beach areas.
- The fine beach areas.
- The pond(s).

The contribution from each source area to the concentration of dissolved constituents in groundwater leaving the basin at the toe of the embankment was predicted under steady-state conditions. Flow conditions for Years 1, Year 8, Year 9, Year 20 and Closure were used in this analysis. (Closure actually refers to Post-closure in comparison with the Mine Site terminology). The exact same Years 1, Year 8, Year 9, Year 20 and Closure models that were used for the Tailings Basin water balance were used as the basis of the transport models (see RS13 for documentation of these flow models, and these are also summarized in **Section 4.1.1.16** of this EIS).

For each source area, SURFACT was used to predict the contribution from that source at downgradient locations using a unit source concentration. This was done by performing a model run with the concentration of the source component set equal to unity and the concentration of all other components equal to zero. For the beach and embankment areas, the concentration was applied to the recharge zone simulating these features. For the pond, the concentration was applied to the constant head cells simulating the pond. This was done using each model (Year 1, Year 8, Year 9, Year 20 and Closure models). For each model run, concentrations were tracked forward in time until equilibrium was achieved or for 1,000 years. The result of this contaminant transport modeling was a series of breakthrough curves for each source area considered for each model year/flow condition simulated. The breakthrough curves were predicted at a hypothetical well location in the center of the toe of the LTVSMC Cell 2E embankment. These curves are shown in Figures 6-5 through 6-16 of RS74B.

The general results of the MODFLOW-SURFACT modeling were that water from the coarse tailings beach areas (which has the highest solute loads) appears at the toe of the embankment first, which is to be expected since the material has the highest saturated hydraulic conductivity and the shortest flow path. However, because the coarse beach area is unsaturated, the average travel time for this water is slower than for the water originating in the pond, which has a flow path through fully saturated conditions. Figures 6-17 through 6-21 of RS74B show the percent of the source concentrations from each source area that reaches the toe of the embankment.

SRK 2008 [“Updates to Water Quality Predictions in Support for RS74 (Draft 2)", Memo from Stephen Day (SRK) to Miguel Wong (Barr Engineering), Sept. 12, 2008], also proved as Appendix H in RS74B) provided mass load terms for each source area for each year of operations and for closure. In the memo, reference is also made to RS54/RS46 for the source-term load predictions, for which release ratios (**see Table 4.1-38**) have been reportedly updated to represent more recent waste characterization humidity cell tests. RS54/46 presented pore water concentrations in Table 7-15 and Appendix D.3. For the revised Tailings Basin modeling presented in RS74B, it was necessary to have the mass loads and flows for these sources rather than simply pore water concentrations; the load and flow values provided by SRK and are shown in Tables 6-1through 6-5 of RS74B.

The spreadsheet model was developed to predict the concentration of dissolved constituents for water collected by the seepage collection system and water released to the environment using the results from the SURFACT modeling and the transient SRK loads. The spreadsheet model assumed plug flow for each source area (embankment, coarse beach, fine beach and pond) and used the travel time calculations for the transport times of the plugs described above.

For each parameter, for each year, three sets of predictions were made. The first prediction was for completely mixed water. That is, the entire mass load from Cell 2E was mixed with the entire volume of water leaving the basin as groundwater flow (“Total Water”). This represents a scenario where no water is collected in the horizontal drains that will be placed in the LTVSMC dams. In reality, the horizontal drains will capture some water and the water captured will be a higher percent of water from the embankment and coarse beach areas, due to the placement of the drains relative to these source areas.

The SURFACT model was used to predict an upper bound for the amount of embankment (80 percent), coarse tailing (50 percent) and fine tailing (20 percent) source water that the drains could collect. These values were agreed to by Agency staff as a reasonable upper bound for the amount of water captured. The flow to the horizontal drains based on these collection efficiencies (“Captured Water”) was used to predict the concentration of dissolved constituents in the water collected by the horizontal drains. Under this scenario, the groundwater flow leaving the basin (“Uncaptured Water”) is “Total Water” minus “Captured Water” (see **Figure 4.1-40**). The quantity of Captured Water that was used for these calculations came from the MODFLOW modeling in RS13

During Closure, only the Total Water scenario was predicted because it is likely that the horizontal drains will collect very little water as seepage flow diminishes to eventual long term conditions. The is because in Closure, the embankment and coarse beach areas will be capped, the pond edge will move away from the crest of the embankment and the horizontal drains collect less water. It is considered likely that the water that is collected will be better mixed than during operations.

4.1.5.5.2.2 Deterministic Water Quality Predictions for the Tailings Basin

The results of PolyMet’s deterministic water quality predictions for the seepage escaping the Tailings Basin during operational years are in Tables 6-8 through 6-10 in RS74B and Tables **4.1-32** and **4.1-33**. For comparability of operational and closure calculations, only the “Total Water” calculation is used for this EIS. Using the “Total Water” calculation, Table 4-2 in RS74B provides the water chemistry of seepage to ground water from Cells 1E and 2E for selected operational years together with Closure and Post-closure years for the Proposed Action.

The predicted concentrations in Tables 4-2 and 4-5 in RS74B are provided in **Tables 4.1-32** and **4.1-33,** together with a comparison to ground water evaluation criteria.

4.2 WETLANDS

4.2.1. Existing Conditions

4.2.1.1. Introduction

Wetlands are protected under state and federal laws, including the Minnesota Wetland Conservation Act (WCA), MPCA's Jurisdictional Rules (Minn.R. part 7050.0186, Subpart 6A), and the Federal Clean Water Act (CWA).

Under the Federal CWA the project is required to obtain an individual Section 404 permit from the USACE and a CWA Section 401 certification from MPCA to determine that the project complies with the State of Minnesota water quality standards. Minnesota's WCA is administered by the MnDNR for mining projects that require a Permit to Mine. In addition, some wetlands are also designated as Minnesota Public Waters and subject to the Public Waters Work Permit Rules (Minnesota Rules 6115) administered by MnDNR. Although permits are required by both the state and federal agencies, the permitting processes differ in the definition of wetlands/waters that are regulated in each process.

Under the WCA regulations 'isolated' wetlands are regulated, but not 'incidental' wetlands (i.e., a wetland created solely by actions not meant to create the wetland). All of the wetlands on the Project site would be regulated through either the CWA or the WCA.

The public notice period for the Section 404 permit authorization and Section 401 certification was concluded in 2005 before the required environmental review proceeded beyond the EAW scoping stage. The public notice for the Section 404 permit was issued by the USACE in May of 2005. Subsequently the MnPCA waived 401certification in May of 2006.

4.2.1.2. Wetland Delineation

Existing wetland resources were evaluated within the approximately 3,016-acre Mine Site as well as an additional 1,000 acres at the Plant Site and along the railroad and treated water pipeline corridors.

Potential wetland locations were determined through non-field analyses that included review of historic aerial photographs; USGS quadrangle maps; two-foot contoured topographical data; National Wetlands Inventory (NWI) maps; MnDNR color aerial infrared photography; and, where available, soils and hydrology information.

4.2.1.3. Soils

The soils at the Mine Site have been mapped by the USFS using the Superior National Forest Ecological Classification System. This system utilizes Ecological Land types (ELTs). ELTs present at the mine area include Lowland Loamy Moist

(ELT 1), Lowland Loamy Wet (ELT 2), Lowland Organic Acid to Neutral (ELT 6), Upland Deep Loamy Dry Coarse (ELT 13), and Upland Shallow Loamy Dry (ELT 16). These ELTs have been correlated by the University of Minnesota with the NRCS classification as follows:

- ELT 1 – Babbitt-Bugcreek complex 0-2% slope
- ELT 2 – Bugcreek stony loam
- ELT 6 – Rifle-Greenwood
- ELT 13 – Babbitt-Eaglenest complex 0-8% slopes
- ELT 16 – Wahlsten-Eaglesnest-Rock outcrop complex, 2-8% slopes and Eveleth-Conic Rock complex

4.2.1.4. Hydrology and Wetland Vegetation

The hydrology of the wetlands at the site has been stable over time. Factors contributing to this stability include: 1) the lack of continuity between the bedrock and surficial aquifers; 2) slow water movement through soils causing perched water tables; 3) a slow lateral flow component that helps sustain down gradient wetlands with a continual supply of groundwater over time; 4) recharge from surrounding uplands; 5) relatively flat topography across most of the site; and 6) the high water-holding capacity of the soils (Barr 2008c).

The soils, hydrology and overall high quality water (low in nutrients) have resulted in stable wetland systems comprised in large part by bog communities represented by open and coniferous bogs, shrub carr/alder thicket dominated by alder and willows, and forested swamp communities comprised of hardwood and coniferous trees.

Field wildlife habitat type mapping within the mine and stockpile area occurred in 2004. The field effort characterized and described the general wildlife habitats on the 3,016-acre mine site by traveling roads, straight line transects, and circular paths through a variety of habitat types. Vegetation cover types and plant composition were documented and mapped on color infrared aerial photographs. Habitats were characterized based on whether the area was upland or wetland using the USFWS Cowardin Classification System as a guide (Cowardin et al.1979). The general wetland habitat areas were mapped based primarily on the presence of photographic signatures represented by observed wetland vegetation communities. During this initial field habitat survey sampling effort, portions of approximately one-half of the wetland habitats within the study area were observed.

Based on the habitat mapping, wetland field delineation/mapping was performed in 2004, and supplemented in 2005, 2006, 2007, and 2008 (Barr 2006a, Barr 2007a). These investigations delineated and mapped the portion of each wetland located within the evaluation area, rather than the entire wetland. In total, PolyMet delineated 76 wetland areas covering 1,302 acres within an area covering approximately 3,016 acres within the Mine Site, and an additional 57 acres in eight wetlands along the rail line. In addition, portions of 52 wetlands were delineated within the tailings basin drain system, tailings basin mitigation, treated water pipeline, and Dunka Road areas

(Table 4.2-3, Figures 4.2.1 through 4.2.4). The wetland delineations were based on the 1987 USACE Wetland Delineation Manual. A description of these wetlands is provided below.

4.2.1.5. Mine Site

The wetland delineation identified 1,302 acres of wetlands within the Mine Site (Figure 4.2-1). The majority of the wetlands are in complexes that either lie in the floodplain of the Partridge River or are tributary to the Partridge River, including:

- Coniferous bog and open bog communities – 938 acres
- Shrub carr/alder thicket wetland communities – 155 acres
- Forested swamp (hardwood and coniferous)) communities – 120 acres
- Wet/sedge meadow communities – 49 acres
- Shallow marshes – 39 acres

A bog is a peatland that is nutrient poor because it lacks access to substantial quantities of mineral-rich waters (Brinson 1993). Shrub carr and alder thicket are wetlands in which the upper most stratum of vegetation is comprised primarily of shrubs. Swamps are emergent wetlands in which the upper most stratum of vegetation is comprised primarily of trees. Sedge meadows are wetlands dominated by plants in the family Cyperaceae. Marshes are wetlands with emergent, herbaceous vegetation.

The coniferous bog and open bog communities make up the majority of the wetlands at the mine area. Black spruce, with some tamarack, balsam fir, and white cedar, are the dominant canopy tree conifers. The deciduous swamp birch is occasionally found in this community. Shrubs are usually ericaceous (belonging to the heath family) and/or speckled alder and raspberry. Sphagnum moss comprises an almost continuous mat with interspersed forbs such as bunchberry and blue beard lily along with sedges and grasses. Hydrologically, this complex is characterized by a stable water table (Barr 2006b). All but one (wetland ID 27, Table 4.2-3) of the coniferous bog community wetlands identified at the site are rated as high quality. Wetland 27 has some fill and therefore was rated as moderate quality.

The shrub communities are mostly alder thickets with some willow and raspberry and generally have a sparse tree canopy. Occasionally, balsam fir and paper birch were observed along the perimeter of the wetlands. Grasses, sedges, rushes, and some ferns comprise most of the ground story vegetation with some areas of sphagnum moss. Hydrologically, this community appears to be characterized by prolonged periods of shallow inundation with the water table dropping 6-12 inches below the ground during dry periods (Barr 2006b). Soils are typically fibric (i.e., the least decomposed of the peats and containing un-decomposed fibers) and hemic peat (i.e., peat that is somewhat decomposed) at the surface underlain by bedrock or mineral soils. All of these wetlands are rated as high quality.

The forested swamp communities are comprised of a mix of coniferous (conifers) and deciduous (hardwood) dominated communities. Common trees include black spruce, tamarack, and balsam fir, with some white cedar, black ash, paper birch, and aspen present. The shrub canopy is comprised of speckled alder, willows, and raspberry. Grasses and sedges comprise a majority of the ground story with occasional sphagnum moss. Soils include organic and mineral soils. Some hydrologic observations indicate a greater level of hydrologic fluctuation in the forested swamp community than in the larger bog wetlands, with saturation near the surface early in the growing season and a lower water table in late summer (Barr 2006b). All of these wetlands are rated as high quality.

Sedges, grasses, and bulrushes dominate wet meadow and sedge meadow communities. Soils are organic at the surface and underlain with mineral soils. These plant communities typically have saturated or inundated water levels for prolonged periods during the growing season (Barr 2006c). Two of these communities are rated moderate quality and the others are rated as high quality. The moderate quality wetlands are situated between Dunka Road and the railroad.

Approximately one half of the shallow marsh communities at the Mine Site have resulted from artificial impoundments by roads, railroads, and beaver. These wetlands are dominated by cattails, bulrushes, sedges, and grasses. Soils are usually organic at the surface underlain by mineral soils. Inundation with 1-4 inches of water is common throughout most of the growing season except during dry periods. Six of these shallow marshes are rated as high quality and four as moderate quality. Hydrologic disturbance in these four wetlands is primarily responsible for the moderate quality rating.

4.2.1.6. Tailings Basin

The existing tailings basin is an actively permitted waste storage facility and is therefore not subject to state and federal wetland regulations. No expansion of the tailings basin beyond the existing permitted facility is proposed under the Proposed Action. A tailings basin drainage system, however, would need to be constructed to collect seepage and return the seepage water to the basin. Wetland resources mapped around the tailings basin are shown in Figure 4.2-3 and consist largely of shallow marsh with dead black spruce trees scattered throughout (Barr 2008a). Other smaller wetland areas are comprised of deep marsh, wet meadow, shrub carr, coniferous swamp, and open water.

4.2.1.7. Rail Line

The proposed rail connection includes approximately one mile of rail line that would connect the existing Cliffs Erie railway to the process plant. There are eight wetlands located in the vicinity of the proposed rail connection totaling 57 acres (Figure 4.2-2). Shallow marsh comprises 36 acres (64%), and shrub carr 19 acres (33%) of the existing wetlands adjacent to the rail line. The wetlands are rated as high quality.

4.2.1.8 Treated Water Pipeline and Dunka Road Improvements

A treated water pipeline from the Mine Site to the Plant Site would be constructed to facilitate utilization of the mine pit dewatering and stockpile drainage water. In addition, the existing Dunka Road would be upgraded to handle the necessary mine traffic. The wetlands in the vicinity of the proposed Treated Water Pipeline and Dunka Road improvements consist of coniferous swamp, shrub carr, shallow marsh and deep marsh, and open water (Table 4.2-3 and Figure 4.2-4)

4.2.1.9. Wetland Classification System

Wetlands at the Project were classified using the Circular 39 system (Shaw and Fredine 1971); the Cowardin Classification System (Cowardin et al. 1979); and the Eggers and Reed (1997) wetland classification systems (Table 4.2-1). The Eggers and Reed Classification system (1997), used under the Minnesota Wetland Conservation (WCA) (Table 4.2-3) was selected for consistent use in this EIS.

4.2.1.10 Wetland Functional Assessment

Wetlands can serve many functions, including ground water recharge/discharge, flood storage and alteration/attenuation, nutrient and sediment removal/transformation, toxicant retention, fish and wildlife habitat, wildlife diversity/abundance for breeding migration and wintering, shoreline stabilization, production export, aquatic diversity/abundance and support of recreational activities. Both the USACE and WCA recognize the Minnesota Routine Assessment Method for Evaluating Wetland Functions (MnRAM 3.0) for quantifying wetland functions and values in Minnesota.

The wetland functions that were typically most applicable to the Mine Site include:

- Maintenance of Characteristic Hydrologic Regime
- Maintenance of Wetland Water Quality
- Wildlife Habitat
- Downstream Water Quality

Landscape characteristics are also important for evaluating wetland functions within the NorthMet Project area. Key landscape wetland characteristics considered in rating functional quality in the MnRAM 3.0 assessment are provided in Table 4.2-2.

Table 4.2-1 Wetland Classification System Descriptors

Wetland Plant Community Types (Eggers and Reed 1997)	Classification of Wetlands and Deep Water Habitat of the United States (Cowardin et al. 1979)	Fish and Wildlife Service Circular 39 (Shaw and Fredine 1971)
Shallow, Open Water	Palustrine or lacustrine, littoral; aquatic bed; submergent, floating and floating-leaved	Type 5: Inland open fresh water
Deep Marsh	Palustrine or lacustrine, littoral; aquatic bed; submergent, floating-leaved; and emergent; persistent and non-persistent	Type 4: Inland deep fresh marsh
Shallow Marsh	Palustrine; emergent; persistent and non-persistent	Type 3: Inland shallow fresh marsh

Wetland Plant Community Types (Eggers and Reed 1997)	Classification of Wetlands and Deep Water Habitat of the United States (Cowardin et al. 1979)	Fish and Wildlife Service Circular 39 (Shaw and Fredine 1971)
Sedge Meadow	Palustrine; emergent; and narrow-leaved persistent	Type 2: Inland fresh water
Fresh (Wet) Meadow	Palustrine; emergent; broad- and narrow-leaved persistent	Type 1: Seasonally flooded basin or flat Type 2: Inland fresh meadow
Wet to Wet-Mesic Prairie	Palustrine; emergent; broad- and narrow-leaved persistent	Type 1: Seasonally flooded basin or flat Type 2: Inland fresh meadow
Calcareous fen	Palustrine; emergent; narrow-leaved persistent; and scrub	Type 2: Inland fresh meadow
Open Bog	Palustrine; moss/lichen; and scrub/shrub; broad-leaved evergreen	Type 8: Bog
Coniferous Bog	Palustrine; forested; needle-leaved evergreen and deciduous	Type 8: Bog
Shrub-Carr	Palustrine; scrub/shrub; broad-leaved deciduous	Type 6: Shrub swamp
Alder Thicket	Palustrine; scrub/shrub; broad-leaved deciduous	Type 6: Shrub swamp
Hardwood Swamp	Palustrine; forested; broad-leaved deciduous	Type 7: Wooded swamp
Coniferous Swamp	Palustrine; forested; needle-leaved deciduous and evergreen	Type 7: Wooded swamp
Floodplain Forest	Palustrine; forested; broad-leaved deciduous	Type 1: Seasonally flooded basin or flat
Seasonally Flooded Basin	Palustrine; flat; emergent; persistent and non-persistent	Type 1: Seasonally flooded basin or flat

Table 4.2-2 Key Landscape Factors Influencing Wetland Functional Scores in MnRAM

MnRAM Factor	Role in Wetland Function and Quality
Wetland or Lake Outlet Characteristics	Outlets influence flood attenuation, downstream water quality, and other hydrologic processes
Watershed and Adjacent Land Uses and Condition	Adjacent land uses influence wetland hydrology, sediment and nutrient loading to wetlands, connectivity for wildlife habitat, and other factors
Soil Condition	Soil condition influences plant community type, vegetative diversity, overall wetland quality and productivity (trophic state)
Erosion and Sedimentation	Influences downstream water quality, trophic state of wetlands, vegetative diversity, and overall wetland quality
Wetland Vegetative Cover and Vegetation Types	Influences vegetative diversity and wildlife habitat as well as hydrologic characteristics (e.g., evapotranspiration or resistance to flow in floodplain wetlands)
Wetland Community Diversity and Interspersion	Influences the vegetative diversity and overall wetland quality as well as value for wildlife habitat
Human Disturbance (both past and present)	Mining, logging, road-building, stream channelization, and other alterations to the landscape

These broader landscape factors were applied and evaluated on a larger scale than a single wetland because there are soil and vegetation similarities within the sub-watersheds that are characteristic of large groups of similar wetland types. Human disturbance factors were also similar across broad areas; notably that the majority of the Mine Site is relatively undisturbed by humans and the limited disturbance that does exist is due to logging. Other local factors were considered for each wetland or small groups of wetlands. Summaries of the vegetative diversity/integrity and overall functional quality rating (low, medium, or high) for each delineated wetland within the Project are tabulated in Table 4.2-3 in Section 4.2.3.1.

4.2.2 Impact Criteria

Determination of the potential impacts on wetland communities is based on the functions and values of the particular wetland. A wetland analysis evaluates the functions (i.e., physical, biological, and chemical processes) and values (i.e., processes or attributes valuable to society) of a wetland. Potential physical impacts affecting a wetland's ability to perform its functions and values are then evaluated to determine the level of potential impact**.**

Wetland impacts may be direct or indirect. All wetlands considered to be directly affected by excavation or filling for mining activities would no longer have any wetland functions or values or would not be considered wetland after the mining activity has occurred. Wetlands that are not filled or excavated but have a reduced function or value resulting from hydrological modifications or disturbance from dust and vehicle and facility emissions would be considered indirectly affected. Indirect hydrological impacts from mining activities would be the most likely and significant type of indirect impact on remaining wetland functions and values, followed by dust accumulation and vehicle emissions.

4.2.3 Environmental Consequences

4.2.3.1. Proposed Action

The Proposed Action includes direct and indirect impacts at the Mine Site, along the transportation corridor (i.e., rail line, water pipeline, and Dunka Road), and at the Plant Site (i.e. specifically the tailings basin drainage system). This section describes both direct and indirect impacts within each of these areas and a summary of wetland impacts by project period or time frame.

4.2.3.2 Potential Direct Wetland Impacts

It is assumed that the direct wetland impacts estimated within the designated proposed project impact areas would be the result of excavation or filling or other activities that would result in wetland loss and loss of wetland functions and values. Direct wetland impacts are estimated at 869 acres. Direct impacts to specific project areas are described below.

Table 4.2-3 Total Projected Wetland Impact Detail

Project Area	Wetland ID	Dominant Circular 39 Type	Total Wetland Area (acres)	Projected Direct Wetland Impacts (acres)	Projected Indirect Wetland Impacts (acres)	Dominant Community Type	Vegetative Diversity/ Integrity	Overall Wetland Quality	Disturbance Level	Disturbance Type	Wetland Origin	Field Delineated	Impact Type (Direct/Indirect)
Mine Site	1	3	0.42	0.42	0.00	shallow marsh	Moderate	Moderate	High	Impounded	Natural	Y	Direct
Mine Site	3	3	0.35	0.35	0.00	shallow marsh	Moderate	Moderate	High	Impounded	Natural	N	Direct
Mine Site	5	2	0.61	0.61	0.00	wet meadow	High	High	Low		Natural	Y	Direct
Mine Site	6	3	0.62	0.62	0.00	shallow marsh	Moderate	Moderate	High	Impounded	Natural	Y	Direct
Mine Site	7	2	0.07	0.07	0.00	wet meadow	Moderate	Moderate	High	Impounded	Natural	N	Direct
Mine Site	8	2	6.16	6.16	0.00	sedge meadow	Moderate	Moderate	High	Impounded/Fill	Natural	Y	Direct/Indirect
Mine Site	9	3	1.82	0.54	0.00	shallow marsh	High	High	Moderate	Impounded	Natural	Y	Direct
Mine Site	10	2	1.17	1.17	0.00	sedge meadow	High	High	Low		Natural	Y	Direct
Mine Site	11	8	8.88	0.00	0.00	coniferous bog	High	High	Low		Natural	Y	Direct
Mine Site	12	6	0.13	0.00	0.00	alder thicket	High	High	Low		Natural	Y	Direct
Mine Site	13	2	5.03	0.26	0.00	wet meadow	High	High	High	Impounded	Natural	Y	Direct
Mine Site	14	2	0.33	0.33	0.00	wet meadow	High	High	Low		Natural	Y	Direct
Mine Site	15	8	2.79	0.00	0.00	coniferous bog	High	High	Low		Natural	Y	Direct
Mine Site	16	3	0.30	0.19	0.11	shallow marsh	High	High	Low		Natural	Y	Direct
Mine Site	18	3	18.89	18.89	0.00	shallow marsh	High	High	Moderate	Impounded	Natural	Y	Direct
Mine Site	19	3	1.68	1.68	0.00	shallow marsh	High	High	Low		Natural	Y	Direct
Mine Site	20	2	21.89	21.34	0.55	sedge meadow	High	High	Low		Natural	N	Direct/Indirect
Mine Site	22	3	2.51	0.00	0.00	shallow marsh	High	High	Low		Natural	Y	Direct
Mine Site	24	6	0.80	0.80	0.01	alder thicket	High	High	Low		Natural	Y	Direct
Mine Site	25	8	1.95	0.00	0.00	coniferous bog	High	High	Low		Natural	Y	Direct
Mine Site	27	8	1.07	1.07	0.00	coniferous bog	Moderate	Moderate	High	Road Fill	Natural	Y	Direct
Mine Site	29	3	12.01	2.34	0.00	shallow marsh	High	High	Low		Natural	Y	Direct
Mine Site	32	8	69.89	63.56	2.23	coniferous bog	High	High	Low		Natural	Y	Direct
Mine Site	33	6	23.91	8.45	0.00	alder thicket	High	High	Low		Natural	Y	Direct
Mine Site	34	6	0.99	0.99	0.00	alder thicket	High	High	Low		Natural	Y	Direct
Mine Site	37	6	2.39	2.39	0.00	shrub carr	High	High	Low		Natural	N	Direct
Mine Site	43	6	8.33	8.26	0.04	alder thicket	High	High	Low		Natural	Y	Direct/Indirect
Mine Site	44	6	3.26	1.98	0.00	alder thicket	High	High	Low		Natural	Y	Direct
Mine Site	45	6	30.58	20.63	1.43	alder thicket	High	High	Low		Natural	Y	Direct/Indirect
Mine Site	47	8	0.54	0.54	0.00	open bog	High	High	Low		Natural	Y	Direct
Mine Site	48	8	98.44	40.21	0.92	coniferous bog	High	High	Low		Natural	Y	Direct/Indirect
Mine Site	51	6	2.91	2.91	0.00	alder thicket	High	High	Low		Natural	Y	Direct
Mine Site	52	6	3.88	2.74	1.13	alder thicket	High	High	Low		Natural	Y	Direct
Mine Site	53	6	24.24	2.68	0.48	alder thicket	High	High	Low		Natural	Y	Direct
Mine Site	54	6	4.85	0.00	0.00	alder thicket	High	High	Low		Natural	Y	Direct
Mine Site	55	6	3.91	3.59	0.32	alder thicket	High	High	Low		Natural	Y	Direct
Mine Site	56	8	2.78	0.00	0.00	coniferous bog	High	High	Low		Natural	Y	Direct
Mine Site	57	7	78.01	54.70	0.00	coniferous swamp	High	High	Low		Natural	Y	Direct
Mine Site	58	6	33.29	0.13	0.00	alder thicket	High	High	Low		Natural	Y	Direct
Mine Site	60	6	5.95	5.95	0.00	alder thicket	High	High	Low		Natural	Y	Direct

Table 4.2-3 Total Projected Wetland Impact Detail (Cont.)

Project Area	Wetland ID	Dominant Circular 39 Type	Total Wetland Area (acres)	Projected Direct Wetland Impacts (acres)	Projected Indirect Wetland Impacts (acres)	Dominant Community Type	Vegetative Diversity/ Integrity	Overall Wetland Quality	Disturbance Level	Disturbance Type	Wetland Origin	Field Delineated	Impact Type (Direct/Indirect)
Mine Site	61	7	0.45	0.00	0.00	coniferous swamp	High	High	Low		Natural	Y	Direct
Mine Site	62	8	12.13	0.00	0.00	coniferous bog	High	High	Low		Natural	Y	Direct
Mine Site	64	7	0.31	0.00	0.00	hardwood swamp	High	High	Low		Natural	N	Direct
Mine Site	68	7	20.05	7.30	0.25	hardwood swamp	High	High	Low		Natural	N	Direct
Mine Site	72	7	1.38	0.59	0.79	coniferous swamp	High	High	Low		Natural	Y	Direct
Mine Site	74	7	6.12	6.12	0.00	hardwood swamp	High	High	Low		Natural	Y	Direct
Mine Site	76	8	3.38	2.42	0.00	coniferous bog	High	High	Low		Natural	Y	Direct
Mine Site	77	8	13.00	7.82	0.08	coniferous bog	High	High	Low		Natural	Y	Direct
Mine Site	78	8	0.81	0.81	0.00	coniferous bog	High	High	Low		Natural	Y	Direct
Mine Site	79	8	2.39	0.00	0.00	coniferous bog	High	High	Low		Natural	Y	Direct
Mine Site	80	8	0.29	0.29	0.00	coniferous bog	High	High	Low		Natural	Y	Direct
Mine Site	81	7	1.68	1.21	0.47	coniferous swamp	High	High	Low		Natural	Y	Direct
Mine Site	82	8	61.52	60.16	1.36	coniferous bog	High	High	Low		Natural	Y	Direct/Indirect
Mine Site	83	8	3.99	3.69	0.00	open bog	High	High	Low		Natural	Y	Direct
Mine Site	84	8	1.33	1.33	0.00	coniferous bog	High	High	Low		Natural	Y	Direct
Mine Site	85	8	1.41	1.41	0.00	coniferous bog	High	High	Low		Natural	Y	Direct
Mine Site	86	8	2.47	2.47	0.00	coniferous bog	High	High	Low		Natural	Y	Direct
Mine Site	88	8	5.57	4.00	1.57	coniferous bog	High	High	Low		Natural	N	Direct/Indirect
Mine Site	90	8	184.68	71.88	0.18	open bog	High	High	Low		Natural	Y	Direct/Indirect
Mine Site	95	8	2.54	2.54	0.00	coniferous bog	High	High	Low		Natural	N	Direct
Mine Site	96	8	17.29	16.35	0.94	coniferous bog	High	High	Low		Natural	Y	Direct/Indirect
Mine Site	97	8	3.53	1.66	1.88	coniferous bog	High	High	Low		Natural	N	Direct/Indirect
Mine Site	98	8	15.49	15.49	0.00	coniferous bog	High	High	Low		Natural	Y	Direct
Mine Site	99	8	1.40	0.55	0.85	coniferous bog	High	High	Low		Natural	Y	Direct
Mine Site	100	8	192.25	117.74	2.05	coniferous bog	High	High	Low		Natural	Y	Direct/Indirect
Mine Site	101	8	15.09	7.18	0.00	coniferous bog	High	High	Low		Natural	Y	Direct
Mine Site	103	8	125.89	116.40	9.49	coniferous bog	High	High	Low		Natural	Y	Direct/Indirect
Mine Site	104	8	3.57	3.12	0.46	coniferous bog	High	High	Low		Natural	Y	Direct
Mine Site	105	8	15.47	0.00	0.00	coniferous bog	High	High	Moderate	Logged	Natural	Y	Direct
Mine Site	107	8	65.79	42.14	0.39	coniferous bog	High	High	Low		Natural	Y	Direct
Mine Site	109	6	6.03	6.03	0.00	alder thicket	High	High	Low	Partly cleared	Natural	Y	Direct
Mine Site	114	8	0.73	0.73	0.00	coniferous bog	High	High	Low		Natural	Y	Direct
Mine Site	120	3	0.58	0.58	0.00	shallow marsh	Moderate	Moderate	Moderate	Impounded	Natural	Y	Direct
Mine Site	200	7	6.36	6.36	0.00	hardwood swamp	High	High	Low		Natural	Y	Direct
Mine Site	201	2	13.48	13.48	0.00	wet meadow	High	High	Low		Natural	Y	Direct
Mine Site	202	7	5.67	5.67	0.00	coniferous swamp	High	High	Low		Natural	Y	Direct
Mine Site Subtotal	**76**		**1301.70**	**804.10**	**27.90**		**52/59 High 7/59 Medium**	**52/59 High 7/59 Medium**					

Table 4.2-3 Total Projected Wetland Impact Detail (Cont.)

Project Area	Wetland ID	Dominant Circular 39 Type	Total Wetland Area (acres)	Projected Direct Wetland Impacts (acres)	Projected Indirect Wetland Impacts (acres)	Dominant Community Type	Vegetative Diversity/ Integrity	Overall Wetland Quality	Disturbance Level	Disturbance Type	Wetland Origin	Field Delineated	Impact Type (Direct/Indirect)
Railroad	R-1	2	1.05	0.00	0.00	wet meadow	High	High	Moderate	Road fill	Natural	Y	None
Railroad	R-2	3	1.65	0.00	0.00	shallow marsh	High	High	Moderate	Road fill	Natural	Y	None
Railroad	R-3	7	0.63	0.10	0.00	hardwood swamp	High	High	Moderate	Road fill	Natural	Y	Direct
Railroad	R-4	6	3.50	0.17	0.00	shrub carr	High	High	Low		Natural	Y	Direct
Railroad	R-5	3	24.41	0.00	0.00	shallow marsh	High	High	Moderate	Impounded	Natural	Y	None
Railroad	R-6	3	10.42	0.00	0.00	shallow marsh	High	High	Low		Natural	Y	None
Railroad	R-7	6	12.14	0.00	0.00	shrub carr	High	High	Moderate	Impounded	Natural	Y	None
Railroad	R-8	6	3.00	0.00	0.00	shrub carr	High	High	Moderate	Impounded	Natural	Y	None
Railroad Subtotal	**8**		**56.80**	**0.30**	**0.00**		**8/8 High**	**8/8 High**					
Tailings Basin Drain System	None	None	None	0.00	0.00								
Tailings Basin Subtotal				**0.00**	**0.00**								
Dunka Road & Water Pipeline	4000	3		0.78	0.00	shallow marsh	High	High	Low		Natural	Y	Direct
Dunka Road & Water Pipeline	4001	3		0.45	0.00	shallow marsh	High	High	Low		Natural	Y	Direct
Dunka Road & Water Pipeline	4002	3		0.30	0.00	shallow marsh	High	High	Low		Natural	Y	Direct
Dunka Road & Water Pipeline	22	3		0.47	0.00	shallow marsh	High	High	Low		Natural	Y	Direct
Dunka Road & Water Pipeline	4004	3		0.01	0.00	shallow marsh	High	High	Low		Natural	Y	Direct
Dunka Road & Water Pipeline	4005	4		0.25	0.00	deep marsh	Moderate	Moderate	Moderate	Impounded	Natural	Y	Direct
Dunka Road & Water Pipeline	4006	5		0.05	0.00	open water	Moderate	Moderate	Moderate	Impounded	Natural	Y	Direct
Dunka Road & Water Pipeline	4007	6		0.88	0.00	shrub carr	High	High	Low		Natural	Y	Direct
Dunka Road & Water Pipeline	4008	6		1.28	0.00	shrub carr	High	High	Low		Natural	Y	Direct
Dunka Road & Water Pipeline	4009	6		0.03	0.00	shrub carr	High	High	Low		Natural	Y	Direct
Dunka Road & Water Pipeline	4010	6		0.68	0.00	shrub carr	High	High	Low		Natural	Y	Direct
Dunka Road & Water Pipeline	4011	6		1.27	0.00	shrub carr	High	High	Low		Natural	Y	Direct
Dunka Road & Water Pipeline	4012	6		0.06	0.00	shrub carr	High	High	Low		Natural	Y	Direct
Dunka Road & Water Pipeline	4013	6		0.92	0.00	shrub carr	High	High	Low		Natural	Y	Direct
Dunka Road & Water Pipeline	4014	6		0.29	0.00	shrub carr	High	High	Low		Natural	Y	Direct
Dunka Road & Water Pipeline	4015	6		0.19	0.00	shrub carr	High	High	Low		Natural	Y	Direct

Project Area	Wetland ID	Dominant Circular 39 Type	Total Wetland Area (acres)	Projected Direct Wetland Impacts (acres)	Projected Indirect Wetland Impacts (acres)	Dominant Community Type	Vegetative Diversity/ Integrity	Overall Wetland Quality	Disturbance Level	Disturbance Type	Wetland Origin	Field Delineated	Impact Type (Direct/Indirect)
Dunka Road & Water Pipeline	54	6		0.48	0.00	alder thicket	High	High	Low		Natural	Y	Direct
Dunka Road & Water Pipeline	4017	6		0.04	0.00	shrub carr	High	High	Low		Natural	Y	Direct
Dunka Road & Water Pipeline	4018	6		0.20	0.00	shrub carr	High	High	Low		Natural	Y	Direct
Dunka Road & Water Pipeline	4019	6		0.27	0.00	shrub carr	High	High	Low		Natural	Y	Direct
Dunka Road & Water Pipeline	4021	7		0.45	0.00	coniferous swamp	High	High	Low		Natural	Y	Direct
Dunka Road & Water Pipeline	4023	deepwater		0.45	0.00	deepwater	High	High	Low		Natural	Y	Direct
Water Pipeline Subtotal	22			9.80	0.00		**2/22 Moderate 20/22 High**	**2/22 Moderate 20/22 High**					
East Basin Expansion Area	T1	5		0.17	0.00	open water	Low	Low	High	Impounded	Natural	Y	Direct
East Basin Expansion Area	T2	5		0.90	0.00	open water	Low	Low	High	Impounded	Natural	Y	Direct
East Basin Expansion Area	T3	2		0.09	0.00	wet meadow	Low	Low	High	Ditch	Created	Y	Direct
East Basin Expansion Area	T4	2		1.02	0.00	wet meadow	Low	Low	High	Road Fill			
East Basin Expansion Area	T5	2		0.24	0.00	wet meadow	Low	Low	High	Road Fill	Created	Y	Direct
East Basin Expansion Area	T6	6		0.07	0.00	shrub carr	Low	Low	High	Road Fill	Created	Y	Direct
East Basin Expansion Area	T7	3		0.92	0.00	shallow marsh	Low	Low	High	Impounded	Created	Y	Direct
East Basin Expansion Area	T8	2		0.04	0.00	wet meadow	Low	Low	High	Seepage	Created	Y	Direct
East Basin Expansion Area	T9	2		0.38	0.00	wet meadow	Low	Low	High	Seepage	Created	Y	Direct
East Basin Expansion Area	T10	5		1.48	0.00	open water	Low	Low	High	Impounded	Natural	Y	Direct
East Basin Expansion Area	T11	5		0.96	0.00	open water	Low	Low	High	Impounded	Natural	Y	Direct
East Basin Expansion Area	T12	3		0.39	0.00	shallow marsh	Low	Low	High	Impounded	Created	Y	Direct
East Basin Expansion Area	T13	4		0.60	0.00	deep marsh	Low	Low	High	Impounded	Natural	Y	Direct
East Basin Expansion Area	T14	4		10.06	0.00	deep marsh	Low	Low	High	Impounded	Natural	Y	Direct
East Basin Expansion Area	T15	3		1.70	0.00	shallow marsh	Low	Low	High	Impounded	Created	Y	Direct
East Basin Expansion Area	T31	7		0.03	0.00	coniferous swamp	Low	Low	High	Impounded	Natural	Y	Direct

Table 4.2-3 Total Projected Wetland Impact Detail (Cont.)

Project Area	Wetland ID	Dominant Circular 39 Type	Total Wetland Area (acres)	Projected Direct Wetland Impacts (acres)	Projected Indirect Wetland Impacts (acres)	Dominant Community Type	Vegetative Diversity/ Integrity	Overall Wetland Quality	Disturbance Level	Disturbance Type	Wetland Origin	Field Delineated	Impact Type (Direct/Indirect)
TB Mitigation Alternative - Buttress Area	**16**		**0.00**	**19.05**	**0.00**								
TB Mitigation Alternative - Buttress Area	T16	4		9.03	0.00	deep marsh	Low	Low	High	Ditch	Created	Y	Direct
TB Mitigation Alternative - Buttress Area	T17	7		1.18	0.00	coniferous swamp	Low	Low	High	Impounded	Natural	Y	Direct
TB Mitigation Alternative - Buttress Area	T18	4		4.07	0.00	deep marsh	Low	Low	High	Impounded	Natural	Y	Direct
TB Mitigation Alternative - Buttress Area	T19	4		18.91	0.00	deep marsh	Low	Low	High	Ditch/Impounded	Natural	Y	Direct
TB Mitigation Alternative - Buttress Area	T20	7		0.45	0.00	coniferous swamp	Low	Low	High		Natural	Y	Direct
TB Mitigation Alternative - Buttress Area	T21	6		0.48	0.00	shrub carr	Low	Low	High	Impounded	Natural	Y	Direct
TB Mitigation Alternative - Buttress Area	T23	7		0.22	0.00	coniferous swamp	Low	Low	High	Impounded	Natural	Y	Direct
TB Mitigation Alternative - Buttress Area	T24	7		0.33	0.00	coniferous swamp	Low	Low	High	Impounded	Natural	Y	Direct
TB Mitigation Alternative - Buttress Area	T25	6		0.01	0.00	shrub carr	Low	Low	High	Impounded	Natural	Y	Direct
TB Mitigation Alternative - Buttress Area	T26	6		1.38	0.00	shrub carr	Low	Low	High	Impounded	Natural	Y	Direct
TB Mitigation Alternative - Buttress Area	T27	7		0.03	0.00	coniferous swamp	Low	Low	High	Impounded	Natural	Y	Direct
TB Mitigation Alternative - Buttress Area	T28	6		0.05	0.00	shrub carr	Low	Low	High		Natural	Y	Direct
TB Mitigation Alternative - Buttress Area	T29	2		0.00	0.00	wet meadow	Low	Low	High	Ditch	Created	Y	None
TB Mitigation Alternative - Buttress Area	T30	6		0.02	0.00	shrub carr	Low	Low	High	Impounded	Natural	Y	Direct
TB Mitigation Alternative - Buttress Area	14		0.00	36.20	0.00		14/14 Low	14/14 Low					
Project Total	**119**		**1358.54**	**869.30**	**27.90**								

4.2.3.2.1 Mine Site Direct Wetland Impacts

A total of 76 wetlands are located within the Mine Site comprising 1,302 total acres. Of these, 59 wetlands, totaling 804 acres, would be directly impacted. The locations of the wetlands impacted at the Mine Site are shown in Figure 4.2-5. Table 4.2-3 lists the affected Mine Site wetlands and their community types.

The impacted wetlands would include a number of different types. The most common wetland types are coniferous bog (509 acres) and open bog communities (76 acres). These two communities comprise 73% of the wetland area impacted at the Mine Site (Table 4.2-4).

Coniferous swamp (62 acres of impact) and alder thicket (65 acres of impact) each comprise about 8% of the projected direct wetland impacts at the Mine Site. In addition, 15 acres of sedge meadow, 26 acres of shallow marsh, 20 acres of hardwood swamp, 29 acres of fresh (wet) meadow, and 2 acres of shrub carr would also be directly impacted at the Mine Site. Overall, approximately 97% of the directly impacted wetlands are rated as high quality wetlands, while the remaining 3% are rated as moderate quality.

Post closure, the West Pit would fill with water and eventually discharge water into a 15-acre wetland to the south. The water will flow through the wetlands area before reaching the Partridge River. Currently, the existing flow path is surrounded by wetlands that convey a flow equivalent to 570 gpm. The 15-acre wetland would be altered to accommodate a flow of 1,000 gpm. The direct impacts to a portion of these 15 acres of wetland number 32 have been incorporated in the wetland impact direct totals (Table 4.2-3).

PolyMet proposes to avoid and minimize wetland impacts by placing waste rock back into the East Pit, thereby reducing the need for additional surface stockpile areas that would otherwise affect wetlands. In addition, PolyMet proposes to combine the overburden and Category 1 and 2 waste rock stockpiles. By doing such, the footprint of these stockpiles is reduced or eliminated compared to what would otherwise be required, resulting in less direct wetland impacts.

4.2.3.2.2 Plant Site Direct Wetland Impacts

Most of the Plant Site would be located at the former LTVSMC site, which is situated on the top of a hill. No wetland resources are present in the processing plant area and therefore no direct wetland impacts are anticipated under the Proposed Action.

4.2.3.2.3. Tailings Basin

No new wetland disturbance would be required for the proposed tailings basin under the Proposed Action. Reuse of the existing permitted tailings basin would not involve direct wetland impacts either through construction of the tailings basin or water discharge.

Under the Proposed Action Mitigation Design, the tailings dam would be constructed using LTVSMC taconite tailings. This would require a 300-foot-wide buttress area on the north side of tailings basin and an East Basin Expansion Area on the east and northeast sides of the tailings basin. Thirty-six acres of wetland would be directly impacted by the north side buttress construction. Over 90% of the wetlands are classified as deep marsh that is rated as low quality. This area has been historically impacted by seepage from the tailings basins and other drainage modifications made in the area. Nineteen acres of wetlands would be directly impacted in the East Basin Expansion. Wetland types include deep marsh, shallow marsh, and wet meadow that are rated as low quality because of impoundment caused by past disturbances including beaver, roads, road ditches, railroad embankments, diversion of surface flow, and construction of the tailings basin

4.2.3.2.4 Rail Line Direct Wetland Impacts

Approximately 0.3 acre of wetlands would be directly affected by rail spur construction (Table 4.2-3). The wetland impacts proposed in the spur connection area include a hardwood swamp dominated by aspen and a shrub carr wetland dominated by willow and speckled alder. The rail spur was designed to avoid wetlands to the extent possible based on the location of the existing rail system and requirements for rail construction.

4.2.3.2.5 Treated Water Pipeline and Dunka Road Direct Wetland Impacts

The treated water pipeline corridor and improvements to Dunka Road would require that approximately 10 acres of wetlands be directly impacted by construction (Table 4.2-3 and Figure 4.2-4). These wetlands include shallow marsh, deep marsh, open water, shrub carr, and coniferous swamp habitats.

4.2.3.3. Potential Indirect Wetland Impacts

Indirect wetland impacts considered in the analysis included the following conditions that could potentially result in indirect impacts to wetlands inside and outside the defined Mine and Plant Sites:

- Wetland hydrology changes that could result from surface water flow changes from the surrounding sub-watersheds or adjacent rivers or streams
- Changes in groundwater flow to groundwater-fed wetlands that could result from mine pit dewatering and waste rock stockpile construction
- Non-hydrologic changes that could impair wetland functions, including fugitive dust and vehicle emissions from haul vehicles and wildlife habitat loss or fragmentation

Indirect wetland impacts have been estimated at 28 acres by Polymet due to hydrologic effects (further described below). These estimates were based on potential surface water hydrology changes in the Project drainage area. Wetlands within the Project and immediately adjacent to the impact areas are surface water wetlands, relying mostly on precipitation events and shallow subsurface flow. Based on a preliminary study, groundwater-supported wetlands are considered to be minimal in the area (Barr 2006c). Depending on the extent of the hydrological changes, indirect wetland hydrology impacts may result in conversion of wetland types (i.e., conversions of alder thicket, hardwood swamp, or coniferous bog wetlands to sedge meadow or shallow marsh or other wetland types). Additional indirect impacts are anticipated due to non-hydrologic causes, as discussed below.

For each area assessed for direct wetland impacts – Plant Site (including the tailings basin drainage system), Mine Site (including haul roads), and transportation corridor (i.e., rail line, treated water pipeline, and Dunka Road) – the potential for indirect impacts to wetlands located in and around the impact area was also assessed and summarized below.

4.2.3.3.1 Plant Site Indirect Wetland Impacts

No wetlands are located within the Plant Site (excluding the tailings basin); therefore, no direct or indirect wetland impacts would occur from continued use of the plant area.

4.2.3.3.2 Tailings Basin Indirect Wetland Impacts

Use of the existing LTV tailings basin would involve the creation of new cells within the existing basins. No surface water would be allowed to discharge as discussed below.

During and after basin operations, there would be insufficient water source to fill and overtop the basin into the adjacent wetlands as the tributary area for the basin is small. Even during a severe precipitation event in combination with runoff from a rapidly melting snow pack, the bounce in basin elevation would be expected to be less than one foot – well within the 3-4 foot of freeboard that would be maintained during tailings basin operations.

After closure/reclamation, an overflow would be constructed from the tailings basin. Although there is little potential for overtopping of the tailings basin, an emergency overflow spillway would be constructed as part of the basin closure plan. The spillway would discharge to a channel, and water flow from the channel would then be diverted to a preferred location (Barr 2007, Barr 2007b).

Under the Proposed Action, management of water from horizontal drains and seepage barriers placed along the outside footer of the dams associated with cells 2E/1E would occur during both operations and long term (post closure). This dam seepage would be collected and re-circulated back into the basin as long as seepage continued to occur and until seepage met specified water quality limits. If and when dam seepage water quality met allowable discharge limits, it would be allowed to discharge to adjacent wetlands as it would not be expected to have adverse water quality impacts to wetlands or surface waters.

Under the Proposed Action, the unlined tailings basin cell 2E/1E would have an increase in head during the course of mine operations, resulting in greater groundwater seepage to the surrounding areas, including wetlands, than the currently estimated seepage rate of 900 gpm (Barr 2008e). Groundwater seepage from cell 2E/1E would fluctuate with the head in the pond area during operations with the seepage ranging up to 2,680 gpm (Barr 2007d). This seepage rate is dependent on whether a pond is maintained in cell 2E/1E. Historical estimates from the adjacent existing tailings basin 2W are as high as 4,000 gpm and are predicted to decrease to 1,510 gpm at closure and 610 gpm post-closure (Barr 2007a, Barr 2008h).

Wetlands adjacent to the existing tailings basin, which has been in place for over 40 years, have been historically impacted by seepage from the existing tailings basin as evidenced by inundation and dead black spruce trees in the wetlands. Wetlands further away from the tailings basin appear to have assimilated to these 40-year-plus hydrology changes and do not exhibit inundation and dead trees. The proposed changes in hydrologic flow to adjacent wetlands from both the dam seepage management and the tailings basin bottom seepage from cells 2E/1E are uncertain as quantitative predictions are not possible. Therefore, it is unknown whether impacts will extend beyond this historically impacted area.

Data from five monitoring wells in the surficial aquifer have provided historical monitoring of indicator constituents such as specific conductance, total dissolved solids, and sulfate. Additional sampling at the five monitoring wells for project-specified constituents was also completed in 2007 (Barr, 2008g). These data indicate that surficial ground water in the vicinity of the Tailings Basin has concentrations of several constituents greater than water quality standards. The areal extent of this historical impact is unknown due to the lack of other downgradient monitoring wells.

Predictive modeling indicates that, as a result of bottom seepage from the existing tailings basin, the groundwater flowing under the tailings basin and recharging to adjacent wetlands currently exceeds Minnesota ground water standards for some parameters in some groundwater monitoring wells near the tailings basin. During NorthMet's operations and post closure of the tailings basin, modeling predicts exceedences of ground water quality criteria for several metals (Barr 2008f). However, these water quality parameters are predicted to not exceed Minnesota surface and ground water quality standards beyond PolyMet's property boundary (Barr 2008h).

It is recommended that the Tailings Basin wetland area be included in the wetlands monitoring to be conducted during operations and closure; in the event that the monitoring indicates adverse impact, appropriate mitigation would be implemented such as hydrologic controls or compensatory mitigation. Additional recommendations regarding the wetland monitoring plan are provided in Section 4.2.4.3.

4.2.3.3.3 Mine Site Indirect Wetland Impacts

The proposed mining activities include the collection and conveyance of groundwater and surface water drainage from within the mine pits as well as the dike and ditch system that minimizes lateral movement of surface water and shallow groundwater within surface deposits.

A system of dikes and ditches was designed to minimize the amount of surface water flowing onto the site; eliminate wastewater and non-contact storm water flowing uncontrolled off the Mine Site; and minimize the amount of storm water flowing into the mine pits. Reactive waste rock stockpiles would be lined to prevent wastewater from affecting adjacent wetlands. Where dikes intersect wetlands, seepage control measures would be installed to restrict groundwater movement into mine pits which may help prevent drawing down of wetland water levels.

Process wastewater would include storm water and groundwater that has contacted disturbed surfaces and may not meet discharge limits. Process water would be piped to the Central Pumping Station, treated if necessary at the wastewater treatment facility, and pumped to the tailings basin. As a result, the water-contributing area to downstream wetlands could be reduced.

Haul roads in the mine area would be constructed to drain runoff to one or both sides by crowning (peaking) the road, either in the middle of the road or along one side. Depending on the height of these roads, a drainage ditch would either be built in the road section or adjacent to the road. These ditches would only collect runoff from the road cross-section, since storm water from adjacent areas would be intercepted and redirected before entering the road section.

Post closure, the West Pit would fill with water and eventually discharge water into a 15-acre wetland to the south. The water will flow through the wetlands area before reaching the Partridge River. Currently, the existing flow path is surrounded by wetlands that convey a flow equivalent to 570 gpm. The 15-acre wetland would be altered to accommodate a flow of 1,000 gpm. The indirect impacts to a portion of these 15 acres of wetland number 32 have been incorporated in the wetland impact indirect totals below and enumerated in Table 4.2-3.

These activities (construction of haul roads, drainage ditches, and dikes) would affect hydrology within the mine area and therefore could indirectly impact wetlands by affecting wetland quality or changing wetland type. Approximately 28 acres of wetlands are estimated by Polymet to be indirectly affected in and around the Mine Site. These indirect impacts are likely to occur in wetland areas between the stockpiles and pits where fragmented wetlands are not likely to remain sustainable in their current function. In addition to these 28 acres, other indirect wetland impacts are possible due to hydrologic effects. To analyze potential hydrologic changes, the mine site and surrounding lands were divided into 24 contributing watershed areas, or tributary areas representing the existing, relatively undisturbed conditions at the site (Figure 4.2-6). During mining and after closure this number would be reduced to 22 watershed areas, and the size of the watersheds would change (Figure 4.2-7). The indirect future hydrological impacts to wetlands in most of these watershed areas are predicted to be 6-8% reductions in equivalent contributing groundwater recharge flow under future conditions, except for wetlands in the East-Central watersheds (sub watersheds Main 07e, PM 11 and PM 08). For the wetlands in this area, a 10% reduction in recharge flow is predicted during the Project followed by a 30% increase in flow after closure (Barr 2008c).

In addition to hydrologic changes, the functions of many of the remaining wetlands within the Mine Site would be adversely affected by fragmentation due to construction of haul roads, dikes, and stockpiles, or by water quality changes due to groundwater impacts from operations at the Mine Site. It is expected that the wildlife habitat function of the fragmented wetland areas within the Mine Site would be compromised given the restricted access to these areas. In addition, wetlands could be affected by groundwater quality changes. Data from monitoring wells in the surficial aquifer indicate that surficial ground water in the vicinity of the Mine Site currently indicates background concentrations of several constituents greater than water quality standards. Predictive groundwater modeling indicates exceedences of groundwater criteria for a number of parameters during mining and post-closure for the Proposed Action. It is unknown whether water quality changes would have a significantly adverse effect on wetland function and values.

Based on these potential changes to hydrologic conditions, wildlife habitat, and water quality, it is estimated that an additional 300 acres of wetlands are likely to be indirectly impacted by the Proposed Action beyond the 28 acres estimated by PolyMet, for a total of 328 acres (Figure 4.2-5). These hydrologic changes, as well as potential effects from wetland fragmentation and fugitive dust and vehicle emissions, could affect wetland type, function, and value over time. These additional 300 acres of impacts have not been included in the wetland mitigation plan. It is recommended that mitigation of any indirect wetland impacts beyond the 28 acres originally estimated, as identified during implementation of the wetland monitoring plan, be addressed as part of a permit condition (see Section 4.2.4.3).

In addition, the potential exists for additional minor and localized indirect wetland impacts in areas outside of the Mine Site. These areas are included in the Hydrological Monitoring Plan (Barr 2005). The extent of any indirect impact is unknown but would be expected to be small outside the Mine Site, depending on the degree of hydrologic changes. Relative to the 36,565 wetlands acres estimated to occur in the entire Partridge River Watershed (Table 4.2-8), the overall function and value served by the wetlands in the watershed would not be expected to be significantly affected by the approximately 328 acres of indirect impacts within the Mine Site.

4.2.3.3.4 Transportation Corridor Indirect Wetland Impacts

No significant indirect impacts are anticipated from construction or operation of the new rail spur, the treated water pipeline, or the Dunka Road improvements. Minor indirect impacts from dust and vehicle emissions may occur during facility construction and operations through the life of the project.

4.2.3.4 Summary of Direct and Indirect Wetland Impacts

The proposed Project would impact an estimated 1,197 acres of wetlands, including 869 acres directly affected and 328 acres indirectly affected. A total of 112 distinct wetland complexes would be partially or completely directly affected.

The proposed project would primarily impact coniferous and open bog wetlands that comprise 68% of the total acreage of direct impact (Table 4.2-4). Shrub carr/alder thicket communities and hardwood/coniferous swamp communities comprise 9% and 10% of the direct wetland impacts, respectively. The remaining direct impacts would occur in fresh (wet) meadow and sedge meadow communities, shallow marsh communities, deep marsh, shallow open water, and deepwater habitat.

The quality of wetlands affected is a key factor in determining impact to wetland functional quality. Section 4.2.1.4 and Table 4.2-2 provide an assessment of wetland functional values, including evaluation of applicable wetland functions and ratings of the vegetative diversity/integrity value based on MnRAM 3.0 guidelines. All the wetlands associated with the Mine Site are of natural origin; however, several wetlands associated with the tailings basin mitigation have become established due to human activities. Approximately 93% of wetland areas to be affected, either directly or indirectly, are high quality wetlands with the remaining 1% rated as moderate quality and 6% as low quality. The Mine Site wetlands typically have a high vegetative diversity/integrity score and a low disturbance score, representing high functions and values (MnRAM 3.0). The project would directly impact 841 acres of high and moderate quality wetlands, 55 acres of low quality wetlands and may indirectly impact 28 acres of high and moderate quality wetlands.

The potential exists for localized indirect wetland impacts both inside and outside the 24 existing sub-watershed areas. An additional 300 acres of wetlands may be impacted inside the mine site beyond the 28 acres estimated by PolyMet. Relative to the 36,565 wetlands acres estimated to occur in the entire Partridge River Watershed (Table 4.2-8), the overall function and value served by the wetlands in the watershed would not be expected to be significantly affected by the approximately 328 acres of indirect impacts within the Mine Site.

Table 4.2-4 Summary of Total Project Wetland Impacts by Eggers and Reed Classification[1]

	Circular 39	**1**	**2**	**2**	**3**	**4**	**5**	**6**	**6**	**7**	**7**	**8**	**8**		
Project Area	**Eggers and Reed Wetland Classification**	**Seasonally Flooded**	**Fresh (Wet) Meadow**	**Sedge Meadow**	**Shallow Marsh**	**Deep Marsh**	**Shallow, Open Water**	**Shrub-Carr**	**Alder Thicket**	**Hardwood Swamp**	**Coniferous Swamp**	**Open Bog**	**Coniferous Bog**	**Deepwater**	**Wetland Total**
Mine Site	Direct (acres)	0.0	28.7	14.7	25.6	0.0	0.0	2.4	65.1	19.8	62.2	76.1	509.4	0.0	804.1
	Indirect (acres)	0.0	0.6	0.0	0.1	0.0	0.0	0.0	3.4	0.2	1.3	0.2	22.2	0.0	27.9
	Total (acres)	0.0	29.2	14.7	25.7	0.0	0.0	2.4	68.5	20.0	63.4	76.3	531.6	0.0	832.0
	# wetlands	0	3	5	9	0	0	1	13	3	4	3	23	0	64
Railroad	(acres)	0.00	0.00	0.00	0.00	0.00	0.00	0.17	0.00	0.10	0.00	0.00	0.00	0.0	0.3
	# wetlands	0	0	0	0	0	0	1	0	1	0	0	0	0	2
Tailings Basin Drain System	(acres)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.0
	# wetlands	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dunka Road/Water Pipeline	(acres)	0.0	0.0	0.0	2.0	0.2	0.05	6.1	0.5	0.0	0.4	0.0	0.0	0.5	9.8
	# wetlands	0	0	0	5	1	1	12	1	0	1	0	0	1	22
TB Mitigation Alternative - East Basin Expansion Area	(acres)	0.00	0.00	1.77	3.01	10.66	3.51	0.07	0.00	0.00	0.03	0.00	0.00	0.0	19.1
	# wetlands	0		5	3	2	4	1	0	0	1		0	0	16
TB Mitigation Alternative - Buttress Area	(acres)	0.0	0.0	0.0	0.0	32.0	0.00	1.9	0.0	0.0	2.2	0.0	0.0	0.0	36.2
	# wetlands	0	0	0	0	0	0	5	0	0	5	0	0	0	13
Total	(acres)	0.0	29.2	16.5	30.7	42.9	3.6	10.7	69.0	20.21	66.1	76.3	531.6	0.5	897.2

[1] This wetland summary is based on the predominant wetland type within each wetland. The additional 300 acres of indirect impacts are not included.

4.2.4 Alternatives

4.2.4.1 No Action Alternative

The No-Action Alternative would avoid the direct and indirect wetland impacts associated with the Proposed Action.

4.2.4.2 Subaqueous Disposal of Waste Rock

Subaqueous aqueous disposal of Category 2, 3, and 4 waste rock into the east pit, would slightly reduce the total areal footprint of the stockpiles at mine closure. The Category 3 waste rock and lean ore stockpiles under the Proposed Action would be replaced with Category 1 waste rock under this alternative. This waste rock was originally to be placed in the east pit under the Proposed Action. The additional Category 1 stockpiles would be slightly smaller by approximately 33 acres, reducing impact to upland and wetland areas. The quality of wastewater from stockpile leachate and runoff would be improved, reducing the likelihood of indirect impacts to wetlands in the mine area.

4.2.4.3 Other Mitigation Measures

As discussed earlier in this section, a wetland monitoring plan should be designed and implemented during operations to identify and characterize indirect effects on wetlands and provide for potential mitigation, including additional compensatory mitigation, as needed. In developing this plan, the following factors should be considered:

- The monitoring plan should include wetland areas outside both the Mine Site and the Tailings Basin.
- The extent of the monitoring area should be defined in part on the characteristics of and potential impacts to existing wetland areas. Information to consider, as available, includes the predicted extent of glacial aquifer drawdown (e.g., to 0.25 feet or the Partridge River) or groundwater mounding/flooding, the degree of dependence of wetlands on groundwater vs. precipitation as can be ascertained by existing information, and locations of potential wetlands based on NWI maps and aerial photographs.
- Monitoring should include both hydrologic observations (for impacts from inundation and water table reduction) and vegetation impacts (e.g., conversion from wetland to upland species or from one wetland type to another). The Hydrological Monitoring Plan (Barr 2005c) should be considered in developing the wetland monitoring plan, which should be designed to differentiate hydrologic impacts from the NorthMet Project vs. non-related actions (e.g., Peter Mitchell Mine expansion).

- Monitoring locations should be chosen to include a representative sample of the various wetland types that occur within the monitoring area as can be ascertained by existing information.
- Reference wetland sites should be monitored for comparison to potentially impacted wetlands.

In addition to monitoring for potential future mitigation, planned compensatory mitigation for reasonably anticipated impacted wetlands is described in the section below.

Section 3.2.2.3 describes several potential other mitigation measures for impacts from the Project. Some of these measures have the potential to affect wetlands and are discussed below.

- A mitigated tailings basin design that would use LTVSMC tailings for dam construction would result in increased wetland impacts due to the larger footprint of the tailings basin under this mitigation measure. Approximately 36 additional acres of wetlands would be impacted. It is likely, although not certain, that some water quality improvements would be realized in the groundwater recharging wetlands in the vicinity of the tailings basin.
- A lined tailings basin would provide for a decrease in bottom seepage to a rate less than 100 gpm and that may reach zero during operations. Under this measure, recharge to the evaluation area of the Embarrass River watershed will be limited to the net recharge occurring outside the 1,050 acre cell 2E/1E tributary area. The loss of the tributary area would result in a lower annual net seepage of 7.8 inches/year (a 21% decrease from pre-tailings basin conditions and a decrease of 26% from the existing tailings basin condition (Barr 2008e). Under this alternative, water quality impacts to adjacent wetlands could be reduced compared to the proposed unlined tailing basin as could the quantity of groundwater reaching the adjacent wetlands, at least during operations, depending on the degree of hydrologic connection to wetlands. This reduction in water volume as compared to pre-tailings basin conditions may also adversely impact adjacent wetland hydrology.
- Maximize the elevation of the Category 1/2 stockpile – This measure would minimize the stockpile footprint, thereby decreasing the area of wetland disturbance from the project.

4.2.5 Mitigation Planning

PolyMet proposes to provide compensatory mitigation for the direct and indirect loss of 897 acres of wetland impacts resulting from project activities (an additional 300 acres of indirect wetland impacts has been estimated in this CPDEIS). The wetland mitigation planning process relied on the WCA wetland replacement siting rules, as well as Minn. R. 7050.0186, and the USACE guidelines to first replace lost wetlands on site, then within the same watershed or county, and finally within adjacent watersheds. The primary goal of the wetland mitigation plan was to restore high quality wetland communities of the same type, quality, function, and value as those to be impacted by the Project to the degree practicable.

The USACE mitigation ratio of 1:1 is applicable for mitigation proposals that meet all of the following criteria:

- Mitigation completed one growing season in advance of the wetland impacts,
- Mitigation located "in-place" (within the same major watershed), and
- Mitigation wetlands of the same type as the affected wetlands.

If two of the three criteria are met, the required mitigation ratio is 1.25:1 (Table 4.2-5). If only one or none of these criteria are met, the mitigation ratio required is 1.5:1. According to USACE's draft Compensatory Wetland Mitigation policy (USACE, 2007), requirements for mitigation can exceed the 1.5:1 mitigation ratio in some instances.

Minnesota Rules (Minn. R. 7050.0186, Subpart 6A) require 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. For wetlands in counties where 80% or more of pre-settlement wetlands exist, including St. Louis County, replacement ratios requirements are as follows:

Table 4.2-5 Minnesota Wetland Mitigation Ratio Summary

Replacement Location (in-place)	Type of Replacement Wetland (in type)	Replacement Process (in time)	Minimum Replacement Ratio
In-place	Same type as impact wetland	In advance	1:1
		Not in advance	1.25:1
	Different type	In advance	1.25:1
		Not in advance	1.5:1
Not in-place	Same type as impact wetland	In advance	1.25:1
		Not in advance	1.5:1
	Different type	In advance	1.5:1

The actual replacement ratios required for a replacement wetland may be more than the minimum, subject to the evaluation of wetland functions and values (Minn. R. 8420.0546, 8420.0549).

4.2.5.1 Wetland Mitigation Study Limits

The NorthMet Project lies within the headwaters of the St. Louis River Watershed and Bank Service Area #1. Areas were evaluated for wetland mitigation projects using the following priorities; on-site; St. Louis watershed and adjacent watersheds tributary to Lake Superior; watersheds adjacent to the St. Louis watershed; and watersheds neighboring adjacent watersheds. 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 (Figure 4.2.8).

4.2.5.2 Wetland Mitigation Opportunity Analysis

On-site wetland mitigation potential was considered first. It was determined that there would be potential for developing wetland resources during the later stages of the Project and during reclamation. However, given the approximately 20-year schedule for the Project, a specific plan for on-site mitigation was not developed. Potential mitigation areas for developing wetlands during later stages of the Project and during reclamation are described below in Section 4.2.3.5 and in the Wetland Mitigation Planning and Siting Documentation (Barr 2008d). Available wetland mitigation banking credits were then evaluated and found to be insufficient to satisfy the compensatory mitigation requirements for this project.

A Geographic Information System (GIS) analysis was performed to identify potential wetland mitigation sites within the defined study area (Figure 4.2.9). 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. The identification of sites was established by overlaying and evaluating numerous existing spatial data sources that identified those sites with the greatest mitigation potential. Some of the data sources utilized included:

- 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 (MNDNR 1980)
- Major watersheds
- Land cover (Loesch 1998)

The geomorphology data described a wide variety of conditions related to surficial geology within a hierarchical classification scheme that was devised for use within Minnesota (Loesch 1997). The land ownership data included federal, state, county, city, tax-forfeited, and private land, by 40-acre parcels (MLMIC 1983). The digital elevation model was split into three slope classes: 0-1 percent (high likelihood of wetlands), 1-3 percent (moderate likelihood of wetlands), and >3 percent (diminished likelihood of wetlands) (MLMIC 1999). The stream data consisted of mapping of natural watercourses and ditches by the MnDNR (MnDNR 1980). The land cover data consisted of land use–land cover mapping divided into 16 classes based on satellite imagery from June 1995 to June 1996 (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 ≤ 1 percent slope,
- Mapped areas as peat or lacustrine geomorphology,
- Private or county tax-forfeit property,
- Areas within 1.1 miles of a ditch, and ultimately
- 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 realistically feasible. In addition, the NorthMet Project represented an opportunity to restore large wetland systems and provide greater public and ecological benefit that are typically not available to 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 is in State, Federal, or tribal ownership. Discussions with the various State and Federal entities regarding wetland mitigation on their respective properties resulted in the following conclusions;

The US Forest Service 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 with protection through conservation easements. 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 has a comparable value. NorthMet determined these were not acceptable criteria and the State provided no certainty that there would be a viable project if Northmet expended 1-2 years of effort to meet the imposed criteria.

The Board of Water and Soil Resources (BWSR) has oversight regarding the administration of the Minnesota WCA. The BWSR provides guidance and interpretation of the WCA rules and has the most extensive experience with application of the rules. The BWSR's experiences 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 to restore wetlands as mitigation for the NorthMet project. The deal was rescinded by another County agency. 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 because of uncertainties and risks, that mitigation on State, Federal and Tribal 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. Third, much of the study area is characterized by surface geology that is not indicative of large wetland systems prone to be easily drained. 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 terranes; rolling till plains; and rolling to undulating areas of supraglacial drift (Loesch, 1997). These geo-morphological associations are also typically associated with steeper land slopes containing few drained or sufficiently altered wetlands.

4.2.5.3 On-Site Mitigation

The closure plan for the site was designed to create and restore wetlands for partial compensation, including 175 acres of wetland development. The plan includes:

- 30 acres of created wetlands at the emergency basin
- 75 acres of created wetlands in the tailings basin at closure
- 30 acres of created wetlands at the mine stockpile areas after removal of the temporarily stored lean ore surge stockpile and overburden storage area
- 40 acres of created wetlands within the East Pit after backfilling

4.2.5.4 Off-Site Mitigation

4.2.5.4.1 St. Louis River Watershed

Approximately 101 potential wetland mitigation areas were identified within the St. Louis River Watershed and other watersheds tributary to Lake Superior. A portion of these sites are shown on Figure 4.2.10. No potential mitigation sites were identified within the St. Louis River estuary or the Duluth Metropolitan area. The specific areas identified as having potential for wetland restoration were evaluated in more detail by reviewing National Wetland Inventory maps, plat maps, recent aerial photographs, USGS topography, and sub-watershed divides 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. However, the majority of the potential mitigation sites were determined to have no potential to reasonably satisfy all or even a significant portion of the Project requirements. 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 compensatory wetland mitigation; 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.

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.

4.2.5.4.2 Site 8362

Initially wetland mitigation site 8362 was the preferred and only feasible alternative in St. Louis River Watershed, based on the GIS and field investigations (Figure 4.2.10). The site was chosen for several reasons, including:

- Limited private land ownership within and adjacent to the primary area with wetland mitigation potential,
- The lack of roads or other public infrastructure that could be affected by wetland mitigation,
- The presence of multiple outlets from the wetland to the St. Louis River and the close proximity of the river,
- The density of ditching within the wetland, and
- The apparent lack of flow through the wetland from upstream.

Site 8362 was located within the same watershed as the NorthMet Project, had the greatest potential for wetland restoration with limited peripheral issues, and contained the potential to restore bog wetlands similar to those proposed for impact. Thus site 8362 was initially selected for further study and Polymet signed an agreement with St. Louis County. Site 8362 is a partially drained, 3,900-acre wetland site containing a combination of raised open bog and raised black spruce bog wetlands. The site is located northeast of the Town of Floodwood and west of the Town of Meadowlands in St. Louis County. Approximately 640 acres of the site was owned by the State of Minnesota with the remainder designated as tax-forfeit land.

Outlets from the site are either natural streams or ditches. In addition, the site has a pattern of ditches that are located one-half mile to one mile apart within the interior of the bog. It was determined that hydrologic restoration of this site would require blocking and filling ditches, logging of trees along the ditches and restoration of bog vegetation. The restoration potential of the site was discussed with Federal, State and local authorities on several occasions during the study period. Numerous site visits, town meetings, and agency meetings were held in order to better understand potential conflicts associated with the development of a restoration plan. The site has been utilized by local residents for hunting, tree-topping and recreation. Several potential issues were raised by local residents and peatland hydrology experts during these meetings and discussions. The agencies requested a more detailed study plan to better document the hydrology of the site, the specific extent of hydrologic drainage, the extent of soil subsidence along the ditches, the presence of demonstrable threats to supporting wetland preservation credits, and other issues raised by the agencies and the public.

Before implementation of a plan to restore wetlands at the site, the agreement with St. Louis County required the completion of several actions:

- The public ditch system would have to be abandoned through the ditch abandonment process, which included public hearings.
- The State Legislature would have to pass special legislation allowing a permanent conservation easement to be placed over the restored and protected wetland area, and
- The State would have to enter into an agreement allowing wetland restoration activities to be conducted on the State-owned land.

However, these required actions could not be undertaken until a wetland restoration plan was approved by State and Federal regulatory agencies. In order to complete sufficient planning to support the development of a wetland restoration plan suitable for regulatory approval, a 1-2 year study was going to be needed to develop the information requested by the regulatory authorities and determine the technical and regulatory feasibility.

Further pursuit of wetland restoration activities at Site 8362 was halted for a number of reasons that rendered the site impracticable:

- District court nullified PolyMet's agreement with St. Louis County in April 2007, thereby not allowing any further study of the site.
- Lack of local support, in fact, broad opposition from local residents.
- Extensive hydrologic monitoring and evaluation 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 is a demonstrable threat that could be eliminated, i.e., peat mining, tree-topping, or ATV activity. There is 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 required ditch abandonment proceedings in District Court with public hearings that would likely be opposed by local residents.
- The agreement with the County (if it was to be reinstated) also required receiving legislative authorization to place a permanent conservation easement over the restoration area. The likelihood of that was uncertain.

4.2.5.4.3 Watersheds Adjacent to the St. Louis River Watershed

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.

Six watersheds are located adjacent to the St. Louis River watershed (Figure 4.2.10). Fifteen sites were determined to have high potential for wetland mitigation, including 10 sites evaluated in the Mississippi River–Grand Rapids watershed, 3 sites evaluated in the Kettle River watershed, and 2 sites evaluated in the Nemadji River watershed. These sites were located in Aitkin and Itasca Counties.

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 compensatory wetland mitigation; potential flooding of roads or other infrastructure; upstream ditch drainage through the wetland that would have to be maintained; regulatory applicability; complex land ownership; existing peat mining operations; and legal considerations.

4.2.5.4.4 Watersheds Neighboring Adjacent Watersheds

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 impacted by wetland restoration, insufficient agricultural history, insufficient wetland drainage, considerable existing upstream drainage through the site, or active pursuit of the properties by others.

4.2.5.5 Proposed Wetland Mitigation Projects

Two priority properties were identified with willing landowners that had the potential to accomplish compensatory wetland mitigation for nearly the entire Project. These sites are located in watersheds neighboring those adjacent to the St. Louis River (Figure 4.2.10).

4.2.5.5.1 Aitkin Mitigation Site

The Aitkin wetland mitigation site is located in Aitkin County within the Mississippi River-Brainerd watershed. At this site, it is proposed to restore 810 acres of wetland and preserve 123 acres of upland buffer (Figure 4.2.11). 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 2008d).

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 each non-forested, non-bog 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. General site preparation would occur 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 seedbank 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 and determined if additional seeding is required. These areas include sedge and wet meadows, shallow and deep marsh, emergent fringes, shrub carr and alder thicket.

Hardwood and coniferous swamp, open and coniferous bogs would require herbaceous and woody species seeding as well as some woody seedling installation. Open and coniferous bogs would also require the installation of a sphagnum moss layer. The Mine Site may provide up to half the donor soil material (i.e. sphagnum) for this mitigation site.

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, and garlic mustard.

4.2.5.5.2 Hinckley Mitigation Site

The Hinckley wetland mitigation site is located in Pine County within the Snake River watershed. This site is the proposed location for the restoration of 313 acres of wetlands and the preservation of 79 acres of upland buffer on an existing sod farm (Figure 4.2.12). 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 the hydrology (Barr 2007c).

The vegetative restoration of each non-forested, non-bog 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. General site preparation would occur 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 seedbank 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 and determined if additional seeding is required. These areas include sedge and wet meadows, shallow and deep marsh, emergent fringes, shrub carr and alder thickets.

Hardwood and coniferous swamp, open and coniferous bogs would require herbaceous and woody species seeding as well as some woody seedling installation. Open and coniferous bogs would also require the installation of a sphagnum moss layer. The Mine Site may provide up to half the donor soil material (i.e. sphagnum) for this mitigation site.

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, and garlic mustard.

4.2.6 Wetland Impact and Mitigation Summary

The Proposed Action would impact an estimated 1,197 acres of wetlands, including 869 acres directly affected and 328 acres indirectly affected. Approximately 58 acres of additional impact have been avoided by combining the Overburden and Category 1 and 2 Waste Rock Stockpiles. Detailed wetland impacts proposed for the various activities associated with the Project are provided in Table 4.2-3. The most prevalent impacted wetland type is bogs, with a total of 532 acres in coniferous bogs and 76 acres in open bogs. A total of 65 acres of impacts are proposed in alder thicket communities and 11 acres in shrub carr communities. Swamp impacts include 69 acres of coniferous swamp and 20 acres of hardwood swamp. Also, impacted meadow types include 17 acres of sedge meadow communities and 29 acres of wet meadow communities. Deep marsh wetland impacts total 43 acres and shallow marsh wetlands impacts would number 30 acres, while 4 acres of shallow/open water wetland communities would be impacted along with less than 1 acre of deepwater habitat. No direct wetland impacts are anticipated associated with the tailings basin drain system since the drains and pump station are planned to be constructed on the lower, existing tailings dam bench.

The first five years of mining activity impact the most wetland acreage; the mitigation plan specifically addresses impacts from this first operating phase. The unavoidable wetland impacts projected during the first five years total 768 acres (Table 4.2-6). Within years 6 to 20, an additional 128 acres of wetlands (897 total acres over the 20-year life of the project) would be directly or may be indirectly affected by open-pit mining, stock piling, and associated activities. Due to site limitations and technical feasibility, it is not found to be practicable to replace all impacted wetland types with an equivalent area of in-kind wetlands. Because the two primary wetland mitigation sites included in this plan are located outside of the Project watershed and the on-site mitigation is planned for completion at the end of the project, all mitigation associated with this plan would need to be conducted at a minimum ratio of 1.25:1 or 1.5:1 in accordance with USACE guidance and Minnesota rules. Assuming the restoration is successfully conducted one full growing season ahead of the impacts, replacement in-kind would be credited at a 1.25:1 ratio. Should in-kind compensatory mitigation be deemed unsuccessful such that an equal area of in-kind replacement is not provided for the impacts, those impacts would be replaced at a 1.5:1 ratio. This would meet the minimum replacement ratio requirements. However, given the high quality of the wetlands that would be impacted by the project, additional wetland mitigation resulting in higher compensatory ratios may be required by state permitting processes.

The tabulation of total Project wetland impacts compensated by the proposed wetland mitigation is provided in Table 4.2-7. The overall wetland mitigation strategy for the Project is to replace unavoidable wetland impacts in-kind where possible and in advance of impacts when feasible. Wetland mitigation would be provided by a combination of off-site wetland mitigation and upland preservation (at two out-of-watershed sod farms), as well as on-site wetland mitigation. Off-site wetland restoration of 1,123 acres would provide 834 acres of direct compensatory wetland mitigation at the applicable mitigation ratios. In addition, a total of 202 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 is proposed at a 1:4 ratio, resulting in an additional 51 acres of wetland credit. Including the proposed upland buffer, the proposed off-site wetland mitigation would compensate for 885 acres of wetland impacts as compared to the 897 acres of proposed impacts (plus the 300 acres of potential additional indirect impacts).

Finally, the closure plan for the site is designed to create or restore 175 acres of wetlands, not included in the mitigation discussed above. It is planned that the additional wetland mitigation would provide 117 additional compensatory mitigation acres (at a 1.5:1 ratio), for a total wetland credit of 1,002 acres. The additional compensatory wetland mitigation could also be used to meet higher compensation ratios. The on-site mitigation plan includes:

- 30 acres of created wetlands at the emergency basin
- 75 acres of created wetlands in the tailings basin at closure

- 30 acres of created wetlands at the mine stockpile areas after removal of the temporarily stored lean ore surge stockpile and overburden storage area
- 40 acres of created wetlands within the East Pit after backfilling

The anticipated wetland types to be restored off-site include a combination of the same and different types as the affected wetlands (Table 4.2-7). Some wetlands would be restored in advance of impacts while others would be restored after the impacts, such as the 175 acres of wetlands proposed to be restored or created at mine closure.

Table 4.2-6 Summary of Project Wetland Impacts by Eggers and Reed (1997)—First 5 Years [1]

Project Area	Circular 39	1	2	2	3	4	5	6	6	7	7	8	8		
	Eggers and Reed Wetland Classification	**Seasonally Flooded**	**Fresh (Wet) Meadow**	**Sedge Meadow**	**Shallow Marsh**	**Deep Mars h**	**Shallow, Open Water**	**Shrub -Carr**	**Alder Thicket**	**Hardwood Swamp**	**Coniferous Swamp**	**Open Bog**	**Coniferous Bog**	**Deepwater**	**Wetl and Total**
Mine Site	Direct (acres)	0.0	27.4	14.7	21.0	0.0	0.0	2.4	58.4	14.9	62.2	46.5	426.0	0.0	673.6
	Indirect (acres)	0.0	0.6	0.0	0.1	0.0	0.0	0.0	3.4	0.0	0.5	0.2	24.4	0.0	29.1
	Total (acres)	0.0	28.0	14.7	21.1	0.0	0.0	2.4	61.8	14.9	62.6	46.7	450.4	0.0	702.7
	# wetlands	0	3	5	9	0	0	1	12	3	4	3	22	0	62
Raillroad	(acres)	0.00	0.00	0.00	0.00	0.00	0.00	0.17	0.00	0.10	0.00	0.00	0.00	0.0	0.3
	# wetlands	0	0	0	0	0	0	1	0	1	0	0	0	0	2
Tailings Basin Drain System	(acres)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.0
	# wetlands	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dunka Road/Water Pipeline	(acres)	0.0	0.0	0.0	2.0	0.2	0.00	6.1	0.5	0.0	0.4	0.0	0.0	0.5	9.8
	# wetlands	0	0	0	5	1	1	12	1	0	1	0	0	1	22
TB Mitigation Alternative - East Basin Expansion Area	(acres)	0.00	0.00	1.77	3.01	10.66	3.51	0.07	0.00	0.00	0.03	0.00	0.00	0.0	19.1
	# wetlands	0	0	5	3	2	4	1	0	0	1	0	0	0	16
TB Mitigation Alternative - Buttress Area	(acres)	0.0	0.0	0.0	0.0	32.0	0.00	1.9	0.0	0.0	2.2	0.0	0.0	0.0	36.2
	# wetlands	0	0	0	0	3	0	5	0	0	5	0	0	0	13
Total	(acres)	0.0	28.0	16.5	26.1	42.9	3.6	10.7	62.3	15.0	65.3	46.7	450.4	0.5	768.0

[1] This wetland summary is based on the predominant wetland type within each wetland.

Table 4.2-7 Summary of Wetland Mitigation

Wetland Type	Aitkin Wetland Mitigation Area (acres)	Hinckley Wetland Mitigation Area (acres)	Wetland Mitigation Total (acres)	Proposed Project Wetland Impacts (acres)	Total Wetland Impacts Compensated[1] (acres)
Deepwater				0.5	0.0
Type 1 Seasonally Flooded	0	20.1	20.1	0.0	13.4
Type 2 Fresh (Wet) Meadow	21.8	14.3	36.1	16.4	26.0
Type 2 Sedge Meadow[2]	47.1	39.9	87.0	28.1	61.7
Type 3 Shallow marsh	86.9	1.4	88.3	28.6	62.3
Type 4 Deep marsh	33.6	0.0	33.6	42.9	22.4
Type 5 Shallow, Open Water	0.0	0.0	0.0	3.6	0.0
Type 6 Shrub-Carr	83.9	87.1	171.0	11.1	115.2
Type 6 Alder Thicket	82.8	27.4	110.2	64.9	82.4
Type 7 hardwood Swamp[3]	52.6	13.2	65.8	20.2	46.5
Type 7 Coniferous Swamp	89.1	8.4	97.5	65.5	73.4
Type 8 Open Bog	74.2	0.0	74.2	78.3	59.4
Type 8 Coniferous Bog	238.2	101.2	339.4	538.9	271.5
Upland Buffer	123.1	79.2	202.3		50.6
Offsite Upland Total	**123.1**	**79.2**	**202.3**		**50.6**
Offsite Wetland Total	**810.2**	**313.0**	**1,123.2**	**898.6**	**834.3**
Offsite Total	**933.3**	**392.2**	**1,325.5**	**898.6**	**884.9**
Onsite Wetland Total	**0**	**0**	**175**	**0**	**117**

[1] Assumes 1.25:1 replacement for the same wetland types and 1.5:1 for different types.
[2] The total restoration area includes 0.8 acres of partially drained wetland at Hinckley, credited at 50 percent of the area.
[3] The total restoration area includes 6.1 acres of partially drained wetland at Hinckley, credited at 50 percent of the area.

4.2.7 Cumulative Wetland Impacts

4.2.7.1 Introduction

A semi-quantitative analysis of cumulative wetland impacts was performed. Because several of the primary functions performed by wetlands are directly related to watershed processes, the analysis was performed on the Partridge River watershed and includes the Mine Site, railroad, and haul roads, accounting for approximately 94% of anticipated wetland impacts. The consideration of past, present, and reasonable foreseeable actions provides the context for assessing the wetland cumulative impacts within the Partridge River watershed.

4.2.7.2 Study Area

The Partridge River watershed extends from the City of Babbitt, Minnesota to the mouth of the Whitewater Reservoir near Hoyt Lakes, Minnesota (Figure 4.2-13). The MnDNR Census of the Land (1996) identifies the primary land uses in the watershed as bog/marsh/fen; brushed land; forests; water; cultivated land; hay/pasture/grassland; mining; and urban and rural development. The latter four of these land cover classes were assumed to be associated with human impacts; therefore, the areas classified with any of these four land cover classes were identified as areas in which pre-settlement Trygg wetland data would be used (Trygg 1996).

Three additional data layers were used to identify human-affected areas, including:

- Minnesota Department of Transportation (MnDOT) road layer for St. Louis County – All roads identified within the study area were buffered at 33 feet on each side of center (for a total width of 66 feet).
- MnDOT railroad layer for Minnesota – All rail lines identified within the watershed were buffered at 15 feet on each side of center (for a total width of 30 feet).
- MnDNR mining features layer (2003) – All areas located within the mining feature area were assumed to be affected.

Urban areas identified in the watershed include Babbitt and Allen Junction, which are not experiencing growth. The primary area of growth in the watershed is around Colby Lake.

The major highways that connect the cities within the area include State Highways 135, 21, and 110. Several County and Forest Roads are found within the watershed, including CR 680 (FR113), CR 666, FR 420, FR 120, FR 238, and FR 117, along with numerous other unnamed logging roads. Dunka Road, a private road that runs through the proposed mine area, runs from east to west across the watershed.

Water resources other than wetlands in the watershed include:

- Several water-filled abandoned pits associated with the Peter Mitchell mine, as well as, several named lakes (Mud Lake, Iron Lake, Argo Lake, Big Lake, and Cranberry Lake);
- A number of shallow unnamed water bodies; and
- Several streams and rivers including the Partridge River, South Branch of the Partridge River, Colvin Creek, Wetlegs Creek, Wyman Creek, and Longnose Creek, Knox Creek, and Second Creek, as well as some unnamed stream reaches.

Historical activities within the Partridge River watershed that have affected wetland resources consist primarily of mining activities that started on a large scale in the early 1950s, along with limited urban development. The remainder and majority of the watershed has had limited disturbance except for logging and some associated loss of wetlands. A more detailed description of the baseline condition for wetland resources within the study area is provided below.

4.2.7.3. Study Methods

4.2.7.3.1 Pre-Settlement Wetland Resources and Past Impacts

The wetland area estimated for the pre-settlement time period was developed using historical mapping and the National Wetlands Inventory (NWI). The process was completed in four steps, as follows:

1. The areas of the watershed with significant human impact prior to development of the NWI were identified. The National Wetland Inventory data was used to help establish the baseline wetland condition in the undisturbed areas of the watershed in and around the 1970s, since it is the best data representing the extent of wetland resources in the Partridge River watershed.

2. The area of pre-settlement wetlands within the areas with significant human impact were estimated using historical wetland mapping (Trygg maps) based on the original government land survey notes (Trygg, 1996). The original land survey notes and records were used to produce an original land cover type map of the area (Trygg, 1996). This map provides a broad base of upland and wetland conditions prior to significant European settlement.

3. The total acreage of pre-settlement wetlands were estimated. The Trygg maps were used to identify wetlands in areas with significant human impact. The NWI was used to identify wetlands in areas with insignificant human impact.

4. Selected representative historic aerial photographs dating from the 1930s were reviewed for human impact in the watershed.

The Trygg maps were developed by J. William Trygg (1966), utilizing data from the original government land surveys along with other historical surveys and sources. These historical maps included water features that were identified in the original land surveys such as marshes, bottoms, swamps, lakes or ponds, and rivers. These water features were digitized from the Trygg maps in the Partridge River watershed.
A relationship was developed between the "wetlands" and water features shown on the Trygg maps and the NWI wetlands to account for the differences in map scale, mapping methods, and human disturbance. Because the scale of the Trygg maps is relatively small (1:250,000) it is assumed to be less accurate than the larger-scale and more detailed mapping effort used in developing the NWI (1:24,000). Other reasons for the range of difference may be human impacts on wetlands between the time of the original land survey and compilation of the NWI map in the 1970s as well as differences in the purpose and methods utilized in each mapping effort.

The comparison of Trygg and NWI data was initially conducted within 23 townships located within or adjacent to the Partridge River watershed. The land uses within those townships were evaluated using the criteria described above ("Areas of Human Impact") to identify those minimally affected townships in which less than 5% of the land area was classified in the categories associated with human impacts. A total of eight of the 23 townships were identified as minimally affected.

It is assumed that due to the minimal amount of impact on these eight townships, the NWI mapping in these townships is representative of pre-settlement wetland conditions. The data for these eight townships were used to develop a relationship between the NWI and Trygg wetlands. The total wetland acreage for the two data sets was compiled, and the ratio of NWI to Trygg wetlands was calculated to be 1.13 for these townships. This ratio indicates that there are 13 percent fewer wetlands identified using the Trygg maps as compared to the NWI maps. The ratio was used as an adjustment factor to "normalize" the Trygg data to the standards and scales of the NWI data.

4.2.7.3.2 Existing Wetland Resources

Wetland areas estimated for the existing conditions were developed by compiling the following data:

- Field wetland delineations completed by PolyMet (Barr 2006a), including the PolyMet Mine Area wetland delineations; railroad connection wetland delineations; Dunka Road/tailings basin wetland delineations; 1995-98 wetland delineations conducted at the former LTVSMC site; and the 2003 wetland delineations conducted within the study area.
- The extent of mine pit water bodies was developed using a combination of MnDNR Public Water Inventory maps and interpretation of the 2003 Farm Service Area aerial photography. The extent of open water observed on the 2003 FSA

aerial photography was used for pits not covered by the Public Water Inventory maps.

- The NWI was used to identify wetlands in all areas not covered in the above items.

A "composite" wetlands layer was developed by deleting all the NWI wetlands from the areas in which more detailed mapping was completed. These wetlands were replaced with the delineated wetlands and mine pit water bodies as discussed above. This wetland mapping was compared to the historic wetland (baseline) mapping to quantify the effects of past activities on wetland resources within the analysis area.

4.2.7.3.3 Projected Future Wetland Resources

The extent of future wetlands was estimated by using the existing conditions wetland mapping and deleting projected future impacts from the map. Wetland losses from the following reasonably foreseeable actions in the Partridge River watershed were forecasted for approximately the next 27 years, consistent with PolyMet's proposed mine life:

- Proposed NorthMet Mine,
- Portions of the proposed Cliffs Erie Railroad Pellet Transfer Facility in the Partridge River Watershed,
- Future expansion of Northshore Mining Company's Peter Mitchell Mine Pits,
- Proposed Mesabi Nugget Phase II, and
- Proposed St. Louis County Highway Connection from Hoyt Lakes to Babbitt.

The former LTVSMC mine affected approximately 344 acres of wetlands before the mine closed in 2001. The Northshore (Peter Mitchell) mine area to the north of the proposed PolyMet site and within the Partridge River watershed has approval to impact 73.6 acres of wetlands incrementally through 2016, of which 16 acres have currently been impacted. The St. Louis Highway connector from Hoyt Lakes to Babbitt currently has several proposed routes. Wetland impacts will most likely occur in the Partridge River watershed when the preferred alternative is selected. Wetland impact acreage will vary depending on whether existing routes are used or whether a new corridor is selected.

4.2.7.4 Results: Cumulative Effects Analysis

Impacts related to past, present, and reasonably foreseeable future actions were evaluated through a quantitative summary of the number of acres of various wetland types that were affected in the past and may be affected in the future, and the magnitude of those effects within the Partridge River watershed (Table 4.2-8).

Alternative configurations of the Project were evaluated to determine whether the projected impacts can be minimized. Unavoidable wetland impacts would be mitigated in accordance with the state and federal wetland permitting programs.

The analysis for this study indicated that more than 97% of the existing wetlands in the Partridge River watershed would remain in the foreseeable future with or without the NorthMet Project (Table 4.2-8). The northeastern wetlands of Minnesota are unique in Minnesota as well as most of the other parts of the United States, in that the loss of wetlands has remained relatively small. For instance, it has been estimated that the 48 lower states have lost about 53% of pre-settlement wetland habitat (http://www.epa.gov), compared to a minimal loss (estimated at less than 1%) in northeastern Minnesota.

Most wetland impacts in the Partridge River watershed have resulted from past LTVSMC and continuing Northshore mining operations and would result from the NorthMet Project. The largest wetland impact that has occurred or is proposed to occur is the projected loss of 1,197 acres associated with the NorthMet Project; however, even these impacts are small compared to the estimated 36,565 wetland acres currently present. Wetlands in the study area are similar in type and function to wetlands found throughout this portion of northeastern Minnesota; most wetlands in the study area are black spruce/open bog, forested swamp, and alder thicket/shrub carr.

The NorthMet Project and other proposed projects within the Partridge River watershed would primarily impact high quality wetlands with significant functions and values because of the relative isolation and lack of human disturbance in the watershed. Mining activities would cause additional habitat fragmentation as well as loss of wetland functions and values. The mitigation plan as described in Section 4.2.3.4 addresses the compensatory plans to offset the proposed wetland impacts if the mitigation sites are permitted and achieve the required performance levels, but most of the proposed mitigation would occur outside of the Partridge River watershed.

Table 4.2-8 Partridge River Watershed Cumulative Wetlands Analysis Data Summary

Presettlement Conditions	**Area (Acres)**
Wetland Source	
Remote Sensing Wetland Mapping	33
National Wetlands Inventory	30,981
Trygg Map	4,378
Total	**35,392**
Existing (2007) Conditions	
Wetland Source	

Presettlement Conditions	Area (Acres)
Various Wetland Delineations	3,226
Remote Sensing Wetland Mapping	2,331
National Wetlands Inventory	28,323
Pit Water 2003 Aerial Photography	2,686
Total	**36,565**
Future Conditions	
Deep Water Habitat	**3,098**
Lacustrine	**2,370**
Palustrine	**30,383**
Post Mining Reclamation Wetland	**67**
Riverine	**201**
Total	**36,118**

4.3. VEGETATION

4.3.1. Existing Conditions

4.3.1.1.Cover Types

The Project is in the Laurentian Mixed Forest Province ecoregion, corresponding roughly to the Arrowhead Region of northeastern Minnesota. Because of differences in the level of disturbance, permitting, and mapping, the Mine Site and Plant Site are discussed separately. Detailed ground-verified land cover mapping exists for the Mine Site (ENSR 2005). For the Plant Site, a coarser-scale land cover map was prepared using data from the Minnesota Department of Natural Resources (MnDNR). Little native vegetation exists at this site so detailed land cover mapping was not conducted.

Plant Site

The Plant Site is in the Nashwauk Uplands Subsection. Most of the vegetative cover types in this subsection grow in acid to neutral glacial materials over Precambrian bedrock. The Plant Site was extensively disturbed by a former mineral processing operation and contains an 80-acre processing plant; an approximately 3,000-acre tailings basin; repair shops; office space; and loading and transportation areas totaling approximately 4,425 acres (*Table 4.3-1*).

Table 4.3-1 NorthMet Plant Site Cover Types

Cover Types	Total Acres	Percent of Area
Developed	2,587	58.5
Barren	181	4.1
Grassland	1	0.0
Upland Shrub	262	5.9
Aspen/White Birch	538	12.2
Maple/Basswood	10	0.2
Upland Deciduous	2	0.0
Pine	27	0.6
Spruce/Fir	76	1.7
Tamarack	7	0.1
Lowland Black Spruce	27	0.6
Lowland Northern White-Cedar	4	0.1
Lowland Shrub	75	1.7
Marsh	76	1.7
Aquatic	552	12.5
Total	**4,425**	**99.9**[2]

Total less than 100 percent due to rounding.
Derived from GAP-Land Use Land Cover Data, 1991-1993, Level 3 Descriptions.

Mine Site

The Mine Site is located in the Laurentian Uplands Subsection of the Laurentian Mixed Forest Province ecoregion. Most of the vegetative cover types in this subsection grow in acid to neutral glacial materials over Precambrian bedrock. The Mine Site consists almost entirely of native vegetation covering 3,016 acres. The primary cover types at the Mine Site are mixed pine-hardwood forest on the uplands and black spruce swamp/bog in wetlands (*Table 4.3-2*, *Figure 4.3-1*). Aspen, aspen-birch, jack pine, and mixed hardwood swamp comprise the remaining forest on the site. The relatively small amount of grass/brushland habitat present is land recovering from past logging through natural succession. Small areas of disturbed ground and open water also occur. Disturbed land was cleared for logging roads and landings.

Most of the upland forests were harvested in the last 20 to 60 years and are in fair to fair-good condition (ENSR 2005). The oldest forest on the site includes 297 acres of 40 to 80-year-old trees within the mixed pine-hardwood forest in the southwest portion of the Mine Site. Wetlands at the Mine Site were rated as fair to good-excellent (ENSR 2005). A separate wetland delineation by Barr Engineering reported that 99% of the wetlands were of high quality (*Section 4.2*).

Table 4.3-2 NorthMet Mine Site Cover Types

Cover Types	Total Acres	Percent of Area	Condition Ranking[1]
Disturbed	66	2.2	N/A
Grass/brushland	293	9.7	N/A
Aspen forest/Aspen-birch forest	165	5.5	C, BC, B
Jack pine forest	183	6.1	BC
Mixed pine-hardwood forest	1003	33.3	BC, B
Mixed hardwood swamp	460	15.3	C, B, AB
Black spruce swamp/bog	843	28.0	C, B, AB
Open water	3	0.1	N/A
Total	**3016**	**100.2[2]**	**N/A**

Condition Ranking is a standardized approach to evaluating the ecological condition of vegetation used by the Minnesota Natural Heritage Program. A = excellent, B = good, C = fair, and D = poor ecological condition.
Multiple stands of each cover type occur, and each stand has a separate rank.
Total exceeds 100 percent due to rounding.
Derived from ENSR 2005.

Non-Native Invasive Plants

Non-native invasive plants are a concern because they can quickly form self-sustaining monocultures that out-compete native plants or reduce the quality of wildlife habitat. Non-native invasive plants generally occupy disturbed areas along roads, road ditches, rock piles, and timber harvest landings. There are few non-native invasive plants at the Mine Site because wetland disturbance has been minimal, upland disturbance has been restricted to timber harvest, and human access has been limited reducing the spread of these plants (Pomroy 2004; ENSR 2005; PolyMet Mining, Inc. 2006; personal observation Kim Chapman, John Larson, and Jack Greenlee 2007). The tailings basin at the Plant Site is severely disturbed and already contains non-native invasive plants (e.g., smooth brome grass, reed canary-grass, yellow sweet clover).

A vegetation survey of mines in the Mesabi Iron Range (Apfelbaum and Larson 1995) identified a large number of invasive non-native species that could invade the NorthMet Mine Site (*Table 4.3-3*). Some of these species are grasses and legumes that were planted on mines and other sites to reduce erosion and to fix nitrogen into the soil as part of the reclamation process (e.g., *Agrostis alba, Bromus inermis, Lotus corniculatus, Melilotus officinalis, M. alba, Medicago sativa, Phleum pratense, Poa pratentsis, P. compressa, and Trifolium pratense*). In addition, a survey by the Superior National Forest (2002-2003) documented several invasive species (species tracked by the U.S. Forest Service and Minnesota Class 1 and Class 2 invasive species) within three miles of the Project, primarily along roadways (*Table 4.3-4*). Species with a high percentage of occurrence in the surveys (e.g., common tansy) are likely to invade the Mine Site following disturbance and may displace native species and degrade ecosystem quality.

Table 4.3-3 Non-native Species Found on Mine Sites in the Mesabi Iron Range (Apfelbaum and Larson 1995)

Scientific name	Common Name	Percent Occurrence[1]	Wetland/ Upland	Estimated Abundance at NorthMet Mine Site
Bromus inermis	Smooth brome	60	U	Uncommon
Tanacetum vulgare	Common tansy	60	U	Uncommon
Taraxacum officinale	Dandelion	60	U	Common
Medicago sativa	Alfalfa	50	U	Not Seen
Cirsium arvense	Canada thistle	40	U	Uncommon
Phleum pretense	Timothy	40	U	Common
Poa pratensis	Kentucky bluegrass	40	U	Common
Phalaris arundinacea	Reed canary-grass	30	W	Rare
Chrysanthemum leaucanthemum	Oxeye daisy	30	U	Common
Lotus corniculatus	Bird's-foot trefoil	30	U	Common
Poa compressa	Canada bluegrass	30	U	Not Seen
Trapogon dubius	Goat's beard	30	U	Not Seen
Trifolium hybridicum	Hybrid clover	30	U	Not Seen
Hieracium pretense	Yellow hawkweed	20	U	Uncommon
Silene lychnis	Bladder campion	20	U	Uncommon
Barbarea vulgaris	Yellow rocket	20	U	Not Seen
Berteroa incana	Hoary alyssum	20	U	Not Seen
Hieraceum canadense	Canada hawkweed	20	U	Not Seen
Hordeum jubatum	Foxtail barley	20	U	Not Seen
Melilotus officinalis	Yellow sweetclover	20	U	Uncommon
Rumex crispus	Curly dock	20	U	Not Seen

Scientific name	Common Name	Percent Occurrence[1]	Wetland/ Upland	Estimated Abundance at NorthMet Mine Site
Salsola kali	Russian thistle	20	U	Not Seen
Verbascum thapsus	Common mullein	20	U	Not Seen
Agrostis alba	Redtop	10	W/U	Uncommon
Cirsium vulgare	Bull thistle	10	U	Uncommon
Hieracium aurantiacum	Devil's hawkweed	10	U	Common
Medicago lupulina	Black medic	10	U	Common
Melilotus alba	White sweetclover	10	U	Not Seen
Polygonum persicaria	Spotted ladysthumb	10	W/U	Not Seen
Potentilla norvegica	Norwegian cinquefoil	10	U	Not Seen
Robinia psuedoacacia	Black locust	10	U	Not Seen
Silene vulgaris	Maidenstears	10	U	Not Seen
Trifolium pretense	White clover	10	U	Common

[1]Percent occurrence is the percentage of mine areas in the Mesabi Iron Range with reported observations based on three-minute surveys at 10 mine areas. Three-minute surveys report the most abundant plant species observed during a three minute time period and provide a rough estimate of species abundance.

Table 4.3-4 Weed Species Found Within Approximately Three Miles of the NorthMet Project by the Forest Service Road Weed Survey

Scientific name	Common Name	Percent Occurrence Near NorthMet Site[1]	Wetland/ Upland
Caragana arborescens[2]	Siberian peabush	0.5	U
Centaurea stoebe (C. maculata)[3]	Spotted knapweed	19	U
Cirsium arvense[4]	Canada thistle	14	U
Cirsium vulgare[4]	Bull thistle	9	U
Euphorbia esula[4]	Leafy spurge	2	U
Hypericum punctatum[2]	Spotted St. Johns-wort	14	U
Rhamnus cathartica[2]	European or common buckthorn	0.5	U
Tanacetum vulgare[3]	Common tansy	42	U

[1]Percent occurrence is the number of populations of the noxious weed divided by the 206 total noxious weed populations identified within three miles of the NorthMet Project site.
[2] Tracked by US Forest Service.
[3] Minnesota class 2 noxious weed.
[4] Minnesota class 1 noxious weed.

4.3.1.2.Threatened and Endangered Plant Species

Endangered, Threatened, and Species of Special Concern

No federally listed threatened or endangered plant species occur at the Project. Some State listed endangered, threatened, or special concern (ETSC) plant species have been found at or near the Mine Site. A detailed ETSC plant species survey was not conducted at the Plant Site because suitable habitat for these species is not present at this predominantly disturbed and developed site. A few ETSC species that are disturbance-adapted may exist along the rail line, roads, and tailings ponds, but would not be expected to be adversely affected in the long term by the proposed action. Consequently, the Mine Site is the focus of this analysis and subsequent discussion

Based on a review of the Minnesota Natural Heritage database and field investigations, two state endangered species, two state threatened species, and five state species of special concern were identified at or adjacent to the Mine Site (*Table 4.3-5*). No other listed state species are known to occur on site, and no other populations of state ETSC plant species have been identified within 100 miles of the NorthMet site nor is there appropriate habitat for these species at the Project site. Minnesota's Endangered Species Law (Minnesota Statute 84.0895) and associated Rules (Minnesota Rules 6212.1800 to 6212.2300 and 6134) impose a variety of restrictions, permits, and exemptions pertaining to ETSC species.

Table 4.3-5 Endangered, Threatened, and Special Concern Plant Species Identified at the NorthMet Mine Site

Common Name	Scientific Name	State Status[1]	NorthMet Mine # of Populations[2]	NorthMet Mine # of Individuals	Habitat and Location at NorthMet Site
Pale moonwort	Botrychium pallidum	E	4[(3)]	58	Full to shady exposure, edge of alder thicket, along Dunka Road, and railroad and powerline rights-of-way.
Ternate grape-fern	Botrychium rugulosum (=ternatum)	T	1[(2)]	4	Disturbed habitats, fields, open woods, forests.
Least grapefern	Botrychium simplex	SC	20	1,337	Full to shady exposure, edge of alder thicket, forest roads, along Dunka Road, and railroad and power line rights-of-way.
Floating marsh marigold	Caltha natans	E	13	~150	Shallow water in ditches and streams, alder swamps, shallow marshes, beaver ponds, and Partridge River mudflat.
Neat spikerush	Eleocharis nitida	T	13[(2,3)]	~1,450 sq.ft.	Full exposure, moist ditches along Dunka Road, wet area between railroad grades, and railroad ditch.
Northern comandra	Geocaulon lividum	SC	11	Not reported	On *Pleurozium* and *Sphagnum* moss mats under black spruce, open to partly shaded.

Common Name	Scientific Name	State Status[1]	NorthMet Mine # of Populations[2]	NorthMet Mine # of Individuals	Habitat and Location at NorthMet Site
Lapland buttercup	Ranunculus lapponicus	SC	7	~825 sq.ft	On and adjacent to *Sphagnum* hummocks in black spruce stands, up to 60% shaded with alder also dominant.
Clustered bur-reed	Sparganium glomeratum	SC	13	>100	Shallow pools and channels up to 1.5 feet deep in *Sphagnum* at edge of black spruce swamps, beaver ponds, wet ditches, shallow marshes.
Torrey's manna- grass	Torreyochloa pallida	SC	8	~800 sq.ft	In muddy soil along shore and in water within shallow channels, beaver ponds, shallow marshes, along Partridge River.

Source: Minnesota Natural Heritage Database (June, 2007); Final Scoping Decision Document 2005)
[1]E - Endangered, T - Threatened, SC - Species of Concern
[2] Note that the number of populations for ternate Grape Fern and Neat Spike Rush differ from those given in the Project Description because of populations found during other surveys.
[3] Number based on site survey; additional populations may be present in more marginal, secondary habitat that was not surveyed or in wetter areas.

Species Life Histories

The following summary provides descriptions of the life histories, state-wide distributions, and sensitivity to disturbance of each of the nine ETSC species found at the Mine Site.

Botrychium pallidum (Pale moonwort) is listed as an endangered species in Minnesota and as a Regional Forester Sensitive Species (RFSS) in the Superior National Forest. *B. pallidum* was only first identified in Minnesota in 1990 (FNA 2007) and new populations are documented each year. It occurs in open disturbed habitats, log landings, roadsides, sandy gravel pits, and mine tailings within the Iron Range of northeastern Minnesota. This diminutive perennial fern emerges in the late spring, produces spores, and senesces within 3 to 4 weeks. Like many of the moonworts, *B. pallidum* may be sensitive to changes in soil mychorrhizae; herbivory from introduced earthworms; vegetative cover (i.e., increased vegetative competition and shading); soil moisture; or other environmental factors affecting suitable microhabitats. Disturbance (e.g., vegetation clearing, mining, soil scarification, reduction of vegetative competition, increased sunlight, fire) likely plays an important role in the preservation and proliferation of this species.

Botrychium rugulosum (Synonym: *B. ternatum;* Ternate grape-fern) is listed as a threatened species in Minnesota and as an RFSS in the Superior National Forest. The name "rugulosum" refers to the tendency of the segments to become wrinkled and convex. Relatively little is known about the overall distribution, genetics, and life history requirements of *B. rugulosum,* and some taxonomists question whether *B. rugulosum* is a distinct species. In Minnesota, *B. rugulosum* occurs in the northern and south central portions of the state. In northern Minnesota, *B. rugulosum* prefers habitats that include partially shaded mine tailings, sandy conifer forests and plantations, and shaded vernal pool margins in rich deciduous hardwood forests. *B. rugulosum* is similar morphologically and in its life history requirements to *B. multifidum,* and these two species are often confused in the field. *B. rugulosum* is most easily distinguished from similar species in the late summer and early autumn, when the tropophore has matured. Like *B. pallidum, B. rugulosum* may be associated with soil mychorrhizae and may be sensitive to increased competition, shading, earthworms, changes in soil moisture, and other environmental factors affecting micro-habitats. Disturbance also likely plays an important role in the proliferation of this species.

Botrychium simplex (Least grape-fern) is listed as a species of Special Concern in Minnesota and as an RFSS in the Superior National Forest. Least grape-fern occurs throughout northern and central Minnesota, with no occurrences documented in southern Minnesota (Bell Museum of Natural History 2007). Least grape-fern was first described as a species in 1823 (FNA 2007) and has been extensively surveyed and studied for over a century. *B. simplex* was first collected in Minnesota in 1993 from a jack pine forest in Clearwater County (Bell Museum of Natural History 2007). *B. simplex* is a perennial fern that occurs in a variety of natural and disturbed habitats, including brushy fields (often with other species of *Botrychium*); moist or dry woods; edges of forested vernal pools and swamps; mine tailings; and edges of sand/gravel/exposed forest roads. The morphology of the species is quite variable, and the many environmental forms and juvenile stages of *Botrychium simplex* have resulted in the naming of numerous, apparently mostly taxonomically meaningless, intraspecific taxa (FNA 2007). Like the other *Botrychium* species, disturbance likely plays an important role in the proliferation of this species.

Caltha natans (Floating marsh marigold) is listed as an endangered species in Minnesota and as an RFSS in the Superior National Forest. *C. natans* was first collected in Minnesota in 1889 from Vermilion Lake in St. Louis County (Coffin and Pfannmuller 1988). All subsequent collections have been from St. Louis County (Bell Museum Herbarium Database 2007). Very few populations are known in Minnesota. Floating marsh marigold occurs within shallow open water or on moist mud within northern ponds, lakes, slow-moving rivers, streams, and ditches. The species flowers in late spring-summer (i.e., June to August). *C. natans* is a species of relatively stable aquatic systems and may be sensitive to dramatic changes in hydrology or hydro-period, water quality, and water chemistry, although a few populations are found in disturbed habitats.

Eleocharis nitida (Neat spike-rush) is listed as a threatened species in Minnesota and as an RFSS in the Superior National Forest. Neat spike-rush's distribution in

Minnesota is limited to the northeastern counties of the Arrowhead region of the state and west to Itasca County. *E. nitida* was first collected in Minnesota in 1946 from various wetland habitats in Cook and St. Louis Counties. Despite the long collection record for this species in Minnesota, relatively few populations have been documented and little is known about the overall distribution of the species throughout the state. *E. nitida* occurs within various wetland habitats of northern Minnesota, including acid bog pools; streams; areas of seasonal water drawdown (mucky/peaty flats); disturbed wetland edges, and along roads and trails. Perennial plants flower in late spring and fruit in early to mid summer. Mature achenes are often necessary to positively identify *E. nitida* to species (both in the field and herbarium). This rooted perennial species may be intolerant of hydrologic fluctuations and alterations to water quality and chemistry associated with landscape and wetland alteration and development. However, roadside distributions suggest the species is tolerant of disturbance and at least mild alterations in water quality.

Geocaulon lividum (Northern comandra) is listed as a species of special concern in Minnesota; it is not listed as a RFSS in the Superior National Forest. This rooted perennial wetland species occurs in specific microhabitats within open bog mats and wet coniferous woods. In Minnesota, *G. lividum* has been collected and documented in two major areas: the northeastern Arrowhead counties west to Itasca County and within Lake of the Woods and Roseau counties in extreme north-central Minnesota. Northern comandra is parasitic, relying on nutrients from the roots of a variety of other plants such as bearberry (*Arctostaphylis*) and asters (*Aster* spp.). No populations have been found in heavily disturbed habitats; thus, this plant is likely to be negatively affected by disturbance. Suitable habitats and microhabitats are likely to be sensitive to altered hydrology, water quality, and water chemistry commonly associated with landscape disturbance and development, and may be sensitive to competition from introduced invasive wetland species (e.g., *Typha* spp., *Lythrum salicaria*, *Phragmites communis*, *Phalaris arundinacea*).

Ranunculus lapponicus (Lapland buttercup) is listed as a species of special concern in Minnesota; it is not listed as a RFSS in the Superior National Forest. Lapland buttercup occurs throughout much of northern Minnesota, with the exception of extreme northwestern Minnesota. This species was first documented in 1949 in Minnesota from a tamarack-spruce bog in St. Louis County (Bell Museum of Natural History 2007). *R. lapponicus* is a perennial forb species that occurs within hummocks and pools in conifer swamps in Minnesota. No populations have been found on disturbed sites. Lapland buttercup is sensitive to changes in conifer forest canopy, wetland hydrology/hydro-period, water chemistry, and other environmental factors affecting optimal conifer forest pools and hummock micro-sites.

Sparganium glomeratum (Clustered burr-reed) is listed as a species of special concern in Minnesota and as an RFSS in the Superior National Forest. This species was originally listed as endangered by the Minnesota DNR in the mid-1980s (Coffin and Pfannmuller 1988); however, numerous new populations have since been documented and the species was down-listed from Endangered to Special Concern in the mid-1990s. Within Minnesota, clustered burr-reed is distributed throughout the northeastern Arrowhead counties (including the Chippewa and Superior National Forests); west to north central Minnesota (Becker County); and in central Minnesota (Todd County; Bell Museum of Natural History 2007). *S. glomeratum* is a perennial wetland macrophyte that occurs in partial to full sun within a variety of northern wetland habitats, including edges of floating bog mats in emergent wetland habitats; ephemeral emergent stream channels; along beaver-impounded wetland edges; and disturbed emergent wetland edges. A significant proportion of known populations occur along roadsides and this plant may thus be somewhat tolerant of disturbance. *S. glomeratum*, however, is a rooted emergent perennial species that may be sensitive to pronounced water level fluctuations and prolonged inundation, changes in water chemistry, competition from introduced/invasive species (e.g., *Typha* spp., *Lythrum salicaria, Phragmites communis, Phalaris arundinacea*); and other environmental factors affecting suitable wetland microhabitats.

Torreyochloa pallida (Synonym: *Puccinellia pallida*; Torrey's manna grass) is listed as a species of special concern in Minnesota; it is not listed as a RFSS in the Superior National Forest. Torrey's manna grass was first collected in 1886 from Vermilion Lake in St. Louis County (Bell Museum of Natural History 2007). Within Minnesota, *T. pallida* occurs throughout the Arrowhead Region south to Chisago County (along the St. Croix River drainage). Torrey's manna grass is a perennial graminoid species that occurs in various wetland habitats in northern Minnesota. Habitats include shallow muck-bottomed pond and stream shores, bogs, and beaver meadows. Some populations occur within roadside ditches, suggesting the species may be somewhat tolerant of disturbance; however, this rooted perennial wetland species is sensitive to alterations in wetland hydro-period; water level fluctuations; sedimentation; changes in water chemistry associated with landscape alteration and development; and competition from introduced invasive wetland species (e.g., *Typha* spp., *Lythrum salicaria, Phragmites communis, Phalaris arundinacea*).

4.3.2. Impact Criteria

Direct impacts to vegetative cover types and species occur through clearing, filling, and other construction activities. Direct impacts are a result of the proposed action, are immediate, and often last for years. A direct impact to an ETSC species occurs with the removal or loss of an individual plant or plant populations.

Indirect impacts to plant species 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, rise or fall in water table, loss of pollinators, or loss of fungal associates in the rooting zone), and invasion of non-native species. An indirect impact occurs when a cover type experiences a change in vegetation composition; occurs over time or after the action is completed; and can occur on or off site.

Cumulative impacts to endangered and threatened plant species are evaluated by considering the proposed action together with other similar actions that have occurred or may be reasonably expected to occur. Cumulative impacts to cover types can also affect wildlife, which are discussed in Section 4.4.

4.3.3. Environmental Consequences

4.3.3.1.Proposed Action

This section describes the effects of Project construction, operation, and closure on vegetation cover types and ETSC species at the Plant and Mine sites. Potential effects from non-native invasive species that are common to both the Plant and Mine sites are discussed separately.

Plant Site

Effects on Cover Types

Project construction, operation, and closure at the Plant Site would have minimal effects on native vegetation because most of this site has already been heavily disturbed (*Table 4.3-6*). Most of these impacts are to isolated stands of forest characterized as being in fair condition. Other impacts to cover types at the Plant Site are minor.

Table 4.3-6 Direct Effects on Cover Types at the Plant Site

Cover Types	Affected Acres	Non-Affected Acres[1]	Total Cover Type Acres	Percent of Cover Type Affected
Developed	896	1,691	2,587	34.6
Barren	50	131	181	27.6
Grassland	0	1	1	0.0
Upland Shrub	55	207	262	21.0
Aspen/White Birch	117	421	538	21.7
Maple/Basswood	3	7	10	30.0
Upland Deciduous	0	2	2	0.0
Pine	17	10	27.	63.0
Spruce/Fir	14	62	76	18.4
Tamarack	0	7	7	0.0
Lowland Black Spruce	0	27	27	0.0
Lowland Northern White-Cedar	0	4	4	0.0
Lowland Shrub	39	36	75	52.0
Marsh	24	52	76	31.6
Aquatic	539	13	552	97.6
Total	**1,754**	**2,671**	**4,425**	**39.6**

[1]Areas of cover types not within a 50ft buffer of buildings, tailings pit/spillway reclamation area, railroad connection or treated water pipeline.

At closure of the Plant Site, the building foundations and other infrastructure at the processing plant would be removed or buried to a depth of two feet; the tailings basin would be contoured to promote wetlands creation. The exterior dam faces, dam top, and coarse beach would be revegetated pursuant to Minnesota Rules 6132.2700 by a qualified contractor. Reclamation areas would be inspected in spring and fall, with areas identified for erosion and failed seeding repaired, until MnDNR determines that the areas are stable and self-sustaining.

Effects on ETSC Species

The Project would have no effect on federal or state ETSC species at the Plant Site because none are known to occur within the Plant Site boundary.

Mine Site

Effects on Cover Types

Project construction and operation at the Mine Site would impact approximately 1,454 acres of native vegetation as a result of excavating the mine pits (approximately 450 acres) and creating overburden and waste rock stockpiles and associated internal haul roads and drainage ditches (approximately 1,004 acres) (*Table 4.3-7*). These impacts would include approximately 50% (459 acres) of the mixed pine-hardwood forest at the Mine Site. Approximately 1,562 acres, or about 52 percent of the Mine Site, would not be disturbed.

Table 4.3-7 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
Disturbed	0	66	66	0
Grass/brushland	245	48	293	84
Aspen forest/Aspen-birch forest	68	97	165	41
Jack pine forest[2]	84	99	183	46
Mixed pine-hardwood forest	459	544	1,003	46
Mixed hardwood swamp[3]	195	265	460	42
Black spruce forest/bog[3]	402	441	843	48
Open water	1	2	3	33
Total	**1,454**	**1,562**	**3,016**	**48**

[1]Areas of cover types not directly affected by mine pits and stockpiles.
[2]The Wastewater Treatment Plant and Central Pumping Station facilities at the mine area would directly affect an estimated additional 1-2 acres of jack pine forest.
[3]Cover type acreage, including wetlands acreage for mixed hardwood swamp and black spruce forest/bog, was derived from aerial photo interpretation and therefore differs from wetland acreage resulting from wetland delineation in the field.

Nearly all of the upland forests that would be directly affected by proposed activities at the Mine Site are in fair to good condition according to the Minnesota Natural Heritage Program condition ranking system. Most of the forested wetlands affected by the Project are in good to excellent condition; the wetland field assessment also indicates a high level of wetland quality.

Minor impacts in already disturbed areas would occur along Dunka Road at the Mine Site. A water pipeline for treated water would be constructed along Dunka Road in previously disturbed land. Construction of the pipeline would expose soil during construction and bury vegetation under rock fill. About 10 acres of wetlands would be affected by pipeline construction and improvement of Dunka Road.

Indirect effects on vegetative cover types at the Mine Site are expected to result from dust from road traffic and mining operations and changes in hydrology. Dust on leaves can affect the rate of photosynthesis and respiration that influence plant growth. The greatest effect, if any, of fugitive dust is likely to occur near the East and West pits where haul roads are concentrated and the rail transfer hopper and other facilities are located. The distance dust travels depends on wind speed, antecedent weather conditions, dust particle size, and vegetation density near the source. PolyMet proposes to implement various dust control measures such as stabilizing disturbed soils and water spraying during dry periods. These measures should be adequate to minimize potential indirect impacts from fugitive dust.

The local hydrology of wetlands at the Mine Site may also be affected by haul roads, drainage controls, and mine dewatering. A system of dikes and ditches is proposed to minimize the amount of surface water flowing onto the site; eliminate wastewater and non-contact storm water flowing uncontrolled off the Mine Site; and minimize the amount of storm water flowing into the mine pits. PolyMet proposes to construct a drainage system to carry excess surface water away from the Mine Site, ensuring that vegetative cover type conversion (i.e., from sedge meadow to cattail marsh) is minimized. Even with drainage improvements, however, ponding would likely occur on the upstream side of roads and drying on the downstream side. If existing drainage patterns are largely preserved, this indirect effect would be confined to small areas immediately upgradient of the haul roads. Upon mine closure, some haul roads or culverts would be removed and replaced with channels, eliminating the risk that clogged culverts would permanently alter future hydrology. Further discussion of potential indirect impacts to wetlands from hydrologic changes is provided in Section 4.2.3.

Reclamation and revegetation at the Mine Site would initiate vegetative succession on stockpiles and at the East Pit. The stockpiles would be planted with red pine on the slopes and seeded with grasses/forbs at the tops and bench flats (to minimize the potential for deep-rooted trees from penetrating the cap). Within a few decades, these areas should be occupied by forest. The West Pit would remain open water, while the Central and East pits would support wetland vegetation.

Table 4.3-8 Proposed Vegetation Types and Acreages for Reclaimed Stockpiles and Pits at the NorthMet Mine Site

Type	Proposed Reclamation Vegetation	Acres
Cat. 1/2 Stockpile	Red Pine	563
Cat. 3 Lean Ore Stockpile	Red Pine	157
Cat. 3 Stockpile	Red Pine	72
Overburden Storage (Removed)	Herbaceous	94

Type	Proposed Reclamation Vegetation	Acres
Cat. 4 Lean Ore Surge (Removed)	Herbaceous	55
Cat. 4 Stockpile	Grassland	63
East and Central Pits	Wetland	172
West Pit	Open Water	278
Total		**1,454**

The most significant direct Project effect on vegetation is to wetland cover types in good/excellent condition (e.g., mixed hardwood swamp, black spruce swamp/bog), which are fairly common cover types in the region. Combined on and off-site wetland mitigation would replace more wetland vegetation than would be impacted, although with some changes to the cover type composition. For example, cattail-dominated plant communities, which disturbed wetlands in this area typically develop into, would represent the likely future plant community that would occupy the reclaimed Central and East pits at the Mine Site (refer to Section 4.2 for a detailed discussion of wetland type impacts and mitigation).

Effects on ETSC Species

No federally-listed threatened or endangered plant species occur at the NorthMet site. The Project, however, would have both direct and indirect effects on State ETSC plant species. Table 4.3-6 summarizes the direct and indirect Project effects on each of the ETSC plant species. These numbers may overestimate the actual impacts 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 number of actual populations may be larger than that identified in the Natural Heritage database.

The Project would directly affect six of the nine listed ETSC plant species, all of which are found at the Mine Site or along the Dunka Road, railroad, and power line rights-of-way. Most of the direct impacts involve the complete loss of populations as a result of direct excavation of the mine pits, burial under stockpiles, or disturbance during infrastructure construction.

The Project may result in indirect impacts to many of the remaining ETSC plant populations at the Mine Site (*Table 4.3-9*). These indirect impacts may occur as a result of changes in hydrology or water quality, deposition of particulate matter (dust), application of road salts, or weed incursion. The magnitude of the potential effects could range from almost no effect to potentially significant effects on reproduction and/or population persistence. Individual species appear to differ in their response to these indirect effects. For example, several of the listed species typically occur 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. Disturbance tolerant species may in some cases actually be disturbance-dependent.

Table 4.3-9 Impacts to Known ETSC Plant Populations at the NorthMet Mine Site

	NorthMet Project				Statewide Populations			
Plant Species (state status/ global status[1])	**Total Populations**	**Total Individuals**	**Direct Impacts[2] (Populations)**	**Indirect Impacts[3] (Populations)**	**Total Populations**	**Average Individuals per Population[4]**	**Percent Directly Affected (Populations)**	**Percent Indirectly Affected (Populations)**
Botrychium pallidum (E/G3)	4	58	2	2	64	15	3	3
Botrychium rugulosum (T/G3)	1	4	0	1	75	14	0	1
Botrychium simplex (SC/G5)	20	1,337	11	9	143	25	8	6
Caltha natans (E/G5)	13	~150	0	13	26	unknown	0	50
Eleocharis nitida (T/G4)	13	~1,450 sq.ft.	4	9	62	450	6	15
Geocaulon lividum (SC/G5)	11	unknown	0	11	135	50	0	8
Ranunculus lapponicus (SC/G5)	7	~825 sq. ft	3	4	73	51	4	5
Sparganium glomeratum (SC/G4?)	13	>100	3	10	160	82	2	6
Torreyochloa pallida (SC/G5)	8	~800 sq.ft	2	0	93	unknown	2	6
Total	**89**	**NA**	**25**	**64**	**831**	**NA**	**3**	**8**

[1] 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. 2007. [2] Direct impacts are expected for those populations that would be removed or buried by mine activities. Impacts are calculated for populations rather than individuals because of the large variation and inaccuracies in the estimates of number of individuals per population.
[3] Indirect impacts may occur to those populations within or near the mine area. These populations may be affected by changes in hydrology, water quality, dust, or inadvertent activities. As above, impacts are given for populations rather than individuals.
[4] Population estimates are approximate and used for comparative purposes only. The total number of individuals is based upon populations for which data exists; many localities did not report population sizes.

Botrychium pallidum populations are most commonly observed on mine tailings basins and along roadsides. Of the 64 known populations statewide, the Project may directly impact two populations along Dunka Road from pipeline construction and road improvements/maintenance, and may have indirect impacts on the other two populations at the Project from dust or changes in hydrology. This species, however, appears to be tolerant of disturbance and populations may actually expand into newly disturbed areas along Dunka Road around the tailings basin and at the Mine Site.

Botrychium rugulosum frequently occurs on tailings basins and along roadsides. Of the 75 known extant populations, one (with four individuals) occurs along Dunka Road. No direct impacts to this species are anticipated. Possible indirect impacts may occur from changes in site hydrology, increased dust, or inadvertently from vehicle operation or maintenance along the roadside. This species also appears to be tolerant of disturbance and populations may actually expand into newly disturbed areas along Dunka Road, around the tailings basin, and at the Mine Site.

Botrychium simplex frequently occurs on tailings basins and along roadsides. Of the 143 known populations statewide, 20 occur on the Mine Site. Of these, 11 are expected to be directly affected, six from stockpiles and mine pits and another five from pipeline and ditch construction. The populations affected by pipelines and ditches may be reduced in the short term by construction, but would likely recover, as this species appears to be tolerant of disturbance. The remaining nine populations occur primarily along Dunka Road, with a few in relatively undisturbed habitats. These populations may face indirect impacts from changes in hydrology, water quality, or dust. Overall, long-term impacts may be minimal as this species appears to be tolerant of disturbance and populations may expand along Dunka Road, around the tailings basin, and at Mine Site after closure.

Caltha natans is found primarily in relatively undisturbed habitats and is not likely to be tolerant of disturbance. Of 26 known populations statewide, 50% (i.e., 13 populations) occur within or near the Mine Site. None of these populations are expected to be directly affected, although one population is very close to a proposed ditch along Dunka Road. Four other populations are located downgradient from the mine and could be indirectly affected by changes in hydrology or water chemistry. The remaining eight populations are located outside, but near, the Mine Site. These eight populations are generally found along the Partridge River and are believed to be sufficiently removed from potential direct and indirect affects of the Project so as not to be affected.

Eleocharis nitida is primarily observed in roadside ditches with gravel or sandy substrates along Dunka Road. Of the 62 known populations in the state, 13 occur at the Mine Site. Of these, nine populations are found along the Dunka Road and three along the train tracks. Four of the Dunka Road populations are likely to be directly affected by ditch construction. The other nine populations may incur indirect impacts from changes in hydrology or water quality. This species, however, seems to be tolerant of disturbance; therefore, ditching and road maintenance may have no long-term adverse impacts on this species.

Geocaulon lividum is nearly always found in conjunction with wet conifer forests. Of the 135 known populations statewide, 11 occur at the Mine Site. None of the populations are expected to be directly affected; however, one of the populations is very close to a waste rock stockpile and one is along Dunka Road. All 11 populations may be considered at risk from indirect impacts due to changes in hydrology.

Ranunculus lapponicus is found in conifer/sphagnum bogs. Of 73 known populations statewide, seven occur at the Mine Site. Of these, three populations are expected to be directly affected - two would be covered by a waste rock stockpile and one would be excavated for a planned drainage ditch. The other four populations may face indirect impacts from changes in hydrology, water chemistry, or dust.

Sparganium glomeratum is observed along roadsides as well as in hardwood forests. This plant may be tolerant of some disturbance. Of the 160 known populations statewide, 13 occur at the Project. Of these, three would likely be directly affected - two populations would be eliminated by construction of the West Pit and one population along Dunka Road may be affected by a proposed ditch. The remaining 10 populations, including several populations along Dunka Road, may face indirect impacts from changes in hydrology, water quality, or dust. This species, however, appears to be tolerant of disturbance.

Torreyochloa pallida is often seen along roadsides and may be tolerant of disturbance. Of the 93 known populations statewide, eight occur at or near the Mine Site. Of these, two are along Dunka Road and may be affected by a proposed ditch. The remaining six populations are located distant from any proposed construction and several are found along the Partridge River. These six populations are believed to be sufficiently removed from potential direct and indirect affects of the Project so as not to be affected.

Effects of Non-Native Plant Species

PolyMet proposes to temporarily vegetatively stabilize during mine operation, and permanently reclaim during mine closure, disturbed areas by applying seeds or planting seedlings. Species proposed for revegetation include sweet clover, redtop, alsike clover, Canada bluegrass, Cicer milkvetch, birdsfoot trefoil, perennial ryegrass, smooth brome grass, 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 dam stability. The legume species listed would also fix nitrogen that helps to re-establish soil nutrients. All of these species with the exception of Canada bluegrass, however, are non-native and some of the proposed species are considered invasive (e.g., birdsfoot trefoil, redtop, smooth brome grass, Canada bluegrass, sweet clover). In addition, hay and agricultural grasses are specified as mulch, which may contain propagules or seeds of invasive species such as reed canary-grass.

Use of the proposed seed mix would introduce non-native invasive species to an area of primarily natural vegetation. 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. Dominance of non-native invasive species would reduce the quality of cover types and habitat remaining at the Project.

4.3.3.2. Alternatives

No Action

Cover Types

Under the No-Action Alternative, forest harvesting would continue to occur in portions of the Mine Site under the Land and Resource Management Plan for the Superior National Forest. While timber harvest would result in the immediate loss of some habitat types, permanent changes are not expected. The plan does call for an increase in older-age stands, which would likely come at the expense of younger age stands in the long term. At the Plant Site, the former LTV process facility would be reclaimed and areas revegetated in accordance with the LTV Closure Plan much sooner than under the Proposed Action. Revegetation under the LTV Closure Plan would be expected to use standard non-native seed mixes.

Direct and indirect effects of the No-Action Alternative on cover types are considered minimal. Non-native species may still invade the site as a result of logging, exploration, vehicle traffic, and natural disturbances, but are likely to do so much more slowly than under the proposed action.

ETSC Plant Species

Under the No-Action Alternative, timber harvests are expected to continue to occur on site. The Project area, however, has historically been logged and the ETSC species present on site have survived, so there is little reason to think that continued logging, which now is more likely to employ best management practices to minimize detrimental effects, would adversely affect the ETSC species. Potential indirect impacts under the No-Action Alternative could come from increased competition as succession proceeds. Effects of increased competition due to succession include reduced spore production and consequent reduced population size in the early successional plant species (e.g., *Botrychium* spp.). Continued mowing and maintenance, however, would likely occur along Dunka Road and the railroad where several of the *Botrychium* populations occur, so succession at these locations is unlikely and these populations would persist.

Subaqueous Disposal of Reactive Waste Rock Alternative

Subaqueous disposal of Category 2, 3, and 4 waste rock into the east pit would have similar affects on vegetative cover types and ETSC plant species at the NorthMet Project as the proposed action. The subaqueous disposal, rather than long-term surface stockpiling, of the more reactive waste rock would reduce the risk of ARD, which could indirectly impact ETSC species.

Other Mitigation Measures

Section 3.2.2.3 describes several potential mitigation measures for impacts from the Project. Several of these measures have the potential to affect vegetation.

PolyMet currently proposes to stabilize disturbed areas during Project operations and at the time of mine closure using a seed mix that includes several non-native and potentially invasive species. This seed mix has been selected in order to quickly and effectively stabilize disturbed areas and re-establish soil nutrients. An alternative would be to reseed with native non-invasive species as long as they can perform as effectively as the non-native species. In some areas (e.g., tailings dam and dikes) where erosion control is critical to prevent slope failures, non-native species may be needed.

Dust from mining operations can adversely affect nearby vegetation. PolyMet proposes to implement various dust control measures (see *Section 5.0, Mitigation, and Monitoring*), but it is recommended that annual surveys be conducted to confirm the effectiveness of these measures.

Widening of the Dunka Road and construction of the mine infrastructure (e.g., haul roads, stockpiles) would likely impact several ETSC plant species that are near, but outside, the footprint of these facilities. In several cases, these potential impacts could be avoided or reduced by fencing or flagging ETSC populations to prevent disturbance.

The following potential mitigation measures may also indirectly benefit vegetation:

- Monitoring of Waste Rock Stockpiles and Tailing Basin – would help ensure that water quality would meet state standards and not adversely affect cover types or ETSC species at the Project.
- Chemical Modification of the Reactive Waste Rock Stockpiles – application of lime to neutralize ARD would help ensure that changes in water quality would not adversely affect cover types or ETSC species at the Project.
- Use Overburden in the East Pit – reuse of overburden to help create wetlands in the East Pit would help restore native habitat and also reduce the permanent footprint of the overburden stockpile.

- Maximize the Elevation of the Category 1/2 Stockpile – maximizing the height of the category 1/2 stockpile would reduce the footprint of this stockpile and thereby minimize direct impacts to native cover types, although it is expected that the reduction in direct impacts would be small (e.g., a few acres) because the stockpile height is already at or close to its maximum height from a geotechnical engineering perspective.

4.3.4. Cumulative Impacts - Loss of Threatened and Endangered Plant Species

4.3.4.1.Summary of Issue

ETSC plant species are protected under the Minnesota Endangered Species Law (Minnesota Statute 84.0895) and associated rules (Minnesota Rule 6212.1800 to 6212.2300 and 6212.6134). Project-related impacts to the nine ETSC plant species were identified and evaluated in Section 4.3.3.1. This section evaluates the potential cumulative effects of the NorthMet Project, as well as other past, present, and reasonably foreseeable future activities, on these nine ETSC plant species.

4.3.4.2.Approach to Analysis

The nine ETSC plant species found at the Project were evaluated for potential cumulative effects using a semi-quantitative evaluation. Existing information from the Minnesota Natural Heritage database and other existing data sources were used to create a distribution map for each species. The data were compiled and mapped to analyze the number of known populations, approximate numbers of plants, proportion of statewide populations expected to be affected, habitat preference, role of disturbance in each species' life history, sensitivity to disturbance, species distribution (i.e., range), current level of understanding for each species, and potential mitigation. Much of this information is summarized in Table 4-3.9

The entire state of Minnesota was used as the geographic boundary for the analysis, with a focus on the Laurentian Mixed Forest Section as representative of the approximate statewide range of all nine ETSC plant species, although their North American distribution and abundance is also presented to provide context. Data for the Laurentian Uplands Subsection were analyzed to assess impacts from the Project.

Cumulative effects related to past, present, and reasonably foreseeable future actions were evaluated. Past and present conditions were derived from *Tomorrow's Habitat for the Wild and Rare: an Action Plan for Minnesota Wildlife* (2006). Land use changes (including logging and development) were described by Emmons and Olivier Resource (2006) in a cumulative effects assessment of wildlife habitat in the Iron Range. Impacts in the reasonably foreseeable future (e.g., approximately 27 years, which is generally consistent with the proposed life of the Project, including construction, operations, and closure) were also evaluated. Potential future impacts were identified by analyzing takings permits as well as GIS information from the

MnDNR to determine the extent of expected losses from recently permitted projects. Species losses from the following reasonably foreseeable actions were considered:

- Proposed Minnesota Steel DRI/Steel Plant
- Proposed Minnesota Steel taconite mine and tailings basin
- Proposed Cliffs Erie railroad pellet transfer facility;
- Proposed Mesabi Nugget Phase I processing facility
- Proposed Mesabi Nugget Phase II mining operation
- Proposed expansion of Northshore Peter Mitchell Mine Pits
- Proposed Mesaba Energy Power Generation (coal gasification) Station
- Proposed Minnesota Power Great River Energy Transmission Project
- Proposed Hoyt Lakes – Babbitt Connection, St. Louis County Highway Project
- ArcelorMittal East Reserve Project
- U.S. Steel Keewatin Taconite Mine and plant expansion
- LTVSMC mine closure
- Community growth and development
- Forestry practices on public and private lands

4.3.4.3.Existing Baseline Conditions and Past Losses

Past changes in cover types show a mixed pattern of gains and losses from the 1890s to 1990s (*Table 4.3-10)*. In the Laurentian Uplands Subsection, no cover type containing ETSC plant species has decreased. In the Laurentian Mixed Forest Province, lowland coniferous and upland coniferous forests experienced significant declines over this period. Among ETSC plant species, *Botrychium rugulosum* is most likely to occur in the upland coniferous type (*Table 4.3-11*). *Caltha natans, Geocaulon lividum,* and *Ranunculus lapponicus* are most likely to occur in the lowland coniferous type. *C. natans* occupies edges of ponds and lakes in the lowland coniferous type; consequently, losses in lowland coniferous types less accurately reflect trends in this species habitat. While there appears to be no habitat loss locally, habitat appears to have decreased statewide for these species.

This conclusion should be qualified by the understanding that the mapped habitat type does not precisely match the habitat actually used by an ETSC plant species. Because ETSC plant species occupy preferred habitats within larger mapped habitat types, the impact of habitat loss may not directly correlate on a 1:1 basis to the effect on a plant species. A reasonable assumption is that significant losses in mapped habitat types represent a trend in losses of preferred habitat types for these ETSC species.

Table 4.3-10 Changes in Habitat Acreage since European Settlement (MnDNR 2006)

Habitat Type	Laurentian Uplands Gain/Loss 1000's of acres (%)	Laurentian Mixed Forest Gain/Loss 1000's of acres (%)	Statewide Gain/Loss 1000's of acres
Lowland Coniferous	+ 40 (7.1%)	- 1300 (-6%)	- 1330
Lowland Deciduous	+ 1.7 (0.3%)	+ 300 (1%)	- 94
Upland Deciduous	+ 1.7 (0.3%)	- 635 (-8%)	-2180
Upland Coniferous	+ 24 (4.2%)	-1473 (-47%)	-1327
Wetland	+ 6.2 (1.1%)	+ 410 (53%)	-14,200[2]
Disturbed[1]	N/A	N/A	N/A
Shoreline[1]	N/A	N/A	N/A

[1] Information not available
[2] Source: Dahl,1990

Table 4.3-11 Preferred Habitat for ETSC Plant Species and Most Likely Associated Habitat Types (MnDNR NHIS 2006, MnDNR 2006)

Species	Preferred Plant Species Habitat	Corresponding Mappable Habitat Type
Botrychium pallidum	Disturbed areas	Disturbed
Botrychium rugulosum	Conifer forests/openings/Disturbed areas	Upland Coniferous
Botrychium simplex	Disturbed areas/lowland hardwood forest	Lowland Deciduous and Disturbed
Caltha natans	Lakeshores and pond edges in deciduous and coniferous forests	Lowland Coniferous and Lowland Deciduous
Eleocharis nitida	Mineral soil of wetlands with open canopy	Disturbed
Geocaulon lividum	Lowland conifer forests and peat bogs	Lowland Coniferous
Ranunculus lapponicus	Lowland conifer forests and peat bogs	Lowland Coniferous
Sparganium glomeratum	Sedge meadow/poor fen/lakeshore	Wetlands
Torreyochloa pallida	Pond/lake margins/lowland hardwood forest	Lowland Deciduous

4.3.4.4. Environmental Consequences of Reasonably Foreseeable Actions on ETSC Plant Species

Future impacts to ETSC plants were evaluated by overlaying the MnDNR Division of Minerals GIS mining layer on all known populations of ETSC plant species. These populations can contain from a few to thousands of individual plants. Of the nine ETSC species found at the Project, only four species (*Table 4.3-12*) have potential impacts from the reasonably foreseeable activities.

Table 4.3-12 Potential Future Impacts to ETSC Plant Species Populations Occurring From Reasonably Foreseeable Activities[1]

Species	Other Projects Direct Impact (Populations)	Other Projects Indirect Impact (Populations)	NorthMet Project Total Impact (Populations)	Total Known Statewide Populations	Percent of Known Statewide Populations Affected
Botrychium pallidum	5	2	4	64	17
Botrychium rugulosum	5	0	1	75	8
Botrychium simplex	4	3	20	143	19
Sparganium glomeratum	1	0	13	160	9

[1] Species for which no other projects are expected to have impacts are discussed in the "Proposed Action" section.

In addition to permitted and reasonably foreseeable activities, future changes in habitat types may affect ETSC plant populations. Forestry management has a much greater effect on habitat acreage within the range of these ETSC plant species than does mining and other land development. The forestry impact in a single year exceeds the expected acreage loss to habitat from all permitted mining projects and land development. Future timber harvest in the Arrowhead Region from government and private actions may affect over 42,000 acres annually

Cumulative effects on each of the ETSC species known to occur at the Project are discussed below.

B. pallidum is widely distributed across five Canadian provinces and four border states (ME, MI, MN, MT) as well as Colorado. This species is considered "vulnerable" by NatureServe (www.natureserve.org) and to be of conservation concern (www.efloras.org), although Minnesota is the only state to list it as threatened or endangered. Given that Minnesota is at the southern edge of its historical range, *B. pallidum* was probably never common in Minnesota. The Project would directly impact two populations and may indirectly impact two more populations. Other activities would directly impact five and indirectly affect two additional populations. In total, approximately 17% of the known populations in Minnesota would be directly or indirectly affected by these activities. New populations, however, are being found regularly. Its relatively short lifespan (approximately 4 weeks from emergence to senescence) may account for the few populations documented to date. Given its preference for disturbed sites, the cumulative effects of the Project and other reasonably foreseeable activities are not expected to jeopardize the presence of *B. pallidum* in Minnesota or in North America.

B. rugulosum is widely distributed across three Canadian provinces and four border states (MI, MN, NY, VT) as well as Connecticut, and is only listed as threatened (Minnesota) or endangered (New York) in two states. This species is considered "vulnerable" by NatureServe (www.natureserve.org). Given that Minnesota is at the southern edge of its historical range, *B. rugulosum* was probably never common in Minnesota. The Project may indirectly impact one population of the species. Other reasonably foreseeable activities would directly impact five additional populations; no additional populations would be indirectly affected. In total, approximately 8% of the known populations in Minnesota would be directly or indirectly affected. Given its tolerance for disturbance, the cumulative effects of the Project and other reasonably foreseeable activities are not expected to jeopardize the presence of *B. rugulosum* in Minnesota or in North America.

B. simplex is widely distributed across 34 states and 10 Canadian provinces. This species is considered "secure" by NatureServe (www.natureserve.org). The Project would directly impact 11 populations and may indirectly impact nine populations of the species. Other reasonably foreseeable activities would directly impact four and indirectly affect three additional populations. In total, approximately 19% of the known populations in Minnesota would be directly or indirectly affected. Given its tolerance for disturbance and that the species is considered "secure," the cumulative effects of the Project and other projects are not expected to jeopardize the presence of *B. simplex* in Minnesota or in North America.

Caltha natans is more common to the Canadian provinces and Alaska with a southern range that extends into northeastern Minnesota and northwestern Wisconsin. It is considered "secure" by NatureServe (www.natureserve.org). The Project would not directly impact any populations, but may indirectly affect five populations, which represent 19% of the known populations in Minnesota. No other reasonably foreseeable activities are known to impact this species. Further, the large number of populations discovered during the intensive surveys at the Project site suggests that either populations of this species may be under-reported overall, or that the Project site has exceptionally good habitat for unknown reasons. The lowland/wetland habitats in which *C. natans* occurs are not considered rare or declining in the Laurentian Uplands region, although they are declining in the Laurentian Mixed Forest subsection (Arrowhead) and state of Minnesota overall (*Table 4.3-10*). Given that the Project would not directly impact any populations, that no other reasonably foreseeable activities would impact the remaining populations, and that the species is considered "secure," the Project is not expected to jeopardize the presence of *C. natans* in Minnesota or North America.

Eleocharis nitida is widely distributed across eight Canadian provinces and six border states (AK, MI, MN, NH, VT, and WI). It is considered "apparently secure" by NatureServe (www.natureserve.org). Given that Minnesota is at the southern edge of its historical range, *E. nitida* was probably never common in Minnesota. The Project would directly impact four populations and may indirectly affect nine additional populations, which collectively represent approximately 21% of the known populations in Minnesota. No other reasonably foreseeable activities are known to impact this species. Given its tolerance for disturbance, the cumulative effects of the Project and other reasonably foreseeable activities are not expected to jeopardize the presence of *E. nitida* in Minnesota or North America.

Sparganium glomeratum is found in four Canadian provinces and two border states (MN and WI). This species is considered "apparently secure" by NatureServe (www.natureserve.org), although it is considered rare or only rarely collected in North America and is most abundant in sedge marshes and black ash swamps in Wisconsin and Minnesota near the western end of Lake Superior (www.eFloras.org). The Project would directly impact three and may indirectly affect 10 populations of this species. Other reasonably foreseeable activities would directly impact one population and would not indirectly affect any populations. Collectively, approximately 9% of the known populations in Minnesota would be directly or indirectly affected. This species inhabits non-forested wetlands (e.g., sedge meadow, poor fen, and lakeshore). Enforcement of existing wetland regulations, which require avoidance and minimization of wetland impacts, reduces the likelihood that known populations of this species would be significantly affected over the long term. Forest harvesting would not affect the non-forested wetland habitat of this species. Given its tolerance for disturbance, the cumulative effects of the Project and other reasonably foreseeable activities are not expected to jeopardize the presence of *S. glomeratum* in Minnesota or in North America.

Geocaulon lividum, Ranunculus lapponicus, and *Torreyochloa pallida* are all widely distributed across North America. They are all considered Species of Concern in Minnesota, but their populations are all considered "secure" by NatureServe (www.natureserve.org). These species are all at either the southern or western edges of their historic ranges in Minnesota and were likely never common in the state. The Project would affect between 2 and 9% of the known populations of these species in Minnesota. No other reasonably foreseeable activities are known to impact these species. For these reasons, the Project is not expected to jeopardize the presence of these species in Minnesota or North America.

4.4. WILDLIFE

The section describes the existing wildlife conditions at the Project site and evaluates the direct, indirect, and cumulative effects of the Project on wildlife and wildlife habitat and potentially significant wildlife travel corridors traversing the Mesabi Iron Range. We evaluate Project effects on three, somewhat overlapping, categories of critical wildlife: federally and state listed endangered, threatened, and species of special concern (ETSC – seven species); the Minnesota Species of Greatest Conservation Need (SGCN - 58 species), and the USFS's Regional Foresters Sensitive Species (RFSS – 21 species).

4.4.1. Existing Conditions

4.4.1.1. Endangered, Threatened, and Special Concern Animal Species

The following federally- and state-listed endangered, threatened, and special concern animal species may be present in the Project area:

- Canada Lynx – a federal threatened species, not state listed
- Gray Wolf – a federal threatened species and State species of special concern
- Bald Eagle - a state species of special concern, also protected under the Bald and Golden Eagle Protection Act and the Migratory Bird Treaty Act
- Wood Turtle – a state threatened species
- Heather Vole – a state species of special concern
- Yellow Rail – a state species of special concern
- Tiger Beetle – a state species of special concern

These species are briefly described below.

Canada Lynx

Canada Lynx populations in the United States are protected under the ESA as a federally-listed threatened species, although it is not listed as an ETSC species in Minnesota. Current conditions for this species in the Project area were determined through review of existing data sources, including various lynx sighting databases (http://www.nrri.umn.edu/lynx/general/ sightings.html; http://www.dnr.state.mn.us/eco/nhnrp/research/lynx_sightings.html) and reports (Foth and Van Dyke 1999, ENSR 2000, ENSR 2005), including a winter tracking survey (ENSR 2006). The tracking survey also includes interviews with experts, private conservation groups, and the public, who are familiar with lynx use of the survey area.

Lynx population cycles are related to hare populations, and mortality due to starvation has been documented during periods of hare scarcity (Pool 1994, Slough and Mowat 1996). Hunger-related stress, which induces dispersal, may increase exposure of lynx to other forms of mortality such as trapping and vehicle collisions (Brand and Keith 1979; Carbyn and Patriquin 1983; Ward and Krebs 1985; Bailey et al. 1986). Since 2000, the USFWS (2007) documented five road-killed lynx in Minnesota. Lynx may also be subject to competition (Buskirk et. al., 2000) and predation.

Staples (1995) described lynx as generally tolerant of humans. Other anecdotal reports suggest that lynx are not displaced by human activity, including moderate levels of snowmobile traffic (Mowat et al. 2000) and ski resort activities (Roe et al. 1999). In an area with sparse roads in north-central Washington State, logging roads did not appear to affect habitat use by lynx (McKelvey et al. 2000c). By contrast, lynx in the more heavily roaded southern Canadian Rocky Mountains crossed highways within their home ranges less than would be expected (Apps 2000).

Over three-quarters of lynx records in Minnesota are from the northeastern portion of the state (McKelvey et al. 2000a). Recent research in Minnesota confirmed a resident breeding population of lynx. Of the 408 sightings reported to the Minnesota Natural Heritage and Nongame Research Program since 2000, 78% were in St. Louis, Lake, and Cook Counties. Approximately 100 lynx have been sighted in St. Louis County since 2000 (MnDNR 2006) and 14% of these lynx showed evidence of reproductive activity.

The Project lies outside of the current boundaries of federally designated lynx critical habitat. Designated critical habitat occurs northward at Voyageurs National Park. Additional critical habitat has been proposed, but not adopted, including all of Lake and Cook Counties and most of St. Louis County, encompassing the NorthMet Project (USFWS 2008). A recovery plan has not yet been issued for the Canada Lynx.

At least 20 different individual lynx occur within 18 miles of the study area (NRRI 2006), including several radio-collared and reproductive individuals. The nearest reported sighting was approximately six miles from the proposed Mine Site. The majority of sightings are clustered along roads and other places frequented by people.

The lynx winter tracking survey (ENSR 2006) covered a 250-square-mile area centered on the NorthMet Project. The survey did not find any signs of lynx on the Project site itself, but DNA analysis of scat indicates four unrelated females within the greater survey area. Track surveys suggest that two individuals made most of the trails found. Although preferred cover types for the snowshoe hare exist on the site (e.g., jack pine, fir-aspen-birch, aspen-birch), the forest may be too old or too young for high hare densities (Moen et al. 2005). Lynx density may increase as snowshoe hare populations cycle from a low point.

Gray Wolf

A September 29, 2008 federal judge's ruling rescinded a March 2007 USFWS decision to delist the western Great Lakes population of gray wolves. As a result, the Gray Wolf is again a federally listed threatened species, although the USFWS still proposes to delist gray wolves in the Western Great Lakes (including MN) Distinct Population Segment. The Gray wolf is listed as a Minnesota Species of Special Concern. The Project is located within designated critical habitat for the Gray Wolf (43 FR 9607, March 9, 1978).

Populations of gray wolves have become re-established in several western states from their low point in the mid-1970s when only northeast Minnesota, among the lower 48 states, had a reproducing population. Gray Wolf populations in the western Great Lakes Region (i.e., Minnesota, Wisconsin, and Michigan) are expanding and have exceeded recovery goals for several years (Erb and Benson 2004). A 2007-2008 winter survey estimated that 2,922 gray wolves live in Minnesota, which is second only to Alaska in wolf populations among the U.S. states. MnDNR considers the Gray Wolf population fully recovered as it surpassed the federal delisting goal of 1,251 to 1,400 wolves (MnDNR news release, September 30, 2008).

In northern Minnesota, the principal prey of the Gray Wolf includes White-tailed deer, moose, beaver, hare, and muskrat, with occasional small mammals, birds, and large invertebrates. Most wolves live in 2 to 12 member family packs and defend territories of 20 to 214 square miles. In Minnesota, the average pack size is 5.5 individuals (Erb and Benson 2004). The forest and brush habitats at the NorthMet site are typical wolf habitat.

Radio-collared wolves were documented to the north and northeast of the Mine Site; wolf tracks were observed on the Mine Site in 2000; and calling surveys located wolves south of the Mine Site in 2004 (ENSR 2000, 2005). Because of typical wolf territory size, these reports likely represent a single pack.

Bald Eagle

The Bald Eagle (*Haliaeetus leucocephalus)* was removed from the Federal threatened species list on June 28, 2007. After a period of decline due to hunting and widespread use of DDT, Bald Eagle populations in the lower 48 states rose dramatically beginning in 1972. It continues to be listed by the State of Minnesota as a Species of Special Concern and by the USFS as a RFSS. In addition, the Bald Eagle is federally protected by the Bald and Golden Eagle Protection Act and the Migratory Bird Treaty Act.

The Minnesota Natural Heritage database (June 2007) contains records of 35 nests within 12 miles of the Project. These nests occurred in five groups, with each group assumed to represent nests in close proximity used by a single pair (Guinn 2004). No nests were recorded at the Project and field surveys found no evidence of any nests at the Project (ENSR 2005). Bald Eagles are typically associated with large lakes surrounded by mature forest where large trees provide suitable nest sites and eagles perch while searching for fish and other prey. No large lakes or large nesting trees are located at the Project and it is unlikely that Bald Eagles would use the Project site.

The five nearest Bald Eagle nesting territories ranged from 2.4 to 7.3 miles from the site (averaging 5.7 miles apart), substantially less than the average Bald Eagle nesting territory size in Minnesota (10 mile radius, averaging 20 miles apart). This suggests the area may be saturated with Bald Eagles and that no new eagles are likely to move into the area.

The Project area was also reviewed to evaluate whether it may provide wintering habitat for Bald Eagles. Eagles generally winter where there is available food at or near open water and where carrion is available. There are no large water bodies within the Project area that are likely to remain open in the winter. Animal-vehicle collisions on Dunka Road and/or natural deer mortality are not likely to produce sufficient carrion to sustain bald eagles at the Project (ENSR 2005).

Wood Turtle

The Wood Turtle (*Clemmys insculpta*) is a listed as a threatened animal species in Minnesota. The species range extends from Virginia to Nova Scotia and westward to Minnesota and northeast Iowa. The Project is located at the western edge of its range in Minnesota; populations are restricted to the eastern third of the state. Natural Heritage Program records indicate the northernmost population in the state was observed in the Partridge River, downstream of the Dunka Road bridge and about 0.7 miles from the Mine Site. Significant populations of Wood Turtle, however, are unlikely to be found at the Project because its preferred habitat of sandy-gravelly streams and bars, which are used for hibernating, mating, and nesting (Bradley et al. 2002), are not found at the Project.

Heather Vole

The Heather Vole (*Phenacomys intermedius)* is listed as a species of special concern by Minnesota, but is not federally listed or globally sensitive according to The Nature Conservancy (TNC). The Heather Vole is a habitat generalist, but generally inhabits the montane to alpine zone in upland forests, brushlands and meadows with low shrub species, and usually near water. Habitats of this type may occur at the Project; however, the Heather Vole has not been recorded within 10 miles of the Project by the Minnesota Natural Heritage Program (NHP). It was also not found in nearby surveys of small mammals on the Chippewa National Forest (Christian 1999) and in Cook County (Jannett 1998). It is at the southern edge of its range in far northern Minnesota and only a few collections of the species exist.

Yellow Rail

The Yellow Rail (*Coturnicops noveboracensis*) is a state-listed Species of Special Concern. It is not federally listed, although its global rank is considered marginally secure by TNC. Habitat for Yellow Rail includes lowland sedge meadows. Several small patches totaling 49 acres of wet meadow/sedge meadow occur at the Mine Site. The NHP, however, has no records of the Yellow Rail occurring within 10 miles of the NorthMet site and field surveys did not find any Yellow Rail at the NorthMet site (ENSR 2005).

Tiger Beetle

A species of Tiger Beetle (*Cicindela denikei*) is on the State Species of Special Concern list. Although it was not searched for during field surveys, it has not been reported by the NHP as occurring within 10 miles of the Project. This species inhabits sandy or rocky openings in hardwood forests. Hardwood forests occur on the Project site, but field surveys did not detect sandy or rocky openings in the forest. Rock exposures are evident in areas disturbed by past mining, but hardwood forests do not surround these areas.

4.4.1.2. Species of Greatest Conservation Need

The Minnesota Comprehensive Wildlife Conservation Strategy (MCWCS), an ecoregion-based wildlife management approach (MnDNR, 2006) identifies SGCN by ecoregion subsections based on a statewide approach. The MCWCS was created with input from multiple stakeholders and expert panels to cover issues of regional as well as statewide concern. The Project is located within the Nashwauk and Laurentian Upland subsection and includes six key habitat types (Table 4.4-1).

Table 4.4-1 Species in Greatest Conservation Need (SGCN) in the Nashwauk and Laurentian Uplands Subsections (MnDNR and USACE 2007) Which Occur or May Occur at the NorthMet Project

Key Habitat Type	Cover Types at NorthMet Project in the Key Habitat Types	Associated Species of Greatest Conservation Need[1]	Plant Site (Acres)	Mine Site (Acres)
1. Mature Upland Forest, Continuous Upland/Lowland Forest	Aspen forest/Aspen-birch forest, Jack pine forest, Mixed pine-hardwood forest	Veery, Whip-poor-will, Eastern Wood-pewee, Yellow-bellied Sapsucker, Ovenbird, Canada Warbler, ***Northern Goshawk***, Cape May Warbler, ***Spruce Grouse***, Winter Wren, Boreal Chickadee, Wood thrush, ***Black-backed Woodpecker***, *Bald Eagle*[2], ***Boreal Owl***, *Bay-breasted Warbler, Black-throated Blue Warbler*	653	1,351
2.Open Ground, Bare Soils	Disturbed/Developed	None	2,768	66

Key Habitat Type	Cover Types at NorthMet Project in the Key Habitat Types	Associated Species of Greatest Conservation Need[1]	Plant Site (Acres)	Mine Site (Acres)
3.Grassland/Brushland, Early Successional Forest	Brush/Grassland	Eastern Meadowlark, Franklin's Ground Squirrel, Brown Thrasher, White-throated Sparrow, Sharp-tailed Grouse, Golden-winged Warbler, *American Woodcock*, Northern Harrier, Sedge Wren, LeConte's Sparrow, Common Nighthawk, Black-billed Cuckoo, Red-headed Woodpecker, Tawny Crescent, *Least Weasel*	263	293
4.Open Water	Tailings basin, Partridge River, Embarrass River, former LTVSMC mine pits	Common Loon, Red-necked Grebe, Common Snapping Turtle, Northern Rough-winged Swallow, American White Pelican, Common Tern, Wilson's Phalarope, Black Tern, Trumpeter Swan	552	3
5.Wetland	Mixed hardwood swamp (Hardwood swamp, Eggers and Reed 1997), Black spruce swamp/bog (Coniferous swamp and Open bog, Eggers and Reed 1997)	Black Duck, American Bittern, Swamp Sparrow, Eastern Red-backed Salamander, Bog Copper, Disa Alpine, *Marbled Godwit*	189	1,303
6. Multiple Habitats	Combinations of Habitat Types	***Gray Wolf***[2] (1-3, 5), ***Canada Lynx***[2] (1-3, 5), Rose-breasted Grosbeak (1, 3), Macoun's Arctic (1, 3), ***Least Flycatcher*** (1, 3), *Connecticut Warbler* (1, 3), *Olive-sided Flycatcher (1, 4)*, Grizzled Skipper (2, 3), Nabokov's Blue (2, 5), Wood Turtle (1, 3, 4)[2,]		
Total			**4,425**	**3,016**

[1]Bold italicized text indicates SGCN species observed at NorthMet Project; italicized text indicates SGCN species targeted by ENSR (2005) that were not found; plain text indicates SGCN species identified as likely to be present at the Project site but not targeted in surveys.
[2]Bald Eagle, Gray Wolf, Canada Lynx, and Wood Turtle are or have recently been listed as Endangered, Threatened, or Special Concern (ETSC) species as discussed in detail in the ETSC species section.

Mature upland and lowland forest is the most common habitat type at the Project (primarily at the Mine Site), with the majority of the forest currently in the 5 to 12 inch diameter at breast height (dbh) class. Northern Goshawk, Spruce Grouse, Black-backed Woodpecker, and Boreal Owl were observed in these forests (ENSR 2005). These species represent a group of species that generally requires large forested blocks and/or minimal human intrusion.

Areas of open ground/bare soils are rare at the Mine Site, but abundant at the Plant Site in areas disturbed by the LTVSMC operations. No SGCN are associated with this habitat type.

Brush/grassland and very early successional forest (trees less than 5 inch dbh) are uncommon at the Project and are typically found as relatively small patches resulting from recent logging. The American Woodcock was observed at the Mine Site and the Least Weasel may occur as well. Most of the other SGCN species in *Table 4.4-1* are associated with large patches of grassland and savanna habitats that are not present at the Project.

Open water and aquatic communities are confined to the tailings basin at the Plant Site. The tailings basin attracts Canada Geese and other waterfowl during migration and may at other times as well; however, the Project area does not appear to provide good waterfowl or waterbird habitat. Common Loon, American White Pelican, Common Tern, Wilson's Phalarope, Black Tern, and Trumpeter Swan were searched for, but not found (ENSR 2000, 2004). The Common Loon is common in the nearby area (e.g., Partridge and Embarrass rivers), but was not observed at the tailings basin.

The Project, especially the Mine Site, contains a large expanse of wetlands habitat consisting primarily of coniferous and open bog. No wetland SGCN species, however, were observed at the Project. Marbled Godwit, which was surveyed for, was not found probably because its preferred habitat is graminoid wetlands and shallow marshes near extensive upland grassland, which are not present at the Project.

Multiple habitats are not mapped as such, but made up of combinations of habitat types. This category is used for SGCN species that are known to use multiple habitats during a season. The Gray Wolf, Canada Lynx, Least Flycatcher, and Wood Turtle were observed in the general vicinity of the Project and are known to utilize multiple key habitat types, including mature and early-successional upland forest and wetlands. The Connecticut Warbler, which also uses mature and early-successional upland forest and wetlands, was searched for, but not found. Similarly, the Olive-sided Flycatcher was searched for in both lowland forest and wetlands, but was not found, probably because it prefers more open and mature conifer and mixed conifer-deciduous stands. The butterfly species Grizzled Skipper and Nabakov's Blue are not found within 12 miles of the NorthMet Project and are unlikely to occur on the Project site as suitable habitat is not present.

4.4.1.3. Regional Foresters Sensitive Species

The Project would be located within the current boundaries of the Superior National Forest. The Forest Service manages for 21 RFSS of terrestrial wildlife on this forest. Four of these species are state ETSC species (i.e., wood turtle, heather vole, yellow rail, and tiger beetle) and are discussed above. Twelve other species are on the SGCN list and are discussed by habitat type in Table 4.4-1. These species are Northern Goshawk (*Accipiter gentilis*), Boreal Owl (*Aegolias funereus*), Olive-sided Flycatcher (*Contopus borealis*), Black-throated Blue Warbler (*Dendroica caerulescens*), Bay-breasted Warbler (*Dendroica castanea*), Connecticut Warbler (*Oporornis agilis*), LeConte's Sparrow (*Ammodramus leconteii*), Peregrine Falcon (*Falco peregrinus*), Disa Alpine (*Erebia disa mancinus*), Sharp-tailed Grouse (*Tympanuchus phasianellus*), Freija's Grizzled Skipper (*Pyrgus centaureae freija*), and the Nabokov's Blue (*Lycaeides idas nabokovi*). The remaining five species are discussed briefly below.

The Great Gray Owl (*Strix nebulosa*) is not state or federally listed nor is it tracked by the NHP. It is considered globally secure by TNC. Its preferred habitat includes coniferous and mixed forests and boreal bogs. These habitats are found at the Project. Calling surveys did not identify any Great Gray Owls at the NorthMet site (ENSR 2005); however, the USFS has records of a Great Gray Owl nesting unsuccessfully at the Project in 2006.

The Three-toed Woodpecker (*Picoides tridactylus*) is not state or federally listed and is globally secure according to TNC. This species was not searched for during field surveys, nor is it tracked by the NHP. A limiting factor for this species is foraging habitat where sufficient insects can be found to feed its young during the breeding season. Three-toed Woodpeckers prefer and are most abundant in large tracts of old growth coniferous forest near recent burns where they forage on dead and dying trees for bark beetles (Burdett and Niemi 2002). No old growth coniferous habitat or recent burns exist at the Project. A Three-toed Woodpecker was observed at the Mine Site by USFS personnel in 2007; however, the birds are unlikely to be common at the Project because of the lack of suitable habitat.

The Red-disked Alpine (*Erebia discoidalis discoidalis*), a butterfly, is not state or federally listed and is globally secure according to TNC. This species was not searched for during field surveys, nor is it tracked by the NHP. It was found in 1979 and 1982 at Greenwood Lake, about 12 miles from the Project. Its preferred habitat is acidic open bogs, of which there are 189 acres present at the Mine Site (see Table 5.1A), so this species may occur at the Project.

The Jutta Arctic (*Oeneis jutta ascerta*), a butterfly, is not state or federally listed and is globally secure. This species was not searched for during field surveys nor is it tracked by the NHP. However, 749 acres of its preferred habitat of spruce bogs is present at the Mine Site (see Table 5.1A), so this species may occur at the Project.

The Quebec Emerald *(Somatochlora brevicincta)*, a dragonfly, is not state or federally listed, however, it is considered vulnerable globally by TNC. This species was not searched for during field surveys, nor is it tracked by the NHP. However, the Minnesota Odonata Survey Project found an individual in northern Lake County approximately 30 miles north of the Project. This species' habitat requirements are not well understood in Minnesota, although reports suggest it that it inhabits poor fens. This habitat type is not found at the Project, but it is similar to wet meadow/sedge meadow habitat, which is found at the Mine Site.

4.4.2. Impact Criteria

The following criteria are considered in evaluating Project effects on wildlife:

- Direct effects to federally or state listed species due to the taking of an individual animal or population. Such effects may include deaths due to traffic collisions or during habitat destruction; a change in habitat use due to noise; or visual disturbance from lights, mining, and transportation activity.
- Indirect effects to federal or state listed species such as increased competition for resources or habitat due to displacement of individuals from an area into the territory of other animals; or other effects which cause mortality or reduced breeding and recruitment in the future population.
- Effects on habitat types that affect species population size and long-term viability for both federally or state listed species and other species potentially at risk (i.e., SGCN or RFSS species). These effects include direct impacts such as removal by clearing, burial, or other destructive activity. The effects also include indirect effects that occur within the general Project area (e.g., the Laurentian Uplands or Partridge River Watershed), but not necessarily at the Project site and/or could occur at a later point in time, such as a change in vegetation composition or dominance over a period of time; a change to another habitat type due to hydrologic changes; invasion by non-native species; or disruption of natural disturbance regimes (e.g., the annual natural hydrological cycle).

4.4.3. Environmental Consequences

4.4.3.1. Proposed Action

Endangered, Threatened, and Special Concern Animal Species

Canada Lynx

The Project area is not within current designated critical habitat for the Canada Lynx, but all of Lake and Cook counties and most of St. Louis County, encompassing the Project, have been proposed for inclusion (USFWS 2008). Surveys did not find any evidence of lynx use (e.g., breeding) at the Project site, but at least 20 different individual lynx were identified within 18 miles of the Project.

Site clearing and mining activities associated with the Project would potentially adversely affect lynx by reducing available habitat and increasing habitat fragmentation. The total impact from increased activity is not known, as lynx may habituate to increased activity. The Project would, however, result in the destruction of approximately 2 mi^2 of suitable lynx habitat, a mix of upland forest and lowland forest and bog. Assuming that the territory size of a resident lynx pair is 42 and 54 mi^2 (female and male territory size, respectively), this corresponds to a loss of 4 to 5% of the territory for a single pair of lynx. Any lynx currently using the Mine Site could expand their territory into surrounding areas since lynx density in the vicinity is considered low relative to the rest of the Minnesota lynx range (ENSR 2006). The effect on statewide lynx populations would therefore be insignificant since no individual lynx or pair of lynx would be significantly affected by the habitat loss. Habitat loss at the Mine Site, however, would result in fragmentation of lynx habitat in a portion of its current range.

The increased vehicle traffic associated with the Project, including train and small vehicle traffic between the Plant and Mine sites, could potentially result in vehicle collisions with lynx (Table 4.4-2). The Project would generate approximately 960 (948 vehicle and 12 rail) trips per day, totaling about 3,799 miles, between the Mine and Plant sites. This traffic would consist primarily of light trucks and maintenance vehicles traveling between 30 to 45 mph, and a few large fuel trucks, waste/supply trucks, and trains traveling between 25 to 40 mph. An additional 3,930 miles per day of vehicular traffic are expected within the Mine Site itself, primarily to haul ore to the rail siding and waste rock to stockpiles.

Table 4.4-2 Vehicular and Train Traffic Volume Between The Plant and Mine Sites (Barr Engineering).

Vehicle Type	Vehicle Weight (tons)	Speed	Road Segment	Trips per Day	Roundtrip Miles per Trip	Total Miles (per day)
Light Cars and Trucks	2	30-45	C, B, A	90	16.8	1512
Light Cars and Trucks	2	30-45	H	390	4.4	1716
Light Cars and Trucks	2	30-45	D	456	0.4	182
Light Vans	2	30-45	F-E	6	3.2	19
Fuel Trucks	40	25-40	H,C, B, A	3	21.2	64
Supply & Waste Trucks	40	25-40	B, C, D, F	2.4	25.2	60
Haul Trucks	Unspec-ified	30-34	J, B, A	1	17.6	18
Trains	3,000	15-25	Train track from mine area to plant site	12	19.0	228
Total				960	3.96	3,799

Table 4.4-3 Vehicle Traffic Within The Mine Site Only (Barr Engineering).

Vehicle type	Vehicle Weight (Tons)	Speed (mph)	Road Segment	Total Road Miles in Mine Site	Total Miles (per day)
Haul Trucks and Construction Vehicles	100-240	30-34	Mine area only	4.44	3,930

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 impact on lynx, since lynx use of the Mine Site appears to be very low and the area would be heavily affected by mining operations and not likely to be used by lynx during the active mining phase. State and federal forest lands near the Project 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.

Restoration of disturbed areas as part of mine closure would eventually create a complex of upland forest, wetlands, and open water at the Mine Site, which would likely serve as lynx habitat, but this successional process would likely 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 mine closure before suitable lynx habitat would again occur at the Mine Site.

In conclusion, the Project would be likely to adversely affect the Canada Lynx because of the direct loss of suitable habitat and fragmentation of additional habitat in an area proposed for designation as critical habitat and the increased potential for incidental take resulting from vehicular collisions.

Gray Wolf

The Project is located within designated critical habitat for the Gray Wolf. Observations indicate the likelihood of a single wolf pack whose territory includes the NorthMet site. The overall footprint of the Mine Site would remove approximately 2 square miles of habitat, or 1% to a maximum of 10% of a single wolf pack territory. This reduction in available habitat is relatively small and is not expected to significantly affect the wolf population in the region, which is considered healthy by the MnDNR. After mine closure, this area would again be available and suitable as wolf habitat, but this would not occur for over 40 years.

Vehicle collisions are a major cause of wolf mortality (Fuller 1989; Kohn et al. 2000; Mech 1977). The increased vehicular and rail traffic associated with the Project, including haul truck traffic within the Mine Site and truck and rail traffic between the Mine and Plant sites, could potentially result in vehicle collisions with wolves (see Table 4.4-2). Although there is the potential for incidental take from collisions, haul traffic at the Mine Site would likely have little direct impact on wolves because the area would be heavily affected by mining operations (e.g., high levels of noise, traffic, disturbance), which would discourage wolf use during the active mining phase. State and federal forest lands near the Project 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. Increased Project use of Dunka Road would increase the potential for vehicular collisions with wolves for the duration of mining operations.

The *Recovery Plan for the Eastern Timber Wolf* (USFWS 1992), which is the same species as the Gray Wolf, identifies five main factors critical to the long-term survival of this species. These critical factors are: 1) large tracts of wild land with low human densities and minimal accessibility by humans; 2) ecologically sound management; 3) availability of adequate wild prey; 4) adequate understanding of wolf ecology and management; and 5) maintenance of populations that are either free of, or resistant to, parasites and diseases new to wolves, or are large enough to successfully contend with their adverse effects.

In conclusion, the Project would be likely to adversely affect the Gray Wolf because of the direct loss of suitable habitat and fragmentation of additional habitat, as well as the increased potential for incidental take resulting from vehicular collisions. However, the Gray Wolf population in Minnesota (estimated at 2,922 gray wolves) is proposed for delisting by the USFWS and is considered fully recovered by MnDNR as it has surpassed the federal delisting goal of 1,251 to 1,400 wolves.

Bald Eagle

In Minnesota, Bald Eagles typically nest in large trees within 500 feet of lakes or rivers (Guinn 2004). Activities that occur within one-quarter to two miles of nests[1] may have adverse effects on nesting eagles. Generally, the closer the activity the greater the effect. The nearest recorded Bald Eagle nest is approximately 2.4 miles from the Mine Site; consequently, there should be no adverse effect on existing nesting eagles due to activities at the NorthMet Project.

Bald Eagle nesting territories in Minnesota generally have a 10-mile radius that varies with habitat quality (Guinn 2004). Bald Eagle nests near the Project area are on average 5.7 miles apart (3.8 to 9.4 mile range), which is less than the average territory radius and suggests that the area is saturated with Bald Eagle nesting territories and that no new eagles are likely to move into the area. As eagles become more numerous in an area, any eagles seeking to establish new territories in the Project area would need to select lower quality habitat and/or move into closer proximity to human activity. At the time of mine closure, the open water habitat created at the West Pit could potentially provide additional suitable nesting habitat for Bald Eagles.

Wood Turtle

The only known population of Wood turtles in the Project area is located downstream of the Dunka Road bridge and about 0.7 miles from the Mine Site. There is not

[1] The US Fish and Wildlife Service eagle management guidelines suggest that human activity within this tertiary zone can be seen by eagles and, depending on the level of screening and habituation of individual eagles, may cause them to abandon a nest.

suitable habitat for Wood turtles at the Project. Therefore, the Project should not have any direct effects on the Wood turtle.

The Project would not result in violations of water quality standards; therefore, there would be no Project-related changes to water quality in the Partridge River and no indirect effects on downstream habitat where Wood turtles are located. Changes in the Partridge River that may affect the Wood turtle include increased sedimentation and modifications in the flow regime. A small decrease in runoff volume during the active mining period is not likely to negatively affect the Wood turtle. The most likely effect of a decrease in water level would be to expose additional areas of riverbank for nesting. Over the long term, gains in exposed soil at the lower bank would be lost to vegetation growth at the upper bank.

Heather Vole

- The Heather Mole has not been observed during field surveys within 10 miles of the Project or found in small mammal surveys in the region (Christian 1999; Jannett 1998) and is at the southern edge of its range. Potentially suitable habitat does exist at the Mine Site, so the Heather Vole could be present, but, if so, likely in very small numbers. The Project would impact much of the Heather Vole's potential habitat on-site, but is unlikely to jeopardize the presence of Heather Vole in Minnesota.
- Yellow Rail
- The Yellow Rail was not found during surveys at the Mine Site and was not reported in NHP database within 10 miles of the Project area. Small, scattered areas of its preferred habitat, wet meadow/sedge meadow, are present at the site, but the minimum nesting patch size used by rails (54 acres; Goldade et al 2002) exceeds the total amount of suitable habitat on site. Since the 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 to be present at the Project site. Therefore, the Project should have no effect on the Yellow Rail.
- Tiger Beetle
- The lack of suitable habitat and any recorded observations in the Project area for the Tiger Beetle (*Cicindela denikei*) suggest that the species does not exist at the Project site. Therefore, the Project should have no effect on the Tiger Beetle.

Species of Greatest Conservation Need

The Project would affect SGCN as a result of increased human activity, collisions with vehicular and rail traffic, and loss of habitat.

Increased Human Activity

Direct impacts due to increased human activity and consequent increases in trapping and hunting are unlikely during the life of the mining operation because public access would be restricted. The main access road (Dunka Road) is privately owned and would remain gated to prevent non-mining access. However, some increase in human use may occur following mine closure as some Project access roads would remain open for ongoing monitoring and could be accessed for recreational purposes.

Increased human activity may also frighten some species and discourage their use of otherwise suitable habitat. In general, suitable habitat is available in the Project area and most mobile animal species would simply be displaced. Less mobile species would likely incur relatively high mortality rates.

Vehicular and Rail Traffic Impacts

Vehicular and train traffic, primarily between the Mine and Plant sites, is expected to average approximately 3,799 miles per day with travels speeds averaging between 30 and 45 mph, with trains, fuel, and waste/supply trucks traveling somewhat slower (see Table 4.4-2). There is additional vehicular traffic totaling approximately 3,930 miles per day within the Mine Site itself (see Table 4.4-3).

Traffic impacts from collisions with wildlife depend to a large extent upon micro-site features, traffic volume, traffic speed, and the species involved (Forman et al. 2003). Micro-site features that increase the potential for road impacts are the presence of wildlife travel corridors across, and attractive habitat along, roads. The high density of wetlands at the Mine Site and the proposed retention of wetland “islands” among the haul roads may result in a relatively high rate of amphibian and turtle impacts. Shrub and trees near roadsides can increase road crossings by deer and bird use.

Wildlife mortality generally increases with increasing traffic volumes and speed. In general, highly mobile species and habitat generalists are expected to have higher road mortalities. While mortality estimates vary widely, a rough estimate based upon the number of road miles is between 63 and 725 total traffic related wildlife mortalities at the Project per year (Forman et al. 2003).

There is little research on the visual and noise effects of traffic on certain animal groups (e.g., invertebrates, reptiles, amphibians). Small passerine birds appear affected by noise at distances up to several hundred meters from a road, while other wildlife groups (e.g., mammals) appear less sensitive (Kaseloo and Tyson 2004). The barrier effect of roads is greater for small mammals, amphibians, and reptiles than for birds and large mammals (Kaseloo and Tyson 2004). Edge effects in the small preserved forest island remnants between haul roads at the Mine Site would be greatest for species that require large blocks of continuous habitat (i.e., “area sensitive” or “core habitat” species). Some SGCN species are of this type. In general, the indirect effects of the Proposed Action are expected to be significant for some SGSN species in the Mine Site and along the road and railroad, but not significant at the scale of the Nashwauk and Laurentian Uplands or the Partridge River watershed.

Wildlife Habitat Impacts

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 Proposed Action. The area disturbed was derived from the U.S. Geological Service (USGS) Level 3 Gap Analysis Program (GAP) GIS data and the 2006 mine features layers from the MnDNR Division of Lands & Minerals. The impact was considered more severe if it would occur to a "significantly reduced cover type" (i.e., one that covered at least 5% of the land surface in the 1890s and experienced a greater than 50% decline in the 1890 to 1990 period). Jack pine forest has faced significant reductions over historical levels in the Laurentian Uplands Subsection and is considered a "significantly reduced cover type." Other cover types at the Project are at or above historic levels in this Subsection (MnDNR 2006).

Table 4.4-4 Direct Effects of the Proposed Action on Key Habitat Types

Key Habitat Types	Directly Affected at Mine Site (Acres)	Directly Affected at Plant Site (Acres)
Mature Upland Forest, Continuous Upland/Lowland Forest[1]	611	151
Open Ground, Bare Soils[2]	0	946
Brush/Grassland, Early Successional Forest	245	55
Open Water	1	539
Wetland[3]	597	63
Multiple Habitats	NA	NA
Total	**1,454**	**1,754**

[1] Contains significantly reduced cover types Jack pine forest (84 acres) and Mixed pine-hardwood forest (460 acres). Lowland forest may include small areas of wetlands not reflected in the total wetland impact of the project.
[2] The GAP GIS data did not map mud flats, but the NorthMet Project Description reports that the tailings basin contains 389 acres of "beach," of which 145 acres on average are expected to be bare, wet soil. Bare wet soil is important habitat for several SGCN species in the region.
[3] The tailings basin is not considered a jurisdictional wetland. However, this wetland provides habitat for open water and mud flat species. Wetland acreage provided here is based solely on land cover mapping and therefore varies from the wetland acreage delineated for regulatory purposes as described in Section 4.2.

Mature Upland/Lowland Forest

Most of the Plant Site is developed or disturbed with only approximately 16% of the site (691 acres) consisting of forest habitat. Approximately 151 acres of this forest habitat at the Plant Site would be disturbed, most of which are in small or isolated patches of aspen-birch forest that are in poor to fair condition and that do not represent any significantly reduced cover types. Therefore, the Project would have little effect on SGCN in mature upland/lowland forest habitat at the Plant Site.

At the Mine Site, approximately 611 acres (45%) of the upland and lowland forest would be lost as a result of the Project, including about 84 acres of jack pine forest, which, as indicated above, is considered a "significantly reduced cover type" in the Project area. All of the SGCN species found in this mature forest habitat are birds (see

Table 4.4-1), which would be displaced, but likely not injured or killed, during mine construction and operation.

Reclamation of the Mine Site would include revegetating nearly all disturbed ground according to Minnesota Rule 6132.2700. At the Mine Site, red pine would be planted to reclaim approximately 792 acres of the Category 1/2 and 3 stockpiles, although woody growth would be controlled on the tops and benches of the Category 3 stockpiles to prevent deep-rooted trees from penetrating the cap.

Tree plantings would begin to resemble forest habitat types in approximately 10 to 30 years following mine closure. Natural succession may increase the jack pine composition within the red pine restoration area. Because most of revegetation areas are contiguous with remaining upland/lowland forest, the resulting size of the continuous upland/lowland forest patch at the Mine Site would be restored to near pre-mine levels, which would restore much of the SGCN species habitat.

Natural succession would also alter the 148.4 acres of removed stockpile areas at the Mine Site that would be re-vegetated with grasses and other herbaceous materials. Initial colonization by lighter-seeded aspen, willows, and perhaps paper birch would begin at Year 20 following stockpile removal. Subsequent colonization and establishment by heavier-seeded tree species is likely to begin slowly and accelerate after Year 40 (20 years after mine closure) when pole-sized aspen become established. At Year 60 (40 years after mine closure), it is expected that the deciduous forest would contain a greater variety of tree species, possibly including jack pine, paper birch, white spruce, and balsam fir. Natural succession would likely be slower in the tailings basin and in areas with compacted soils (such as reclaimed mining roads)—perhaps taking 50 to 100 or more years in some locations.

Reclamation and re-vegetation on the Mine Site after closure would improve wildlife habitat relative to conditions during mine operations; however, the quality of habitat for SGCN species is likely to remain degraded for some decades after mine 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 species using open ground/bare soils at the Project is small. These areas were created by past mining activity and are expected to decrease after mine closure as a result of reclamation. Therefore, Project effects on open ground/bare ground habitat should result in little adverse effect on wildlife.

Brush/Grassland

Brush/grassland (including early successional forest) at the Project consists of small vegetative patches that are generally not very attractive to SGCN species. Young trees (<4" dbh) make up most of this habitat type. One SGCN species associated with this habitat type was confirmed present at the Mine Site (American Woodcock); Least

Weasel may occur as well. Most of the other SGCN species (see *Table 4.4-1)* are associated with large patches of grassland and savanna habitats, which are not present at the Mine Site. Approximately 245 of the 293 total acres of brush/grassland at the Mine Site would be directly impacted by the Project. Approximately 55 of the 263 acres of brush/grassland at the Plant Site would be directly affected by the Project. Overall, the Project would have minor adverse effects on grassland/brush SGCN species.

Mine reclamation would create 211.7 acres of seeded grassland. In addition, PolyMet would remove or cover portions of the existing road, railroad, ditch, and dike systems and restore them as well as the tailings basin with grass/herbaceous seeding, resulting in an estimated 2,803 acres of grassland/shrub and wetland habitat after closure at the Plant Site. Reclamation of these areas that currently constitute poor wildlife habitat would ultimately enhance wildlife habitat in comparison to current conditions. Some SGCN species, including Eastern Meadowlark, Northern Harrier, and Common Nighthawk, would likely use the grasslands until they are replaced by early successional forest about 20-50 years after mine closure, although these species are not common in the Iron Range. Early successional forests are likely to support the SGCN White-throated Sparrow and American Woodcock.

Open Water

Open water at the Project primarily occurs in the tailings basin. None of the targeted SGCN species were observed on open water during the site survey; however, common waterfowl and water birds were observed at the tailings basin during migration, in particular Canada Geese and ducks. Much of this open water habitat at the Project would be impacted during mine operations. The open water of the tailings basin, however, is unlikely to provide valuable habitat because of the lack of emergent or submerged vegetation for feeding waterfowl, associated vegetated fringes, or upland nesting areas.

As part of mine closure and reclamation, PolyMet proposes to drain the tailings basin and plant herbaceous species, which would result in the loss of about 539 acres of low quality open water habitat. PolyMet would also create approximately 278 acres of open water habitat by eventually flooding the West Pit, which is estimated to fill approximately 40 years after mining ceases. Water quality in the West Pit would generally be poor due to a downgradient zone that would probably exceed the MCL for antimony and arsenic once the pit is full. Despite the presence of these pollutants, the West Pit would provide comparable open water habitat to that which was in the tailings basin prior to draining.

Wetlands

This section focuses on the effects on wildlife species that use wetland habitats; additional discussion on wetland conditions and impacts is presented in *Section 4.2*. Of the SGCN wetland-related species, the Marbled Godwit and Olive-sided Flycatcher were searched for, but not found during site surveys (ENSR 2005); the Black Duck, American Bittern, and Swamp Sparrow are not likely to be present because they require non-forested wetlands and open water, which are relatively scarce on-site; the Red-Backed Salamander is primarily an upland species, but may be present along the edges of mixed hardwood swamps; the Bog Copper was not found during site surveys and there are no records of any sightings within 12 miles of the site; and the Disa Alpine butterfly may inhabit the black spruce bogs of the Mine Site and has been found twice within 12 miles of the Project.

Based on the more accurate site-specific wetland delineation (rather than the less accurate Level 3 GAP GIS data), the Project would impact approximately 1,008 acres of wetlands (660 acres of direct impacts and 348 acres of indirect impacts), primarily coniferous bog (539 acres of total impacts) and open bog (78 acres of total impacts). Although on-site wetland use by the SGCN species described above may be limited, these wetlands are generally considered to be of high quality and provide valuable habitat to a wide range of wildlife species.

Some 36,565 acres of wetland habitat exist in the Partridge River watershed surrounding the site. The wetland types affected at the Project, primarily black spruce and open bogs, are common in the Partridge River watershed and are not considered diminished cover types in the Laurentian Upland Subsection. Consequently the loss of this habitat at the Mine Site is expected to displace wildlife into surrounding similar habitat, which would be sufficiently large to absorb the displaced wildlife.

Wetland mitigation is proposed both on-site and off-site. Approximately 175 acres of shallow and deep marsh wetland creation is proposed for on-site mitigation. This is significantly less than the wetland acreage lost and would not replace in-kind the wetland habitat impacted (primarily coniferous and open bogs). Off-site mitigation would consist of 1,123 acres of wetland creation consisting of various habitat types at two sites and an additional 202 acres of upland buffer at both sites (see Section 4.2). The proposed off-site mitigation, would result in the creation of substantially different habitat types, in a different eco-region, and in a different watershed (e.g., outside the St. Louis River watershed) than that of the impacted wetlands at the Project.

The SGCN species most likely to be present at, and affected by, the Project (e.g., Bog Copper, Disa Alpine) may use the off-site mitigation, although these sites provide less coniferous bog and more of other wetland habitat types (e.g., sedge meadow, marsh, shrub-carr, and hardwood and coniferous swamp) than occur at Project. SGCN species that utilize shallow and deep marsh and open water habitats created at the Mine Site in the East and West Pits would likely benefit from on-site mitigation. These may include American Bittern, Swamp Sparrow, and Black Duck, but their presence depends on the vegetation quality established after mine closure.

Multiple Habitats

The species using multiple habitats and known to occur on or near the Mine Site (e.g., Gray Wolf, Canada Lynx, Least Flycatcher) are discussed above. Most multiple-habitat SGCN species use mature/continuous and early successional forest. Project effects are therefore largely limited to the mature/continuous forest above.

Regional Foresters Sensitive Species

The USFS manages 21 RFSS of wildlife in the Superior National Forest. Four of these species are ETSC species and are discussed above. Twelve of these species are also on the SGCN list and are discussed by habitat type above. The analysis of potential impacts to the remaining five RFSS of wildlife, which are not federally or state listed ETSC or SGCN species, are discussed below:

- The Great Grey Owl may be occasionally present at the Mine Site, since individuals have been seen nesting in the area. However, since this nest was unsuccessful, and subsequent owl calling surveys found no owls, populations in the area are likely small and/or occasional. Owls are sensitive to disturbance, so populations would be unlikely to use the Mine Site during mine operations. Because populations are thought to be low, impacts to the Great Grey Owl populations are expected to be minimal.
- Systematic survey data for Three-toed woodpeckers are lacking, however, one bird was observed by USFS personnel in 2007. Generally, the young condition of the forest habitat at the Project is not suitable for Three-toed woodpeckers, and they are unlikely to be common. Woodpeckers are sensitive to disturbance and would not be expected to use the Mine Site during mining operations. Because populations are expected to be low, impacts to the Three-toed woodpecker populations are expected to be minimal.
- Survey data are lacking, but the Red-disked Alpine butterfly's acidic open bog habitat is present in the Mine Site. Since 73 of the 189 acres of this habitat present at the Mine Site would be disturbed by the Project, impacts to this species may occur. This species, however, is not an ETSC or SGCN species and is globally secure; therefore, the Project is unlikely to jeopardize the presence of this species in Minnesota.
- Although the Jutta arctica has not been found at the Project, 749 acres of this butterfly's preferred spruce bog habitat is present on the Mine Site. The Project would impact 492 acres of this spruce bog habitat. If this species is present at the Project, it would incur impacts. This species, however, is not an ETSC or SGCN species and is globally secure; therefore, the Project is unlikely to jeopardize the presence of this species in Minnesota.
- The Quebec Emerald dragonfly inhabits poor fens, a wetland type similar to wet meadow/sedge meadow found at the Mine Site. Approximately 41 of the existing 49 acres of wet meadow/sedge meadow at the Project would be affected by mining

activities. The presence of the Quebec Emerald in the region and the existence of similar habitat at the Project site suggest that this species may be impacted by the Project. This species, however, is not considered a SGCN and, therefore, the Project is unlikely to jeopardize the presence of this species in Minnesota.

4.4.3.2. Alternatives

No Action

The No Action alternative would likely have a neutral to slightly positive effect on wildlife. It is assumed that the LTVSMC plant site reclamation would proceed as planned including revegetation of open ground and disturbed soil, removal of buildings, and revegetation of the tailings basin. The Mine Site, which is primarily young forest, would continue to mature, except where it is logged, which would benefit the majority of the SGCN species found or likely to occur at the NorthMet Project that prefer mature forest habitat.

Subaqueous Disposal Alternative

The subaqueous disposal alternative would dispose of the more reactive Category 2, 3, and 4 waste rock in the East Pit as opposed to long-term surifical stockpiles, thereby reducing the total areal footprint of the stockpiles at mine closure. This alternative would reduce the impacts primarily to jack pine forest and mixed hardwood swamp habitat and retain these areas for resident wildlife species.

Also, under this alternative, shallow/deep water marsh habitat would be created in the East Pit in a fashion similar to the Proposed Action. The shallow/deep marsh wetland type is currently rare at the Mine Site and therefore would not mitigate the direct impact to black spruce swamp/bog (coniferous swamp and open bog of Eggers and Reed) and mixed hardwood swamp (hardwood swamp of Eggers and Reed). The shallow/deep marsh may attract wildlife, as water quality in the East Pit under this alternative would constitute an improvement over the proposed action. This alternative would eliminate potential MCL exceedances for several key metals (copper and nickel), although water quality would still potentially exceed the secondary MCLs for iron, manganese, and aluminum.

Other Mitigation Measures

Section 3.2.2.5 describes several potential additional mitigation measures for impacts from the Project. Several of these measures have the potential to affect wildlife and are discussed below.

As discussed above, the potential for wildlife mortality resulting from vehicle collisions is high given the projected annual traffic volumes. This is especially critical for ETSC species (e.g., Gray Wolf, Canada Lynx, and Wood Turtle). The risk of vehicle collisions with wildlife could be reduced by controlling vehicular speeds, educating drivers using Dunka Road about potential collisions, and other similar prevention and avoidance techniques.

PolyMet currently proposes to reclaim disturbed areas as part of mine closure primarily with a combination of red pine and herbaceous planting. Although rapid stabilization of these disturbed areas is a priority, there may be opportunities to enhance wildlife habitat using alternative revegetation measures. Planting a broader mix of native conifers and other native trees, shrubs, forbs, and grasses would result in a more diverse and better quality wildlife habitat at an earlier stage of forest succession. In addition to red pine, other appropriate species to plant could include jack pine, white pine, red fescue, Canada goldenrod, and other native plants that have proven successful in mine land reclamation projects in the Laurentian Mixed Forest Province. Patches of forest with non-forested openings provide ideal habitat for white-tailed deer, a major wolf food in the Arrowhead Region. The Canada Lynx would benefit from a focus on conifer species that would provide winter habitat for snowshoe hare, the lynx's preferred food.

At mine closure, the surface of haul roads and other infrastructure would be scarified and vegetatively stabilized; however, they would continue to potentially provide access to this area. Prohibiting off-road vehicles and foot traffic by no trespassing signage, and installing gates, rock barriers, or berms at likely entry points to the Mine Site would reduce human intrusion, enhance habitat restoration, and promote wildlife use.

The following potential mitigation measures may also indirectly benefit wildlife:

- Monitoring of Waste Rock Stockpiles and Tailing Basin – would help ensure that water quality would meet state standards and not adversely affect wildlife at the Project.
- Chemical Modification of the Reactive Waste Rock Stockpiles – application of lime to neutralize ARD would help ensure that changes in water quality would not adversely affect wildlife.
- Use Overburden in the East Pit – reuse of overburden to help create wetlands in the East Pit would help restore native habitat and also reduce the permanent footprint of the overburden stockpile. In order to maximize wildlife benefits, the East Pit should be filled to create a shallow emergent marsh, which would be similar to the lost wetland habitat, rather than a deep marsh with open water.
- Maximize the Elevation of the Category 1/2 Stockpile – maximizing the height of the Category 1/2 stockpile would reduce the footprint of this stockpile and thereby minimize direct impacts to wildlife habitat, although it is expected that the reduction in direct impacts would be small (e.g., a few acres) because the stockpile height is already at or close to its maximum height from a geotechnical engineering perspective.

Cumulative Impacts

Cumulative impacts affecting wildlife may include the loss or fragmentation of habitat and encroachments into critical wildlife travel corridors. These impacts were assessed by evaluating the effects of the proposed action with other past, present, and reasonably foreseeable future federal, state, tribal, and private actions.

Loss and Fragmentation of Wildlife Habitat

The study area for loss and fragmentation of habitat was the 16,848 square-mile Arrowhead Region consisting of eight ecological subsections. The Project is in the 1,266 square-mile Nashwauk Uplands (Plant Site) and the 886 square-mile Laurentian Uplands (Mine Site) subsections. The extent of habitat loss and fragmentation in the Arrowhead Region was analyzed semi-quantitatively using:

- Minnesota's Comprehensive Wildlife Conservation Strategy (MCWCS);
- Marschner's Original Pre-settlement Vegetation Map of Minnesota as interpreted and analyzed by researchers, the Minnesota Forest Resources Council, and at the subsection level in the MCWCS approach by the MnDNR;
- Scientific literature and reports (e.g., Minnesota Generic Environmental Impact Study on Timber Harvest, University of Minnesota researchers, Minnesota Forest Resources Council);
- Reports on mining, infrastructure, and forestry impacts (e.g., MnDNR Lands & Minerals Division mining impact and permit GIS data; Superior National Forest Management Plan Revision Final Environmental Impact Statement; state and county timber harvest data); and
- GIS land cover and ecological data (e.g., MNGAP Analysis Level 3 GIS data) and summaries of GIS land cover and ecological data in the MN GEIS on Timber Harvest, by the Minnesota Forest Resources Council as part of the MCWCS approach.

The MCWCS is a central component of MnDNR's strategy for managing wildlife populations in the state; use of the MCWCS is therefore appropriate as the basis for assessing cumulative effects on wildlife habitat loss and fragmentation for the NorthMet Project.

Past and Current Habitat and Wildlife Trends

Two periods of changes in forest composition were evaluated – the 1890s-1990s and 1977-1990, as indicative of past and relatively current trends in wildlife habitat, respectively.

Forest changes from the 1880s to the 1990s are indicative of past wildlife habitat trends. The MCWCS approach uses Marschner pre-settlement mapping as a baseline for describing changes taking place in sixteen vegetation types/ecosystems since the

1800s, using recent land cover data from the MnGAP Analysis and reported by ecological subsection (MnDNR 2006b). The effects on wildlife were evaluated by noting the change in amount of each Marschner habitat type in terms of the effect on wildlife species which use that habitat type. Wildlife habitats that decreased in acreage from pre-settlement to current conditions present a higher risk of future SGCN species population decreases and are in greater need of conservation in Minnesota.

The changes in habitat types in the Nashwauk and Laurentian Upland subsections from the 1890s to 1990s are presented in *Table 4.4-6*. These data indicate a significant decrease occurred from the 1890s to 1990s in red-white pine forest and mixed pine-hardwood forest in the Nashwauk Uplands, and in jack pine woodland in the Laurentian Uplands. At the Project, there is little red-white pine forest; about 1,003 acres of mixed pine-hardwood forest (but it is in the Laurentian rather than the Nashwauk uplands); and 183 acres of jack pine forest (in the Laurentian Uplands). Although much of the Mine Site is classified as "Mature Upland Forest" by MnDNR definition (> 5-inch dbh), in fact most of this forest is still relatively young.

Table 4.4-6 Change in habitat types in the Nashwauk and Laurentian Upland Subsections from the 1890s to 1990s [1]

Habitat Type	Nashwauk Uplands Subsection (Plant Site and Tailings Basin)		Laurentian Uplands Subsection (Mine Site)	
	% of Subsection Land Surface in 1890s	% of Subsection Land Surface in 1990s	% of Subsection Land Surface in 1890s	% of Subsection Land Surface in 1990s
Aspen Forest (Upland Deciduous Forest)	32.5	32.0	34.6	36.1
Lowland Conifer Forest/Shrubland	25.2	21.3	28.2	35.3
Jack Pine Woodland (Upland Shrub/Woodland)	10.5	19.4	19.4	4.7
Red-White Pine Forest (Upland Conifer Forest)	17.9	9.9	13.2	17.4
Mixed Pine-Hardwood Forest (Upland Deciduous Forest)	7.1	1.7	0	0
Grassland	0	5.2	0	0
Water[2]	6.3	6.1	0	0

[1] Minnesota Department of Natural Resources 2006b
[2] Water was not used in calculations for the Laurentian Uplands Subsection.

Other data for northeastern Minnesota (MFRC 1999) also show that conifer species (e.g., tamarack, white pine, jack pine, red pine, spruce) and birch declined significantly in abundance, while other deciduous (e.g., aspen/cottonwood, sugar maple/maple, ash, balm-of-Gilead) and fir trees increased from the late 1880s to the 1990s. At the time of European settlement, forest patches were typically large and were dominated by a few species with white pine common in most forests (Friedman et al. 2001). In the majority of the region, forest communities have shifted from pine and tamarack as consistent co-dominants with other tree species, to aspen as a consistent co-dominant with other tree species, resulting in a loss of landscape diversity (Jaakko Poyry 1994, Friedman and Reich 2005). Further, research indicates that current mature forest represents only about 4.4% of the old growth acreage that existed in the 1800s (Jaakko Poyry Consulting 1994).

Current trends in habitat and wildlife are indicated by 1977-1990 forest changes. Forest harvesting data circa 1990 indicate overharvesting of some cover types (e.g., aspen, jack pine) in northeast Minnesota, although overall harvesting was less than the net growth of forests (MFRC 1999, Jaakko Poyry 1994). The USFS data (1977-1990) show significant increases in elm-ash-soft maple, tamarack, northern white-cedar, red-white pine, and maple-basswood forest. Spruce-balsam fir, black spruce, jack pine, and aspen-birch forests declined significantly. Some forest types (e.g., tamarack) that are currently increasing include species that decreased in abundance during the last century.

In general, land use in the Arrowhead Region over the past century has reduced the conifer component, size, age, and diversity of forests. The greatest impact has been to jack pine, red-white pine, and mixed pine-hardwood forests. Reasons for the change include past timber harvesting, catastrophic wildfire, fire suppression, current timber harvesting practices, and general climate change.

Although there have been changes in forest composition, the Minnesota Forest Resources Council (1999, 2003) concluded that the extent of current forest cover in northeastern Minnesota is approximately the same size as it was in the late 1800s. The Mesabi Iron Range is the largest developed area in northeast Minnesota, followed by Duluth and other smaller towns (*Figure 2.3*, MFRC 1999). Agricultural use is minimal. Developed land (including mined lands), cropland, and pasture land total 11% of the Nashwauk Uplands and 1% of the Laurentian Uplands (MnDNR 2006). The balance is forest (54% and 79%, respectively), wetlands, and open water. The majority of forest land in northeast Minnesota is public (MFRC 1999), including reserved forests in the Boundary Waters Canoe Area Wilderness, Voyageurs National Park, and state parks. Private forest ownership is shifting from farmers and industry to private individuals, especially near lakes.

Wildlife in northeast Minnesota is affected by habitat changes. Lane et al. (2003) concluded that past management practices produced a landscape pattern that contains less habitat for species needing large habitat patches, and poorer quality habitat for species requiring older and more diverse forest vegetation. The MFRC (1999) evaluated 1977-1998 MnDNR data and concluded that some wildlife populations (e.g., otter, fisher, marten) have increased over that period, while some were stable or within normal cyclical patterns (e.g., bobcat, ruffed grouse). More recent data show white-tailed deer, which were in decline historically, have recently increased dramatically (MnDNR 2008), but moose may have declined, although long term trends are not clear (MnDNR 2008).

These studies generally suggest that Minnesota's forests are recovering from poor harvesting practices of a century ago and that wildlife is responding accordingly. The total amount of forest cover has returned to 1890 levels and the conifer component has recently increased, although not all conifer types have recovered (e.g., jack pine). As a result, wildlife species that depend on forest cover with a conifer component were harmed by past forest changes but are favored by recent forest changes in the Arrowhead Region. Wildlife species that require mature to old forests or large forest patches were harmed by past forest changes, but may benefit from recent forest changes.

Future Habitat and Wildlife Trends

An assessment of future cumulative impacts through 2014 from forestry, and for an unstated near-term period from mining and non-mining development, was completed for the 16,848 square-mile Arrowhead Region (EOR, 2006). This study estimated a loss of approximately 14 square miles (0.1%) for all cover types used as wildlife habitat in the Arrowhead Region. Forestry accounted for approximately 84%, mining 10%, and non-mining development 6% of these wildlife habitat losses.

The MnDNR (2007b) calculated that 0.87 square miles (0.56%) of wildlife habitat would be lost due to reasonably foreseeable future urban development and mining within the Nashwauk Uplands through the year 2026. The MnDNR did not calculate losses due to forestry because forestry is assumed to result in relatively rapid recovery to forested conditions, whereas mining and development require longer periods to recover. This estimate of the future impact of mining and non-mining development is consistent with EOR (2006) finding that forestry has a significantly greater effect on wildlife habitat than mining and non-mining development.

Table 4.4-7 Losses of Wildlife Habitat Due to Reasonably Foreseeable Urban Development and Mining

			Future Losses to Urban/Developed		Future Losses to Mining		Total Future Losses to Urban/Developed & Mining	
Habitat Type	**Acres in Nashwauk Uplands**	**Percent of Nashwauk Uplands**	**Acres**	**Percent of Habitat Type**	**Acres**	**Percent of Habitat Type**	**Acres**	**Percent of Habitat Type**
Open Wetland	6,014	0.7	2	0.03	4	0.07	6	0.1
Lowland Deciduous	13,000	1.6	6	0.05	3	0.02	9	0.07
Lowland Conifer/Shrubland	160,541	19.8	7	0	10	0.01	17	0.01
Upland Conifer	75,025	9.0	6	0.01	3	0	9	0.01
Upland Deciduous (Aspen/Birch)	234,518	29.0	46	0.02	102	0.04	148	0.06
Upland Deciduous	15,995	2.0	4	0.03	18	0.11	22	0.14

			Future Losses to Urban/Developed		**Future Losses to Mining**		**Total Future Losses to Urban/Developed & Mining**	
Habitat Type	**Acres in Nashwauk Uplands**	**Percent of Nashwauk Uplands**	**Acres**	**Percent of Habitat Type**	**Acres**	**Percent of Habitat Type**	**Acres**	**Percent of Habitat Type**
(Hardwoods)								
Upland Shrub/Woodland	133,684	16.5	21	0.02	42	0.03	63	0.05
Water	31,989	3.9	1	0	4	0.01	5	0.02
Cropland	9,000	1.1	1	0.01	1	0.01	2	0.02
Grassland	30,456	3.8	23	0.08	17	0.06	40	0.13
Subtotal Vegetated Habitat	710,222	87.7	117	0.02	204	0.03	321	0.05
Urban/Developed	8,779	1.1	20	0.23	14	0.16	34	0.39
Mining	91,013	11.2	21	0.02	500	0.55	521	0.57
Subtotal Urban/ Developed and Mining	**99,792**	**12.3**	**41**	**0.04**	**514**	**0.52**	**555**	**0.56**
Total	**810,014**	**100**	**158**	**0.02**	**718**	**0.09**	**876**	**0.11**

The future impact of forestry practices on wildlife habitat in the six Arrowhead counties (Cook, Lake, St. Louis, Itasca, Carlton, Aitkin) was estimated over the next 20 years for this EIS using data from the Superior National Forest Revised Management Plan (USDA Forest Service 2004a and 2004b); the MnDNR (2006) timber sale database; St. Louis County timber harvest plans; and MnDNR estimates of private forest harvests (Miles 2007; Pro-West and Associates 2007). From these sources it is estimated that future timber harvest due to government and private actions may annually affect about 65.6 square miles (0.9%) of the nearly 7,100 square miles of timberland in the 15,125 square miles constituting the Arrowhead counties.

Logging temporarily changes wildlife habitat by reducing the acreage of mature forest. Timber harvesting trends are shifting to more longer-rotation harvests that promote the regeneration of conifers. If this trend continues, the acreage of late-successional forest would increase, especially in spruce-fir and mixed conifer-deciduous stands (Mehta et al. 2003).

Cumulative impacts from historic, current, and reasonably foreseeable future mining activities in the Arrowhead Region (primarily the Mesabi Iron Range) are estimated to be 238 square miles. Existing mine features (already disturbed wildlife habitat) cover 188 square miles. These features include ore mines that were in operation before permitting requirements were established by the State, as well as past and currently permitted taconite mines. Future losses of existing vegetative cover types due to all recently permitted mining projects on both public and private lands in the Mesabi Iron Range total approximately 50 square miles (*Table 4.4-8*). This estimate is inconsistent with the EOR, 2006 data described above because the DNR data likely includes additional projects permitted since the EOR study was published. Recently permitted projects would primarily impact upland conifer habitat, with grasslands, open wetlands, existing urban/developed land, upland deciduous hardwoods, and upland conifer-deciduous habitats affected to a lesser extent. The grasslands are unlikely to be native prairie, but rather non-native hay meadows, pastures, and reclaimed mine sites.

Table 4.4-8 Losses of wildlife habitat due to all permitted mining projects in the Mesabi Iron Range [1]

Habitat Type	Acres (Sq. Mi) Affected by Future Permitted Mining Activity	Percent of Total Affected Area
Open Wetland	3,528 (5.51)	10.2
Lowland Deciduous	1,489 (2.33)	4.3
Lowland Conifer/Shrubland	1,239 (1.94)	3.6
Lowland Conifer-Deciduous	1,538 (2.40)	4.5
Upland Conifer[2]	13,768 (21.52)	40.0
Upland Deciduous (Aspen/Birch)	606 (0.95)	1.8
Upland Deciduous (Hardwoods)	2,078 (3.25)	6.0
Upland Conifer-Deciduous	2,200 (3.44)	6.4
Upland Shrub/Woodland	13 (0.02)	0.0
Water	293 (0.46)	0.9
Cropland	31 (0.05)	0.1
Grassland	5,040 (7.88)	14.6
Subtotal Vegetated Habitat	**31,823 (49.74)**	**92.4**
Urban/Developed	2,612 (4.08)	7.6
Total	**34,435 (53.82)**	**100.0**

[1] Data are from the GIS Mining database, Minnesota Department of Natural Resources Division of Minerals
[2] Of these, 13,588 acres (21.23 sq. mi) are a "red cedar" cover type of sparse trees

Conclusions

Assuming a harvest level of approximately 65.6 square miles annually in northeast Minnesota, the wildlife habitat affected by forestry over 20 years (the life of the NorthMet Project) would be about 1,312 square miles. This level of harvest and the trend towards longer-rotation harvests and larger harvest units would slowly increase the conifer component and the age of forests in northeast Minnesota. Forest diversity and forest patch size may increase depending on ownership. These trends would benefit wildlife that depend on mature forest, forests with conifers, and large forest patches. As noted above, habitat for this type of wildlife had been reduced by forestry practices since 1890. The proposed mining projects would affect an additional 50 square miles over approximately the same period.

In total, 1,362 square miles of forest land could be impacted over the next 20 years by forestry (96%) and mining (4%). It should be noted that forestry impacts are short term and the affected areas still provide habitat that can support nearly continuous wildlife use, although for different species, while it recovers through the process of natural forest succession. Mining impacts, on the other hand, tend to have a longer duration (i.e., wildlife use is essentially eliminated in the affected area for the duration of mine operations) and slower recovery (e.g., lack of nutrients and organic material in soils slow forest succession). It is assumed that all existing and future mining projects would be required to revegetate disturbed areas as part of mine closure. Over time, the extent of area affected by mining should decrease as revegetation and forest succession occur.

In terms of effects on wildlife, forestry and mining would primarily impact species requiring large habitat patches. Current trends in forestry practices favoring longer rotation harvest would incrementally benefit species that require older and more diverse (e.g., larger conifer component) forest, but even with this trend, relatively little forest would reach "maturity." Mining contributes to habitat loss in some cover types that have declined historically (e.g., upland conifer, upland conifer-deciduous), but these habitat types are gradually increasing with current harvesting levels and practices. Mining may have some positive effects on wildlife by offsetting the loss of non-forested habitats (e.g., abandoned farms converting to forest) with the creation of grasslands as part of mine closure. This benefit, however, is only temporary as these areas will eventually become forested as a result of natural succession.

Wildlife Travel Corridors

Approach

The minerals present in the Mesabi Iron Range have and will likely continue to attract mining operations. The potential for relatively continuous mining operations and/or habitat loss along this range could pose a barrier for wildlife movement. Wildlife populations move less frequently between habitat patches when passage is blocked by mining operations, roads, and urban development. This may lead to increased population and genetic isolation and decreased meta-population dynamics, which in turn can lead to decreases in overall population stability and persistence. The study area for this analysis of wildlife corridor fragmentation was a 15-mile-wide zone along the approximately 115-mile-long Mesabi Iron Range

Emmons and Olivier Resources (EOR) (2006) completed an analysis of the wildlife corridors for moose, deer, bear, and other large mammals in the Mesabi Iron Range. The study identified 13 remaining major wildlife travel corridors connecting large roadless blocks along the Iron Range. These corridors ranged from less than 0.1 to over 3.2 miles wide, with a total combined length of 20.2 miles. Emmons and Olivier considered the loss of any of the 13 remaining corridors as significant.

The EOR analysis may have underestimated the number of corridors because it treated all historic mining features as impediments to travel, and did not take into account closed mines, revegetation, and natural succession. Historic mining impacts may range from relatively small, gently-sloped spoil piles and ore mine pits less than 50 feet deep (no to slight impediment), to large, steep-sided taconite pits that may be up to several hundred feet deep (significant impediment). The EOR analysis, therefore, represents a conservative estimate of the number and size of remaining wildlife travel corridors in the Iron Range.

EOR classified impacts to the 13 wildlife travel corridors as: 1) direct loss of habitat inside the corridor; 2) fragmentation of habitat inside the corridor; 3) isolation of a corridor by the creation of a barrier inside or near its termini; and 4) direct loss or fragmentation of large habitat blocks outside the corridor. These large habitat blocks are the presumed destinations of animals using the corridors; if they disappear, it is assumed that there would be fewer large mammals in the vicinity that would use the corridors.

For this analysis, the EOR analysis was updated to include the following projects that could potentially represent new barriers to wildlife travel (Figure 4.4-1):

- Minnesota Steel DRI, Steel Plant and Connected Actions (Corridors 2, 3, 4)
- US Steel Keewatin Taconite Mine and Plant (Corridor 4)
- Mittal Minorca East Reserve/Inspat Inland (Corridor 8)
- NorthMet Mine, Tailings Basin, and Railroad Spur (Corridors 11, 12)
- Northshore Peter Mitchell Mine Pits Expansion (Corridors 12, 13)
- Mesabi Nuggett Phase I and II
- Mesaba Energy Power Generation Station
- Cliffs Erie RR Pellet Transfer Facility

Wildlife Corridor Impacts by the NorthMet Project

Of the 13 wildlife corridors identified by Emmons and Olivier Resources, Corridors 11 and 12 are in the vicinity of the Project.

Corridor 11 is located southeast of the existing tailings basin at the Plant Site (Figure 4.4-1). The existing LTVSMC tailings basin provides poor habitat, is not likely to be heavily used by wildlife, and currently obstructs animal movement in Corridor 11. Because current use is already limited, increased activity at the tailings basin would have minimal impact on wildlife movement through Corridor 11. The proposed vegetative restoration of the tailings basin and adjacent processing plant at mine closure may increase the value of Corridor 11 by improving habitat northwest of Corridor 11.

Corridor 12 is located northwest and adjacent to the Mine Site. Operations at the Mine Site would impact the corridor by reducing the size of the large habitat block southeast of Corridor 12 and by being a source of noise and activity in the habitat block. Vegetative restoration of the stockpiles and disturbed areas, as proposed during mine closure, would mitigate some of the effect of habitat loss in this large habitat block in the long term. Not all 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 and the Plant sites would increase as a result of the Project, but this transportation corridor is outside of Corridors 11 and

12. Because the railroad is outside of the corridor, it would present a minimal barrier to travel.

In sum, the Project would have negligible effect on Corridor 11, and would eventually enhance this corridor after the completion of mine restoration. Although the Project would not physically encroach into Corridor 12, mining operations could generate sufficient activity and noise to discourage wildlife use of this corridor during the life of the Project. Long term effects after mine closure and restoration are not expected to be significant.

Wildlife Corridor Impacts by Other Projects

The other reasonably foreseeable projects are anticipated to affect eight of the 13 wildlife travel corridors (Table 4.4-9). These effects may include blocking or encroachment into the mapped wildlife corridors, affecting adjacent habitat that may make the corridor less valuable, and increasing traffic along new or existing roads through the corridor. These impacts range from the possible complete loss of Corridors 3, 5 and 13 (depending upon final extent of mining activities); to minor fragmentation within Corridor 2; and habitat loss near Corridors 4, 6, and 12. These impacts should be considered significant.

Table 4.4-9 Cumulative Impacts to Wildlife Travel Corridors in the Mesabi Iron Range

Wildlife Travel Corridor	Original EOR Identified Impacts to Corridors		Additional Identified Impacts to Corridors		
	Type of Impact	Project	Type of Impact	Project	Impact
1	Minimal Isolation	Urban Development	None		
2	Isolation	Highway Traffic	Fragmentation and Isolation	MN Steel Connected Action	Nashwauk-Blackberry Gas Pipeline (underground with grass cover) passes through this forested corridor from north to south; RR spur traffic crosses NE of corridor
3	Direct Loss	Mining/ Urban Development	Direct Loss	MN Steel mine pits and stockpiles	East half and least fragmented part of corridor largely removed
4	Isolation	Mining / Highway Traffic	Direct Loss	MN Steel tailings basin/ Keewatin	Habitat loss to NE and SE of corridor
5	Fragmenta-tion	Highway Traffic/ Urban Development	Direct Loss	US Steel/ Hibbing Taconite Co.	Mining operations nearly block northern extent and west third of corridor

Wildlife Travel Corridor	Original EOR Identified Impacts to Corridors		Additional Identified Impacts to Corridors		
	Type of Impact	**Project**	**Type of Impact**	**Project**	**Impact**
6	Isolation	Highway Traffic	Direct Loss	US Steel Minntac	Mine and tailings basin may have small effect on habitat to NE of corridor
7	Minimal Impact	Urban Development	Isolation	Mittal RR spur	Additional RR line several miles northeast of corridor
8	Isolation	Mining	Direct Loss	Mittal Steel East Reserve	East Reserve pit prevents access between north and south blocks of the corridor.
9	Minimal Impact	Urban Development	None	None	None
10	Minimal Impact	Mining/ Urban Development	Minimal Impact	Cliffs-Erie RR Pellet Transfer Facility/ Erie Mining	RR transfer facility overlaps with prior impacts, no additional habitat or corridor loss. Likely increase in traffic/noise.
11	Minimal Impact	Urban Development	None	None	None
12	No Impact		Direct Loss and Fragmentation	NorthMet mine area/ Northshore mine	Mine area reduces habitat to south of corridor (<1000 acres) / Permitted actions may directly fragment corridor or nearly block northern end part of corridor
13	No Impact		Direct Loss	Northshore Peter Mitchell	Possible expansion eastward may block or fragment Corridor 13

Travel Corridor Mitigation

No wildlife travel corridor mitigations are specifically proposed for the Project. Reclamation work, especially establishment of diverse forest cover, would partially restore the large habitat blocks northwest and southeast of Corridors 11 and 12. In addition, removal of the rail spurs, buildings, and roads, and re-vegetation of disturbed areas would improve wildlife habitat near the corridors. Lastly, cessation of mining and manufacturing would reduce activity and noise levels near the corridors, changing the perception by wildlife of the area.

4.5. FISH AND MACROINVERTEBRATES

4.5.1 Existing Conditions

The potential impact area for the Proposed Project encompasses several waterbodies which provide a variety of habitats for fish and aquatic macroinvertebrates. This CPDEIS evaluates impacts to fish and aquatic macroinvertebrates in the Embarrass River, Partridge River, Colby Lake, and White Water Reservoir, and in associated wetlands.

As with wildlife resources, assessment of fish and macroinvertebrates included consideration of the Minnesota Comprehensive Wildlife Conservation Strategy (CWCS) (MnDNR 2006). The CWCS identifies Species of Greatest Conservation Need (SGCN) by ecoregion subsections based on a statewide approach. Two mussel species (creek heelsplitter, *Lasmigona compressa*; and black sandshell, *Ligumia recta*) and three species of fish (lake sturgeon, *Acipenser fulvescens*; northern brook lamprey, *Ichthyomyzon fossor*; and shortjaw cisco, *Coregonus zenithicus*) are classified by MnDNR as SGCN. A discussion of the fish species is below, while the two mussel species are discussed with respect to their distribution in the St. Louis River watershed in the following Partridge River section.

Lake sturgeon

The lake sturgeon is a large, ancient fish that is broadly distributed throughout the Mississippi River, Great Lakes, and Hudson Bay drainages (Scott and Crossman 1973a, Wilson and McKinley 2005). Lake sturgeon typically inhabit large lakes and rivers and are usually found in waters that are 15-30 feet deep (Wilson and McKinley 2005 and references cited therein). Spawning takes place in swift-flowing water 2-15 feet in depth, often at the base of a low waterfall that blocks further migration upstream (Scott and Crossman 1973a). The species is adapted to feeding on benthic organisms; the diet includes various invertebrates and (rarely) small fishes (Scott and Crossman 1973a). The species has been classified as threatened in both Canada and the United States by a special committee of the American Fisheries Society (Williams *et al.* 1989) and is a species of Special Concern in Minnesota.

Historically, lake sturgeon migrated approximately 14 miles upriver from Lake Superior in the St. Louis River (Auer 1996). Spawning occurred between the falls near Fond du Lac, which formed a natural barrier to upstream migration, and Bear Island located a few miles downstream (Goodyear *et al.* 1982, Kaups 1984, Schram *et al.* 1999). The Ojibwa speared sturgeon below the rapids and captured them in seines farther downstream (Kaups 1984). The lake sturgeon was extirpated from the St. Louis River during the early 1900s (Schram *et al.* 1999). The St. Louis River currently is one of 17 tributaries to Lake Superior identified by the Great Lakes Fishery Commission (GLFC) as a priority stream where lake sturgeon rehabilitation should be focused, and the St. Louis is one of only six rivers identified by the GLFC as a priority for lake sturgeon stocking (Auer 2003). A stocking program was initiated in 1983 to reintroduce lake sturgeon to the St. Louis River; however, stocking was reduced in 1995 and discontinued in 2000 (MnDNR undated). The stocking has resulted in an increase in lake sturgeon abundance (Schram *et al.* 1999); however, recruitment has not yet been observed (Auer 2003).

Northern brook lamprey

The northern brook lamprey is a small (usually less than 5.9 inches in length), nonparasitic, jawless fish. This species' typical habitat is creeks and small rivers that are warmer than those suitable for brook trout, apparently avoiding small brooks and large rivers (Scott and Crossman 1973b). Spawning occurs on coarse gravel, shingle, or stones 1-6 inches in diameter (Scott and Crossman 1973b). The adults die a few days after spawning (Leach 1940). The larval young, called an ammocete, drifts downstream following hatching until suitable silt or sand substrate is encountered (Scott and Crossman 1973b). It then burrows into the sediment where it lives as a filter feeder for five to seven years, including an ammocete rest phase of a year during which the ammocete does not feed (Leach 1940, Scott and Crossman 1973b). Upon metamorphosis it lives off its accumulated biomass until it spawns and dies.

Cochran and Pettinelli (1987) identified northern brook lamprey in Blackhoof Creek, a dozen miles south of Cloquet, Carlton County, Minnesota. Since 1986 it has been collected from six other sites in the Lake Superior drainage (Hatch *et al.* 2003). There are no known occurrences of this species in the project area.

Shortjaw cisco

The shortjaw cisco grows to about 11 inches. Formerly it was found in deep water (60-600 feet) of several of the Great Lakes (Scott and Crossman 1973c). The species has been extirpated from Lakes Erie, Huron, and Michigan, and is in decline in Lake Superior (COSEWIC 2003). The species is also found in Gunflint and Saganaga Lakes (MnDNR 2006), which are two of the deepest natural lakes in Minnesota. Commercial overharvest probably caused the decline in shortjaw cisco in the Great Lakes; however, invasive species, habitat degradation and competition or predation may be factors that are limiting recovery (Pratt and Mandrak 2007). The species is listed as Threatened by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) (Houston 1988). There are no known occurrences of this species in the project area.

Partridge River and Embarrass River

Partridge River runs approximately 25 miles from its origin on the north side of the Mine Site, just outside of the Project boundary, to Colby Lake. From Colby Lake the Partridge River runs approximately six more miles to its confluence with the St. Louis River about 2.5 miles south of Aurora. The South Branch Partridge River meets the mainstem Partridge River at approximate river mile (RM) 16.1, as measured upstream from Colby

Lake. The catchment area of the Partridge River upstream of the confluence with the South Branch Partridge River is 26.2 mi^2. The catchment of the South Branch Partridge River is comparable in size (28.3 mi^2), but completely outside of the area of direct influence of the proposed project. The upper half (approximately 11 miles) of the Partridge River encircles all but the northwest quadrant of the proposed Mine Site. This makes the Partridge River, especially upstream of the confluence with the South Branch Partridge River, susceptible to any hydrological or water quality effects of the project.

Embarrass River (including the Embarrass River chain of lakes) runs approximately 47 miles from its origin about 2.5 miles west-southwest of Babbit to its confluence with the St. Louis River approximately 10 miles south-southwest of Biwabik. Trimble Creek, which originates in wetlands north of the Plant Site Tailings Basin and runs northwest approximately 2.5 miles to the Embarrass River, also lies in the general project area. The drainage area of the Embarrass River watershed is approximately 181 mi^2. Trimble Creek drains an area of approximately 7.4 mi^2.

Breneman (2005) conducted a biological survey at two sites in the Partridge River near the Mine Site, at a third site on the South Branch Partridge River, and at three sites in the Embarrass River watershed (Figure 4.5-1). The downstream site on the Partridge River (B3) is approximately 16.7 miles upstream of Colby Lake and the upstream site (B2) is approximately 20.5 miles upstream of Colby Lake. A third site on the South Branch Partridge River (B1), judged by Breneman (2005) to be a suitable reference site for the Partridge River, is approximately 4.3 miles upstream of the South Branch confluence with the Partridge River. The sites in the Embarrass River watershed comprised two wetland sites and one stream site (on Trimble Creek). Tables 4.5-1 through 4.5-3 provide information on physical habitat and water quality characteristics coincident with the biological samples. (The two wetland sites (B5 and B7) are excluded from Tables 4.5-1 and 4.5-2 which list stream characteristics.) No rare, threatened, or endangered species were collected by Breneman (2005) in his fish and benthic macroinvertebrate surveys.

Table 4.5-1 Major channel characteristics at biological survey stream sites in the Partridge River and Embarrass River drainages, August-September, 2004

Location				Channel Characteristics			
Name	**Designation**	**River Mile[2]**	**Catchment (mi^2)**	**Width (cm)**	**Depth (cm)**	**Velocity (cm/s)**	**Discharge (m^3/s)**
South Branch Partridge R.	B1	4.3	N/A	753	26.74	6.90	0.10
Partridge R. (upstream)	B2	20.4	15.2	954	20.67	15.13	0.19
Partridge R. (downstream)	B3	16.7	23.0	724	72.23	7.03	0.26
Trimble Cr.	B6	1.5	7.4	190	58.70	10.47	0.13

[1] Source: Adapted from Breneman (2005)
[2] River mile indicated for the S. Branch Partridge River site (B1) is measured from the confluence with the mainstem Partridge River. River mile indicated for sites B2 and B3 are measured from the mouth of Partridge

River at Colby Lake. River mile indicated for Trimble Creek is measured from the confluence with the Embarrass River.

Table 4.5-2 Physical features of the biological survey sites in Project Area streams[1]

Site	Dominant Feature	Coverage (% area)	Secondary Feature	Sampled Reach Length (m)	Silt Depth (cm)	Canopy Cover (%)	QHEI[2] Score
B1	Boulder	81.74	EAV	130	0.31	3.90	70
	Gravel	3.98	Islands				
	Silt	10.62					
	Woody debris	3.65					
B2	Boulder	84.12	EAV	135	1.36	45.50	79
	Pebbles	3.67	Islands				
	Silt	12.21	SAV				
B3	EAV	3.45	Cut bank	120	5.83	4.33	65
	Silt	96.55	SAV				
B6	Sand	43.16	Cut bank	105	5.83	8.23	65
	Silt	56.84	SAV				

[1] Adapted from Breneman (2005). EAV=emergent aquatic vegetation, SAV=submersed aquatic vegetation.
[2] QHEI (qualitative habitat evaluation index (Rankin 1989))

Table 4.5-3 Water quality characteristics at the biological survey sites sampled by Breneman (2005) late August-early September, 2004

	Water Quality Characteristic				
Site	Temp (^oC)	Conductivity (µmho)	Dissolved Oxygen (% sat.)	pH	Oxidation-Reduction Potential (mV)
B1	15.50	55	62.8	6.19	492.60
B2	15.84	112	61.9	6.86	481.20
B3	14.88	98	65.1	6.25	390.20
B5	14.30	857	57.5	7.43	436.10
B6	15.36	506	66.6	7.58	302.80
B7	14.32	760	51.2	7.51	278.10

Breneman (2005) collected benthic macroinvertebrates at the six sites in the Partridge River and Embarrass River watersheds. The results of his collections are summarized in Table 4.5-4. The assemblages observed in the survey are typical of those sampled elsewhere in the northeast region of Minnesota (Breneman 2005).

Table 4.5-4 Composition of aquatic macroinvertebrate assemblages at three sites on Partridge River and South Branch Partridge River by taxonomic and functional groups [1]

Site	No. of Samples	Total Taxa	Mean Abundance	% Ephemeroptera, Plecoptera, or Tricoptera	% Chironomidae	% Detritivores	% Omnivores	% Herbivores	% Carnivores
B1	7	90	626.57	6.24	57.80	46.10	21.46	7.42	20.24
B2	6	89	1260.67	14.56	65.25	60.19	17.51	10.69	8.45
B3	4	82	1278.09	15.78	52.15	45.56	18.31	7.36	23.93
B5	3	54	2529.48	16.94	46.78	57.08	7.92	17.71	14.27
B6	4	64	653.54	0.47	26.96	72.12	10.30	4.73	7.74
B7	3	37	1549.19	1.98	64.64	57.80	10.75	4.00	24.56

[1] Data and functional group assignments in Breneman (2005)

Table 4.5-5 lists the fish species collected at the six sites in the Partridge River and Embarrass River drainages. No recreationally important fish species were collected at the two sites on the Partridge River or at the sites in the Embarrass River watershed. Northern pike was collected at the comparable site on the South Branch Partridge River.

The species composition and species richness (total number of species) of the fish assemblages present at the two sites on the Partridge River and in Trimble Creek are generally consistent with the expectations for a stream of this type in this region and similar to the site on the South Branch Partridge River (B1). Fish species richness is not expected to be high in habitats of the type found in the Partridge River and Trimble Creek. Minnesota PCA is in the process of developing an index of biotic integrity (IBI) for the ecological region encompassing the St. Louis River and its tributaries, including the Partridge and Embarrass Rivers. The IBI establishes expectations for various metrics including species richness, accounting for regional variation and catchment size, and it can be used to evaluate the biological condition of a given site. Scores are assigned to individual metrics based on expectations for sites with minimal human influence, and the scores for individual metrics are summed to produce an overall assessment of the biological condition of the site (Karr 1981, Karr *et al.* 1986).

Table 4.5-5. Fish species collected at six sites in the Project Area

.Scientific Name	Common Name	Breneman (2005)					
		B1	B2	B3	B5	B6	B7
Catostomus commersonii	white sucker	X	X	X		X	X
Rhinichthys cataractae	longnose dace	X	X	X			
Luxilus cornutus	common shiner	X	X				X
Etheostoma nigrum	Johnny darter	X	X				
Hybognathus hankinsoni	brassy minnow	X	X				
Lota lota	burbot	X				X	
Esox lucius	northern pike	X					
Phoxinus eos	northern redbelly dace		X		X	X	X
Culaea inconstans	brook stickleback		X		X	X	X
Rhinichthys atratulus	blacknose dace		X				
Semotilus margarita	pearl dace		X				
Noturus gyrinus	tadpole madtom			X			
Umbra limi	central mudminnow			X	X	X	X
Phoxinus neogaeus	finescale dace				X		X
Pimephales promelas	fathead minnow				X		X
Semotilus atromaculatus	creek chub					X	X

While PCA has not yet developed an IBI applicable to the Partridge River and Trimble Creek, PCA has developed an IBI for each of several ecologically-defined regions in the state, including the Upper Mississippi River Basin (Niemela and Feist 2002) and the St. Croix River Basin (Niemela and Feist 2000). Assuming that collection protocols are comparable and the four stream sites sampled by Breneman (2005) are relatively unaffected by human activities, the results presented in Table 4.5-5 support the expectation of relatively low species richness compared to surrounding ecological regions that contain habitat supporting a richer fish fauna (Table 6). For example, nine species were collected at the upstream site on the Partridge River (B2, catchment 15 mi^2). This degree of species richness is less than what would be expected in a stream in a similar sized catchment in the Upper Mississippi River Basin (≥14 species) or St. Croix River Basin (≥10 species). The observed departure from expectations for other ecological regions is even greater at the downstream site, B3 (catchment area of 23 mi^2), where fewer (only four) species were collected and a greater number would be expected (Upper Mississippi River Basin expectation: ≥14 species, St. Croix River Basin expectation: ≥15 species). This is probably a manifestation of the species-poor nature of habitats encompassed by the Partridge River drainage rather than an indication of existing anthropic impacts. The moderate QHEI scores at the sampled sites (Table 4.5-2) are consistent with this observation.

Table 4.5-6. Index of biotic integrity (IBI) scoring criteria for fish species richness in the Upper Mississippi River Basin and the St. Croix River Basin

Basin and Catchment Size / Score	Scoring Criteria				
	10	7	5	2	0
Upper Mississippi River Basin, 5 to 35 mi^2 (Niemela and Feist 2002)	≥14	11-13	8-10	5-7	0-4
St. Croix River Basin, <20 mi^2 (Niemela and Feist 2000)	≥10	8-9	6-7	4-5	0-3
St. Croix River Basin, 20-54 mi^2 (Niemela and Feist 2000)	≥15	12-14	9-11	6-8	0-5

As discussed above, Minnesota DNR's *Comprehensive Wildlife Conservation Strategy* (CWCS) identifies Species in Greatest Conservation Need (SGCN) by region and habitat type. While the Strategy lists a number of SGCN for the region encompassing the Partridge River and Trimble Creek watersheds, neither the Partridge River and its tributaries nor Trimble Creek constitute habitat for any of these fish or aquatic insect species.

Unionid mussels (Unionidae) constitute one of the most imperiled major taxa in the United States (Master *et al.* 2000), and the CWCS identifies 26 unionid species within the state that are species of special concern. Two of these species, creek heelsplitter (*Lasmigona compressa*) and black sandshell (*Ligumia recta*), are known to exist in the St. Louis River basin (Table 7). Heath (2004) sampled mussels at two sites each in the Partridge River and Embarrass River watersheds (Figure 4.5-2 and Table 8). That survey collected only one mussel species in the Partridge River basin, the giant floater (*Pyganodon grandis*), and collected an additional species, the fat mucket (*Lampsilis siliquoidea*), in the Embarrass River basin (Table 7). The two species collected in the Partridge River and/or Embarrass River (i.e., giant floater (*Pyganodon grandis*) and fat mucket (*Lampsilis siliquoidea*)) are widely distributed generalists, tolerant of silt-dominated substrate, and often found in lakes, ponds or slow-moving water pools of small to medium-sized creeks and rivers (Cummins and Mayer 1992, Heath 2004).

Some of the unionid species known to exist in the St. Louis River basin, but not collected by Heath (2004), are typically found in larger streams than he sampled and may exist farther downstream in the drainage system. These species include creeper (*Strophitus undulatus*); plain pocketbook (*Lampsilis cardium*); white heelsplitter (*Lasmigona complanata*); and the black sandshell (*Ligumia recta*) (Table 7). The SGCN-designated black sandshell is restricted to riffles or raceways in gravel or firm sand (Cummins and Mayer 1992). Other species known to exist in the St. Louis River drainage and also not collected by Heath (2004) at stations M-1 or M-2 (i.e., cylindrical papershell (*Anodontoides ferussacianus*) and creek heelsplitter (*Lasmigona compressa*)) are typically found in small streams and may exist in the upper Partridge River drainage at sites other than those sampled (Heath 2004). The SGCN-designated creek heelsplitter is found in sand and fine gravel (Cummins and Mayer 1992).

Table 4.5-7. Mussel species identified in the Lake Superior Basin, St. Louis River Watershed, Partridge River, and Embarrass River[1]

Species	Location			
	Sietman (2003)		Heath (2004)	
	Lake Superior Basin	St. Louis R. Watershed	Partridge River	Embarrass River
Elliptio complanata (eastern elliptio)	X	X		
Anodontoides ferussacianus (cylindrical papershell)	X	X		
Lasmigona complanata (white heelsplitter)	X	X		
*L. compressa** (creek heelsplitter)	X	X		
Pyganodon grandis (giant floater)	X	X	X	X
Strophitus undulatus (creeper)	X	X		
Utterbackia imbecillis (paper pondshell)	X			
Lampsilis cardium (plain pocketbook)	X	X		
L. siliquoidea (fat mucket)	X	X		X
Ligumia recta* (black sandshell)	X	X		

1. Adapted from Heath (2004).
2. Minnesota Species of Special Concern

Table 4.5-8 Location and physical characteristics of mussel sample sites[1]

Station	River Mile	Mean Depth (m)	Substrate Composition
M-1 Partridge River	20.5	0.8	95% silt 5% boulder
M-2 Partridge River	16.7	0.6	40% silt 30% boulder 15% coarse sand 15% fine sand
M-3 Trimble Creek	N/A	0.2	50% gravel 50% coarse sand
M-4 Embarrass River	N/A	0.6	20% boulder 20% rubble 20% coarse sand 20% fine sand 20% clay

1 Modified from Heath (2004)

Colby Lake and Whitewater Reservoir

Colby Lake and Whitewater Reservoir are the two lentic waterbodies potentially affected by water discharges and withdrawals associated with the proposed project. Colby Lake receives water from and discharges water to the Partridge River. Whitewater Reservoir is hydrologically connected to Colby Lake by a diversion works, and water moves between the two waterbodies either by controlled gravity-fed flow or by pumps depending on the relative water levels in the two waterbodies. LTV Steel Mining Company impounded Whitewater Reservoir (formerly Partridge Lake) and constructed the diversion works in 1955 to increase storage capacity and provide make-up water for taconite mining operations at its mining facility while maintaining stable water levels in Colby Lake. Withdrawals by LTV continued until taconite mining operations ceased in 2000; currently, the inlet/outlet structure is controlled by Minnesota Power. Historically, Colby Lake water levels have fluctuated approximately 3 feet within a calendar year. Annual fluctuations historically generally have been much greater in Whitewater Reservoir, although have only averaged 3.5 feet more recently (Figure 4.5-3).

Colby Lake is a mesotrophic lake with a surface area of 539 acres and a littoral (to depth of 15 ft) area of 377 acres. Maximum depth is 30.0 ft. The dominant littoral substrate is boulders (>10"), rubble (3-10"), and gravel. Aquatic plants are moderately abundant, dominated by water lilies (Nympheadeae), *Potamogeton* sp., and water shield (*Brasenia schreberi*). Average Secchi depth is 2.00 ft and submersed plants grow to a maximum depth of 6.0 ft. The non-native curly-leaf pondweed (*Potamogeton crispus*) is found in the west end of the lake. At the time of the fisheries survey conducted in July 2005, surface water temperature was 81°F, and the bottom temperature was 55°F. Oxic (>2 ppm dissolved oxygen) water supporting fish extended to a depth of 22 ft where the temperature was 57°F. A heated water plume (≥100°F at the surface) extended from the power plant discharge. There were 20 private homes or cabins on Colby Lake in 2005 (MnDNR 2007b). Fish species collected in the lake are listed in Table 9. Investigations through July 2005 indicate that fish abundances have been generally low (MnDNR (Minnesota Department of Natural Resources) 2008a). While explicit expectations for the composition of the fish assemblage have not been established for Colby Lake, the fish assemblage appears to be similar to what might be expected for Colby Lake and other similar lakes in the region based upon physical and water quality conditions.

Whitewater Reservoir is a mesotrophic lake that encompasses an area of 1,210 acres and a littoral area of 564 acres. Maximum depth is 73.0 ft. The dominant littoral substrate is gravel, rubble, and sand. Aquatic plants are moderately abundant along the shore and in shallow bays. The dominate taxa are cattails (*Typha* sp.), sedges (Cyperaceae), northern milfoil (*Myriophyllum sibericum*), and *Potamogeton* sp. Average Secchi depth is 12.0 ft and submersed plants grow to a maximum depth of 8.0 ft. At the time of the fisheries survey in mid-August 2002, the surface water temperature was 72°F, and the bottom temperature was 48°F. Oxic water extended to a depth of 25 ft where the temperature was 66°F. Walleye were introduced to the reservoir following impoundment, and stocking continued through 1984. Whitewater Reservoir receives treated sewage effluent from the town of Hoyt Lakes. Minnesota Power recently acquired the land around Whitewater Reservoir from LTV and plans to develop lots for 20 homes along the shoreline (MnDNR 2007a). Fish species collected in the reservoir are listed in Table 9. Total catch of fish in gillnets in 2007 was well above average among the 41 lakes in northeast Minnesota that share similar ecological characteristics, and was above average for this lake (MnDNR 2008b). As for Colby Lake, explicit expectations have not been established for the composition of the fish assemblage in Whitewater Reservoir; however, composition appears to be similar to what might be expected for Whitewater Reservoir and other similar lakes in the region based upon physical and water quality conditions.

Both Colby Lake and Whitewater Reservoir are listed by MnPCA as impaired with respect to aquatic consumption because of fish consumption advisories for mercury. This is typical of many lakes in the region. The lake is not listed as impaired with respect to any other aquatic life criteria (MPCA 2006).

Table 4.5-9. Fish species collected in Colby Lake and Whitewater Reservoir by MnDNR fisheries surveys [1]

Species		**Waterbody**	
Common Name	**Scientific Name**	**Colby Lake[2]**	**Whitewater Reservoir[3]**
black bullhead	*Ameiurus melas*		X
black crappie	*Pomoxis nigromaculatus*	X	X
bluegill	*Lepomis macrochirus*	X	X
channel catfish	*Ictalurus punctatus*	X	
largemouth bass	*Micropterus salmoides*	X	X
northern pike	*Esox lucius*	X	X
pumpkinseed	*Lepomis gibbosus*	X	X
rock bass	*Ambloplites rupestris*	X	X
shorthead redhorse	*Moxostoma macrolepidotum*	X	X
walleye	*Sander vitreus*	X	X
white sucker	*Catostomus commersonii*	X	X
yellow bullhead	*Ameiurus natalis*	X	
yellow perch	*Perca flavescens*	X	X

[1] Collection methods included gillnets, trapnets, and shoreline seining.
[2] Surveys conducted in 1968, 1985, and 2005.
[3] Ten surveys conducted post-impoundment, 1967-2002.

Little information exists on the macroinvertebrate assemblages of Colby Lake and Whitewater Reservoir. Sampling conducted in many lakes in the region (including Colby and Whitewater) as part of the Regional Copper-Nickel Study (MSPA et al. 1981) found that nearly all of the taxa collected in the littoral zone of lakes were also collected in the streams of the region. The littoral zone of the lakes had a more diverse macroinvertebrate fauna than did the profundal (i.e., deep water) zone. Gastropods (snails) were collected from the littoral zone of Colby Lake as were pelecypods (clams) from the profundal zone (Johnson and Lieberman 1981). The most frequently collected and most abundant taxa collected from the profundal zone of Colby Lake were *Chaoborus* sp., *Hexagenia limbata*, *Procladius* sp. and *Chironomus* sp., similar to other lakes of the region (Figure 4.5-4) and characteristic of good water quality.

4.5.2 Impact Criteria

The following criteria were considered in evaluating impacts to fish and aquatic species:

- Project construction, operation, or post-closure results in non-attainment of narrative or numeric water quality criteria for the protection of aquatic life in affected water bodies.
- Project construction, operation, or post-closure exacerbates conditions in water bodies that are designated non-attaining with respect to narrative or numeric water quality criteria for the protection of aquatic life.
- Project construction, operation, or post-closure alters stream conditions resulting in a benthic macroinvertebrate assemblage that is degraded compared to that found at appropriate reference sites.
- Project construction, operation, or post-closure results in degradation of the structure or function of the fish assemblage in affected stream segments compared to appropriate reference sites.
- Project construction, operation, or post-closure adversely affects one or more aquatic Species of Greatest Conservation Need (SGCN) or their habitat.
- Project construction, operation, or post-closure adversely affects the growth or abundance of RFSS species in affected lakes or streams.

4.5.3 Environmental Consequences

4.5.3.1 Proposed Action

Potential impacts to fish and macroinvertebrates can be a result of alteration of water quality or alteration of the physical habitat supporting the aquatic biota. Water quality potentially can be altered through deposition of materials released to the atmosphere, surface runoff of contaminated water, or discharge of contaminated groundwater to the surface water body. Alteration of physical habitat may be a direct result of changes in the hydrological regime that reduce the quantity of habitat through changes in stream flow, or may be an indirect effect of changes in the flow regime that alter the physical structure of the stream channel. Each of these types and pathways of impact is discussed below.

The principal potential sources of atmospherically-deposited materials are atmospheric suspension of material by mining and processing operations (fugitive emissions) and stack emissions of the Process Plant. Projected emissions from the Plant Site are quantified in Barr (2007a) and from the Mine Site in Barr (2007b). The results of these calculations are further characterized in the Air Emissions Risk Analysis (AERA) for the Plant Site (Barr 2007c). Cumulative impacts of air emissions from three new projects (including the NorthMet Project) in the immediate vicinity of the former LTVSMC site are characterized in Barr (2007d), and the potential cumulative impacts related to ecosystem acidification are characterized in Barr (2006). The data and analyses contained in these reports are consistent with MPCA's (2005) conclusion that the impacts associated with anticipated air emissions from the proposed project did not have the potential for significant environmental effects. Considering the composition and magnitude of fugitive and stack emissions, airborne deposition is not a likely pathway of contamination leading to significant impacts on fish or macroinvertebrates in local streams and lakes. Further discussion of air quality impacts is provided in Section 4.6. Mercury is addressed separately in Section 4.5.4 below.

This analysis classifies surface water runoff as either process water or storm water. Process water includes outflow from the Tailings Basin, mine water discharges, runoff from haul roads and the lean ore surge pile and rail transfer hopper, and precipitation that contacts disturbed surfaces such as un-reclaimed stock piles. Storm water is defined as precipitation that falls on natural or reclaimed vegetated surfaces, including reclaimed stockpiles (Barr 2007e, 2007f). With the exception of leakage to groundwater and evaporation, process water will treated at the WWTF and piped to the Plant Site for use in the Process Plant or used to fill the East Pit, and no surface water point discharge is planned. Consequently, surface water discharge of process water is not a potential source of impacts to fish and macroinvertebrates. Unrecovered leakage from Category 1/2 Waste Rock, Category 3 Waste Rock, Category 3 Lean Ore and Category 4 Waste Rock Stockpiles and Category 4 Lean Ore Surge Pile, however, constitutes a potential pathway for water quality impacts to the Partridge River. Water quality modeling of the potential for this pathway to impair water quality indicates that predicted concentrations of the modeled parameters in the Partridge River will meet Minnesota water quality standards, and therefore is expected to be protective of aquatic life.

The Beneficial Use classification of Colby Lake (Class 2Bd) encompasses drinking water as well as cool and warm water fisheries. The applicable water quality standards in Colby Lake are more stringent than those in the Partridge River.

Predicted water quality meets the more stringent water quality criteria in Colby Lake for all constituents except iron and thallium. This is not considered to be a result of the Proposed Action, but rather a consequence of existing baseline concentrations that exceed the standards and, in the case of thallium, detection limits that are higher than the standard. This resulted in artificially high predicted levels for thallium and therefore uncertainty in the modeled outcome. However, the thallium standard is based on the potential for human health effects rather than potential for effects on aquatic life. Consequently, the proposed action is not expected to have water quality-based impacts on aquatic life in Colby Lake.

Storm water will be managed with a system of interconnected ditches and sedimentation ponds. These structures are designed to intercept storm water prior to reaching process water areas, to convey storm water to sedimentation ponds, and to provide sufficient retention time to promote settling of suspended material. Sedimentation ponds are designed to reduce total suspended sediment concentrations of storm water to within discharge limits before it is discharged to offsite surface waters (Barr 2007e, 2007f). Wash-off of material suspended in the air by mining operations and re-deposited within the Mine Site is not expected to contribute significant levels of toxic materials to the storm water runoff entering the Partridge River. In other respects, storm water runoff should reflect background conditions characteristic of the region.

Seepage of water from the Tailings Basin is a potentially significant pathway for contamination of groundwater. Discharge of contaminated groundwater to off-site surface waters could result in contamination of the receiving waterbodies in the Embarrass River watershed. Water quality modeling indicates that the Embarrass River will meet Minnesota water quality standards for all modeled constituents except aluminum downstream of groundwater discharges affected by the NorthMet Plant Site (see Section 4.1.3). Baseline aluminum concentrations observed at PM-13 in 2004, 2006, and 2007 averaged 0.1916 mg/L, which exceeds the applicable water quality criterion for protection of aquatic life (0.125 mg/L) by 53%. Seepage from the Tailings Basin is predicted to increase the aluminum concentration at PM-13 an additional 29% over existing conditions. Thus, aquatic life may already be impaired in the Embarrass River due to aluminum, and aluminum in Tailings Basin leakage may exacerbate the impairment. Other impacts to aquatic life are not expected as a result of discharge of contaminated groundwater.

Predictive modeling of the highest sulfate concentration in the Embarrass River at PM-13 indicated a concentration of 63.4 mg/L in Year 20 under low flow conditions, as compared to an average background concentration of 36.1 mg/L. Most of this increase has been attributed to the Pit 5NW discharge, which is unrelated to the Proposed Action. There is no applicable Minnesota surface water quality standard for sulfate. However, additional loading of sulfate to down-gradient wetlands and streams has potential implications for biologically mediated production of methylmercury leading to bioaccumulation of mercury in fish tissue. This potential impact is discussed in Section 4.5.4 below.

Slope stability or seepage control at the Tailings Basin embankment may be inadequate, potentially resulting in a release of the impounded PolyMet flotation tailings and process water (see Section 4.1.3.3). Such a release could contaminate an extended reach of the Embarrass River down-gradient of the Tailings Basin. The intensity, spatial extent, and duration of contamination would depend on the magnitude of the release, as would the nature and extent of impacts to aquatic life.

Hydrologic changes are one of the major potential sources of impacts to fish and macroinvertebrates. Predicted hydrologic changes to the Embarrass River are so small as to be non-quantifiable (Section 4.1.3); consequently, hydrologic impacts on aquatic life in the Embarrass River watershed are expected to be insignificant. The following discussion addresses potential hydrologic impacts in the Partridge River. While many aspects of the hydrologic regime can be important to the maintenance of fish and macroinvertebrate assemblages (Richter *et al.* 1996, Poff *et al.* 1997, Richter *et al.* 2003), reduction in baseflow is particularly relevant because it represents a loss of habitat. Table 4.1-27 indicates effects on baseflow in the Partridge River generally increase through the period of mining operations, with the impact subsequently diminishing somewhat once mining operations cease and the West Pit begins to fill with water. The model predictions for three locations on the Partridge River (Figure 4.1-10) indicate impact on baseflow is greatest at the most upstream location and that impact is progressively smaller with relative position downstream. Peak impacts on baseflow occur in Year 20 and range from 22% reduction at SW002 (on the north branch of the Partridge River, northeast of the Mine Site) to 10% at SW004 (on the north branch of the Partridge River, immediately upstream of the confluence with the south branch). Following mine closure and refilling of the West Pit, predicted reductions in baseflow range from 20% at SW002 to 8% at SW004. Reduced flow is also predicted to be manifested as a 20% decrease in the 1-day, 3-day, 7-day, 30-day, and 90-day annual minimum flow at SW002. Reduced habitat quantity resulting from this reduction in flow may be of sufficient magnitude to appreciably alter the structure and function of biotic assemblages in the Partridge River in the vicinity of SW002 and to a lesser degree in the vicinity of Stations SW003 and SW004 further downstream. Below the confluence with South Branch Partridge River (Stations SW004a, SAW005, and USGS gage), reductions in minimum flows and baseflow are only a few percent and biologically insignificant. Predicted percentage changes (reductions) in maximum flows are greatest at SW004, ranging from -4.9% for 90-day maximum to -6.6 percent for 1-day maximum. Duration of the high flow pulse (measured in days) is predicted to decrease by 16%. Sediment accumulation that may result from these predicted reductions in high end flows is not expected to have a significant effect on physical habitat for aquatic biota.

Generally, flows are reduced during and following mining operations. Following filling of the West Pit, however, average monthly flow increases at the more downstream locations (SW004a, SW005, and USGS Gage) during the summer and early fall. The resulting flow, however, is less than the monthly average flows during spring. Furthermore, predicted maximum flows decrease during and following mining activity, and the frequency of high flow events is not predicted to increase. Consequently, hydrologic alteration is not expected to degrade physical habitat by destabilizing and resizing the stream channel.

While seasonal minimum flows occur during January when biological activity is also at a minimum, a secondary seasonal minimum occurs during late summer when biological activity is high. Low flow during late summer when water temperatures are relatively high can stress aquatic communities, particularly fishes. Late summer monthly flows will be reduced by 5-8% during mining depending on location along the Partridge River, but are predicted to increase as much as 16% at SW004a immediately below the confluence with the south branch of the Partridge River. Thus, over the longer term, hydrologic alteration may reduce this seasonal stress to the aquatic biota.

Potential impacts to Colby Lake and Whitewater Reservoir, if they occur, would result from changes in the hydrologic characteristics of inflows to Colby Lake from the Partridge River, or from water withdrawals made from Colby Lake to provide make-up water for the NorthMet processing plant. Since water levels in Colby Lake are and will continue to be maintained by drawing water from Whitewater Reservoir, the principal effect of Project-related water withdrawals from Colby Lake would be on water levels in Whitewater Reservoir. Given the expected average demand of 3,500 gpm, average water level in Whitewater Reservoir is predicted to be 0.39 feet lower than under baseline conditions. Under the higher 5,000 gpm withdrawal scenario, average water level in Whitewater Reservoir is 1.00 feet lower than the base case. Annual water level fluctuations in Whitewater Reservoir are predicted to be 4.27 ft under the 3,500 gpm withdrawal scenario and 6.89 feet under the 5,000 gpm scenario. This is comparable to historical water level fluctuations (although somewhat higher than more recent fluctuations after LTVSMC stopped mining) and is not expected to have an adverse impact on fish or macroinvertebrate assemblages in Whitewater Reservoir. However, increased water level fluctuations in Whitewater Reservoir have the potential to promote mercury methylation (addressed in Section 4.5.4, below).

4.5.3.2 Alternatives

No Action Alternative

Under the No Action alternative, fish and other aquatic life 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 in impacts from the baseline conditions.

Subaqueous Disposal of Reactive Waste Rock

By reducing water quality impacts associated with reactive waste rock, this alternative could potentially reduce impacts on aquatic life if reactive waste rock were a source of impact; however, impacts to aquatic life due to water quality changes in the Partridge River or Colby Lake are not expected due to the Proposed Action. This alternative would not affect hydrology in the Partridge River, Colby Lake, or Whitewater Reservoir.

Other Mitigation Measures

Section 3.2.2.5 describes several potential other mitigation measures for impacts from the Project. Some of these measures have the potential to affect fish and macroinvertebrates and are discussed below.

- The mitigation design alternative for the Tailings Facility would not affect hydrology in the Embarrass River. Predicted impacts to water quality in the Embarrass River are similar to those of the Proposed Action in that all modeled compounds remain below water quality criteria limits except for aluminum, which is above the water quality criterion for protection of aquatic life at PM-13 under baseline conditions.
- Construction of a fully lined tailings basin on top of the former tailings basins 1E and 1W would reduce the potential for leachate from the tailings to migrate off site and exacerbate the aluminum and sulfide levels in the Embarrass River (and thereby reduce the potential for contributing to methylmercury production in the Embarrass River watershed). The Proposed Action is not expected to have hydrological impacts to the Embarrass River, so this mitigation would not provide hydrologic benefits.

4.5.4 Mercury and Bioaccumulation in Fish

Purpose

Bioaccumulation of mercury in fish is a multi-faceted issue that encompasses multiple media, pollutants, pathways, and mechanisms. Current scientific understanding of the factors and mechanisms affecting mercury bioaccumulation is limited. Much of the current knowledge is tentative and subject to change in light of ongoing and future research. The purpose of this section is to provide a simple but comprehensive synthesis of readily available information to support a general characterization of the potential for the proposed NorthMet project to contribute to or exacerbate elevated mercury concentrations in fish in the Project area. Both cumulative effects due to atmospheric deposition and project-specific effects associated with methylmercury are examined.

Background

Mercury contamination of fish is a widespread problem in Minnesota and elsewhere. Many of the waterbodies in the Project area are among those listed as impaired by mercury, including the Partridge and St. Louis Rivers; Wynne, Sabin, Embarrass, and Esquagama Lakes (through which the Embarrass River flows); Colby Lake and Whitewater Reservoir (MPCA 2006a). These water bodies have fish consumption advisories because the mercury concentrations in fish tissue pose a hazard to human health (MDH 2007). Mercury contamination of fish also poses a toxicity risk to fish-eating wildlife (Wolfe *et al.* 1998, Wiener *et al.* 2003).

The Minnesota Pollution Control Agency (MPCA) has developed a statewide plan (known as a TMDL, for Total Maximum Daily Load) to reduce mercury concentrations in fish over time and eventually allow de-listing of water bodies that are currently impaired with respect to fish consumption because of mercury-related fish consumption advisories. Minnesota's TMDL for mercury (MPCA 2007) serves as the state's blueprint for reducing mercury concentrations in fish and eliminating this cause of waterbody impairment. Because the TMDL is a statewide plan, and because atmospheric deposition of mercury generally is the ultimate source of the contamination, the TMDL focuses on releases of mercury to the atmosphere. Atmospheric emissions enter a global pool of airborne mercury that is characterized by long-range transport (up to thousands of miles) and residence times of up to a year (Porcella *et al.* 1996, USEPA 1997). Mercury originating outside of northeast Minnesota, and even outside of Minnesota, dominates atmospheric deposition in the Project area. Approximately 10% of the mercury deposition in northern Minnesota is emitted from Minnesota-based sources (Jackson *et al.* 2000). The remaining 90% is evenly divided among other North American sources, global sources, and natural background emissions (Engstrom and Swain 1997, MPCA 2005, 2007).

The waterbodies listed above, as well as most other waterbodies in the St. Louis River watershed were excluded from the statewide mercury TMDL, because mercury levels in the fish were above the level considered achievable by the TMDL. These waterbodies may be subject to one or more separate TMDLs to be developed in the future.

A report prepared in support of PolyMet Mining, Inc.'s, NorthMet project and Minnesota Steel Industry, LLC's mining to steel project near Nashwauk (Barr 2006b) examined the contribution of several projects and actions to mercury deposition in northeast Minnesota, including the NorthMet project. That analysis concluded that collectively the facilities included in the analysis have the potential to increase statewide mercury emissions by 6% and deposition of mercury by 0.6%. The analysis assumes that deposition within Minnesota happens to be equal to emissions from within the state, and that ten percent of the increased emissions would be deposited within the state, assumptions that may not be valid. Based on that analysis, atmospheric emissions associated with the proposed NorthMet project would not be likely to have a significant effect on mercury bioaccumulation in fish (see Section 4.6).

In addition to atmospheric deposition, local factors related to project construction and operation have the potential to promote mercury bioaccumulation, either through mobilization of mercury stored in rock, soil, peat, and vegetation on site, or through enhanced methylation of mercury (described below). Factors other than atmospheric deposition of mercury are potentially more important with respect to the potential for the NorthMet project to contribute to mercury bioaccumulation in fish. The additional factors considered here are:

- Mobilization of sulfate resulting from the NorthMet project,
- Hydrologic changes and water level fluctuations,
- Land cover changes, including forest clearing, and
- Peatland disruption, including stockpiling of overburden and decomposition of organic matter from wetlands.

The role that each of these factors plays in methylmercury production is discussed in the following sections.

Virtually all dispersal of mercury in the environment (especially atmospheric dispersal) occurs in inorganic form (Fitzgerald and Clarkson 1991). Virtually all of the mercury accumulated in edible fish tissue (>95%), however, is accumulated as organic monomethylmercury (CH_3Hg) (Bloom 1992). Thus, methylation is a key step in bioaccumulation of mercury. Methylmercury is a product of inorganic mercury reduction by sulfate-reducing bacteria, a process that is stimulated by elevated sulfate concentrations (Gilmour *et al.* 1992, Krabbenhoft *et al.* 1998).

Mobilization of Sulfate

The MPCA recognizes the important role of sulfate in methylmercury production, as well as uncertainties regarding site-specific effects. The MPCA has set forth a strategy (MPCA 2006b) for addressing 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 specific sulfate discharge limits. The strategy, however, sets forth steps MPCA can take to improve the technical basis for controlling sulfate discharges and establishes guidance for considering potential sulfate impacts during environmental review and NPDES permitting. This evaluation reflects that guidance.

Watras *et al.* (2006) presented a theoretical relationship between mercury methylation rate (MMR) and the two key substrates: inorganic mercury (Hg^{II}) and sulfate:

$$MMR = MMR_{\max}\left(\frac{[Hg^{II}]}{k_{Hg^{II}} + [Hg^{II}]}\right)\left(\frac{[SO_4^{2-}]}{k_{SO_4^{2-}} + [SO_4^{2-}]}\right)$$

where MMR is the mercury methylation rate, $[Hg^{II}]$ and $[SO_4^{2-}]$ are the concentrations of divalent mercury and sulfate ion, respectively, and k_{Hg} and k_{SO4} are the rate constants for divalent mercury and sulfate ion respectively. This relationship highlights the co-limitation of methylmercury production by Hg^{II} and SO_4^{2-} at typical environmental concentrations.

Gilmour *et al.* (1992) and Branfireun *et al.* (1999) experimentally demonstrated the mechanistic relationship between sulfate addition and production of methylmercury. Watras *et al.* (2006) found a strong, positive correlation between methylmercury accumulation in the hypolimnion and the hypolimnetic sulfate deficit in Little Rock Lake (R^2=0.9, p<0.0001). Heyes *et al.* (2000) reported a significant positive correlation between methylmercury and sulfate in a poor fen (R^2=0.765, p=0.005) and in a bog (R^2= 0.865, p=0.022); however, they found no such correlation in an impounded wetland.

Gilmour *et al.* (1992) found that both the rate of production and the final concentration of methylmercury in sediment slurries were in proportion to the initial sulfate concentration over a sulfate concentration range of approximately 20-100 µM. Experimental additions of sulfate to lake water over intact sediment cores also resulted in increased methylmercury production (Gilmour *et al.* 1992). Branfireun *et al.* (1999) reported a 3-4 fold increase in pore water methylmercury concentration after 24 hours in response to additions of sulfate equivalent to two and 20-times background; however, the 20-fold addition did not produce ten times the concentration of the 2-fold addition of sulfate (Figure 4.5-5).

NorthMet is a disseminated sulfide deposit, and development of the mine pit would involve exposure of the sulfide-bearing rock to the atmosphere and to water. Water quality impact predictions indicate this would result in oxidation of sulfidic material and mobilization in water, although mitigation measures are expected to reduce this effect. To the extent it occurs, mobilization of sulfate or mercury by mining operations can be expected to stimulate methylmercury production in suitable environments and thereby enhance bioaccumulation. This may occur either onsite or offsite as a result of increased sulfate or mercury concentrations in water draining from the site.

Hydrologic Changes and Water Level Fluctuations

Methylation of environmental mercury by sulfate-reducing bacteria is stimulated by drying and rewetting associated with hydrologic changes and water level fluctuations (Gilmour *et al.* 2004, Selch *et al.* 2007). Drying 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 the elevated methylmercury concentrations observed in discharge from wetlands during high flow events (Balogh *et al.* 2006). Thus, hydrologic changes and water level fluctuations can stimulate mercury methylation and enhance bioaccumulation.

Numerous studies have documented the stimulatory effect of hydrologic changes and water level fluctuations on methylmercury production (Table 4.5-10). Based upon three years of monitoring of 14 northeastern Minnesota lakes, Sorensen e*t al.* (2005) concluded that effects of water-level fluctuations on methylmercury production contributed to a two-fold variation in annual mean mercury concentration in young-of-year yellow perch (*Perca flavescens*).

Table 4.5-10 Summary of reported relationships between hydrology and environmental mercury concentration

Hydrologic Effect	**Mercury Response Reported**	**Change in Mercury Level**	**Source**
Water level fluctuation	Change in Hg concentration in YOY yellow perch	2x variation	Sorensen *et al.* (2005)
Surface area fluctuation	Change in Hg concentration in adult walleye		Selch et al. (2007)
Wetland impoundment	Elevated porewater MeHg concentration	5x baseline	Heyes *et al.* (2000)
Reservoir construction	Elevated Hg concentration in fish	1.5x – 4x baseline	Schetagne and Verdon (1999)
Annual wetland drying	Elevated Hg concentration in fish	0.1 ng g^{-1} increase per year with wetland drying	Snodgrass *et al.* (2000)
Stormwater retention in temporary pools	Elevated MeHg concentration in outflow	1.8x baseline	Brigham *et al.* (2002)
Transit through beaver impoundment	Elevated MeHg concentration in outflow	1.2x baseline	Driscoll *et al.* (1998)

Selch et al. (2007) found that an increase in the surface area of natural lakes was significantly related to the concentration of mercury in adult walleye.

Heyes *et al.* (2000) found that impounded peatlands produced high levels of methylmercury. They attribute the elevated methylmercury to an expanded area conducive to methylmercury production (flooding of riparian wetland produces anoxic conditions over organic rich wetland material) and enhanced rate of methylmercury production (average methylmercury concentration in the near-surface peat pore water increased from 0.2 to 1.0 ng L^{-1}).

Schetagne and Verdon (1999) reported that concentration of mercury in fish in new reservoirs was 1.5 to 4 times the levels in natural lakes and declined after

10-15 years, reaching background levels 20-40 years after reservoir creation if water levels are stabilized (Anderson *et al.* 1995, Schetagne and Verdon 1999).

Snodgrass *et al.* (2000) examined the relationship between wetland drying and methylmercury in fish in a suite of southeastern depression wetlands. The number of years in which the wetlands dried (0, 1, or 2) during a two-year period was significantly related to mercury concentrations in fish tissue. Each observation of dry conditions was associated with a 0.1 $\mu g\ g^{-1}$ (dry weight) increase in mercury concentration in lake chubsucker, *Erimyzon sucetta*, and redfin pickerel, *Esox americanus*.

Stormwater basins will constitute new sites for mercury methylation. Brigham *et al.* (2002) found that retention of stormwater in temporary-pool impoundments resulted in a pronounced (77%) increase in methylmercury concentration of outflow (4.6 ng L^{-1}) compared to inflow (approximately 2.6 ng L^{-1}).

Driscoll *et al.* (1998) examined annual fluxes of total mercury and methylmercury at inflow and outflow sites on a relatively old Adirondack beaver impoundment. They found the annual watershed flux of total mercury was 2.2 $\mu g/m^2$-yr at both locations. Flux of monomethylmercury, however, was 0.20 $\mu g/m^2$-yr at the outflow versus 0.17 $\mu g/m^2$-yr at the inflow. Net production of monomethylmercury in the beaver pond was 0.45 $\mu g/m^2$-yr, similar to rates reported for wetlands (0.3 $\mu g/m^2$-yr), near the lower end of the range observed for lakes (0.5-3 $\mu g/m^2$-yr), and below the values reported for recently flooded upland areas (13 $\mu g/m^2$-yr) [Driscoll *et al.* (1998) citing Rudd (1995)].

Land cover changes, diversion of process water to the mine plant, and water withdrawal from Colby Lake may cause water level fluctuations in wetlands and surface waters that could promote mercury methylation. Analyses conducted by Barr (2007b) predict an increase in flow variability with decreases of mean annual flow and baseflow.

Land Cover Effects and Peatland Disruption

Foliage is a major sink for airborne mercury. Gaseous mercury appears to be absorbed through the foliar stomata as a function of time and air concentration (Ericksen *et al.* 2003). Mercury accumulated in the foliage of vegetation is then added to the surface litter layer and the soil upon litterfall (Ericksen *et al.* 2003). This pathway is the largest single mercury flux in forested ecosystems (Iverfeldt 1991, Rea *et al.* 1996, Rea *et al.* 2002). As a consequence, total deposition to forested areas is approximately four-fold greater than that deposited to open areas, such as grassland or open water (Grigal 2002). Thus, forest clearing would reduce mercury flux associated with this depositional pathway. Evasion of gaseous mercury from bare soil and grassland can be an order of magnitude higher than from shaded forest floor (Carpi and Lindberg 1998) further diminishing the mercury available for methylation and leaching from these open areas compared to forested sites. Open water and wetland areas also differ in methylmercury yield (St. Louis *et al.* 1994, St. Louis *et al.* 2001, Grigal 2002).

Grigal (2003) noted that the mass of mercury in forests of the contiguous 48 states is two orders of magnitude higher than annual anthropic emissions of mercury from those states. Organic matter contained in peat and wetland soils also constitutes a large reservoir of mercury. Peatlands, which constitute less than 2% of the land area contain more than 20 times annual anthropic emissions (Grigal 2003). While peatlands are major sites of methylmercury production, mercury is strongly bound to the organic material comprising the peat (Drexel *et al.* 2002). Disruption of peat deposits resulting in oxidation and decomposition of the peat would increase the mobility of the stored mercury.

While recent research (e.g., Hintelmann *et al.* 2002) suggests recently deposited mercury dominates that which is methylated,

> *[t]he recovery rate of a water body and its fishery resources to reduced atmospheric loadings of total mercury depends in part on the transport of mercury that has accumulated in the surrounding catchment. Increased transport of mercury from the catchment is associated with soil disturbance, erosion, strong hydrologic connectivity, shallow surficial deposits, high organic matter content in soil, and decomposition in soils and of plants. Available evidence indicates that human-associated disturbances and land-use change strongly influence the delivery of mercury from the catchment to receiving waters, which affects the timing and magnitude of fishery recovery.* (The Madison Declaration on Mercury Pollution 2007)

For example, Porvari *et al.* (2003) reported significant increases in total mercury and methylmercury concentrations and loads in streams following clear-cutting and soil treatment (e.g., harrowing, scarification, and mounding which is commonly undertaken "to improve survival and growth of planted or self-regenerated conifers") in a boreal forest catchment.

Mining operations at the NorthMet site would result in forest clearing and soil and wetlands disruption over an area of approximately 3,260 acres (1320 hectares). Mercury accumulated in the affected surficial material may be mobilized in the process of land clearing, and overburden removal and stockpiling. Oxidation and decomposition of peat would also likely mobilize stored mercury. Mobilized mercury may then be transported to sites conducive to mercury methylation by sulfate-reducing bacteria. Furthermore, stockpiling of overburden and other disruption of peat deposits would likely partially oxidize to sulfate the reduced forms of sulfur contained in the organic material. Periodic rewetting of exposed peat by precipitation and water level fluctuations may then promote methylation of mercury by sulfate-reducing bacteria within the oxidizing peat material. Thus, disruption of peatlands may stimulate the methylation and mobilization of mercury that has accumulated over many years.

Each of these four factors – sulfate mobilization, hydrologic changes, land cover effects, and peatland disruption - was evaluated using readily available, existing information to estimate the general magnitude of effect as described in the following section.

Synthesis and Impact Estimation

Bioaccumulation of mercury by fish is assumed to be limited by availability of methylmercury. Methylmercury availability is assumed to respond proportionally to changes in total mercury availability and mercury methylation rate. Results of a semi-quantitative analysis of selected factors affecting total mercury availability and mercury methylation rate associated with the proposed NorthMet Project are presented below. The analysis does not permit quantitative aggregation of the effects of the various factors. Rather the objective is to obtain an estimate of the sign (i.e., direction) and general magnitude of the effect associated with individual factors discussed above.

Partridge River Watershed

Mobilization of Sulfate

Mercury methylation rate is assumed to respond proportionally to changes in sulfate concentration. Barr (2007a) presents baseline and predicted sulfate concentrations under average flow conditions at several surface water monitoring stations along the North Branch of the Partridge River and along the main stem Partridge River between the confluence of the North and South Branch Partridge River and the inlet to Colby Lake (Table 4.5-11).

Table 4.5-11 Baseline and predicted sulfate concentration at surface water monitoring stations on the Partridge River [1]

	Sulfate Concentration		
Station	**Baseline (mg/L)**	**Predicted (mg/L)**	**Change Ratio (Predicted/Baseline)**
SW-002	6.2	8.8	1.4
SW-003	8.4	10.3	1.2
SW-004	8.5	9.4	1.1
SW-004a	8.5[2]	8.4	1.0
SW-005	6.8	8.0	1.2
USGS gage	6.8[3]	8.0	1.2
Colby Lake inlet	4.9[4]	7.9	1.6
Mean			1.2

[1] Source: Barr (2007a) (except Colby Lake baseline)
[2] Assumed to be the same as SW-004.
[3] Assumed to be the same as SW-005.
[4] Source: Pilgrim and Borovsky (2006)

The effect of elevated sulfate on methylmercury production in the Partridge River watershed was estimated based on the spatial extent of wetlands and stream corridors in the Partridge River basin above Colby Lake, and the portion of those areas potentially exposed to elevated sulfate concentration. Input values are listed in Table 4.5-12. Selected variables were propagated through the analysis as intervals. Sulfate effects in the stream corridor were limited to the North Branch of the Partridge River and the reach of the Partridge River extending from the confluence of the North and South Branch to Colby Lake. It was also assumed that only wetlands within the North Branch of the Partridge River are potentially affected by elevated sulfate concentrations.

Table 4.5-12 Input values for estimation of the effect of elevated sulfate concentrations on methylmercury production in the Partridge River above Colby Lake

Variable	Symbol	Value	Source/Comment
Wetlands			
Variable	**Symbol**	**Value**	**Source/Comment**
Total wetland area (ha.)	W_{Total}	11,559 (28,563 acres)	Barr (2007b)
North Branch watershed (ha.)	H_N	6,760 (16,704 acres)	Barr (2007b)
Wetlands in North Branch watershed (fraction)	w_N	0.1 – 0.9	Assumed interval
North Branch wetlands area affected (fraction)	$a_{Wetlands}$	0.1 – 0.6	Assumed interval. All wetlands on opposite side of N. Branch and main stem Partridge River assumed to be unaffected.
Streams			
Variable	**Symbol**	**Value**	**Source/Comment**
North Branch length (km)	L_1	14 (9 miles)	DeLorme (2006)[1]
Main stem length (km)	L_2	26 (16 miles)	DeLorme (2006)[1]
Stubble Creek length (km)	L_3	4 (2 miles)	DeLorme (2006)[1]
South Branch length (km)	L_4	14 (9 miles)	DeLorme (2006)[1]
Colvin Creek length (km)	L_5	25 (16 miles)	DeLorme (2006)[1]
Wetlegs Creek length (km)	L_6	4 (2 miles)	DeLorme (2006)[1]
Longnose Creek length (km)	L_7	7 (4 miles)	DeLorme (2006)[1]
Stream corridor width (m)	C	10 – 30 (30 – 100 ft)	Assumed interval
North Br. and Main stem area affected (fraction)	$a_{Streams}$	0.5 – 1.0	Assumed interval
Wetlands and Streams			
Variable	**Symbol**	**Value**	**Source/Comment**
Sulfate enrichment (x baseline)	s	1.0 – 1.6	Table 2
ΔMethylation Rate : Δ Sulfate Concentration	m	1 - 2	Gilmour *et al.* (1992) Branfireun *et al.* (1999)

[1] Measurement obtained using the profile tool of Topo USA 6.0.

The effect of elevated sulfate concentration on methylmercury production draining to the base of the watershed at Colby Lake is estimated as an area-weighted average that combines the contributions of methylmercury production from affected wetlands and streams in the watershed[1]:

$$\text{Relative Methylmercury Production} = \frac{Wetlands(W_{Total}) + Streams\left(\frac{c\sum_{i=1}^{7} L_i}{10}\right)}{W_{Total} + \frac{c\sum_{i=1}^{7} L_i}{10}}$$

where:

$$Wetlands = \frac{a_{Wetlands} w_N H_N}{W_{Total}} sm + \left(1 - \frac{a_{Wetlands} w_N H_N}{W_{Total}}\right), \text{ and}$$

$$Streams = \frac{a_{Streams}\left(L_1 + L_2\right)}{\sum_{i=1}^{7} L_i} sm + \left(1 - \frac{a_{Streams}\left(L_1 + L_2\right)}{\sum_{i=1}^{7} L_i}\right)$$

The above equations and the input values in Table 4.5-12 yield a roughly estimated relative methylmercury production of less than two times the baseline production level.

Land Cover Change

Effect of land cover change is roughly estimated as relative change in methylmercury yield. Spatial extent of baseline and altered land cover and assumed area-specific annual yields are listed in Table 4.5-13.

[1] Note: The factor of 10 in the equations converts units of stream length (km) and width (m) to hectares (10,000 m^2).

Table 4.5-13 Baseline and altered land cover classifications for the Partridge River watershed draining to the USGS gage above Colby Lake and cover type-specific methylmercury yields

Land Cover Type	Methyl-mercury Yield (mg ha^{-1} yr^{-1})	Spatial Extent (ha.)			Source/Comment
		Baseline[1]	Altered[2]	Change	
Water	0.06 – 30	1,245 (3,076 acres)	1,245 (3076 acres)	0	Methylmercury yield: St. Louis *et al.* (1994), Grigal (2002)
Wetland	1.84 – 5.55	11,559 (28,562 acres)	11,282 (27,878 acres)	-277 (-684 acres)	Methylmercury yield: St. Louis *et al.* (1994)
Upland forest	0.07 – 0.63	12,618 (31,179 acres)	12,361 (30,544 acres)	-257 (-635 acres)	Methylmercury yield: St. Louis *et al.* (1994), St. Louis *et al.* (2001)
Developed	0.06 – 30	1,140 (2,817 acres)	1,140 (2,817 acres)	0	Methylmercury yield: assume range for other cover types
Grassland/ Scrub	0.014 – 0.126	219 (541 acres)	753 (1,861 acres)	+534 (1,320 acres)	Methylmercury yield: Assumed 5x lower than upland forest based on 50-100% higher Hg deposition to forests (Kolka *et al.* 1999), 5x greater emission of Hg from grassland soils (Zhang *et al.* 2001), and lower organic content of grassland surface layer

[1] Source: Table 2, Barr (2007b)
[2] Source: See Section 4.X.X. Land cover type determination including wetland changes were taken land cover analysis using GIS techniques.

The assumptions listed in Table 4.5-13 result in an approximate net reduction of less than 8% in estimated methylmercury production due to the increase in grassland cover type (Predicted/Baseline = 0.9-1.0). As a check on this estimate, methylmercury output from the watershed under baseline and altered land cover conditions was estimated using the regression equation of Grigal (2002) which relates methylmercury flux to the percent wetland coverage in the watershed:

$$\ln(\text{methylmercury flux } (\mu g\ m^{-2}\ yr^{-1}) = -3.71 + 0.57 \ln(\text{Wetland }\%),\ R^2 = 0.38,\ n=16$$

Application of this regression to the baseline and altered land cover in the Partridge River watershed indicates an approximate 1-2% decline in methylmercury yield (Predicted/Baseline=0.98-0.99).

The estimated loss of wetlands based on a wetlands survey of the mine site is greater than that derived from the comprehensive land cover analysis; however, the wetlands survey did not include other land cover types and the difference is insignificant at the scale of the Partridge River watershed.

While the results from both methods of estimating change in methylmercury yield are consistent in predicting a small decrease in methylmercury production, the methods themselves are more applicable to long term effects than to transient effects associated with land cover alteration. In the short term, physical disturbance associated with land cover change is likely to increase methylmercury yield through mobilization and enhanced methylation of mercury.

Water Level Fluctuation

The effect of water level fluctuation on methylmercury production in the watershed is estimated in a manner similar to that used for estimating the effect of elevated sulfate concentration. Input values listed in Table 4.5-14 are applied in the following equation, with interval values propagated through the calculation.

$$\text{Relative Methylmercury Production} = \frac{Wetlands(W_{Total}) + Streams\left(\frac{c\sum_{i=1}^{7} L_i}{10}\right)}{W_{Total} + \frac{c\sum_{i=1}^{7} L_i}{10}}$$

where,

$$Wetlands = \frac{a_{Wetlands} w_N H_N}{W_{Total}} f + \left(1 - \frac{a_{Wetlands} w_N H_N}{W_{Total}}\right), \text{ and}$$

$$Streams = \frac{a_{Streams}(L_1 + L_2)}{\sum_{i=1}^{7} L_i} f + \left(1 - \frac{a_{Streams}(L_1 + L_2)}{\sum_{i=1}^{7} L_i}\right)$$

Given the assumptions listed in Table 4.5-14, this calculation yields an approximate methylmercury concentration change as a consequence of water level fluctuation of one to four times baseline levels in the Partridge River drainage system above the USGS gaging station upstream of Colby Lake. The actual effect is probably closer to the lower end of this range, because decreased mean annual flow may tend to reduce stream connectivity with wetlands, and model input values are derived from settings where water level fluctuations are greater than expected in the Partridge River drainage.

Table 4.5-14 Input values for estimation of the effect of water level fluctuation on methylmercury production in the Partridge River above Colby Lake

Variable	Symbol	Value	Source/Comment
Wetlands			
Total wetland area (ha.)	W_{Total}	11,559 (28,563 acres)	Barr (2007b)
North Branch watershed (ha.)	H_N	6,760 (16,704 acres)	Barr (2007b)
Wetlands in North Branch watershed (fraction)	w_N	0.1 – 0.9	Assumed interval
North Branch wetlands area affected (fraction)	$a_{Wetlands}$	0.1 – 0.6	Assumed interval. All wetlands on opposite side of N. Branch and main stem assumed to be unaffected.
Streams			
Variable	**Symbol**	**Value**	**Source/Comment**
North Branch length (km)	L_1	14 (9 miles)	DeLorme (2006)[1]
Main stem length (km)	L_2	26 (16 miles)	DeLorme (2006)[1]
Stubble Creek length (km)	L_3	4 (2 miles)	DeLorme (2006)[1]
South Branch length (km)	L_4	14 (9 miles)	DeLorme (2006)[1]
Colvin Creek length (km)	L_5	25 (16 miles)	DeLorme (2006)[1]
Wetlegs Creek length (km)	L_6	4 (2 miles)	DeLorme (2006)[1]
Longnose Creek length (km)	L_7	7 (4 miles)	DeLorme (2006)[1]
Stream corridor width (m)	c	10 – 30 (30 – 100 ft)	Assumed interval
North Br. and Main stem area affected (fraction)	$a_{Streams}$	0.25 – 1.0	Assumed interval
Wetlands and Streams			
Variable	**Symbol**	**Value**	**Source/Comment**
Water level effect multiplier	f	2 – 10	Sorensen *et al.* (2005) Kelly *et al.* (1997)

Peatland Disruption

The potential for increased export of methyl mercury due to stockpiling of peat at the mine site was assessed using two methods. Simola and Lodenius (1982) reported a five-fold greater export of methylmercury following drainage of 80% of the peatland in a watershed in which the peatland constituted 35% of the watershed area. Peatland and total wetland composition was similar in the watersheds studied by Westling (1991) who reported a 1.7-1.9 fold greater methylmercury concentration in runoff following peatland drainage.

The mine site encompasses approximately 8.4% of the peatland within the Partridge River basin. Scaling of the drainage-related impacts reported in Simola and Lodenius (1982) and Westling (1991) by the relative portion of the peatland affected, drainage of the peatland on the NorthMet mine site would result in a nominally estimated increase of 7-42% in export of methylmercury from the watershed (Predicted/Baseline=1.07-1.42). Stockpiling of peat, such as would occur on the Northmet mine site could result in a larger increase in methylmercury export because stockpiling may enhance oxidation of sulfides and peat to a greater degree than does drainage alone. Relative increases in methylmercury export will be greater in affected reaches upstream of major unaffected tributaries.

An alternative analysis of peatland disturbance effects on methylmercury export was based on the total mercury content of the peat of the NorthMet mine site and a range of assumptions about the rate at which the mercury contained in the stockpiled peat is methylated and transported from the watershed. It is assumed that peat is stockpiled at a constant rate over the first 15 years of mine operation, and a constant fraction of the mercury contained in the stockpiled peat is methylated and transported in runoff; thus, estimated annual methylmercury export due to peatland disturbance peaks in year 15 and declines thereafter. Assuming 30 mg m^{-2} as the total mercury content of peat (Grigal 2003) and 380 ha of peat (Barr 2006a), the results of the analysis are listed in Table 4.5-15. The broad range of values for annual peat yield (left column of Table 4.5-15) encompasses the uncertainty in this model parameter. Baseline methylmercury export from the watershed for comparison was estimated as was done for the assessment of the long term effects of land cover changes.

Table 4.5-15 Peak increment in annual methylmercury (MeHg) export from the Partridge River watershed resulting from mobilization and methylation of total mercury (TotHg) contained in peat on the mine site

Annual Peat Yield (fraction of Hg converted to MeHg in g MeHg/g TotHg-yr)	Change Ratio (Predicted/ Baseline)
0.00001	1.0 - 1.1
0.0001	1.1 - 1.5
0.001	2 – 6
0.01	8 -- 50

Collection and use in the processing plant of stormwater runoff and leachate from overburden stockpiles or treatment prior to release to the Partridge River would significantly reduce transport of methylmercury to downstream surface waters.

Estimation of methylmercury yield from stockpiled peat at the mine site is highly uncertain given this analysis of available information. This high degree of uncertainty derives from the uncertainty in the methylmercury yield of peat. Consequently, the analysis does not lead to definitive conclusions regarding the potential for enhanced methylmercury production. Because of the large pool of mercury sequestered in the peatland within the NorthMet mine site, however, mobilization of even a small fraction of that pool would have a large effect on methylmercury production at the scale of the Partridge River watershed.

Embarrass River and Upper St. Louis River Watersheds

Among the factors potentially affecting mobilization and methylation of mercury, sulfate is the principal concern in the Embarrass River watershed. Other factors examined for the Partridge River watershed are not of concern in the Embarrass River given the nature of the proposed Project-related activities in the Embarrass River watershed. Thus, the analysis for the Embarrass River watershed is limited to the effects of sulfate mobilization. Sulfate also is the principle factor of concern for the St. Louis River downstream of the confluence with the Embarrass River.

An analysis similar to that performed for sulfate in the Partridge River was applied separately to the Embarrass River and to the St. Louis River watershed upstream of the Embarrass River confluence (encompassing the Embarrass River and Partridge River watersheds and the St. Louis River and tributary watersheds upstream of the confluence). This analysis differed from that performed for the Partridge River in that affected and unaffected areas were derived from National Wetlands Inventory polygon data obtained from the Minnesota DNR (http://deli.dnr.state.mn.us/data_catalog.html). Affected areas were those estimated to receive seepage or groundwater flow from the Mine Site (Partridge River watershed) or the Tailings Basin (Embarrass River watershed), or the stream channel and riparian wetlands immediately adjacent to the stream channel downstream of such areas.

For the purpose of this analysis, baseline sulfate concentration was assumed to be the same throughout the study area. Assumed sulfate concentration given Project impacts are listed in Table 4.5-16 Discharge from each watershed was assumed to be proportional to its area. The ratio of change in methylation rate to change in sulfate concentration was assumed to be in the interval of 1.0 to 2.0, as was assumed for the Partridge River analysis.

Table 4.5-16 Assumed project-related sulfate concentrations relative to a uniform baseline concentration

Watershed	Sulfate Concentration Relative to Baseline
Embarrass River	1.6
Upper Partridge River (above Colby Lake)	1.6
Lower Partridge River (Colby inflow to mouth)	1.6
Middle St. Louis River (Embarrass confluence to Whitewater Reservoir outflow channel)	1.3
Upper St. Louis River (above confluence with Whitewater Reservoir outflow channel)	1.0

This conservative estimation method indicates methylmercury production in the Embarrass River watershed and in the St. Louis River watershed above the mouth of the Embarrass River will be less than twice baseline conditions. The estimate assumes the response of methylmercury production to increased sulfate concentration could be as much as 2 to 1.

Summary and Conclusions

The analyses described here do not support precise estimates of project effects on mercury bioaccumulation. Furthermore, effects are not estimated in ways that allow them to be quantitatively aggregated. This situation arises, in part, from the current state of the science related to mercury cycling in ecosystems. Despite these limitations, some broad interpretations can be made from the results. First, local changes to the terrestrial and aquatic environment resulting from the project have greater potential to enhance bioaccumulation of mercury than does the increase in atmospheric deposition of mercury from the projects included in the cumulative impact analysis. Second, loss of wetlands may marginally reduce methylmercury yield of the Partridge River watershed over the long term; however, the projected magnitude of this effect is relatively small and would appear, if at all, only after transient effects of the project have diminished. Third, factors tending to increase methylmercury production and delivery to surface waters would dominate during mine operation and perhaps for some time following mine closure. Sulfate mobilization, water level fluctuation, and mobilization and methylation of mercury sequestered in peat all tend to increase the potential for mercury bioaccumulation in fish. The potential effect of water level fluctuation in the Partridge River is highly uncertain, ranging from *de minimus* change to four times baseline. Finally, the effects of sulfate and mercury mobilization and their effects on mercury methylation are cumulative although not necessarily strictly additive. Individually and collectively these factors may significantly increase the potential for bioaccumulation in fish by increasing the production and bioavailability of methylmercury.

Increased sulfate can be expected to no more than double mean methylmercury bioavailability upstream of the USGS gage above Colby Lake, in the Embarrass River, and in the St. Louis River watershed upstream of the Embarrass River confluence.

Over the long term wetlands loss associated with land cover changes could reduce methylmercury yield of the watershed by less than 10%; however, over the near term land cover disturbance is expected to increase mercury yield by an unquantified amount. The effect of peat excavation and stockpiling is highly uncertain. Mobilization and methylation of mercury sequestered in the peat on the mine site could result in large increases in methylmercury bioavailability in the Partridge River drainage depending on the rate at which the mercury in the peat is mobilized and methylated. This effect would be influenced by the manner in which stockpiled peat and associated runoff and leachate are managed.

Potential monitoring and mitigation measures

There is a high degree of uncertainty regarding mobilization and methylation of total mercury contained in peat on the mine site (Table 4.5-15) as well as uncertainty in the degree of mercury release and transport from waste rock stockpiles and tailings. Monitoring of mercury levels in leachate and groundwater at the Tailings Basin and waste rock stockpiles and in stormwater runoff from overburden stockpiles containing peat and from other physically disturbed areas consisting of peat would provide valuable information for reducing uncertainty regarding this source of methylmercury loading to the Partridge River. Depending on the results of such monitoring, additional mitigation measures may be needed to control this potential methylmercury source.

4.6 AIR QUALITY

4.6.1 Existing Conditions

4.6.1.1 Regional Climate and Meteorology

The climate classification for the project area and Minnesota in general, is defined as continental. The region is subject to continental polar air masses throughout most of the year and during the cold season is subject to more frequent Arctic air masses. During the summer months, the southern portion of the state gives way to warm air entering northward from the Gulf of Mexico. As Pacific Ocean air masses move across the western United States, relatively mild and dry weather can be observed throughout the year, depending upon the strength of the air mass.

Based upon surface data taken at Hibbing Monitoring Station (see Figure 4.6-1), predominant winds are from the north-northwest through northwest. Average monthly temperatures range from 5.1^{o}F in the coldest month (January) to 65.1^{o}F in the hottest month (July). Extreme temperatures throughout the state can vary from 114^{o}F in the summer to -60^{o}F in the winter (Michigan, 2008). During the three coldest months (December through February), maximum daily temperatures are below 32^{o}F for 24 days per month. Temperatures in the summer months rarely reach maximum temperatures above 90^{o}F (only 5 to 6 days per year).

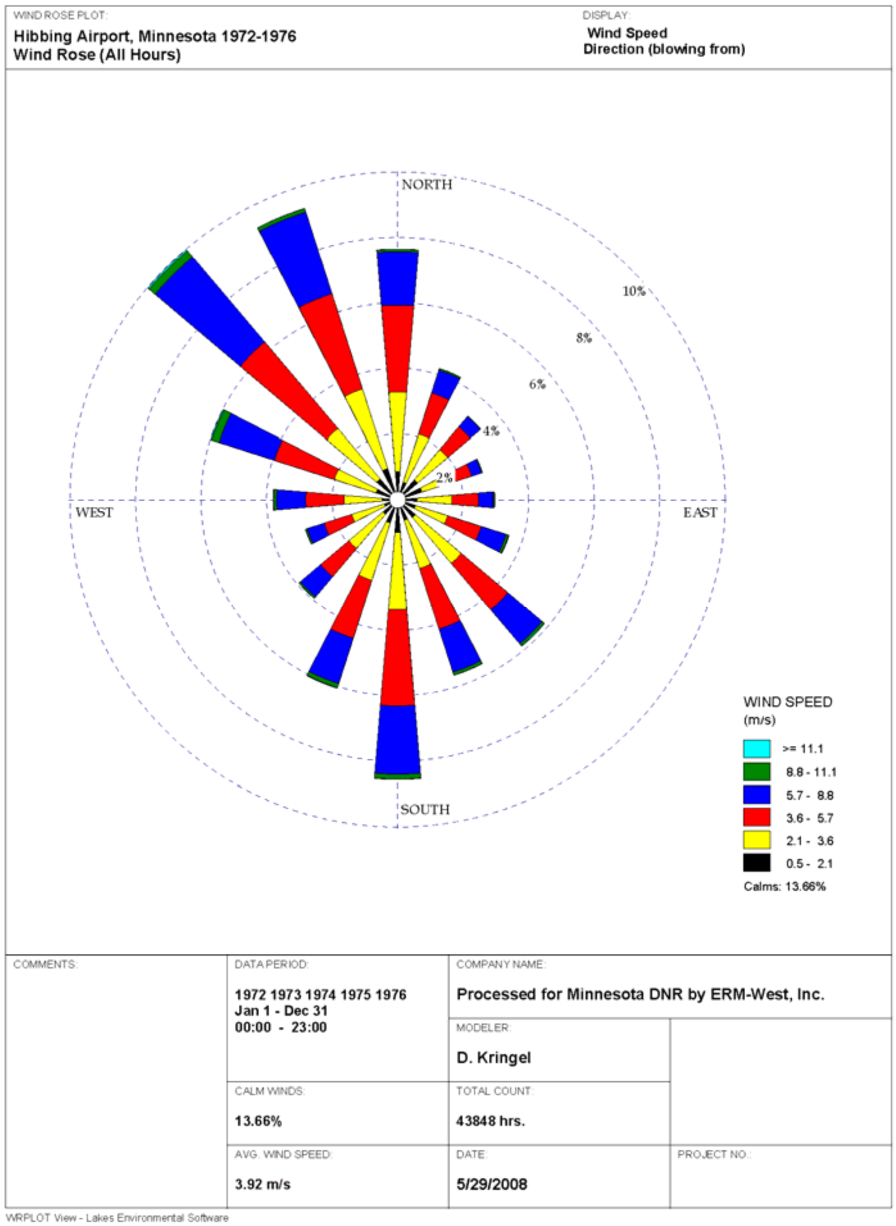
The vast majority of precipitation (approximately two-thirds) occurs between May and September. Northeastern Minnesota generally receives approximately 51 inches of snow per year. Snow cover occurs much of the year in Minnesota with an average of 110 days per year with one inch or more on the ground, although there is a marked difference between the northern (where the Project is located) and southern portions of the state, ranging from 140 days per year to 85 days per year of snow cover, respectively.

4.6.1.2 Local and Regional Air Quality

The United States Environmental Protection Agency (USEPA) has established National Ambient Air quality Standards (NAAQS) for seven criteria air pollutants including, nitrogen dioxide (NO_2), sulfur dioxide (SO_2), carbon monoxide (CO), ozone (O_3), particulate matter less than 10 microns (PM_{10}), particulate matter less than 2.5 microns ($PM_{2.5}$), and lead (Pb). 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.

In addition, the Minnesota Pollution Control Agency (MPCA) has also promulgated ambient air standards for the State of Minnesota, known as the Minnesota Ambient Air

Figure 4.6-1 Wind Frequency Distribution Plot for Hibbing, Minnesota



Air Quality Standards (MAAQS). In addition to the criteria pollutants, the MAAQS contain ambient safe levels for total suspended particulates (TSP) and hydrogen sulfide (H_2S).

The NAAQS and MAAQS are summarized in Table 4.6-1).

Table 4.6-1 Summary of NAAQS and MAAQS

Pollutant	Averaging Period	Standard Value	Standard Value	Standard Type[1]	Notes
Carbon Monoxide	1-Hour	35 ppm	40 mg/m^3	Primary	Cannot be exceeded more than once per year
	1-Hour[2]	30ppm	35 mg/m^3	Primary	
	8-Hour	9 ppm	10 mg/m^3	Primary and Secondary	
Nitrogen Dioxide	Annual Arithmetic Mean	0.05 ppm	100 µg/m^3	Primary and Secondary	Cannot be exceeded.
Ozone	8-Hour	0.075 ppm	147 µg/m^3	Primary and Secondary	Daily maximum 8-hour average
Lead	Quarterly		1.5 µg/m^3	Primary and Secondary	Quarterly Average
Total Suspended Particulate (TSP)[2]	Annual Geometric Mean		75 µg/m^3 60 µg/m^3	Primary Secondary	Cannot be exceeded.
	24-Hour		260 µg/m^3 150 ug/m3	Primary Secondary	Cannot be exceeded more than once per year
PM_{10}	Annual Arithmetic Mean[2]		50 µg/m^3	Primary and Secondary	Cannot be exceeded.
	24-Hour		150 µg/m^3	Primary and Secondary	Not to be exceeded more than once per year on average over 3 years
$PM_{2.5}$	Annual Arithmetic Mean		15 µg/m^3	Primary and Secondary	Not to exceed the 3-year average of the weighted annual mean concentrations
	24-Hour		35 µg/m^3	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 ppm 0.02 ppm	80 ug/m3 60 ug/m3	Primary Secondary[2]	Cannot be exceeded.
	24-Hour	0.14 ppm	365 µg/m^3	Primary and Secondary	Cannot be exceeded more than once per year
	3-Hour	0.5 ppm	1300 µg/m^3	Primary and Secondary	
	3-Hour[2]	0.35 ppm	915 µg/m^3	Secondary	
	1-Hour[2]	0.5 ppm	1300 µg/m^3	Primary	
Hydrogen Sulfide[2]	½-Hour	0.05 ppm	70 µg/m^3	Primary	Not to be exceeded over 2 times per year
	½-Hour	0.03 ppm	42 µg/m^3	Primary	Not to be exceeded over 2 times in any 5 consecutive days

[1]Primary standards set limits to protect human health; Secondary standards set limits to protect public welfare.
[2]Minnesota State Ambient Air Quality Standard only
Source: MPCA, 2008.

Ambient air quality is measured at various locations throughout the State. Ambient monitoring data from the closest monitoring stations to the Project are provided in Table 4.6-2. As seen from the table, all reported air quality data are below the NAAQS and MAAQS. .

Table 4.6-2 Monitored Background Concentrations (2004 – 2006)

Pollutant	Averaging Period	Monitored Background Concentration	Standard Value	Standard Type	Monitoring Station
Carbon Monoxide	8-Hour	1.6 ppm	9 ppm	Primary	314 West Superior Street, Duluth
	1-Hour	3.3 ppm	35 ppm 30 ppm(1)	Primary Primary and Secondary	314 West Superior Street, Duluth
Nitrogen	Annual	0.004 ppm	0.05 ppm	Primary and Secondary	Carlton County
Ozone	8-Hour	0.066 ppm	0.08 ppm	Primary and Secondary	Voyageurs national Park
Lead	Quarterly	0.01 μg/m^3	1.5 μg/m^3	Primary and Secondary	Virginia City Hall
Total Suspended Particulate (TSP)(1)	Annual	16 μg/m^3	75 μg/m^3 60 μg/m^3	Primary Secondary	Virginia City Hall
	24-Hour	32 μg/m^3	260 μg/m^3 150 μg/m^3	Primary Secondary	Virginia City Hall
PM_{10}(2)	Annual	16 μg/m^3	50 μg/m^3	Primary and Secondary	Virginia City Hall
	24-Hour	32 μg/m^3	150 μg/m^3	Primary and Secondary	Virginia City Hall
$PM_{2.5}$	Annual	6.1 μg/m^3	15 μg/m^3	Primary and Secondary	Virginia City Hall
	24-Hour	19 μg/m^3	35 μg/m^3	Primary and Secondary	Virginia City Hall
Sulfur Dioxide	Annual	0.001 ppm	0.03 ppm 0.02 ppm(1)	Primary Secondary	Rosemount, MN
	24-Hour	0.005 ppm	0.14 ppm	Primary and Secondary	Rosemount, MN
	3-Hour	0.010 ppm	0.5 ppm 0.35 ppm	Primary and Secondary(3) Secondary(4)	Rosemount, MN
	1-Hour	0.019 ppm	0.5 ppm(1)	Primary	Rosemount, MN

(1) Minnesota State Ambient Air Quality Standard only.
(2) The EPA revoked the annual PM_{10} standard (effective December 17, 2006). However, it is still reflected in the State of Minnesota's regulations.
(3) Secondary standard for Air Quality Control Regions 128, 131, and 133.
(4) For Air Quality Control Regions 127, 129, 130, and 132.

Source: MPCA, 2008

4.6.1.3 Federal Regulations

Attainment Status

Areas that do not meet NAAQS are considered to be a "nonattainment area" for that pollutant and are required to provide state implementation plans (SIPs) to control existing and future emissions in order to bring the area into compliance with the NAAQS. "Attainment areas" are those areas that either have collected ambient air quality data to demonstrate that it is in compliance or do not have data to show they are in non-compliance with the NAAQS, known as "unclassified areas".

The immediate project area is in attainment for all criteria air quality pollutants and is considered to be a Class II attainment area. For attainment areas, the USEPA has promulgated Prevention of Significant Deterioration (PSD) Increments for three pollutants, NO_2, SO_2, and PM_{10}. There are two sets of PSD Increments, one for generally pristine areas, and one for the remaining areas in the country. 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, having more restrictive allowable increment thresholds. These areas include national parks, wilderness regions, monuments, and other areas as specified in 40 FR 51.166(e). Class II PSD increments are designed to allow further growth within the rest of the country. Table 4.6-3 provides a summary of the Class I and Class II PSD Increments.

Table 4.6-3 Summary of Allowable PSD Class I and Class II Increments

Pollutant/Averaging Period	Allowable Increment (ug/m3)	
	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_{10}, Annual	4	17

PSD Increments

In addition to PSD Increments, Projects that are located within 300 kilometers (186 miles) of a Class I area may be required by the Federal Land Manager (FLM) to evaluate impacts on air quality related values (AQRVs), including visibility flora/fauna, water quality, soils, and odor. The proposed site is located within 300 km of four Class I regions, including Boundary Waters Canoe Area Wilderness (BWCAW) and Rainbow Lakes Wilderness (RLW), administered by the U.S. Forest Service (USFS), and Voyageurs National Park (VNP) and Isle Royale National Park (IRNP), under the administration of the National Park Service (NPS). Table 4.6-4 provides the distances to each region from the site.

Table 4.6-4 Project Setting to Class I Regions

Class I Region	Nearest Distance from Proposed Site (km/mi)
BWCAW	34/21
VNP	82/51
RLW	142/88
IRNP	218/135

New Source Performance Standards

The Federal New Source Performance Standards (NSPS) are technology-based standards that are applicable to new or modified stationary sources of regulated emissions. The NSPS program has defined emission limitations for approximately 70 sources categories that are designated by size as well as types of process. A comprehensive list of the applicable regulations for this facility will be included as part of the air quality permit. The following is a partial list of standards that may apply to the Project:

- Subpart A – General Provisions, which provides for general notification, record keeping, 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 affected sources.
- Subpart OOO – Standards of Performance for Nonmetallic Mineral Processing Plants, which limits particulate emissions and opacity from new, modified, or reconstructed affected 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 an air basin is designated as a nonattainment area or a maintenance area. Since the Project area is classified as in attainment for all criteria pollutants, a General Conformity Determination is not required.

4.6.1.4 State of Minnesota Regulations

The Minnesota Pollution Control Agency (MPCA) has promulgated rules concerning the control and permitting of sources throughout the State of Minnesota. The following regulations will be evaluated for the Project

Prevention of Significant Deterioration Review

Minnesota Rule 7007.3000 provides 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 program includes:

- BACT Demonstration
  Ambient Air Quality Analysis to assess project impacts with NAAQS, MAAQS, and PSD Increments
  An assessment air quality related values (AQRV) of the direct and indirect effects of the 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.
  Public comment.

Although the Project is not considered a major source for PSD (BACT, demonstration, PSD Increment assessment and AQRV assessment is not required via Minnesota Rule 7007.3000), a comprehensive analysis of NAAQS, MAAQS, PSD Class I and II Increments, and air quality related values was performed to help the evaluation of impacts in the CPDEIS.

Minnesota Standards of Performance

A comprehensive list of Minnesota Standards of Performance would be identified in the air quality permit. The following provides a partial list of Minnesota Standards of Performance that may be applicable to the Project. It should be noted that this list may increase or decrease, depending upon the final assessment of the permit application by the MPCA.

- Control of Fugitive Particulate Matter (Minn.R. 7011.0150), which applies to bulk material handling operation. The rule prohibits the release of "avoidable amounts" of particulate matter 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 (Minn.R. 7011.2300). This applies to the emergency fire water pumps and the emergency generators, which limits SO_2 emissions to 0.5 lb/MMBTU heat input.
  Standards of Performance for Post-1969 Industrial Process Equipment (Minn. R. 7011.0715). This would apply to all new ore handling equipment that would generate particulate matter emissions. Due to the remote location of the Project, the required control equipment efficiency standard would be 85 percent.

- Standards of Performance for Existing Indirect Heating Equipment (Minn. R. 7011.0510). The rule limits the PM emissions between 0.4 and 0.6 lb/mmBTU, limits SO_2 emissions 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 mine processing operations.
- Standards of Performance for New Indirect Heating Equipment (Minn. R. 7011.0515). The rule limits emissions of PM to between 0.1 and 0.4 lb/mmBTU, SO_2 emissions between 0.8 and 4.0 lb/mmBTU, NOx emissions 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 (Minn. R. 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 (Minn. R. 7011.0710). The rule limits mass PM emissions based upon process weight and limits opacity to 20 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 (Minn. R. 7011.3520). The rule incorporates federal Standards of Performance for Stationary Compression Ignition Internal Combustion Engines under the Code of Federal Regulations (CFR), Title 40, 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 (Minn. R. 7011.8150). The rule incorporates federal National Emission Standards for Hazardous Air Pollutants (NESHAP) under the CFR, Title 40, Part 63, Subpart ZZZZ. This may apply to fire water pumps and emergency generators that may be used in the mine processing operations.

4.6.2 Impact Criteria

Various state and Federal air quality standards and emissions standards have been established to minimize degradation of air quality. The impact criteria used for the evaluation of potential impacts on air quality from the Project or an alternative is whether it would cause any of the following conditions:

- Exceedence of National and Minnesota Ambient Air Quality Standards (NAAQS and MAAQS);
- Adversely affect human health as determined by an Air Emissions Risk Analysis (AERA);
  Result in consumption of PSD increments as defined by the Clean Air Act (CAA),

Title I, PSD rule;
Adversely affect visibility and cause regional haze in Class I areas;
Adversely affect Air Quality Related Values in Class I areas.

4.6.3 Environmental Consequences

To determine whether the Project would result in any of the above listed conditions, an evaluation of the emissions associated with the Project was performed through air dispersion modeling. The results of air dispersion modeling were reviewed against the stated conditions. Detailed air dispersion modeling was conducted to evaluate compliance with NAAQS and MAAQS, to conduct PSD increment analysis, and to review potential impacts to Class I and Class II areas. Although the Project is not considered a major source for PSD considerations, the modeling analysis for the purpose of the CPDEIS was conducted pursuant to the PSD regulations. The methods used for modeling are summarized below. Also summarized below are the results of the modeling and potential impact of the Project used to represent an upper bound for assessing potential impacts.

The potential effects of air pollutants emissions discussed in this section based on activities and operations at each Site. The majority of potential criteria and non-criteria pollutant emissions are expected from the autoclaves, limestone material handling and the mine haul roads. Fugitive emissions of PM_{10} would result from the handling of limestone and other materials. Air quality modeling addressed emissions from all of the sources (inclusive of mobile sources). NorthMet is accepting limits to be classified as a synthetic minor PSD source and therefore is not subject to PSD requirements including modeling attainment with PSD increments for permitting purposes. Even so, the facility performed modeling analyses to assess its impact for the purposes of the CPDEIS. As demonstrated in Table 4.6-5, the NorthMet Project does not have the permitted potential to emit above major PSD threshold on an annual basis.

Impacts due to these emissions for both the NorthMet Plant and Mine sites are examined in more detail later in this section. This section describes the potential impacts that may occur on local and regional air quality from implementing the Project. Potential visibility impacts that could occur from increases in regional haze and localized visibility are also discussed.

4.6.3.1 Proposed Action

Criteria Pollutants

From an air quality perspective, emissions from the Project would be expected to occur from the mining operations at the Mine Site and ore/concentrate processing at the Plant Site. Although these two sites are separated geographically, they are joined by the rail line that would be used exclusively to transport ore from the Mine Site to the Plant Site. As such, the project is considered as a single project for permitting purposes, and thus, the total emissions from both sites are summed for the purposes of this analysis.

At the Mine Site, emissions were estimated for material handling sources associated with excavation, portable crushing and screening operations, blast hole drilling, 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 separate the larger rocks from soil and gravel in the overburden to produce rock suitable for construction purposes. Haul trucks would be traveling over unpaved roads from the excavation site to the rail loading and stockpiling areas. Fugitive emissions would be generated as part of these operations.

At the Plant Site, point source emissions are predicted to occur from the crushing plant, flotation operation autoclaves, hydrometallurgical processes, process consumables handling sources, and combustion sources. In addition, fugitive emissions are expected to occur from raw materials handling, Plant Site roads, tailings basin, and Dunka Road sources.

Detail information of the emission calculations for the Mine Site and Plant Site sources are provided as separate documents (Barr, 2008a, Barr 2008b, Barr, 2008c, Barr, 2008d). Table 4.6-5 summarizes the projected actual emissions for the Mine Site, Plant Site, and Total Emissions, calculated as per the PSD regulations. It should be noted that fugitive sources are not included in the determination of a major source.

Table 4.6-5 Annual Criteria Air Pollutant Emissions

Pollutant	Plant Site Projected Actual Emissions (TPY)	Mine Site Projected Actual Emissions (TPY)	Total Projected Actual Emissions (TPY)	PSD Major Source Thresholds (TPY)
NO_x	43	10	53	250
SO_2	18	0.9	19	250
PM_{10}	175	3	178	250
VOC	101	0.6	102	250
Pb	0.2	.2	0.4	250
CO	99	2	101	250

Currently, no assessment of $PM_{2.5}$ emissions from the project has been evaluated. $PM_{2.5}$ has been determined to be a criteria pollutant by the USEPA, however, due to the complexity in developing and assessing $PM_{2.5}$ emissions from a regulatory standpoint and challenges in the federal courts, the USEPA has been delayed in developing guidance on assessing $PM_{2.5}$ for regulatory compliance. In 2008, the USEPA issued guidance to the states for inclusion in their state plans. Just recently (July, 2008), the USEPA issued guidance to the states on addressing $PM_{2.5}$ in regulatory permitting.

Due to these recent changes, PolyMet is currently developing analyses to address the $PM_{2.5}$ emissions and impacts for inclusion into their permit application to the MPCA. Currently, these analyses have not been completed and are, therefore, not addressed in this CPDEIS. However, the analyses are expected to be completed and included in the Final EIS for this project.

Toxic Emissions

Small amounts of toxic emissions known as Hazardous Air Pollutants (HAP) are expected to occur from the Project throughout the processes. Table 4.6-6 provides the estimate of HAP emissions for the Project. As seen from the table, total emissions of a single HAP is below 10 tpy and the combined HAP emissions are below 25 tpy, indicating that the HAP emissions would not exceed USEPA PSD major source thresholds.

Table 4.6-6 Annual HAP Emissions

Pollutant	Plant Site Potential To Emit (TPY)	Mine Site Potential To Emit (TPY)	Total Potential To Emit (TPY)	PSD Major Source Threshold (TPY)
Single HAP[1]	5	1	6	10
Combined HAPs	15	5	20	25

Predictive Modeling Approach

The AERMOD (Version 07026) air quality model was used with the Building Profile Input Program (BPIP, version 04274) at the Plant Site and no building downwash parameters at the Mine Site to model Project operations with the exception that downwash was used for locomotive exhaust. The MPCA prefers the AERMOD modeling system and USEPA has included AERMOD as an approved guideline model. Deposition was accounted for in the modeling using AERMOD's half-life option (Barr, 2008e). The model was set to RURAL dispersion because the terrain/land use within 3 kilometers (1.9 miles) of the site is almost completely rural. Meteorological data (2001-2005) from the Hibbing station and concurrent

[1] Note: Nickel is worst-case HAP for the Plant Site, manganese is worst-case for the Mine Site. Worst-case for project totals is nickel. Values in Table 4.6-6 reflect nickel emissions.

International Falls mixing heights data, suitable for input to AERMOD were used for the NorthMet modeling.

The air quality modeling addressed the individual point sources, as well as all sources of fugitive particulate matter. The modeling was conducted to determine the extent of impacts from criteria pollutant emissions on ambient air quality and to identify the significant impact area (SIA) for each pollutant. Modeling was conducted for particulate matter less than 10 microns (PM_{10}), nitrogen dioxide (NO_2), and sulfur dioxide (SO_2) and their respective applicable averaging time at both the Plant and Mine sites (Barr, 2008f, Barr, 2008g). Ozone (O_3) 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 O_3 is not emitted directly from any mining or ore-processing source. Emissions of lead (Pb) were not modeled because the NorthMet Project would not result in an appreciable lead emissions. Carbon Monoxide (CO) emissions were not modeled due to experience within the MPCA and the likelihood that there would not be any concern about the outcome of the modeling.

The significance impact area was determined for pollutants, which are shown to have a significant impact in ambient air at any point and more refined modeling was carried out to evaluate compliance with PSD increments and NAAQS. All point and fugitive sources associated with the Plant and Mine sites were included in the source input for PSD increment modeling, with the exception of the Plant Site paved roads and the tailings basin which were in operation at the baseline date. Additionally, data on the following nearby major increment-consuming (or - expanding) sources, which were provided by the MPCA, were also included as source input:

- Northshore Peter Mitchell Mine
- Mesabi Nugget Phases 1 and 2 Projects
- Cliffs Erie Pellet Yard
- Laskin Energy
- LTV Steel Mining Company (LTVSMC)

The facilities listed above, except for Northshore Mine, were modeled as nearby sources using model inputs from the Minnesota Steel Class II report. The Northshore mine inputs were taken from its Title V permit. For comparison to the NAAQS, a background concentration was added to the modeled concentration. PM_{10} background concentrations represent the 2004-2006 average concentrations for the high-second-high 24-hour concentration and annual average concentration from Virginia, Minnesota. SO_2 and NOx background concentrations are from Table 6 of MPCA's Air Dispersion Modeling Guidance – Northshore Mining, Silver Bay, MN PSD application (Dec 1999).

Class I Area-Related Modeling Approach

An air quality modeling analysis was conducted to estimate impacts of the NorthMet Project on air quality in Class I areas. The Class I air quality related value (AQRV) analyses addressed PSD Class I Increments for SO_2, PM_{10}, and NO_2, sulfur and nitrogen deposition, and visibility impairment (regional haze). The dispersion modeling analysis used standard EPA long-range transport modeling methodologies, and followed guidance as presented in EPA's Guideline on Air Quality Models, the IWAQM Phase 2 report, and the FLAG Phase I report (Barr, 2008h). The analyses also incorporated suggestions and guidance received from the U.S. Forest Service and the National Park Service (Barr, 2008h). The CALPUFF air quality model was used for all Class I area analyses.

Input options and data utilized in the models generally corresponded to default or recommended values; however for the NorthMet Project, a list of representative, project-specific input parameters were used (Barr, 2008g and Barr, 2008h) The CALPUFF modeling analysis used meteorological data for the years 2002, 2003, and 2004. Additional surface, upper air, and precipitation data were used in CALMET to refine the meteorological fields. Hourly surface data from 74 stations and precipitation data from 99 stations were used along with three upper air data from five stations.

The Class I AQRV analysis addressed impacts to the BWCAW, IRNP RLW and VNP.

NAAQS and PSD Increment Impact Analysis

State and Federal air quality rules prohibit emissions from a new process plant that cause or contribute to a conflict with MAAQS or NAAQS. In addition, impact from these emissions cannot exceed established PSD increments. To demonstrate compliance with these requirements, an air dispersion modeling analysis for the NorthMet Project was conducted (Barr, 2008f and Barr, 2008g). The Plant Site emissions were modeled with all sources operating at full capacity in a single modeling run. This conservatively over estimates the impact as not all sources will be capable of operating simultaneously. PM_{10} is the primary pollutant emitted from the Plant Site. Emissions of SO_2 and NO_X would be in small quantities because the process is conducted at relatively low temperatures and would not include any continuous operating fuel combustion sources. The Mine Site emission rates are based on a daily average throughput of 32,000 tons of ore.

The Plant and Mine sites are located 8 miles apart other and connected by a private railway that was originally constructed to transport iron ore pellets from Erie Mining Company' process plant to their ore dock. The railway is used for the transportation of ores from the Mine Site to the Plant Site. Due to the distance between the Plant and Mine sites, it is more practical and reasonable to perform individual air dispersion modeling for receptors at each site and adding the other site as a volume source contribution to estimate maximum concentrations, as agreed upon with MPCA. The results are discussed below.

Significant Impact Analysis in Table 4.6-7 shows modeled impacts at the Plant and Mine site receptors. The Maximum Area modeled impacts are maximum from either the Plant Site or the Mine Site analyses, since each analysis includes all project emissions, as defined above. The USEPA has developed significant impact levels (SILs) below which facility impacts 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.

Table 4.6-7 Highest Project Impacts and PSD Class II SILs

Pollutant	Averaging Time	Plant Site Area Modeled Impacts (ug/m3)	Mine Site Area Modeled Impacts (ug/m3)	Maximum Area Modeled Impacts (ug/m3)	SIL (ug/m3)
SO_2	3-hour	147	2.1	147	25
	24-hour	37	0.61	37	5
	Annual	5	0.04	5	2
PM_{10}	24-hour	56	29	56	5
	Annual	11	4.9	11	1
NO_2	Annual	9	1.9	9	1

Class II PSD Increment Analysis

Increment analyses were completed for SO_2, PM_{10}, and NO_X for both the Plant and Mine sites. The modeling included all project increment consuming sources at maximum emission rates plus all nearby increment consuming (and expanding) emissions sources, including, Cliffs Erie Pellet Yard, LTV Steel Mining Company (LTVSMC), and Mesabi Nugget. The results of the increment analyses are shown in Table 4.6-8, along with a comparison to the allowable Class II PSD increments.

Mine Site Receptors Analysis

The PM_{10} modeling was conducted for two operating scenarios corresponding to the different Category 1 and 2 waste rock disposal operations that would occur over the 20 year life of the mine. NO_X and SO_2 are primarily emitted by mobile sources at low concentration and constant emission rates; therefore, 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 highest 2nd high (H2H) PM_{10} concentration was 27 ug/m^3 for the Year 8 operating scenario and 29 ug/m^3 for the year 16 operating scenario. Modeling was also performed for NO_X at the Mine Site receptors for PSD Increment analyses. Based on the dispersion modeling results, the PSD Increment concentration for NO_X is 1.9 ug/m^3. SO_2 impacts from the project at the Mine Site were below the SILs, so no additional modeling including nearby sources was performed.

Plant Site Receptors Analysis

The operation at the Plant Site, including fugitive sources, building vents, limestone material handling, and vehicular traffic on paved roads would result in a maximum increment concentration for PM_{10} of 9 ug/m^3 on a cumulative impacts boundary receptor grid, based on the 24-hour H2H modeling. Modeled impacts for SO_2 and NO_X at the Plant Site receptors are well below the PSD Class II increments thresholds.

The data in Table 4.6-8 summarize the PSD Increment modeling results and demonstrate that the NorthMet Project, in conjunction with all other neighboring PSD sources, would comply with all state and Federal increment limits.

Table 4.6-8 Results of Class II PSD Increment Analysis

Pollutant	Averaging Time	Plant Site Modeled Impacts (ug/m3)	Mine Site Modeled Impacts (ug/m3)	PSD Increment Limits (ug/m3)
SO_2	3-hour	27	N/A	512
	24-hour	7	N/A	91
	Annual	1	N/A	20
PM_{10}	24-hour	9	29	30
	Annual	0	4.9	17
NO_X	Annual	1	1.9	25

Note:
(1) SO_2 concentrations were not modeled due to negligible incremental impact.
(2) Modeled PM_{10} concentrations are based on operating scenarios at Year 8 and Year 16.
(3) Plant Site modeled emissions include expansion credit and are evaluated at plant site boundary.
(4) Mine Site modeled emissions include Plant Site, Mesabi Nugget, Cliffs Erie pellet yard, and LTVSMC.

Class II NAAQS and MAAQS Evaluation

The NAAQS modeling calculated the maximum impact of the NorthMet Plant and Mine Sites and all other regionalegional sources and compared the highest total impacts, plus background concentrations, to applicable MAAQS and NAAQS. Maximum emission rates were modeled for all NorthMet sources and key criteria pollutants (NO_X, SO_2, and PM_{10}).

Mine Site

The analysis included potential emissions from nearby sources in the NAAQS analysis, including Mesabi Nugget, Cliffs Erie Pellet Yard, Northshore's Peter Mitchell Mines, and the Plant site. The other 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 impact on the Mine Site receptor grid (Barr, 2008f and Barr, 2008g).

The PM_{10} NAAQS modeling results conservatively added the maximum modeled emissions from the Mine Site plus the maximum modeled impact from the other nearby sources plus ambient background concentrations for comparison to the NAAQS. Cumulative modeling and further analyses for SO_2 were not performed because the SO_2 concentration at the Mine Site was shown to be well below the Significant Impact Levels (SILs). It should be noted that the SILs have been designed by the USEPA such that concentrations below these levels would not contribute to a change in the overall impact when combined with other nearby source impacts. NO_X concentrations were just above the SIL of 1 ug/m^3 and are modeled with contributions from nearby emission sources.

Plant Site

The NAAQS modeling on the Plant Site ambient boundary grid included all PolyMet plant sources evaluated in the PSD increment modeling plus the Tailings Basin emissions and unpaved road emissions not associated with the limestone traffic. The maximum modeled impact of 84 ug/m^3 occurred along the Plant Site southern boundary. All predicted concentrations are below allowable levels, and the results demonstrate compliance with all MAAQS and NAAQS.

Table 4.6-9 below summarizes results of the NAAQS model analysis for Plant and Mine sites. Using the same procedure as described for the PSD Increments, the maximum from either the plant site receptors or the mine site receptors was added to the ambient background to assess total impact, since each area modeling analysis included all of project and nearby sources. The H2H PM_{10} concentration for the five-year modeling period was used for comparison to the NAAQS PM_{10} 24-hour standard. Ambient air background concentrations were added to modeled concentrations to determine compliance with NAAQS and MAAQS. PM_{10} background concentrations represent the 2004-2006 average concentrations from the H2H 24-hour concentration and annual average concentration from Virginia, Minnesota.

Table 4.6-9 Results of Class II NAAQS Modeling

Pollutant	Averaging Time	Maximum Modeled – Plant Site (ug/m3)	Maximum Modeled – Mine Site (ug/m3)	Background (ug/m3)	Total (ug/m3)	NAAQS and MAAQS (ug/m3)
SO_2	1-hour	366	N/A	90	456	1300
	3-hour	285	N/A	25	310	915
	24-hour	140	N/A	11	151	365
	Annual	13	N/A	3	16	60
PM_{10}	24-hour	41	52	32	84	150
	Annual	4	7	16	23	50(1)
NO_X	Annual	3	2	12	15	100

Notes:
(1) The annual NAAQS for PM_{10} was rescinded on October 17, 2006.

Class I PSD Increment Modeling Results

Maximum modeled pollutant concentrations within the BWCAW, VNP, IRNP, and RLW regions were calculated for each of three years and are provided in Table 4.6-10. As seen from the table all of the concentrations, except for the 24-hour PM_{10} concentrations, are below their respective Class I SIL threshold, indicating that for these pollutants and averaging times, no significant impacts are predicted. The exceedence of the PM_{10} 24-hour Class I SIL does not indicate there is a significant impact, rather, a cumulative analysis must be considered. The cumulative analysis for this pollutant and averaging period is reflected in Section 4.6.4.3.

Table 4.6-10 Summary of PSD Class I Increment Analysis

Pollutant	Averaging Period	Year Evaluated 2002	2003	2004	Class I Inc (ug/m3)	Class I SIL (ug/m3)	Max (ug/m3)
		Boundary Waters Canoe Area Wilderness					
SO_2	3-Hour	0.392	0.526	0.441	25	1	0.526
	24-Hour	0.095	0.125	0.118	5	0.2	0.125
	Annual	0.006	0.007	0.005	2	0.1	0.007
NO_2	Annual	0.027	0.034	0.028	2.5	0.1	0.034
PM_{10}	24-Hour	0.443	0.538	0.419	8	0.3	0.538
	Annual	0.030	0.036	0.026	4	0.2	0.036
		Voyageurs national Park					
SO_2	3-Hour	0.055	0.054	0.070	25	1	0.070
	24-Hour	0.017	0.018	0.027	5	0.2	0.027
	Annual	0.001	0.001	0.001	2	0.1	0.001
NO_2	Annual	0.004	0.004	0.004	2.5	0.1	0.004
PM_{10}	24-Hour	0.104	0.109	0.201	8	0.3	0.201
	Annual	0.006	0.006	0.007	4	0.2	0.007
		Isle Royale National Park					
SO_2	3-Hour	0.005	0.005	0.007	25	1	0.007
	24-Hour	0.001	0.002	0.002	5	0.2	0.002
	Annual	0.000	0000	0.000	2	0.1	0.000
NO_2	Annual	0.001	0.000	0.001	2.5	0.1	0.001
PM_{10}	24-Hour	0.028	0.044	0.029	8	0.3	0.044
	Annual	0.002	0.001	0.002	4	0.2	0.002
		Rainbow Lakes Wilderness					
SO_2	3-Hour	0.000	0.000	0.010	25	1	0.010
	24-Hour	0.000	0.000	0.005	5	0.2	0.005
	Annual	0.000	0.000	0.000	2	0.1	0.000
NO_2	Annual	0.000	0.000	0.001	2.5	0.1	0.001
PM_{10}	24-Hour	0.001	0.002	0.046	8	0.3	0.046
	Annual	0.009	0.000	0.003	4	0.2	0.009

Class I Areas-Air Quality Related Values Impact Analysis

An air quality modeling analysis was conducted to estimate impact of the NorthMet Project on air quality in Class I areas. The analysis addressed visibility impacts to the BWCAW, VNP, and IRNP. The Class I AQRV analyses also included sulfur and nitrogen deposition and SO_2 impacts on soils, water, and vegetation. The results are discussed below.

Class I Visibility/Regional Haze Analysis

A visibility/regional haze impact analysis was carried out for BWCAW, IRNP and VNP. The recommended methodology for assessing visibility impacts according to the Federal Land Managers' (FLM) Air Quality Related Values Work Group (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 particulate 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 are believed to represent potential adverse impacts on visibility. These thresholds are 5 percent (a potentially detectable change) and 10 percent (a level that may represent an unacceptable degradation).

Table 4.6-11 presents results of the initial CALPUFF visibility analysis following the FLAG methodology and using "Method 2" of CALPOST for calculation of visibility impacts. The FLAG Method 2 represents a conservative screening approach, which generally over-predicts actual visibility effects that would be observed. In Method 2, hourly relative humidity data is used to calculate both source and background light extinction.

Table 4.6-11 Class I Area Visibility Results for NorthMet Project (Method 2 Analysis)

Class I Area and Meteorological Data Year	Days with ≥5% Visibility Impact	Days with ≥10% Visibility Impact	Maximum Δb_{ext} (%)
BWCAW 2002/2003/2004	14/6/6	1/0/0	10.58/7.39/7.39
VNP 2002/2003/2004	0/0/0	0/0/0	3.18/3.32/3.78
IRNP 2002/2003/2004	0/0/0	0/0/0	0.94/0.91/0.81

"Method 2" is the method currently approved in guidance from the Federal Land Managers (FLMs) for the assessment of visibility impacts in Class I areas. However, the FLMs are in the process of updating this guidance and other guidance is currently on federal notice for the use of "Method 6".

The data in Table 4.6-11 indicate that calculated visibility impacts greater than five or 10 percent could occur at some point within the BWCAW on a small number of days each year.

Based upon the modeling, approximately 34 percent of the worst-case day impacts were associated with the space heaters at the Plant Site, primarily due to NOx emissions. Potential mitigation measures to reduce these emissions include the use of low-NOx burners in the heaters, switch to electric heating, and the use of waste heat for plant space heating requirements.

Based upon preliminary review of these options no information is available to demonstrate that low-NOx burner technology is commercially available for space heaters. In addition, energy conversion of natural gas combustion to heat energy is approximately 80 percent versus only 30 percent for electric energy to heat energy. This equates to approximately 2.6 times more electric energy generation that would be necessary to meet the current heating requirements, and therefore, is not a viable alternative.

The use of waste heat from the autoclaves to assist in the space heating requirements could ultimately achieve a 65 percent reduction in the overall NOx emissions. However, natural gas space heating may still be required during the early phase of the project until the waste heat would be available for use. This option has not been fully investigated by PolyMet as a technologically achievable option and this option should be further investigated as a viable mitigation measure.

The NOx emissions from the locomotives are predicted to account for 26 percent of the worst-case day impacts. As such, possible mitigation measures to reduce these emissions include the replacement of the older locomotives for newer, lower emitting engines. PolyMet has agreed to replace the locomotives with units that will meet USEPA Tier-III emission requirements and are a viable mitigation measure for this project.

In addition to the control measures and since these data suggest a potential for detectable visibility degradation due to Project emissions when “Method 2” is used, a cumulative analysis was carried out to better quantify and evaluate the possibility of overall visibility impacts (see Section 4.6.4).

To provide additional information for assessing the visibility impacts for the NorthMet project, an analysis using “Method 6” was also completed. Using the best 20% background levels in Method 6, the results for the BWCAW show zero days with greater than 10% visibility impact for all three years of meteorological data and three, six, an four days with greater than 5% impact with 2002, 2003, and 2004 data, respectively. The maximum impact would be 5.44%, 6.15% and 5.49, respectively, for the three-year period.

Deposition of Nitrogen and Sulfur

Potential impacts to soils, waters, and vegetation in Class I areas were evaluated on the basis of the model-predicted pollutant concentrations and the magnitude of predicted annual sulfur (S) and nitrogen (N) deposition. Criteria for assessment of deposition impacts are different for USFS areas (BWCAW and RLW) and National Park Service (NPS) areas (IRNP and VNP). The NPS has established a Deposition Analysis Threshold (DAT) of 0.01 kilograms per hectare per year for both S and N deposition for Class I areas in the eastern United States. The DAT is a level below which incremental adverse impacts are not anticipated. The USFS have established “Green Line Values” for assessing impacts of deposition at BWCAW and RLW, 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 impacts (Barr, 2008c).

The CALPUFF results for each of the Class I areas were processed with CALPOST to calculate total annual deposition of N and S at each receptor as a result of the NorthMet facility emissions. Model results for annual impacts (maximum annual average emissions) were assumed in the modeling. 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. Results are shown in Table 4.6-12.

Table 4.6-12 Maximum Annual Deposition of S and N from NorthMet Project in Class I Areas (kilogram per hectare per year)

Class I Area	Project Deposition	Background Level	Total Deposition (Project + Background)	Aquatic Green Line Value/DAT	Terrestrial Green Line Value/DAT
BWCAW					
Sulfur	0.004	2.9	2.9	7.5-8.0[1]	5-7[1]
Nitrogen	0.010	4.8	4.8	-	5-8[1]
Sulfur + 20% Nitrogen	0.006	3.8	3.8	9-10[1]	-
IRNP					
Sulfur	0.000	2.2	2.2	0.01[2]	0.01[2]
Nitrogen	0.000	3.9	3.9	0.01[2]	0.01[2]
RLW					
Sulfur	0.000	3.9	3.9	3.5-4.5[1]	5-7[1]
Nitrogen	0.000	5.9	5.9		5-8[1]
Sulfur + 20% Nitrogen	0.000	4.2	4.2	4.5-5.5[1]	
VNP					
Sulfur	0.001	1.8	1.8	0.01[2]	0.01[2]
Nitrogen	0.002	3.9	3.9	0.01[2]	0.01[2]

[1] USFS Green Line Value (include total deposition)
[2] NPS DAT (includes increment deposition only)

Effects on Soils, Waters, and Vegetation

Potential impacts to soils, waters, and vegetation in Class I areas were evaluated on the basis of the model-predicted criteria pollutant concentrations and the magnitude of predicted annual deposition of sulfur and nitrogen. The USFS has set screening criteria for potential air pollution impacts on vegetation for SO_2. According to the USFS, 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 Forest Service (i.e., BWCAW and RLW) it is reasonable to apply the same criteria to VNP and IRNP, which is administered by the NPS but does not have a published standard similar to the USFS. Table 4.6-13 compares CALPUFF projections of NorthMet Project impacts and existing background concentrations to the Green Line screening levels for each Class I area. The summation of NorthMet Project and background contributions is well below the Green Line levels. It can therefore be concluded that there would be no threat to sensitive vegetation in Class I areas from SO_2 emissions produced by the NorthMet Project.

NorthMet Project contributions, in addition to background concentrations, are all well below the Green Line levels. It can therefore be concluded that there would be no threat to sensitive vegetation from SO_2 emissions produced by the NorthMet Project. There are no established screening criteria for NO_2 and PM_{10}. However, as shown in Section 4.6.2.5.3, Class I area concentrations of NO_2 and PM_{10} from the NorthMet Project would be below significance levels and therefore can be expected to have negligible impacts.

Table 4.6-13 Comparison of Projected Class I SO_2 Concentrations to Green Line Screening Criteria for Vegetation Impacts

Class I Area	Background (ug/m3)	Max. NorthMet (ug/m3)	Total (ug/m3)	Green Line Value (ug/m3)
	Annual	Annual	Annual	Annual
BWCAW	1.2	0.007	1.2	5
IRNP	2.0	0.000	2.0	5
RLW	1.6	0.000	1.6	5
VNP	0.7	0.001	0.7	5

Incremental Human Health Risks

An incremental human health risk assessment was conducted for specific chemicals for potential evaluation (CFPE) as defined in MPCA's Air Emissions Risk Assessment (AERA) Guidance (MPCA, 2004). Seventy-four CFPEs were identified in the evaluation for the Plant Site, of which 39 having reference toxicity values available were considered in the quantitative assessment (Barr, 2007i). Table 4.6-14 summarizes the emissions used for this assessment.

Table 4.6-14 Chemicals for Evaluation of the Incremental Human Health Risk Assessment

Table 2 **Chemical**		**March 2007 AERA**	**Emissions 2007 (lb/hr)**	**Emissions 2007 (tons/yr)**
1,3-Butadiene	106-99-0	X	2.08E-05	9.11E-05
7,12-Dimethylbenzo(a)anthracene	57-97-6	X	1.35E-06	5.92E-06
Acetaldehyde	75-07-0	X	1.01E-03	3.62E-03
Acrolein	107-02-8	X	1.10E-04	2.31E-04
Antimony	7440-36-0	X	4.53E-04	2.04E-03
Arsenic	7440-38-2	X	8.54E-04	8.07E-02
Barium	7440-39-3	X	2.20E-02	2.97E-01
Benz(a)anthracene	56-55-3	X	6.74E-06	9.70E-06
Benzene	71-43-2	X	7.34E-03	7.40E-03
Benzo(a)pyrene	50-32-8	X	1.19E-06	1.13E-06
Benzo(b)fluoranthene	205-99-2	X	8.77E-06	3.04E-06
Benzo(k)fluoranthene	205-82-3	X	1.08E-06	1.24E-06
Beryllium	7440-41-7	X	4.88E-05	3.75E-04
Boron	7440-42-8	X	1.60E-02	1.27E-01
Cadmium	7440-43-9	X	5.05E-03	2.22E-02
Carbon Disulfide	75-15-0	X	8.57E-01	3.75E+00
Chromium (III)	7440-47-3	**[b]**		
Chromium (VI)	18540-29-9	X	5.67E-05	2.48E-04
Chrysene	218-01-9	X	1.23E-05	5.26E-06
Copper	7440-50-8	X	1.86E+00	8.66E+00
Cumene	98-82-8	**[b]**		
Dibenzo(a,h)anthracene	53-70-3	X	1.75E-06	2.14E-06
Dichlorobenzene	25321-22-6	X	2.03E-04	8.87E-04
Formaldehyde	50-00-0	X	1.45E-02	6.11E-02
Hexane	110-54-3	X	3.04E-01	1.33E+00
Hydrogen Chloride	7647-01-0	X	1.00E+01	2.44E+00
Hydrogen Fluoride	7664-39-3	X	1.34E-03	5.85E-03
Hydrogen Sulfide	7783064	X	1.45E-02	6.11E-02
Indeno(1,2,3-cd)pyrene	193-39-5	X	9.33E-01	4.09E+00
Isopropyl Alcohol	67-63-0	**[b]**		
Lead	7439-92-1	X	2.67E-02	4.83E-01
Manganese	7439-96-5	X	9.16E-02	1.74E+00
Mercury	7439-97-6	X	9.41E-04	4.17E-03
Naphthalene	91-20-3	X	6.48E-03	1.07E-02
Nickel	7440-02-0	X	1.18E+00	5.67E+00
Oxides of Nitrogen	NA	X	5.47E+01	1.37E+02
Propylene	115-07-1	X	2.75E-03	1.20E-02
POM	NA	X	1.90E-03	1.64E-03

Table 2 **Chemical**		**March 2007 AERA**	**Emissions 2007 (lb/hr)**	**Emissions 2007 (tons/yr)**
Selenium	7782-49-2	X	5.30E-04	3.42E-03
Sulfuric Acid	7664-93-9	X	2.73E+00	1.15E+01
Toluene	108-88-3	X	3.18E-03	4.96E-03
Xylene (mixed isomers)	1330-20-7	X	1.79E-03	1.70E-03
Number of CFE			39	39
CFE Emissions			72.78	177.84

[a] Pollutants that were not expected to be potentially emitted based on the information available at the time the May 2005 AERA was being prepared but due to project revisions/refinements they now have the potential to be emitted from the proposed project.

[b] Project revisions/refinements since the May 2005 AERA was prepared that now eliminate these pollutants from the list of chemicals potentially emitted from the proposed plant processes or plant area processes.

Estimations of risk were conducted for both the maximum exposed individual (MEI) and the reasonable maximum exposed off-site worker (RME_OSW). The MEI represents a worst-case screening assessment that is designed to represent the upper-limit bounds of potential incremental risk and assumes a continuous exposure of 24 hours per day, 365 days per year for a period of 70 years. This screening procedure is conservative by nature and is intended as a regulatory tool to define whether more detailed analysis is warranted rather than estimating actual risk levels. The RME_OSW is designed to assess hypothetical risks to offsite workers and is based upon exposure level of 8 hours per day, 250 days per year for a period of 25 years (USEPA, 1993).

Air dispersion modeling was conducted to assess the potential for exposure of the chemicals for evaluation (CFE), using the AERMOD model with 5 years of hourly meteorological data from the Hibbing Monitoring Station. Direct and indirect risk estimates were made for inhalation and bioaccumulative toxic pollutant ingestion, respectively, using the MPCA Risk Assessment Screening Spreadsheet (RASS). The RASS estimates pontential incremental cancer and noncarcinogenic human health risks for both acute and long-term effects.

Acute risks were estimated at the ambient air at and beyond the property boundary. Because of the historical and present land use, the reasonable future land use for residential and farming was considered in assessing chronic risks. This included outside of the former LTVSMC air boundary.

The results of the assessment demonstrate that the chronic cancer and noncarcinogenic impacts were below significance thresholds and the acute noncarcinogenic health effects were also below the significance level, when adjusted for locational differences of the risk-driver emissions (Barr, 2008j).

The MEI cancer risk was estimated to be 5x10-6 for farmers and 4x10-6 for a nearby residence, which is below the Minnesota Department of Health (MDH) guidance value of 1 x 10-5. Similarly, the maximum RME_OSW cancer risk was predicted at 3x10-6, again below the MDH cancer risk significance level. the major risk drivers for these risks were nickel, arsenic and cadmium compounds.

The non-cancer chronic MEI hazard index (HI) for the farmers and residences were each calculated to be 0.19, primarily from the nickel emissions. Due to the variation in estimating the health effects for noncarcinogenic effects, the hazard index is sum of the ratios of the maximum concentration to the chemicals' reference exposure level (REL); the MDH has defined the significance value for chronic HI as 1.0. Thus, the MEIs for both farmer and residences are approximately 20 percent of the chronic significance threshold. The chronic HI for the RME_OSW was predicted to be 0.45, which is still half of the chronic significance criteria.

The results of the acute non-cancer MEI HI was predicted at the Plant Site operating boundary with a value of 1.1, as compared to the acute HI guidance threshold of 1.0. This screening value assumes the summation of the acute HIs for all pollutants regardless of their toxic endpoint (specific target organ) and the specific location of the actual emissions for various compounds. The risk drivers for the maximum MEI was NO2 from the natural gas combustion, nickel from the Hydrometallurgical Plant, and arsenic emissions from the Tailsings Basin. When adjusting the emissions for various locations, the maximum MEI HI was reduced to 0.9, just below the acute significance threshold.

Greenhouse Gases

Greenhouse gases include water vapor, CO_2, methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6). Next to water vapor, CO_2 is the second-most abundant greenhouse gas and would be the primary greenhouse gas that would likely be emitted from the NorthMet facilities. CO_2 emissions from the NorthMet facilities are a function of the fuel consumption at the proposed facility and the use of limestone for neutralization.

Global CO_2 emissions resulting from fossil fuel combustion were estimated at 26,000 million tons for the year 2000 (IPCC, 2001). A more recent study estimated global emissions of CO_2 from fossil fuel combustion to be 28,000 million tons in the year 2003 (Marland et al., 2006). Because CO_2 is relatively stable in the atmosphere and essentially uniformly mixed throughout the troposphere and stratosphere, the climatic impact of CO_2 emissions does not depend upon the air source location on the earth. Instead, an increase in CO_2 emissions from a specific source is effective in contributing to global increases in CO_2 concentrations (DOE, 2007).

Based on samples of air trapped in arctic ice, scientists have determined that, prior to the industrial revolution (which began in England in the mid 1800s), the concentration of carbon dioxide in the atmosphere had been stable at a level of around 288 parts per million (ppm). After the industrial revolution (when people began to burn fossil fuels), the concentration of carbon dioxide in the atmosphere began to increase and is now at 384 ppm with a 3 to 9 ppm annual fluctuation. This strong correlation indicates that increased concentrations of greenhouse gases in the atmosphere have likely increased the amount of heat from the sun that stays within the Earth's ecosystem, thus contributing to increased global temperatures. It should be noted, however, that greenhouse gases are not currently regulated by the U.S. or by State of Minnesota.

Differences of opinion arise in (1) the extent to which any climate changes are caused by greenhouse gas emissions from human activity, and (2) how much and when the changes in the climate will disrupt agriculture, forestry, and other human activities as well as natural ecosystems beyond a level that can be easily adapted to. The Intergovernmental Panel on Climate Change (IPCC) is the leading scientific body studying the effects of increased greenhouse gases in the atmosphere. The IPCC's most recent report (2001) projects that, under a business-as-usual scenario, globally averaged surface temperature will increase by 2.5 to 10.4°F between 1990 and 2100. A 2.5°F increase in temperature would be a relatively mild outcome, but a 10.4°F increase in temperature would be severe. For comparison, during the last ice age the average temperature was roughly 6°F lower than it is today.

It is estimated that the NorthMet facility would potentially directly emit approximately 0.25 million metric tons per year of CO_2-equivilant emissions. The direct project emissions represent approximately 0.001 percent of estimated global emissions. There are approximately 26 billion metric tons per year of CO_2 emissions globally (as estimated by the Energy Information Administration in 2004 [EIA, 2005]). The estimated direct CO_2 emissions do not account for any CO_2 removal from atmosphere that would occur through vegetation uptake, absorption, or other removal mechanisms. Potential indirect GHG emissions, primarily related to power production for the project are estimated at 0.58 million metric tons per year or an additional 0.002 percent of the global emissions.

Based upon these emissions, the potential incremental increase in global CO_2 air concentration due to the project is expected to range from 0.00002 to 0.000009 ppm. This is roughly only 0.001 to 0.003 percent of the annual fluctuation in global concentration and only 0.000023 percent of the annual mean global concentration of CO_2. Correspondingly, the estimated increase in global temperature is expected to increase from 0.0000002 to 0.000001 decree Centigrade due to the Project. This potential change in temperature is orders of magnitude below the standard daily and seasonal variation in global temperature and is not within the accuracy of current temperature measurements that would have an effect on the environment. Therefore, no significant effects on climate are expected to be associated with this project (Barr 2008a).

Mercury Deposition

A evaluation was conducted on the potential deposition of mercury to assess the project's potential effects upon 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 Heikkilla Lake, north of the Plant Site, using the MPCA's mercury risk estimation method (MMREM) to assess the potential risks. It was assumed that 80 percent of the mercury would be in the elemental form, 10 percent in oxidized form, and 10 percent particle bound (Barr, 2007d) The Mine Site AERA did not assess potential local Hg deposition because potential emissions ere less than one lb/yr.

The analysis estimated that the maximum potential incremental increase in mercury concentrations in the fish is 0.015 ppm, which is an order of magnitude lower than the mercury background concentrations estimated for the Lake (0.65 ppm). The projected risk to a recreational or subsistence fisher is 0.01 and 0.33, respectively. These risks are below the Minnesota Department of Health (MDH) incremental risk guideline level of 1.0. Therefore, no significant impacts are expected from potential mercury deposition from the Project.

However, as part of the CPDEIS, a cumulative assessment of mercury deposition has been conducted at the request of the state. The results of this analysis has been addressed in Section 4.6.4.

In addition, in January, 2008, the MPCA made recommendations for reduction of mercury emissions in order to meet the state's Mercury Total Maximum Daily Load standard required by federal regulations. In July, 2008, specific recommendations have been developed to limit the mercury emissions from new and expanding sources in order to meet the TMDL goal of 789 lb/year statewide by 2025. These recommendations include:

- Define and achieve best available control on mercury emitting sources;
- Conduct environment analysis for project and cumulative impacts;
- New sources must seek and secure offsets on a 1:1 ratio with existing sources within the state;
- If no offsets are available, sources must develop emission reductions in of at least 90% by 2025; and
- The reductions will be enforceable by the MPCA permitting process.

The specific requirements for implementing this strategy are currently being developed by the MPCA. PolyMet would be required to meet these requirements as part of their permit application review process by the MPCA.

4.6.3.2 Alternatives

No Action Alternative

Since this alternative would not involve introducing new emission sources, the No Action Alternative would have no air quality impacts either regionally or locally. Therefore, air quality would be substantially similar to existing conditions.

Subaqueous Disposal of Reactive Waste Rock

Relative to air quality issues, the Subaqueous Disposal Alternative would require some additional "double handling" of waste rock, which could result in some additional vehicular and fugitive emissions. Another element of the alternative is the addition of lime or limestone to the temporary stockpiles to neutralize acid formation prior to subaqueous disposal in the pit. Additional emissions due to the use of lime or limestone have been shown to be minimal.

As a result, the major difference between this alternative and the Project is the variation of the haul traffic volumes for each year of the mining operations at the mine site. Since the haul truck fleet is not expected to change between the Project and this alternative, an evaluation of the change in haul traffic volumes can be used to assess the impacts for this alternative. An analysis was conducted for each year of the mining operation to calculate the total annual ton- miles for both the Project and this alternative. Ton-miles (product of tons hauled and haul distance) was used as an indicator of truck traffic levels and therefore emissions.

Based upon the analysis, the maximum annual haul truck ton-miles from the Project is estimated at approximately 135,516,400 ton-miles/year in Mining Year 16. The maximum annual haul truck ton-miles from this alternative is estimated at approximately 134,488,200 ton-miles/year in Mining Year 13. It should be noted that even though this alternative would have increased haul truck ton-miles over the lifetime of the project, the annual maximum truck volume for this alternative is less than the maximum annual traffic volume used to assess maximum impacts in the Project analysis. As a result, the modeling analysis conducted for the Project (Year 16) would be a conservative representation of the impacts associated with this alternative. Thus, the air quality impacts from this alternative would be similar to the Project and would, therefore, not have any significant air quality impacts.

4.6.4 Cumulative Impacts

Air quality modeling analyses were conducted for cumulative impacts to assess the effects on NAAQS, MAAQS, PSD Class II Increments, and Class I Increments using a similar modeling approach discussed in Section 4.6.2.3 and Section 4.6.2.4. However, relative to NAAQS, MAAQS, and PSD Class II Increments, the receptors locations were restricted to areas at and beyond the former LTV property boundary as defined in the Final Scoping Decision (FSD). For PSD Class I Increments, the cumulative analysis utilized the Project impacts in combination with the recently conducted cumulative analysis prepared for the Minnesota Steel EIS to assess overall impacts. The following sections describe the results of the assessments.

Cumulative NAAQS/MAAQS Impacts

As stated earlier, an assessment was conducted using the same modeling approach as presented in Section 4.6.2.3 with the exception that receptor locations were limited to at or beyond the boundary of the former LTV facility. Figure 4.6-2 shows the receptor boundary for the former LTV site. The analysis included potential emissions for all NorthMet Project sources and from nearby sources and other foreseeable projects in the cumulative NAAQS analysis. These included Mesabi Nugget, Excelsior Energy, Minnesota Steel, U.S. Steel, Cliffs Erie Pellet Yard, Northshore's Peter Mitchell Mines, and the Lasken Energy, as well as potential effects from proposed Minnesota and federal Air Quality Regulations.

Table 4.6-15 below summarizes results of the cumulative NAAQS model analysis. The H2H PM_{10} concentration for the five-year modeling period was used for comparison to the NAAQS PM_{10} 24-hour standard. Ambient air background concentrations were added to modeled concentrations to determine compliance with NAAQS and MAAQS. PM_{10} background concentrations represent the 2004-2006 average concentrations from the H2H 24-hour concentration and annual average concentration from Virginia, Minnesota.
None of the cumulative NAAQS model results exceed NAAQS and MAAQS.

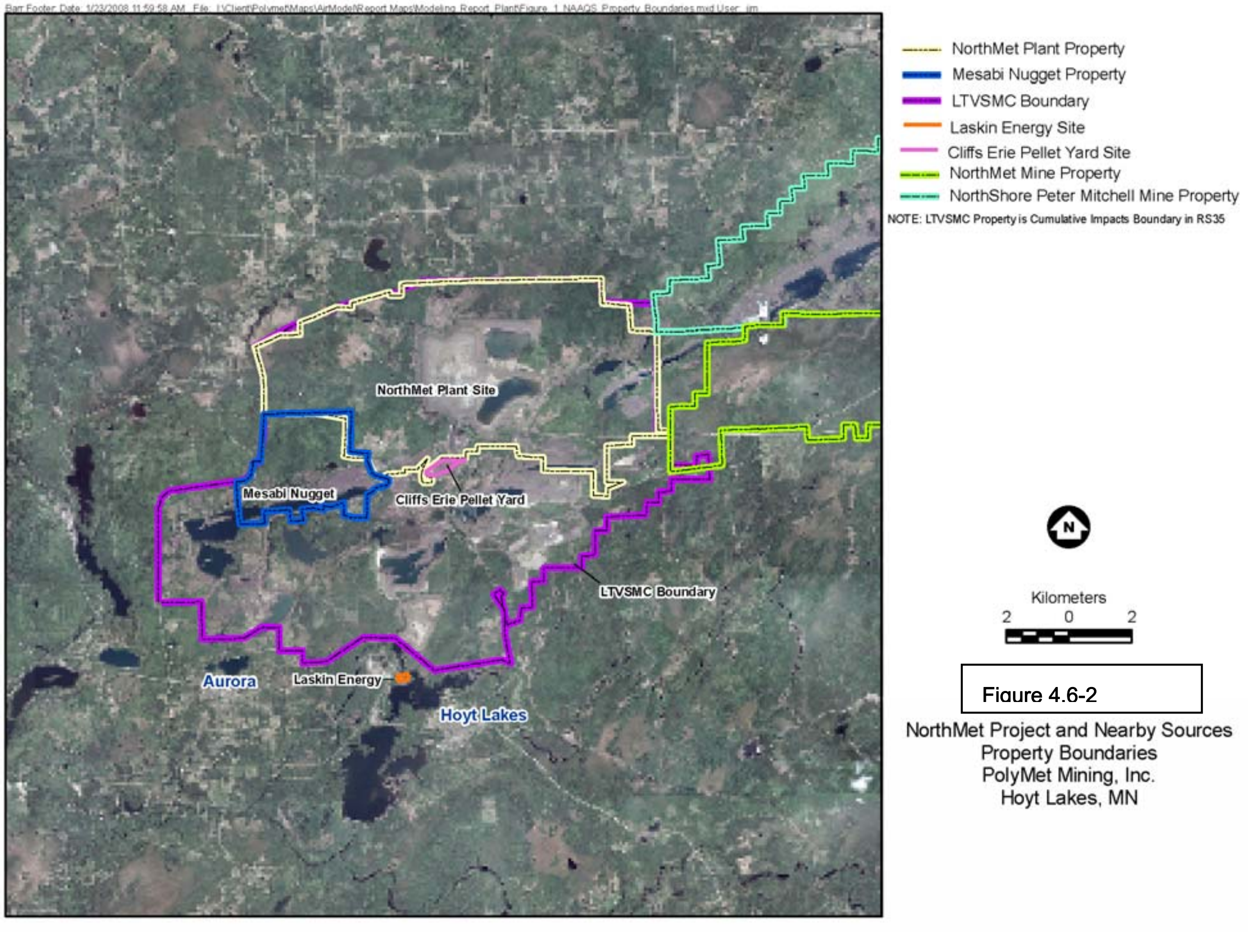


Figure 4.6-2

NorthMet Project and Nearby Sources
Property Boundaries
PolyMet Mining, Inc.
Hoyt Lakes, MN

Table 4.6-15 Results of Cumulative Class II NAAQS Modeling

Pollutant	Averaging Time	Maximum Modeled Concentration (ug/m3)	Background (ug/m3)	Total (ug/m3)	NAAQS and MAAQS (ug/m3)
SO_2	1-hour	366	90	456	1300
	3-hour	285	25	310	915
	24-hour	140	11	151	365
	Annual	13	3	16	60
PM_{10}	24-hour	41	32	73	150
	Annual	4	16	20	50(1)
NO_X	Annual	3	12	15	100

Notes:
The annual NAAQS for PM_{10} was rescinded on October 17, 2006.

Cumulative Class II Increment Impacts

Cumulative Class II Increment analysis was completed for PM_{10} , NO_X , and SO_2 for all PolyMet sources at both the Plant and Mine sites. The modeling included all sources at maximum emission rates plus all nearby increment consuming (and expanding) emissions sources, including Northshore's Peter Mitchell Mine, Laskin Energy, Cliff's Eire Pellet Yard, LTB Steel Mining Company (LTVSMC), Mesabi Nugget, Mesaba Energy, Minnesota Steel, United Taconite, U.S. Steel, . The results of the increment analyses are shown in Table 4.6-16, along with a comparison to the allowable Class II PSD increments.

The data in Table 4.6-16 summarize the PSD Class II Increment modeling results and demonstrate that the NorthMet Project, in conjunction with all other neighboring PSD sources, would comply with all state and Federal increment limits.

Table 4.6-16 Results of Cumulative Class II PSD Increment Analysis

Pollutant	Averaging Time	Cumulative Modeled Emissions (ug/m3)	PSD Increment Limits (ug/m3)
SO_2	3-hour	27	512
	24-hour	7	91
	Annual	1	20
PM_{10}	24-hour	9	30
	Annual	0	17
NO_X	Annual	1	25

Note:
(5) Modeled PM_{10} concentrations are based on operating scenarios at Year 8 and Year 16.
(6) Plant Site modeled cumulative emissions include Plant Site, Mesabi Nugget, Cliffs Erie pellet yard, and LTVSMC.
(7) Mine Site modeled cumulative emissions included

Cumulative Class I Increment Impacts

Based upon the analysis presented in Section 4.6.2.6, the only Class I analysis that failed acceptable screening thresholds was associated with 24-Hour Class I Increments for PM_{10} at BWCAW, which requires a cumulative assessment. Recently, a comprehensive cumulative analysis of the BWCAW region was conducted as part of the Minnesota Steel Environmental Impact Statement (DNR, 2007).

An assessment was conducted to assess the Class I 24-hour PM_{10} concentrations within the BWCAW boundary that exceed the 24-hour PM_{10} SIL. The maximum concentration within those receptor locations exceeding the SIL was added to the maximum 24-hour PM_{10} concentration from the Minnesota Steel comprehensive cumulative analysis, which included sources from all foreseeable Projects and regulatory actions. This is a conservative approach, since the maximum from the NorthMet sources was not predicted at the same location as the maximum from the comprehensive assessment. Table 4.6-17 summarizes the results of the analysis, showing that the cumulative Class I 24-hour PM_{10} is below the Class I threshold limit, indicating that there is no significant impact.

Table 4.6-17 Results of Cumulative Class I PSD Increment Analysis

Pollutant	Averaging Time	NorthMet Modeled Emissions (ug/m3)	Cumulative Modeled Emissions (ug/m3)	Total Cumulative Modeled Emissions (ug/m3)	PSD Increment Limit (ug/m3)
PM_{10}	24-hour	0.5	7.0	7.5	8

Cumulative Impacts of Acid Deposition on Ecosystems

The cumulative impacts of acid deposition on ecosystems were evaluated in terms of the potential increased acidification on the terrestrial and aquatic systems within a four county area (Itasca, Saint Louis , Lake and Cook Counties) from1980 to 2015, as defined in the final scoping decision (MDNR, 2005). The pollutants of consideration included both sulfate depositions from air quality SO_2 emissions and nitrate deposition from NO_2 emissions.

Based upon the most recent information, there are approximately 9 new Projects for the four-county area, including the NorthMet Project. Collectively, without accounting for recent past reductions or expected future reductions, these sources could emit up to an additional 6,455 tons per year NO_2 and 2,340 tons per year SO_2, if all were constructed and operated (Barr 2007k). This represents approximately a 12 percent and 6 percent increase in the current emissions for the two pollutants in the four county “zone of interest” (Itasca, St. Louis, Lake, and Cook Counties), respectively. However, due to the recent shutdown of the LTVSMC and the projected decreases in emissions from the Minnesota Power AREA proposal, the overall emissions would be reduced by 2,195 tpy and 5,710 tpy for the NO_2 and SO_2

respectively, since 2000 (Barr 2008j). In addition, supplemental decreases in emissions from the two pollutants are expected to occur due to various federal programs, including the implementation of the Taconite and electric utility MACTs, the EPA's "Clean Air Interstate Rule, Best Achievable Retrofit Technology on Regional Haze (BART) Program and Clean Fuels Regulations.

As such, the emissions from the Project, in combination with other Projects, would emit increases in SO_2 and NO_2 emissions, resulting in a potential increase in acid deposition that may be too small to measure. However, due to the Projects having relatively low emissions of SO_2 and NO_2 and potential deposition of sulfate and nitrate are below both the Minnesota standard threshold value and the federal Class I threshold values, in combination with the overall reduction in sulfate and nitrate-producing emissions cumulatively since 2000, the Projects would not likely cause a cumulative significant impact on the ecosystems.

Cumulative Mercury Deposition

A cumulative assessment on mercury deposition was conducted to assess the effects of mercury emissions from nine new Projects in combination with emission reductions from two additional facilities. The nine new facilities include the Excelsior Energy Phase I and Phase II projects, Mesabi Nugget's Proposed facility, Minnesota Steel Industries, Northshore Minig Company Furnace 5 Reactivation Project PolyMet Mining, NorthMet Project, United Taconite Emissions and Energy Reduction Project, US Steel Keewatin Taconite Fuel Diversification and Pollution Control Equipment Upgrade, UPM/Blandin Paper Mill Expansion, and the Lauretian Wood-Fired Energy Project. Emission reductions are associated with the LTVSMC Plant closure and the Minnesota Power Arrowhead Regional Emission Abatement (AREA) program. Table 4.6-18 summarizes the emission increases due to the nine new foreseeable projects (Barr, 2008l).

Table 4.6-18 Maximum potential mercury emissions from Projects and comparison to selected voluntary proposed actions that reduce emissions.

Project	Location	Potential Emissions (pounds/year)	Mass Balance Completed/ Controls Evaluated?	Estimated Speciation Of Air Emissions [13]
Excelsior Energy [1]	Subject to State Site Process	42	Pending	Hg(0): 100%
Mesabi Nugget DRI Plant [2]	Hoyt Lakes	75	Yes	Hg(0): 99.3% Hg(II): 0.5% Hg(p): 0.2%
Minnesota Steel Industries[3]	Nashwauk	81	Yes	Hg(0): 99.8% Hg(II): 0% Hg(p): 0.2%
Northshore Mining Company: Furnace 5 Reactivation Project [4]	Silver Bay	1	Yes	Hg(0): 100%
PolyMet Mining, NorthMet Project [5]	Hoyt Lakes	8	Yes	Hg(0): 100%
United Taconite: Emissions and Energy Reduction Project [6]	Forbes	0	No	--
US-Steel Keewatin Taconite Fuel Diversification and Pollution Control Equipment Upgrade [7]	Keewatin	0	Yes	--
UPM/Blandin Paper Mill Expansion [8]	Grand Rapids	2	Yes	Hg(0): 100%
Laurentian Wood-Fired Energy Project [9]	Virginia/Hibbing	12	Yes	Hg(0): 100%
Total		221		
LTV Steel Mining Company (LTVSMC): Facility Closure (2001) [10]	Hoyt Lakes	-83		
Minnesota Power AREA proposal [11] (implemented by 2009)	Taconite Harbor	-64		
"Net" Emissions: Net Emissions = Projects – LTVSMC – AREA		74		
Other Emissions: Butler Taconite [12]	Nashwauk	-55		

Adapted from: Table 1, Cumulative Impact Analysis, Mercury Deposition and Evaluation of Bioaccumulation in Fish in Northeast Minnesota, RS70; November 2006 draft:

[1] Preliminary emission estimates, total for Phase I and Phase II, based on emission factors and heat inputs provide on Excelsior Energy Web site, www.excelsiorenergy.com, accessed on October 28, 2005.

[2] Mesabi Nugget's Proposed Facility: Receive concentrate from off-site, Rotary Hearth Furnace: Air Permit Application, May 2005. Mercury mass balance completed; HG-2003 form completed.

[3] Minnesota Steel Industries, Draft Permit Application and HG-2003 Form submittal to the MPCA, September 2006. Based on data from Minnesota Steel's drill core analysis, the 95% confidence level high-end estimated emissions of mercury to air = 81 pounds. The "average" potential estimated emissions of mercury to air = 61 pounds. For this cumulative analysis, the high-end estimate of 81 pounds per year is used. If the average of 61 pounds per year is used in this analysis, the "net" increase in potential Hg emissions is 49 pounds/year, not taking into account the emissions reduction from Butler Taconite.

[4] Northshore Mining's Furnace 5 Project: reactivating 2 crushing lines, 9 concentrating lines, one pellet furnace (Furnace 5); new sources emissions only; EAW Table 6 (May 20, 2005). A "Total Facility Mercury Evaluation" was completed in 1999 for a direct reduced iron project. This total facility evaluation included an assessment of potential control technologies for reducing mercury releases to air, water, and land. The evaluation included Furnace 5. This 1999 evaluation was considered relevant and valid for the Furnace 5 Reactivation Project and was used as a reference in lieu of completing the HG-2003 form.

[5] PolyMet Mining's Proposed Facility: crushing/grinding of ore, reagent and materials handling, flotation, hydrometallurgical processing. Emission estimate is an update to EAW based on preliminary analysis of 2005 and 2006 pilot-plant stack test data using standard EPA Method 29; conservatively assumes non-detects are one-half the detection limit.

[6] United Taconite Emissions and Energy Reduction Project; this project did not involve a change in potential mercury emissions. MPCA, Permit Change/Modification Application Forms, Line 1 Emissions and Energy Reduction Project (EERP), September 2004.

[7] U.S. Steel Keewatin; Technical Support Document Permit Action #13700063-003, Dated 2/28/05. A total facility mercury mass balance was completed for the project. MPCA determined that there would be no change in the total facility mercury emissions.

[8} Draft EIS, UPM/Blandin Paper Mill Project Thunderhawk, January 2006, Table 6-29; (PTE Increase due to expansion).

[9] Laurentian Energy Project, Technical Support Documents for Virginia Public Utilities (MPCA Permit # 13700028-005) and Hibbing Public Utilities (MPCA Permit #13700027-003); Combined PTE for two new wood fired boilers (one at each site). The permit technical support documents estimate that actual Hg emissions are likely to be reduced by about one pound per year due to wood use in new boilers displacing coal in existing boilers.

[10] LTVSMC: Permitted emissions (potential to emit) information from Technical Support Document for Air Emissions Permit No. 13700009-001, Table 1. From http://www.pca.state.mn.us/data/edaAir/index.cfm; downloaded on December 14, 2005. Emission reductions due to the shutdown of Butler Taconite in 1985 were not included because statewide mercury inventory comparison data starts in 1990. Mercury emissions from Butler Taconite peaked at 59 pounds per year in 1971 (Berndt, 2003, Appendix 3).

[11] MPCA, January 17, 2006, Review of Minnesota Power's Arrowhead Regional Emission Abatement (AREA) Project. Table 12 (MPCA 2006a). Just prior to the MDNR's Final Decision Document being made available to the public on October 25, 2005, Minnesota Power announced a major initiative to reduce pollutant emissions, including mercury, at several of its power plants in northern Minnesota. Due to the significance of the AREA project, it was included in the analysis.

[12] Butler Taconite. Maximum estimated emissions of 55 pounds/year for Butler Taconite using an emission factor similar to National Steel Pellet Company (Berndt 2003, Appendix 3). (Note: National Steel Pellet Company is now known as US Steel - Keewatin Taconite).

[13] Speciated mercury air emissions for the Projects are from available information. As a point of comparison, speciation of taconite processing emissions has been characterized by the MPCA and MDNR for 2001 emissions (unpublished data):

Hibbing Taconite*: 93.3% elemental; 6.6% oxidized; 0.1% particle-bound
United Taconite*: 93.3% elemental; 6.6% oxidized; 0.1% particle-bound.
U.S. Steel Minnesota Ore Operations (MinnTac)* 93.3% elemental; 6.6% oxidized; 0.1% particle-bound
U.S. Steel - Keewatin Taconite 80% elemental; 10% oxidized; 10% particle-bound

*note: speciation for Hibbing Taconite, United Taconite, and MinnTac is based on Ontario Hydro test data from Hibbing Taconite (2000).

Recognizing uncertainty in the estimated speciation for the Projects, deposition calculations in Section 6.0 of this report are also conducted with the following mercury speciation for all of the Projects: 93% elemental, 5% oxidized, 2% particle-bound.

The MPCA currently estimates that total statewide mercury emissions are about 3,340 pounds per year. Therefore, on a statewide basis, the new projects represent a potential 6% emission increase, but this potential increase does not account for planned or proposed emission reductions. Since 1985 mercury emissions in the four-county project area have decreased by about 138 pounds per year due to the shutdown of two taconite facilities. Minnesota Power has proposed to initiate the Arrowhead Regional Emission Abatement (AREA) Project, which will reduce mercury emissions in the four-county project area and Xcel Energy has initiated the Metropolitan Emission Reduction Project (MERP), which will reduce statewide mercury emissions. Between the two projects, an expected reduction of 234 lb/year in Hg emissions would occur.

Also, the 2006 Mercury Reduction Act of 2006 requires a 90% reduction in mercury emission from the three largest power plants in Minnesota by 2012 to 2015, in which an estimated 1,100 lbs/year reduction in Hg emissions is expected. Table 4.6-19 displays the statewide net Hg emissions summary for the state.

Table 4.6-19 Mercury emissions summary related to Projects and expected future reductions due to Minnesota voluntary actions and the 2006 Mercury Reduction Act

Description	**Mercury Emissions (lbs/year)**
Total Statewide Emissions in 2000 *	3,638
Emission Reductions from Point Sources 2000-2003**	(188)
Potential Emission Increases from Projects***	221
Reasonably Foreseeable Future Emission Reductions (2003-2015)****	(1,334)
Total	2,337
Net Change in Mercury Emissions Due to Reasonably Foreseeable Actions*****	(1,301)

Adapted from: Table OV-1, Cumulative Impact Analysis, Mercury Deposition and Evaluation of Bioaccumulation in Fish in Northeast Minnesota, RS70; November 2006 draft * Statewide emissions of 3,638 pounds/year from the MPCA's "2005 Mercury Reduction Progress Report to the Legislature". (MPCA 2005a).

**Emission reductions include: 70 pounds/year due to Minnesota Power's switch to Western coal; 83 pounds/year due to LTV Steel Mining Company plant closure in 2001; 35 pounds/year Xcel Energy switch from coal to natural gas at the Black Dog facility.

***Projects: In addition to the Minnesota Steel project and PolyMet Mining's NorthMet project, seven other Projects are included in this analysis, including the Mesabi Nugget DRI project. Table 1 in Section 1.1 of this report lists the Projects included in this analysis and their estimated potential mercury emissions.

For Minnesota Steel which is reactivating the former Butler mine that closed in 1985, the estimated Project emissions include a high-end estimate of 81 pounds per year. The estimated emissions from Butler Taconite were approximately 55 pounds per year (Berndt 2003). Therefore the potential net site emission increase, based on these emission estimates for Minnesota Steel and Butler Taconite, is approximately 26 pounds per year. The actual emissions increase for the site may be approximately 6 pounds per year when the average Minnesota Steel mercury emissions of 61 pounds per year is taken into consideration.

****Future emission reductions include: 64 pounds/year, Minnesota Power AREA project; 170 pounds/year, Xcel Energy MERP; 1,100 pounds/year 2006 Mercury Reduction Act. The relationship between the emission reductions anticipated under the 2006 Mercury Reduction Act and the Clean Air Mercury Rule is uncertain at this time. To avoid double counting reductions, the estimated reductions due to the Clean Air Mercury Rule are not included in this table.

*****Additional reductions due to the implementation of the Statewide Mercury Total Maximum Daily Load (TMDL) are not included here.
The TMDL goal is to reduce Minnesota mercury emissions to approximately 789 pounds per year. Based on the estimated "Total" emissions of 2,332 pounds per year, an additional reduction of 1,543 pounds per year (a 66% reduction) will be needed to meet the TMDL goal.

Additional emissions reductions are expected as part of implementing the Statewide Total Maximum Daily Load (TMDL) where the statewide emission goal in the mercury TMDL is 789 pounds per year. Based upon the table above, an additional 1,500 lb/yr Hg emission reductions would be needed statewide to meet the emissions goal of the TMDL.

When potential mercury emissions from the Projects are compared to the emission reductions above, there is an overall net decrease in mercury emissions from Minnesota sources. Mercury emissions on a statewide and national basis are expected to continue to decline over the next decade due to proposed regulatory actions such as the EPA's Clean Air Mercury Rule. Additional future reductions in mercury emissions from the Projects and existing taconite facilities are also possible as new control technologies become available. Based on the available information, the cumulative potential emissions from the Projects do not have the potential to cause or significantly contribute to mercury deposition and bioaccumulation in fish in northeast Minnesota lakes or streams.

Cumulative Visibility Impacts

A cumulative impacts analysis assessing the potential visibility impacts on Federal Class I areas was performed to provide information for the NorthMet Project EIS (Barr, 2008h). The reports assessed the cumulative visibility impacts by:

- Assessing the IMPROVE data for Voyageurs and/or the BWCAW to provide the current status of PM_{10} air concentrations (depending on data availability), including a trends analysis (improvement, no change, or continued degradation given past, current and/or expected future emission reductions) from 1980 to 2020;
- Assessing available modeling results that identify emission sources and/or emission source regions as significant contributors to ambient air concentrations in the Class I areas located in Minnesota;
- Evaluating statewide SO_2, NO_x, and PM_{10} emissions and trends using existing statewide emission inventory data (listing of sources and ton/year emissions). A detailed trend analysis providing a breakout of emissions by geographic area of the state is contained in the 2006 Visibility CI Study and is not repeated here.
- Evaluating the cumulative impacts from the Projects based on the potential increases in SO_2 , NO_x, and PM_{10} emissions in Minnesota from current and reasonably foreseeable projects and the projections for state and national emissions in regard to expected decreases in the future.

The list of specific past and reasonably foreseeable future projects to be assessed in addition to the Project, included: type, geographic limits, and project status

- Cliffs Erie Railroad Pellet Transfer Facility;
- Excelsior Energy, Mesaba Energy Project, Coal Gasification Power Plant;
- Laurentian Wood Fired Energy Project;
- Mesabi Nugget Company, DRI Plant;
- Minnesota Steel Industries, Mining/Taconite/DRI/Steel Plant;
- Northshore Mining Company, Furnace 5 Reactivation Project;
- PolyMet Mining, NorthMet Project;

- United Taconite, Emissions and Energy Reduction Project;
- UPM/Blandin Paper Mill Expansion, Project Thunderhawk, and
- U.S. Steel-Keewatin Taconite, Fuel Diversification and Pollution Control Equipment Upgrade.

The list of actions that have been identified to reduce emissions include:

- Butler Taconite, facility closure (1985);
- LTVSMC Taconite Furnaces shutdown;
- Minnesota Power AREA Project (voluntary; proposed), and
- Xcel Energy MERP (voluntary; initiated).

The following regulatory actions were also addressed:

- Implementation of the Taconite MACT;
- Implementation of the Regional Haze Rule and BART Rule;
- Implementation of the CAIR Rule;
- The NO_x SIP call (40 C.F.R. parts 51, 72, 75, 96);
- USEPA proposed rule for NO_x in Class I areas (Fed. Register, Vol. 70, No. 35);
- State acid rain rule and statewide SO_2 emissions cap, and
- Title IV of the 1990 Clean Air Act Amendments.

The specific geographic area of concern ("zone of impact"), including visibility, ecosystems, and populations of concern was defined as Voyageurs and the BWCAW. Voyageurs is primarily located in St. Louis County, while the BWCAW encompasses parts of St. Louis, Lake, and Cook Counties.

Table 4.6-20 shows the estimated potential emissions of SO_2, NO_x, and particulate matter less than 10 microns (PM_{10}) from each of the Projects included in this analysis. Emission reductions due to the 2001 closure of the LTVSMC taconite plant in Hoyt Lakes and other "reasonably foreseeable actions" included in the cumulative impacts analysis are provided for comparison to the emissions estimated for the proposed NorthMet project.

Table 4.6-20 Maximum potential sulfur dioxide, nitrogen oxide, and particulate emissions from Projects in the four-county project area in comparison to selected likely statewide emission reductions. (Four-county project area = Itasca, St. Louis, Lake, Cook counties)

Project	Location In Minnesota	SO_2 (tpy)	NO_x (tpy)	PM_{10} [15] (tpy)	BACT/ MACT [16]
POTENTIAL INCREASES					
Cliffs Erie Railroad Pellet Transfer Facility [1]	Hoyt Lakes	0	0	140	No
Excelsior Energy, Mesaba Energy Project [2]	Subject to PUC Site Process	1300	2,822	478	Yes
Laurentian Wood Fired Energy Project [3]	Hibbing and Virginia	50	302	50	Yes
Mesabi Nugget DRI Plant [4]	Hoyt Lakes	417	954	514	Yes
Minnesota Steel Industries [5]	Nashwauk	539	1,599	1,525	Yes
Northshore Mining Company: Furnace 5 Reactivation [6]	Silver Bay	56	200	149	Yes
PolyMet Mining, NorthMet Project [7]	Hoyt Lakes	15	247	2,269	Yes [17]
United Taconite – Emissions and Energy Reduction Project [8]	Forbes	0	0	14	Yes
UPM/Blandin Paper Mill Expansion: project Thunderhawk [9]	Grand Rapids	1	23	2	Yes
US-Steel Keewatin Taconite, Fuel Diversification and Pollution Control Upgrade [10]	Keewatin	35	35	-287	Yes
Total Potential Increases ("net")		2,413	6,182	4,855	
REDUCTIONS					
LTV Steel Mining Company: (Closure in 2001) [11]	Hoyt Lakes	1,150 [~4,500]	760 [~4,900]	3,720 [~11,079]	N/A
Minnesota Power – AREA Proposal [12] (voluntary action by 2009)	Aurora; Schroeder	3,552	3,745	--	Yes
Butler Taconite [14]	Nashwauk	n/a	n/a	1,372	N/A
Total Estimated Actual Emission Reductions ("net")		4,702	4,505	5,092	
Net Emissions Net Emissions = Total Potential Increases - Est. Actual Reductions		(-2,289)	1,677	(-237)	

Prepared September 2005; updated July 2006, November 2006, footnote 17 added June 2008:

[1] Estimated limited emission increase from modification; PTE increase for permitting purposes is -3.8 tons per year due to contemporaneous decrease in PTE from shutdown of currently idled "LTV" equipment, from Technical Support Document for Air Emissions Permit No. 13700009-005, Table 1.

[2] Preliminary emission estimates (Phase I and Phase II) based on emission factors and heat inputs provide on Excelsior Energy Web site, www.excelsiorenergy.com, accessed on October 28, 2005.

[3] Potential to emit from Technical support documents for Virginia Public Utilities (MPCA permit #13700028-005) and Hibbing Public Utilities (MPCA permit #13700027-003)

[4] Mesabi Nugget's Proposed Direct Reduced Iron (DRI) Facility: No crushing/grinding at the site; receive concentrate from off-site. Air Permit Application, May 2005.

[5] SO_2 and NO_x estimates are expected updates to air permit application, which assume controlled emissions for the pellet plant and DRI plant.

[6] Northshore Mining's Furnace 5 Project: reactivating 2 crushing lines, 9 concentrating lines, one pellet furnace (Furnace 5); new sources emissions only; EAW Table 6 (May 20, 2005).

[7] PolyMet Mining's Proposed Facility: crushing/grinding of ore, reagent and materials handling, flotation, hydrometallurgical processing. Emissions from Scoping EAW Tables 23-2, 23-3, NO_x emissions: very conservative estimates of emissions because natural gas fired boilers operating at maximum capacity to generate heat and steam for all processes. Process changes have occurred since public notice of the EAW that affect particle emissions. Additional changes are likely to occur prior to finalizing the air permit. The current conservative estimate of PM_{10} emissions for the proposed NorthMet project is 2,269 tons/year (1,170 tons/year stack emissions, 52%; 1,099 tons/year fugitive emissions, 48%). Final emission calculations will be submitted in support of the air permit application.

[8] United Taconite – A minor permit amendment has been submitted to the MPCA. The projected increase in actual PM_{10} emissions, for PSD permitting purposes, is 14 tons/yr. The maximum permitted PM_{10} emissions are not yet available from the MPCA. The project is also expected to reduce NO_x emissions by ~ 2,000 tons/yr. However, since the permit amendment is only for PM_{10} emissions increase, the NO_x reduction is not included in this table. United Taconite LLC - Fairlane Plant, Forbes, Minnesota, MPCA, Permit Change/Modification Application Forms, Line 1 Emissions and Energy Reduction Project (EERP), September 2004.

[9] Difference in permitted allowable emissions from Blandin Project Thunderhawk Draft EIS, January, 2006.

[10] U.S. Steel Keewatin; Technical Support Document Permit Action #13700063-003, Dated 2/28/05

[11] LTVSMC: Actual past emissions as annual average emissions since 1996, from http://www.pca.state.mn.us/data/edaAir/index.cfm; downloaded on December 14, 2005. Permitted emissions (potential to emit) information from Technical Support Document for Air Emissions Permit No. 13700009-001, Table 1. Potential emissions are in parenthesis.

[12] MPCA, January 17, 2006, Review of Minnesota Power's Arrowhead Regional Emission Abatement (AREA) Project, Table 12 (MPCA 2006a). Just prior to the MDNR's Final Decision Document being made available to the public on October 25, 2005, Minnesota Power announced a major initiative to reduce pollutant emissions, including mercury, at several of its power plants in northern Minnesota. Due to the significance of the AREA project in regard to air emission reductions, this future project has been included in this analysis.

[13] Xcel Energy's Metropolitan Emission Reduction Project was approved by the Public Utilities Commission on June 13, 2006. SO_2 and NO_x emissions will be reduced by ~ 90%, and PM_{10} emissions will be reduced by more than 70%. Information from: MPCA 2002a; MPCA 2003.

[14] Butler Taconite facility closed in 1985. Estimates of SO_2 and NO_x emissions are not readily available, but historical PM_{10} data are available from earlier reports to the MPCA. Emission reduction of 1,370 tons/year PM_{10} is included (85% of 1,615 tons per year TSP assumed as PM_{10}). From *Iron Range Air Quality Analysis*, MRI Draft Final Report to MPCA, MRI project No. 4523-L(2) June 5, 1979 (1976 inventory). Assumption of 85% TSP as PM_{10} based on Hannah Mining Co. (1980) submittal to MRI and MPCA dated August 8, 1980.

[15] PM_{10} emission estimates include point and fugitive emissions for all sources at a facility.

[16] MACT = Maximum Achievable Control Technology; BACT = Best Available Control Technology.

[17] When this table was prepared, PolyMet was planning on permitting the NorthMet project as a PSD major source. Since that time, PolyMet has decided to permit the project as a synthetic minor source, so the BACT requirement no longer applies. A detailed discussion of the proposed pollution control practices for the NorthMet project can be found in RS58A and RS58B.

Abbreviations:
Tpy = tons per year;
BACT = Best Available Control Technology
MACT = Maximum Achievable Control Technology
SO_2 = sulfur dioxide
PM_{10} = particulate matter less than 10 micrometers in size
NO_x = nitrogen oxides
PUC = Public Utilities Commission
AREA = Arrowhead Region Emission Abatement
MERP = Metropolitan Emission Reduction Project
N/A = not applicable
DRI = Direct Reduced Iron

The PM_{10} emissions in Table 4.6-20 include both stack and fugitive emissions for all projects. For regional haze and visibility impairment, emissions from high temperature stacks are considered to be of most importance due to their height of emission, potential buoyancy and ability to travel long distances. Fine particle emissions are typically associated with stack emissions. Fugitive emissions are typically coarse particulate and are most often ground-level emissions, having the potential for local air quality impacts near the facility, but likely not associated with impacts at distance from a facility. Past and projected direct emissions of PM_{10} are used as a surrogate for direct emissions of $PM_{2.5}$ because readily available MPCA emissions inventory data only report PM_{10} emissions and $PM_{2.5}$ data are only available for 2004.

The MPCA emissions inventory data that was readily available to the public as of January 2006 and used in the cumulative impacts analysis is for total facility emissions and includes both fugitive emissions and stack emissions. For certain types of facilities, such as mining facilities, fugitive emissions can account for 50 percent or more of the particulate emissions. The inclusion of PM_{10} fugitive emissions in the analysis likely overestimates the potential cumulative impacts from the Projects in regard to the visibility impairment that is related to direct emissions of particulate (i.e., PM_{10}) since these emissions typically fall out near where they are generated and would not reach the Class I areas. The results and environmental consequences from the analysis are summarized below.

Class I Area Visibility Gradually Improving. Between 1992 and 2004, visibility in the BWCAW on the 20 percent worst visibility days improved from 21.4 deciviews to 19.8 deciviews, based on a rolling 5-year average. This 1.6 deciview reduction is equivalent to about a 16 percent improvement in visibility. Visibility also appears to have improved by more than 2.0 deciviews in Voyageurs, although continuous data at a single site are not available at Voyageurs as they are in the BWCAW.

Sulfate Particles are Largest Contributor - Sulfate particulates are the largest contributor to visibility impairment in the BWCAW year round. Organic carbon particulates are the second largest contributor in warm weather months (April through September). Nitrates are the second largest contributor in cold weather months (October through March). Elemental carbon, soil, coarse particulate matter and gaseous species are minor contributors.

Improvement Due to Reduced Sulfate and Nitrate Particulates - The 1.6 deciview improvement in the BWCAW on the 20 percent worst visibility days is mostly due to a reduction in sulfate particulate concentrations, although nitrate particulate concentrations also declined. Between 1992 and 2004, the calculated light extinction coefficient due to sulfate particulates declined by 24 percent, and the extinction coefficient due to nitrate particulates declined by 22 percent. Changes in organic carbon concentrations did not significantly impact visibility in the BWCAW, although organic carbon concentrations did decline in Voyageurs.

Nature of Visibility Impairment - Local industrial sources have a limited impact on visibility in BWCAW and Voyageurs, based on $PM_{2.5}$ data and preliminary regional modeling and back-trajectory analyses. Modeling and other studies indicate that 65 percent to 90 percent of the secondary sulfate and nitrate particulates in Minnesota Class I areas are formed from SO_2 and NO_x emitted by many sources located outside the state—primarily in the eastern United States and Canada. The source of the increase in organic carbon fine particulates in the summer is not clear.

Local Emissions Changes and Effects - MPCA emission inventory data indicate that point source air emissions of both SO_2 and direct PM_{10} in northeast Minnesota have increased somewhat since 2001. Over the same time period, however, sulfate particulate concentrations and visibility have not changed significantly in the BWCAW and Voyageurs.

Small Magnitude of Cumulative Project Impact - Worst-case total potential emissions from the proposed Iron Range projects represent a comparatively small increase in statewide emissions: less than 1 percent of PM_{10}, 1.5 percent of SO_2, and 1.3 to 1.6 percent of NO_x emissions, depending on the current level of NO_x controls, statewide.

Impact of National Emission Reductions - Over the next decade, voluntary and mandatory reductions in SO_2, NO_x and direct particulate emissions from exiting sources in Minnesota and nationwide are likely to more than offset emissions from the Projects. However, despite currently planned overall emission reductions in Minnesota and nationwide, it is possible that reasonable progress targets for visibility improvement in Minnesota Class I areas would not be met without further emission reductions.

The cumulative analysis conducted shows a gradual improvement in visibility and in particular noted that sulfates have the largest impact. The net emissions change calculated in Table 4.6.20 shows a decrease in SO_2 emissions and therefore potentially a decrease in sulfate impacts from the cumulative projects..

Table 4.6.20 shows an overall net reduction in SO_2 and PM_{10} emissions and a net increase in NO_x emissions. The net increase for NO_x is much larger than the projected actual emissions for the Project (see Table 4.6-5). Therefore, the Project is not expected to be a major contributor to any future visibility degradation. The current estimate of potential NO_x emissions for the project is also about 30% lower than that listed in Table 4.6-5.

Pending upcoming regulatory actions indicate a significant reduction in SO_2, NO_x and direct particulate emissions and associated impacts. These reductions would be expected to far exceed impacts from the NorthMet project

4.6.5 Asbestiform Fibers

4.6.5.1 Existing Conditions

Background

The NorthMet Project would be mining ore from the Duluth Complex. Taconite ore mined from the Biwabik Iron Formation at Northshore Mining's Peter Mitchell Mine, processed at the Silver Bay plant, has received public attention with regard to potential releases of thread-like fibers formed from amphibole mineral crystals, a class of silicate minerals containing iron and magnesium such as those found with taconite ore. The Duluth Complex does not contact the Biwabik Iron Formation at the NorthMet deposit, but the Biwabik Iron Formation is presumed to be related to the Duluth Complex.

Northshore Mining's Silver Bay processing plant was formerly operated by Reserve Mining Company. In a landmark ruling in 1974 regarding the dumping of taconite tailings from the Silver Bay plant into Lake Superior, the United States District Court for the District of Minnesota found that evidence existed regarding the potential for exposure to amphibole mineral fibers to cause cancer and other health effects [*United States. v. Reserve Mining Company*, 380 F. Supp. 11, 17 (D. Minn. 1974)]. This led to the construction of a tailings basin in 1980. Amphibole mineral fibers incorporate asbestos,[2] as discussed below, as well as non-asbestos fibers. The Court found that since it can be difficult to tell the difference between asbestos and non-asbestos amphibole fibers under the microscope, these fibers, classified as asbestos or not, have the same potential in the court's ruling to produce some of the same health effects that can result from asbestos exposure, such as asbestosis, mesothelioma, or other cancers (described below). Scientific work, including health effects, on the question of exposure to non-asbestos amphibole mineral fibers is still ongoing at the present time.

Regulatory definitions for classifying fibers vary. The USEPA defines the dimensions of an asbestos fiber as a particle 5 micrometers (µm)[3] 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). The Minnesota Department of Health (MDH) defines 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). This definition, which includes amphibole mineral fibers that can either be asbestos or non-asbestos, is consistent with the findings of *United States v. Reserve Mining Company*.

Asbestos Fibers. Asbestos is made up of fiber bundles with two or more of the following features:

- Parallel fibers occurring in bundles
- Fiber bundles displaying splayed ends

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[2] The term "asbestos" is not a mineralogical definition; it is a regulatory and commercial term designating mineral products that possess high tensile strength, ability to be separated into long, thin, flexible fibers, low thermal and electrical conductivity, high mechanical and chemical durability, and high heat resistance. The fibers can be woven into various commercial products because of their flexibility. Asbestos refers to the fibrous variety of several naturally occurring silicate minerals.

[3] A micrometer (µm) is one millionth (10^{-6}) of a meter.

- Matted masses of individual fibers
- Fibers showing curvature

Bundles have splaying ends and are extremely flexible. When pressure is applied to an asbestos fiber, it bends much like a wire, rather than breaks. These long, thin fibers, called "fibrils," often less than 0.5 µm, can be easily separated from each other, which is one of the most important characteristics of asbestos (MSHA, 2005). The mean aspect ratio for fibers can range from 20:1 to 100:1 or higher for fibers longer than 5 µm. Asbestos exposure has been identified as the cause of both malignant and non-malignant diseases.

The USEPA Integrated Risk Information System (IRIS) has classified asbestos as a Group A Human Carcinogen (USEPA, 2008). This classification means that there is sufficient human and animal carcinogenicity data to support the weight-of-evidence characterization of asbestos as a human carcinogen from the inhalation route of exposure. The Group A classification is based on observations in occupationally-exposed workers of increased mortality and incidence of lung cancer, mesothelioma, and gastrointestinal cancer. Evidence of carcinogenicity via the ingestion pathway was not supported in the animal studies reviewed for the USEPA IRIS classification in 1988 (USEPA, 2008). A review of the toxicological literature for asbestos was performed for the Minnesota Department of Natural Resources (MDNR) (ERM 2008). A brief description of potential human health effects from inhalation exposure to asbestos fibers, summarized from this toxicological literature review, follows.

Lung cancers caused by asbestos are mainly bronchial carcinomas and are indistinguishable from those caused by smoking or other agents (Doll and Peto, 1985). Carcinomas do not generally form until several years after the initial exposure. ***Mesothelioma*** is a form of cancer almost always associated with a previous exposure to asbestos. The cancer forms in the mesothelium, most commonly in the pleura, the outer lining of the lungs and chest cavity. Symptoms take 15 to 50 years after exposure to appear and include shortness of breath and coughing. There is no cure for human mesothelioma (Suzuki and Yuen, 2002).

Asbestosis is a disease associated with occupational levels of exposure to asbestos (Atkinson, 2006). Most patients with asbestosis suffer from shortness of breath and a dry cough (Mossman and Churg, 1998). It is characterized by chronic inflammation of the parenchymal tissue of the lungs. The increase of fibrous tissue reduces tissue elasticity and gas diffusion, which reduces oxygen transfer to the blood and removal of carbon dioxide. Asbestosis appears to be associated with a high level of aggregate exposure, either a very high level over a short period or a low level for an extended period (Atkinson, 2006). The level of exposure seems to control the latency period between initial exposure and the development of disease. Mossman and Churg (1998) indicate that asbestosis requires a threshold level of exposure; the lower the exposure, the longer it takes to reach the threshold. Historically, asbestosis progresses even after workers are no longer exposed to asbestos dust (Atkinson, 2006).

There are two groups of minerals that can crystallize as asbestos: serpentine and amphibole. Serpentine and amphibole minerals can have fibrous and nonfibrous structures. While there are approximately 100 minerals that may contain asbestos fibers, there are six regulated types of asbestos. The six regulated minerals and their associated mineral group are:

Mineralogy	
Serpentine	***Amphibole***
Chrysotile	Crocidolite (Reibeckite)
	Amosite (Cummingtonite-grunerite)
	Anthophyllite Asbestos
	Tremolite Asbestos
	Actinolite Asbestos

Mineralogically, amphibole minerals are distinguished from each other by the amount of sodium, calcium, magnesium, and iron that they contain.

A mineral can be analyzed for asbestos using a microscope. Chrysotile asbestos is easily identified by microscopic analysis because of its distinct particle shape. For amphiboles, the distinction between asbestos and non-asbestos fibers is much less clear. Amphibole particles have a spectrum of shapes from blocky to prismatic to acicular to asbestiform.[4] Amphiboles also break (or cleave) into smaller fragments when finely ground. Long, thin cleavage fragments[5] resemble asbestos fibers. An analyst can compare amphibole particle shapes to asbestos reference materials and determine whether a sample is asbestiform with a fair degree of certainty. However, unless a fiber bundle has splaying ends, it is impossible to determine if a single long, thin particle is an asbestos fiber or a cleavage fragment (USGS, 2001; Berman and Crump, 2003). It is more difficult to classify individual fibers as asbestiform or cleavage fragments because individual fibers do not exhibit all the characteristics of a population. Cleavage fragments tend to be roughly twice as thick as asbestos fibers (Addison and McConnell, *in press*). 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).

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[4] Asbestiform refers to a specific type of mineral fibrosity in which crystal growth is primarily in one dimension and the crystals form as long, flexible fibers. The fibers form in bundles and can be separated into smaller bundles and ultimately single fibers or fibrils.

[5] A cleavage fragment is a particle formed by comminution (i.e., crushing, grinding or breaking) of minerals, often characterized by parallel sides. In contrast to fibers from an asbestos mineral, elongated mineral fibers in a population of cleavage fragments are generally wider and shorter, have generally lower aspect ratios, and do not exhibit fibrillar bundling.

Non-Asbestos Fibers. The toxicological literature review prepared for the MDNR also discussed non-asbestos 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 (*in press*) 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 these researchers 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 15-50 years are not uncommon, creating uncertainties in the interpretation of studies performed to date.

The MDH is currently updating an epidemiological study of workers in Minnesota's iron mining industry, as described in Section 4.6.5.2.

Potential for Exposure to Amphibole Mineral Fibers at Proposed Site

Northshore Mining's Peter Mitchell Mine and Silver Bay processing plant has been associated with releases of amphibole mineral fibers to air and water. PolyMet's proposed mine is in close proximity to Northshore Mining's existing mine. Ore in intrusive rocks to be mined from the NorthMet deposit in the Duluth Complex is 700 million years younger than the taconite ore obtained from Northshore Mining's Peter Mitchell Mine in the Biwabik Iron Formation, and was formed under different conditions (Barr 2007d).

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).[6] The MEQB (1979) indentified 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)[2] provided results for amphibole and serpentine minerals representative of the MEQB (1979)[2] 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.

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[6] References to MEQB (1979), SGS (2004), and Stevenson (1978) are as cited by Barr (2007d).

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 (TEM) by additional grinding of the ore and tailings samples with mortar and pestle to produce a very fine powder. Stevenson (1978)[2] 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 (Barr 2007d). The results of the July/August 2005 flotation pilot testing are summarized below:

- A small amount of amphibole minerals are likely to be associated with the processing of ore from the NorthMet deposit; approximately 9% of MN-fibers identified in the samples were characterized as amphibole and 91% were characterized as non-amphibole.
- One of the MN-fibers identified in the samples (or 0.2% of the MN-fibers) met the USEPA definition of an "asbestos fiber," but it was a non-amphibole fiber.
- No chrysotile fibers, the asbestos form of serpentine, were identified in the samples analyzed by TEM.
- The MN-fibers identified in the samples were predominately less than 2.5 µm in aerodynamic diameter (99.6% less than 2.5 µm), placing them in the fine fraction of particulate matter ($PM_{2.5}$).

These data suggest a low probability of asbestos fiber generation from the proposed operations. However, with the presence of amphibole minerals in the Duluth Complex and the presence, albeit low, of MN-regulated fibers from analysis of NorthMet deposit samples, the potential exists for the release of amphibole mineral fibers from the proposed operations, which could pose a potential public health risk of uncertain magnitude.

4.6.5.2 Impact Criteria

As summarized in Section 4.6.5.1, there are many factors that contribute to carcinogenesis and disease from exposure to asbestos and non-asbestos fibers via inhalation. The literature review prepared for the MDNR (ERM 2008) summarizes the results of many toxicological studies presenting varying conclusions as to the significance of fiber aspect ratios, fiber lengths, and cleavage fragments in the expression of human health effects. However, in the case of cleavage fragments, the literature review suggests a minor carcinogenic risk though some researchers could not exclude exposure as a contributing factor to lung cancer. In addition, the MDH is currently updating an epidemiological study of workers in Minnesota's iron mining industry. There have been 58 cases of mesothelioma documented among the 72,000 workers in the study (MDH, 2007). Investigations into the toxicity of taconite dust are also underway by the University of Minnesota, School of Public Health.

Although a risk assessment protocol for evaluating asbestos by type and dimensions has been developed for the USEPA by Berman and Crump (2003), it may never be formally adopted. This model also does not consider fibers shorter than 10 micrometers in length. To date, there is no accepted methodology for performing a formal health risk assessment for the quantitative assessment of human health impacts from airborne fibers emitted from the proposed operations.

However, amphibole minerals are present in the Duluth Complex in close proximity to the NorthMet deposit. Thus, there remains an uncertain level of potential health risk from airborne amphibole fibers for the Project.

4.6.5.3 Environmental Consequences

Proposed Action

Section 4.6.5.1 described a likelihood of exposures to airborne amphibole mineral fibers from the proposed mining and processing 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% 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%).

Although not identified from the flotation pilot testing (Barr 2007d), the probability of amphibole mineral fibers released from the Project is not zero. Potential airborne fibers could contain asbestos fibers, which have known health effects. Non-asbestos amphibole mineral fibers in these emissions have less well known health effects; however, these fibers are regulated as MN-fibers pursuant to the *United States v. Reserve Mining Company* court decision due to the potential for human health impacts.

PolyMet's June 2007 Fibers Data Report (Barr 2007d) included an assessment of alternative control technologies for the proposed Plant Site operations. These data were taken from a Best Available Control Technology (BACT) review for the Plant Site prepared for PolyMet (Barr 2007e).

Under the USEPA's PSD regulations, BACT is defined at 40 CFR 52.21(b)(12) as:

> *"**Best available control technology** means an emissions limitation (including a visible emission standard) based on the maximum degree of reduction for each pollutant subject to regulation under Act which would be emitted from any proposed major stationary source or major modification which the Administrator, on a case-by-case basis, taking into account energy, environmental, and economic impacts and other costs, determines is achievable for such source or modification through application of production processes or available methods, systems, and techniques, including fuel cleaning or treatment or innovative fuel*

combustion techniques for control of such pollutant. In no event shall application of best available control technology result in emissions of any pollutant which would exceed the emissions allowed by any applicable standard under 40 CFR parts 60 and 61. If the Administrator determines that technological or economic limitations on the application of measurement methodology to a particular emissions unit would make the imposition of an emissions standard infeasible, a design, equipment, work practice, operational standard, or combination thereof, may be prescribed instead to satisfy the requirement for the application of best available control technology. Such standard shall, to the degree possible, set forth the emissions reduction achievable by implementation of such design, equipment, work practice or operation, and shall provide for compliance by means which achieve equivalent results."

The BACT review for the proposed PolyMet operations was performed in accordance with the USEPA's "top-down" approach (USEPA 1990), where control technologies are ranked in order of effectiveness, and starting with the most stringent technology, each are evaluated until a technology can not be ruled out on technological or economic grounds.

The "top-down" BACT review found the option with dry baghouse controls on the crushing plant to be the most effective in controlling particulate matter emissions. Typical particulate matter outlet concentrations for baghouse controls are around 0.005 grains per dry standard cubic foot (gr/dscf).[7] The next most stringent level of control was associated with wet scrubbers, with an outlet emission concentration of 0.006 gr/dscf. Emissions from both technologies are primarily in the PM_{10} size range. In terms of $PM_{2.5}$, baghouse controls are better than wet scrubbing at controlling the $PM_{2.5}$ fraction on a particle count basis. In the USEPA RACT/BACT/LAER Clearinghouse (RBLC) data search,[8] the most stringent level of particulate matter control was found for the Northshore Mining Company (RBLC ID MN 0064), with an outlet particulate matter concentration of 0.0025 gr/dscf. The Northshore Mining facility's permit indicates that this level was imposed to demonstrate modeled compliance with PSD increments; other material handling sources had limits of 0.005 gr/dscf and were considered BACT (Barr 2007e).

In a September 2007 Supplemental Fibers Data Report (Barr 2007f), PolyMet incorporated project changes made in a July 2007 Supplemental Detailed Project Description (DPD) (Barr 2007g) to further reduce particulate matter and fugitive dust emissions from the Plant and Mine Sites, as well as additional changes related to particulate matter control and monitoring for amphibole MN-fibers following August 2007 discussions. The main points related to potential amphibole MN-fiber emissions are summarized below:

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[7] One "grain" is 1/7000th of a pound.

[8] The USEPA RBLC is a compilation of permitted control technologies across all states, found at http://cfpub.epa.gov/rblc/htm/bl02.cfm. RBLC stands for RACT/BACT/LAER, or reasonably available control technology (RACT), best available control technology (BACT), and lowest achievable emission rate (LAER) Clearinghouse.

- PolyMet has agreed to upgrade the particulate matter controls on crushing plant sources to baghouses at an outlet particulate matter concentration of 0.0025 gr/dscf. This is the most stringent level of particulate matter control possible with current technology, as documented by the USEPA RLBC. In addition, MN-fibers are predominately in the $PM_{2.5}$ size range. Baghouse controls achieve the highest degree of collection efficiency for $PM_{2.5}$ particles.
- The Tailing Basin will be operated to minimize PM_{10} emissions by management to minimize exposed beach areas, and wind erosion fugitive dust by treatment of Tailings Basin roads, active work areas, and beach areas.
- PolyMet has agreed to operational changes at the Mine Site to minimize PM_{10} emissions by road layout and truck size changes, reducing potential emissions of airborne amphibole mineral particles.

The modeled air concentrations presented earlier in Section 4.6.3 incorporated these project changes and emission control technology commitments.

The operational and air pollution equipment controls agreed to between PolyMet and MPCA represents the highest feasible level of particulate matter emissions control. This coupled with the considerable distance to the closest residential community, Hoyt Lakes, provides a degree of protection for exposure to airborne amphibole mineral fibers. To monitor the effectiveness of this protection, PolyMet has agreed to pre-construction and post-operation ambient monitoring for MN-fibers in the community of Hoyt Lakes. The MPCA approved locating the monitor near the wastewater treatment plant in the southwest portion of Hoyt Lakes, near a residential area. Pre-construction monitoring began on May 12, 2008.

The baseline sample period will continue for a period of one year. The monitor will run every 12 days to collect a 96-hour sample on a 47-millimeter filter to capture the airborne material. Samples will be forwarded to the MDH for fiber analysis. After initial startup of the PolyMet facility, the monitor will be run again for another one-year period using the same sample protocol as the baseline monitoring. The measured baseline levels of airborne amphibole MN-fibers will be compared to the levels measured during the one-year operational monitoring period.

Alternatives

No Action

Since this alternative would add no new operations, potential new asbestiform fiber emissions would not occur. Therefore, ambient fiber levels would be the same as those associated with existing conditions.

Subaqueous Disposal of Reactive Waste Rock

As described in Section 4.6.3.2, the major difference between this alternative and the Project is the variation of haul traffic volumes for each year of the mining operations at the Mine Site. Section 4.6.3.2 concludes that air dispersion modeling for the Project is representative of haul road fugitive dust impacts for this alternative. Therefore, this alternative is not expected to have significantly different asbestiform fiber impacts from the Project.

4.7 NOISE

This section discusses potential effects of noise on humans in the Project area. The effect of noise on wildlife is discussed in section 4.4.

Noise is generally defined as unwanted sound. Sound travels in mechanical wave motion and produces a sound pressure level. This sound pressure level is commonly measured in decibels (dB), representing the logarithmic increase in sound energy relative to a reference energy level. Sound measurement is further refined by using an A-weighted decibel scale to emphasize the range of sound frequencies that are most audible to the human ear (i.e., between 1,000 and 8,000 cycles per second). Therefore, unless otherwise noted, all decibel measurements presented in this EIS are A-weighted (dBA) on a logarithmic scale. A sound increase of 3 dBA is barely perceptible to the human ear, a 5 dBA increase is clearly noticeable and a 10 dBA increase is heard twice as loud. For example, if sound energy is doubled, there is a 3 dBA increase in noise, which is just barely noticeable to most people. This indicates that two sound levels are added logarithmically, not linearly or arithmetically (e.g., 70 dBA plus 70 dBA equals 73 dBA, not 140 dBA). If noise increases to where there is 10 times the sound energy level over a reference level, then there is a 10 dBA increase and it is heard twice as loud.

4.7.1 Existing Conditions

The NorthMet Project site is located in a sparsely populated region in northeast Minnesota. The region has traditionally supported various mining activities as well as logging on county, State, National Forest, industrial, and private forest lands. The existing Peter Mitchell Mine is located approximately one mile north of the proposed Mine Site. Dunka Road, which provides access to the Project area, is an existing private road with no public access and little usage.

The closest noise-sensitive receptor from the Mine Site is a Boy Scout camp located approximately five miles to the southeast. Other noise-sensitive receptors in the general area of the Mine Site include the City of Babbitt, six miles to the north; Skibo (a small residential area), approximately eight miles to the south-southwest; and the City of Hoyt Lakes, approximately 9 miles to the southwest. The Boundary Waters Canoe Area Wilderness (BWCAW) is part of the national wilderness preservation system where sensitivity to human-caused sound and noise impacts are important considerations. It is approximately 20 miles (in a northeasterly direction) from the Mine Site to the closest portion of the BWCAW. The closest noise-sensitive receptors to the Plant Site consist of a few private residences located approximately 3.5 miles north and the City of Hoyt Lakes, which is approximately five miles south.

A comparison of the noise levels of some common outdoor noise sources is shown in Table 4.7-1.

Table 4.7-1 Typical Values of Sound Levels of Common Outdoor Noise Sources

Sound Pressure Level (dBA)	Common Outdoor Noise Levels
110	Jet flyover at 1,000 feet
100	Gas lawn mower at 3 feet
80	Noisy urban daytime
70	Gas lawn mower at 100 feet
65	Commercial area, heavy traffic at 300 feet
50	Quiet urban daytime
40	Quiet urban nighttime
35	Quiet suburban nighttime
25	Quiet rural nighttime

Source: Phoenix Mining Project in Battle Mountain, Nevada – FEIS (BLM, 2002)

Based on the sound levels in Table 4.7-1 and considering the proximity of the Peter Mitchell mine to the Mine Site (undeveloped area), the existing ambient steady equivalent noise levels (L_{eq}) for the Mine Site are anticipated to be approximately 40 dBA and 35 dB for daytime and nighttime, respectively. Although the Plant Site is farther away from the Peter Mitchell mine, it is located in a more developed area. Therefore, the existing daytime and nighttime ambient L_{eq} for the Plant Site are also anticipated to be approximately 40 dBA and 35 dBA, respectively.

Noise exposures in communities usually have a noise level distribution that may be closely approximated by a normal statistical distribution. The estimated L_{eq} for the distribution was converted to other noise percentile metrics such as L_{50} and L_{10} using the calculation methodology described in Appendix A of EPA's *Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Safety Margin* (EPA, 1974). The calculation was based on an assumed standard deviation of 3 dB for the sound level distribution. L_{50} is the sound level exceeded for 50 percent of the measurement period. L_{10} is the sound level exceeded for 10 percent of the measurement period. A summary of the estimated existing daytime and nighttime ambient levels (i.e., L_{eq}, L_{50}, and L_{10}) expected at the Project site are presented in Table 4-7-2.

Table 4.7-2 Summary of Estimated Existing Ambient Noise Levels at the Project Site

Ambient Noise Levels	Daytime	Nighttime
Mine Site		
L_{eq}	30	25
L_{50}	29	24
L_{10}	32.8	27.8
Plant Site		
L_{eq}	40	35
L_{50}	39	34
L_{10}	42.8	37.8

4.7.2 Impact Criteria

Noise impacts 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.

According to the noise standards for the State of Minnesota (Minnesota Rules, Part 7030.0040, Subpart 2), permissible noise levels are generally classified according to residential, commercial, and industrial areas. The standards further 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 one hour. A summary of the applicable Minnesota Noise Standards is shown in Table 4.7-3.

Table 4.7-3Applicable Noise Standards for Different Land-Uses in Minnesota

Noise Area Classification	Noise Standard dB(A)			
	Daytime (7 a.m. to 10 p.m.)		Nighttime (10 p.m. to 7 a.m.)	
	L_{50}	L_{10}	L_{50}	L_{10}
Residential	60	65	50	55
Commercial	65	70	65	70
Industrial	75	80	75	80

As shown in Table 4.7-3, the most stringent standard is the nighttime (10 p.m. to 7 a.m.) standard in a residential area, 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 during nighttime, 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 nighttime, noise levels may not exceed 55 dBA more than 6 minutes in an hour. As another point of reference, the U.S. Department of Housing and Urban Development (HUD) has developed standards for use in evaluating activities under its jurisdiction. The HUD standard for “acceptable” day-night average sound levels (L_{dn}) in residential areas is 65 dBA and instructive as a guide to human disturbance (HUD, 1984). The day-night average sound level (L_{dn}) is the 24-hour equivalent measure of cumulative noise exposure during a 24-hour period, with a 10 dBA weighting applied to nighttime equivalent sound levels between the hours of 10 p.m. and 7 a.m. to account for people's greater sensitivity to sound during nighttime hours.

In addition to the State standard, 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 Project. 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).

Because the State noise levels standards are more stringent than the federal HUD standards, Project-related noise effects will be evaluated at sensitive receptors (residential areas) using the State nighttime L_{50} and L_{10} of 50 and 55 dBA, respectively.

Effects of air overpressure and ground vibrations from blasting operations must meet the requirements of the Minnesota State Rules, 6132.2900, Subpart 2. According to the Rules:

- Air overpressure on lands not owned or controlled by the permittee shall not exceed 130 decibels as measured on a linear peak scale, sensitive to a frequency band ranging from six cycles per second to 200 cycles per second; and
- The maximum peak particle velocity from blasting shall not exceed one inch per second at the location of a structure located on lands not owned or controlled by the permittee.

Ground vibration and air blast (overpressure) from rock blasting is primarily related to the weight of explosive detonated during any one instant and distance to a structure or sensitive receptor.

There are no specific local noise regulations that would apply to the NorthMet Project.

4.7.3 Environmental Consequences

4.7.3.1 Proposed Action

Mine Site

The primary sources of noise from the NorthMet Mine Site are blasting, haul trucks, and train horns. A noise propagation model, SPM 9613, developed by Power Acoustics, Inc., was used to assess noise impacts associated with mine haul trucks, as they are the most dominant and steady noise source at the Mine Site.

In order to predict the most conservative estimates of noise impacts, the model assumed wind and weather conditions ideal for sound propagation and minimal ground attenuation effects (i.e., hard and level ground with a ground effect limit of 10 dB).

The assessment predicted impacts at six different receptor locations or noise sensitive areas (NSAs): the Boy Scout Camp, the City of Babbitt, the City of Hoyt Lakes (southwest of the Mine Site), Skibo, and two separate boundary locations of the BWCAW (directly north and to the northeast). Noise emissions levels were developed for the Cat 793C trucks proposed for the Project based on information provided by the Caterpillar Company and by separating the sound level into octave bands using truck noise spectrum data from the Minnesota Copper-Nickel Study (Minnesota State Planning Agency, 1979). A total of 16 trucks, each with a sound power level of approximately 121 dBA, were assumed to be in concurrent operation. The modeling analysis did not include any potential shielding effects from pit walls, stockpiles, or berms.

Modeled sound levels from the 16 haul trucks heard at the six nearest NSAs to the Mine Site (i.e., NSA #3 to NSA #8) are listed in Table 4.7-4. The noise modeling analysis is conservative because it does not reflect a recent decision by PolyMet Mining, Inc. to purchase and use 9 newer and larger trucks at the Mine Site rather than the 16 modeled above. A comparison by David Brauslau Associates in 1992 between noise monitoring studies on smaller haul trucks and a more recent study by Barr and Caterpillar on larger haul trucks indicated that the size of the haul truck is no longer a reliable parameter for determining noise level because of great improvements in engine and truck technology over the past 10 to 15 years (Minnesota Steel FEIS, 2007). Therefore, the use of fewer, newer, and larger trucks (each with the same sound power level of approximately 121 dBA) at the Mine Site would likely reduce modeled noise levels beyond the predicted noise levels shown in Table 4.7-4.

When the projected noise levels at the NSAs are combined logarithmically with the existing ambient noise levels at the Mine Site, the total cumulative nighttime L_{50} and L_{10} would remain below 35 and 39 dBA, respectively.

Table 4.7-4 Predicted Noise Impact for the NorthMet Project

Noise Sensitive Areas (NSAs)	Distance/ Direction of NSA to Project Site (miles)	Existing Ambient Noise Levels (dBA)			Predicted Project Noise Levels at NSAs (dBA)			Total Project Plus Ambient Noise Levels (dBA)[2]			Minnesota Nighttime Noise Level Standards for Residential Areas	Project Compliance with Minnesota Nighttime Noise Standards? (Yes/No)
		Nighttime, Leq	Nighttime, L50	Nighttime, L10	Nighttime, Leq	Nighttime, L50	Nighttime, L10	Nighttime, Leq	Nighttime, L50	Nighttime, L10		
Plant Site												
Private residences (NSA #1)	3.5 miles - north of Plant Site	35	34.0	37.8	34.4	33.4	37.2	37.7	36.7	40.5	L_{50} of 50 dBA; L_{10} of 55 dBA	Yes
City of Hoyt Lakes - South (NSA #2)	5 miles - south of Plant Site	35	34.0	37.8	30.1	29.1	32.9	36.2	35.2	39.0	L_{50} of 50 dBA; L_{10} of 55 dBA	Yes
Mine Site												
Boy Scott Camp (NSA #3)	5 miles - southeast of Mine Site	35	34.0	37.8	18.1	17.1	20.9	35.1	34.1	37.9	L_{50} of 50 dBA; L_{10} of 55 dBA	Yes
City of Babbitt (NSA #4)	6 miles - north of Mine Site	35	34.0	37.8	24.3	23.3	27.1	35.4	34.3	38.2	L_{50} of 50 dBA; L_{10} of 55 dBA	Yes
Skibo (NSA #5)	8 miles - southwest of Mine Site	35	34.0	37.8	16.4	15.4	19.2	35.1	34.0	37.9	L_{50} of 50 dBA; L_{10} of 55 dBA	Yes
City of Hoyt Lakes - Southwest (NSA #6)	9 miles - southwest of Mine Site	35	34.0	37.8	12.3	11.3	15.1	35.0	34.0	37.8	L_{50} of 50 dBA; L_{10} of 55 dBA	Yes
BWCA - Northeast (NSA #7)	20 miles - north of Mine Site	35	34.0	37.8	0	0	0	35.0	34.0	37.8	L_{50} of 50 dBA; L_{10} of 55 dBA	Yes
BWCA - North (NSA #8)	> 20 miles - northeast of Mine Site	35	34.0	37.8	0	0	0	35.0	34.0	37.8	L_{50} of 50 dBA; L_{10} of 55 dBA	Yes

Notes:

[1]Noise impacts were based on the most stringent Minnesota noise level standards i.e., nighttime noise standards for residential areas. Predicted equivalent steady sound levels (Leq) were converted to L50 and L10 using the calculation methodology described in Appendix A of EPA's *Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Safety Margin* (EPA 1974).The calculation was based on an assumed standard deviation of 3 dB for the sound level distribution.

[2]Total Project Plus Ambient Noise = 10 Log ($10^{(\text{Ambient Noise}/10)} + 10^{(\text{Project Noise}/10)}$).

Table 4.7-4 indicates the projected nighttime noise levels at the nearest NSAs are expected to be well within the Minnesota State noise standards. The most stringent State L_{50} standard of 50 dBA (i.e., nighttime; residential) would not be exceeded beyond 8,200 feet from the Mine Site; residential areas are well outside this radius.

The highest predicted nighttime L_{50} and L_{10} *impact* from the Mine Site on a residential area were 34.3 and 38.2 dBA, respectively at the City of Babbitt, but this estimate is considered very conservative because there is a ridge (Giant's Ridge) located between the Mine Site and Babbitt that would topographically shield noise from the mine. Since the total predicted nighttime L_{50} and L_{10} are well within the most stringent Minnesota State noise standards, it is anticipated that typical mining operations at the Mine Site would have an insignificant effect on the noise environment.

Although ore would be delivered from the mine to the Plant Site by train, noise from train horns is expected to be minimal because the railroad route near the mine and Plant sites is far (about 4 to 5 miles) from the nearest NSAs. There is one private at-grade crossing between the mine and the processing plant, and the rail line has been used in other mining operations for many years. While up to 24 trains per day are expected to deliver ore to the Plant Site, this frequency of traffic is less than that previously experienced on the rail line.

The other potential source of noise emissions is the blasting at the mine. The environmental impacts of blasting at non-ferrous mining operations are regulated by the Minnesota Department of Natural Resources under Minnesota Rules Part 6132.2900 to ensure that effects of air overpressure and ground vibrations from production blasts will not be injurious to human health or welfare and property outside the mining area. The distance from the Mine Site to the nearest receptors is such that impacts from blasting are expected to be minimal. Much of the area currently experiences blasting at the Peter Mitchell Mine and has previously experienced blasting during the operation of other mining interests over the years. Blasting noise is not included in the noise level estimates presented in Table 4.7-3 because mine blasting is typically an extremely brief 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 to 3 days. This would usually include separate blasts of ore and waste rock benches. Typically, rock blasting could potentially have single event noise levels (SEL) ranging from 111 to 115 dBA at 50 feet from the blasting site. With modern blasting techniques, the blasting would be experienced by people at the nearby 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.

Because the closest receptors and structures would be located at least 5 miles away from the Mine Site, effects of air overpressure and ground vibrations from blasting operations are expected to meet the requirements of Minnesota State Rules, 6132.2900, Subpart 2. Once Polymet develops blast data and blasting experience at the Mine Site, specific estimates of ground motion and air overpressure can be determined. For blast source areas closest to receptors, it may be necessary to adjust drill hole density along with delay weights to keep vibrations below the MnDNR prescribed limits. Air overpressure levels can be maintained through a reduction of delay weights, appropriate stemming depth, use of shock tubes and depth of burden (distance of blast from free bench face). Unfavorable atmospheric conditions, such as low level inversions or winds toward nearby buildings, should be avoided during blasting.

As required by law, NorthMet would implement a seismic monitoring program, including monitoring at a location adjacent to the nearest structure located on lands not owned or controlled by the PolyMet and where the MnDNR would consider necessary to investigate complaints. Minnesota Rules would also require that PolyMet monitor all open pit blasts. As with ground vibration, the air blast monitoring station would be required to be located adjacent to the nearest structure located on lands not owned or controlled by the mining company to monitor atmospheric conditions for air blast effects. In addition, access to natural resources for traditional use by Ojibwe people, as per the 1854 Treaty, could be disrupted by noise associated with the Project. Further discussion of tribal use of natural resources is provided in Chapter 4.8, Cultural Resources.

Plant Site

The primary sources of noise from the Plant Site would be crushers. The PolyMet proposes no changes to the existing crushing systems at the Plant Site. Sound levels associated with crushers typically range from 90 to 105 dBA at a reference distance of 50 feet (BLM, 2002). For stationary noise sources such as crushers, a 6 dB reduction in sound level is achieved per doubling of distance (i.e., assuming hard non-absorptive ground conditions like concrete or asphalt); however, for soft absorptive ground conditions like most parts of the Plant Site, a standard equation used to calculate noise levels based on distance from a reference source is shown in the following equation:

$$L_{eq(h)\,(receiver)} = L_{eq(h)(ref)} - 20\text{Log (D/Ref. Distance)} - 10\text{GLog(D/Ref. Distance)}$$

where D is the receiver’s distance from the source and G is the ground factor ($0 \leq G \leq 1$). Larger ground factors mean larger amounts of ground attenuation with increasing distance.

It is expected that the crushers would be located no closer than approximately 18,500 feet (i.e., 3.5 miles) away from the closest NSA to the north – a few private residences (NSA #1); and approximately 26,400 feet (i.e., five miles) away from the closest NSA to the south - the City of Hoyt Lakes (NSA #2). Using a ground factor G of 0.75 for the soft absorptive ground, typical L_{eq} of 105 dBA at 50 feet from the Plant Site would be heard as 34.4 dBA at NSA #1. The predicted L_{eq} was converted to L_{50} and L_{10} of 33.4 and 37.2 dBA, respectively. When combined logarithmically with the existing ambient noise levels at the Plant Site, the total nighttime L_{50} and L_{10} at the NSA #1 would be approximately 36.7 and 40.5 dBA, respectively (Table 4.7-4). Therefore, the total estimated L_{50} and L_{10} at the closest receptors to the Plant Site are expected to be well within the most stringent Minnesota State noise standards.

Based on the above information, it is anticipated that typical processing operations at the NorthMet Plant Site would have an insignificant effect on the noise environment.

4.7.3.2 Alternatives

No Action Alternative

Under the No Action Alternative, there would be no increase in noise levels at the Project Site or change in noise levels at sensitive receptors.

Subaqueous Disposal of Waste Rock

The subaqueous disposal of waste rock would not significantly change noise generation at the Mine or Plant sites or modify noise effects on NSAs relative to the Proposed Action.

4.7.4 Cumulative Impacts

During the EIS scoping process (see Section 2.1 of the Final SDD), no cumulative impact issues associated with noise were identified.

4.8 CULTURAL RESOURCES

Cultural resources include material remains of past human activities, both historic and prehistoric. In addition, cultural resources include traditional cultural properties, such as areas used for ceremonies or other traditional activities that may leave no material traces, and may have on-going use important to the maintenance of cultural practices. Cultural resources management seeks to identify and protect all of these types of cultural resources with the goals of enhancing understanding of human behavior and protecting cultural practices.

At the Project, three cultural resources were identified: a previously unknown prehistoric archaeological site and two previously known resources – LTVSMC facilities and a railroad associated with these facilities. In consultation with federally recognized tribes who have expressed an interest in the proposed undertaking, no traditional cultural properties within or adjacent to the Project site were identified; however, the tribes did express an interest in maintaining access to natural resources within and near the Project site, citing the rights afforded by the Treaty of 1854, and stated that limited access to the Project site over the last several decades has limited use of any resources that may have historically been traditional cultural properties.

4.8.1 Existing Conditions

Prehistoric Background

The earliest inhabitants of Minnesota date back about 10,000 years, moving into the area after the last glaciation of the Pleistocene (Risjord 2005). The archaeological remains of these Paleo-Indian people are difficult to locate, since the sites are small, contain few artifacts, are few in number, and are usually deeply buried beneath more recent sediments. These sites are recognized by archaeologists by scatters of lanceolate (lance-like) projectile points (Dobbs 1990a; Dobbs 1990b). Skeletal remains of Paleo-Indian people found in Minnesota have been radio-carbon dated to 8,000 to 10,000 years before present (Mondale 2007).

The Paleo-Indian people were followed by Archaic people, likely Paleo-Indian descendants. This cultural transition occurred about 6,000 years before present. Material remains of activities of Archaic people, including large notched and stemmed projectile points, have been more frequently discovered and excavated by archaeologists than Paleo-Indian material (Anfinson 1987; Wilford 1941, 1955, 1960). Archaic Period people developed woodworking tools including axes and adzes, as well as punches to facilitate manufacture of clothing from animal skins. Trade networks connected the Archaic Period people of Minnesota with resources as far away as the Gulf of Mexico, as evidenced by salt-water clam shell found buried with an Archaic Period woman. Later during the Archaic Period, people in the Great Lakes region began making tools from copper, which was found as a raw material in the form of nuggets. Tools fashioned from copper include spear points, knives, fishhooks, and awls—the first metal tools known in the New World (Risjord 2005).

During the Woodland Period, beginning around 1000 BC, people began making pottery and burying their dead in mounds. Woodland people continued to make and use copper tools, and also favored tools made of antler and bone. Very late during the Woodland Period, people began using the bow and arrow. Minnesota was apparently occupied by people related to the present-day Dakota of the Sioux Nation, who followed a typical Eastern Woodland subsistence pattern. The Dakota maintained a seasonal cycle, practicing maple sugaring in the spring, fishing and small-game hunting and gathering in the summer, and large-game hunting in winter. The seasonal cycle included congregating into larger groups during the summer when resources were more plentiful, and then separating into smaller bands during the winter, to be supported by stored supplies and fresh large game. Early evidence for use of wild rice in the region, consisting of threshing pits, dates from AD 1500 (Risjord 2005).

The practice of these Eastern Woodland lifeways was disrupted during the mid-17th Century, as European explorers and trade goods began to enter the region. Wild rice, however, remained a staple food. In addition, European settlements further east began pushing other tribes into the area, creating new pressures on the Dakota people of the region (Risjord 2005).

Historic Background

French fur traders were among the first Europeans to arrive in northeastern Minnesota in the 1650s. Daniel Greysolon, the first European explorer known to enter Minnesota, wintered at Sault Ste. Marie (1678-1679), and then travelled by canoe to Fond du Lac, and was able to trade with the Dakota tribe in the spring, exchanging European trade goods for animal pelts. Numerous other traders, explorers, and missionaries followed soon after. The Dakota people were pressured by the influx of Europeans competing for resources and introducing cultural change, as well as by other tribes moving west, due to pressure from European settlers further east (Risjord 2005).

The Ojibwe people moved westward along the shores of Lake Superior from the St. Lawrence River Valley, due to pressures from Europeans and from their Iroquois neighbors. The Ojibwe have also been known as Outchibouec (French), Chippewa (American), and Anishinabe (their own name for themselves). In 1768, hostilities between the Dakota and Ojibwe people culminated in a raid on an Ojibwe village at Sandy Lake by the Dakotas, swiftly followed by retaliation from the Ojibwe. After these battles in 1768, the Dakotas moved further west into the prairies, seeking big game and less combat with neighbors. Skirmishes continued into the mid-19th Century, but not on as large a scale (Risjord 2005).

The Ojibwe people, like the Dakota people, seasonally exploited fish, game, maple sugar, fruit, berries, roots, and wild rice. Fish were harvested by netting and spearing, both from canoes and through ice. Fish were preserved by salting, smoking, or drying (Risjord 2005). Even without agriculture, the plentiful wild rice and fish around Lake Superior allowed the Ojibwe people to live in sedentary villages for seven months of the year, usually right at the lakeshore. Birch bark was employed in home and canoe construction and container manufacture. Cedar wood and bark were also used for these purposes. Sweet grass was also harvested, and often burned for medicinal and spiritual purposes (McClurken 2000).

Beginning in 1837, Ojibwe treaties with the US government opened the way for European–American settlement. First fur trading, then logging, agriculture, and mining attracted Euro-American settlers to Minnesota (Risjord 2005). Minnesota became a Territory of the United States in 1849. In 1854 and 1855, treaties between the Ojibwe people and the US government allocated permanent reservation lands within ceded territories to the tribe, a rare provision at the time. Annuities to tribal members established by treaties helped fund the development of cities in Minnesota, as traders were paid by tribal members for goods, and then invested in real estate and construction in developing areas, accounting for as much as $4.2 million in the 1850s (Risjord 2005). Minnesota became the 32nd state in 1858. These changes were accompanied by an ever-increasing flow of European-American settlement and the establishment of towns, cities, and non-fur trade-related enterprises (Mason 1981).Wheat surpassed corn as the principal crop in 1860, with much of it being exported out of state. White pine and red pine were sought after by loggers, and were harvested in the Fort Snelling area as early as 1820. By 1870, there were 207 saw mills in Minnesota. In 1877, a law allowing sale of timber off state lands further opened the state for logging. The logging boom had tapered off by the early 1900s (Risjord 2005).

Beginning in 1843, the discovery of large quantities of copper and iron ore led to the opening of mines in northeastern Minnesota. In 1852 the Marquette Iron Company shipped six barrels of ore to New Castle, Pennsylvania, the first shipment of Lake Superior ore on the lake (Stiffler 2008). In 1865, a gold rush at Vermilion increased the influx of Euro-American settlers. Discovery of iron ore in the Vermilion Range led the Pennsylvania industrialist Charlemagne Tower to buy large tracts of land on the Vermilion Range. In 1882, Tower organized the Minnesota Iron Company and by 1884 shipped the first ore from the Soudan Mine by rail on the company's Duluth and Iron Range Railroad to Lake Superior (Risjord 2005).

The Merritt brothers of Duluth laid groundwork for their Mountain Iron Mine through their explorations during 1890s (Minnesota Historical Society 2008). Up to that point, only the far eastern portion of the Mesabi Range had been mined for iron, and not on a large commercial scale, with mostly hand-tools being employed (Walker 1979, Atkins 2007). They opened their second mine in 1891 near Biwabik. By 1892, they shipped their first carload of ore on their Duluth, Missabe and North Railroad to dock in Superior, Wisconsin (Minnesota Historical Society 2008). A loan from John D. Rockefeller to the Merritts to expand the railroad ultimately led to the transfer of all of their mining and rail properties to Rockefeller. Shortly thereafter, all of the mining interests in Minnesota were owned by eastern interests, with J.P. Morgan acquiring Rockfeller and Carnegie holdings in 1901 under US Steel (Risjord 2005).

By 1890, when the Mesabi Iron Range deposits were discovered, nearly 300 iron mining companies had been incorporated in Minnesota. By 1900, the Mesabi Range was the most extensive iron ore district in the world, supplying increasing demand by steel mills throughout the Great Lakes states (Hall 1987). Early mining ventures in the Mesabi Iron Range focused on hematite, a soft granular rock rich in iron that could be mined with steam shovels and required limited processing. More than 95% of the iron deposits in the Mesabi Range consist of taconite, a hard iron-bearing rock that must be pulverized and processed for mineral extraction. A cost-effective technology for taconite processing was developed by the late 1930s. Taconite mining was made even more economically feasible by legislation passed in 1941 eliminating property taxes within the Iron Range, and by increased demand due to World War II. The Reserve Mining Company was formed in 1942 (Risjord 2005).

In 1957, the Erie Mining Company, a subsidiary of US Steel, opened its concentration plant at Hoyt Lakes. This plant was Minnesota's second large-scale taconite plant, and it remained in operation through 2001, with a change in ownership to LTV Steel Corporation in the 1980s, and then to Cleveland Cliffs in 2001 (Zellie 2007). While six new taconite plants went up on the Iron Range in the 1980s, cheap imports changed the industry and decreased demand by two-thirds. The Reserve Mining Company went bankrupt in 1986 due to the changed economics as well as environmental liabilities (Risjord 2005).

Present Day

Existing conditions were defined by several cultural resources studies for the Project. Foth and Van Dyke (1999) produced a study (Supplemental Site Specific Resource Information, PolyMet Mining Corporation, NorthMet 1999 Exploration Project [99P061]) of environmental resources within the proposed mine area to support exploratory drilling. As part of this study, a Phase I archaeological survey of the mine pit area was conducted. No cultural resources were identified within the mine pit area along the proposed exploratory drilling transects. Research identified four previously recorded cultural resources located within two miles of the mine pit, including Knot Camp, a historic logging camp (SNFIN 01- 314), two additional logging camps, and a mill located further east.

A 2004 study by The 106 Group (Cultural Resources Assessment for the Environmental Impact Statement Scoping Document, PolyMet Mining Corporation, NorthMet Project, Hoyt Lakes, St. Louis County, Minnesota), included research, selective visual reconnaissance, and an evaluation of archaeological potential for the lease area; the processing facility; the tailings basins; and three proposed railroad interconnection alternatives. Large portions of the Project site were found to have low potential for archaeological resources, while other portions were found to have unknown potential. Upland areas in the vicinity of the Partridge River or larger wetlands were considered to have high potential for archaeological resources. The study identified the LTVSMC processing facility, associated mining features, and railroad as the only existing structural resource at the Project site. In addition, the study identified the Knot Camp, but described it as outside the area that would be directly affected by the Project.

Soils Consulting prepared the Phase I Archaeological Survey (NorthMet Mine Impact Area, PolyMet Mining, St. Louis County, Minnesota) in 2006. Soils Consulting conducted the survey by selectively sampling landscape types considered to have the highest potential for pre-contact archaeological sites, a strategy developed through coordination with the State Historic Preservation Office (SHPO) and the USACE. A single archaeological site, the NorthMet Site, was identified based on four lithic non-tool artifacts found in four different shovel tests. While no diagnostic artifacts were recovered, the investigators suggest that the lithic raw material types and the landform on which the site is located are consistent with expectations for Late Paleo-Indian or Archaic archaeological sites. Additional studies, conducted in 2008 by Soils Consulting, demonstrated that the NorthMet Site does not appear to be potentially eligible for listing on the NRHP, and therefore requires no further consideration. The Knot Camp was located and found to have been impacted by logging activities, significantly compromising its integrity. Scattered surface debris consistent with historic logging camp use was noted; however, no structural remains of a camp or associated cultural features were identified. While two Indian trails reported to pass through the vicinity were mentioned in the literature, attempts to locate either of these trails in the field were unsuccessful.

Landscape Research LLC (2007) evaluated the Erie Mining Company property as an historic property, and its eligibility for listing on the NRHP. Because the pelletizing plant, a key element in the process and crucial to the interpretation of the facility, has been demolished, the report recommended that the Erie Mining Company property did not appear to meet the criteria for listing on the NRHP as an historic district. The report recommended that the Erie Mining Company Concentrator Building and Railroad may be potentially individually eligible. Detailed documentation of key plant buildings and structures, including the coarse and fine crusher, conveyor and drive house, general shops, and reservoir was recommended should demolition be planned.

In summary, cultural resources studies have identified the following resources within the Project site:

- LTVSMC processing facility structures and associated cultural features;
- LTVSMC railroad; and
- One prehistoric archaeological site (the NorthMet Site).

1854 Ceded Territory

Historic treaty rights in ceded indigenous territories apply to the Project site. These treaty land-use rights involve the ethnographically documented relationship between natural and cultural resources in traditional tribal belief systems. The Project site overlaps one historic treaty-ceded territory: the 1854 Treaty between the Chippewa (Ojibwe) of Lake Superior and the United States.

In 1985, the Grand Portage Band sued the state of Minnesota in federal court claiming that the 1854 Treaty gave them the right to hunt and fish in the ceded territory free of state regulation; the Fond du Lac and Bois Forte Bands later joined the lawsuit. A settlement between all parties was reached. Although the settlement agreement was approved by the federal court, this agreement does not commit to a legal conclusion as to whether the 1854 Treaty harvest rights remain valid (MN DNR 2006; Edwards et al. 2004:25). Subsequently, in 1990, the Mille Lacs Band sued the state claiming harvest rights in the 1837 Ceded Territory, situated adjacent and south of the 1854 Treaty territory. In 1992, the Fond du Lac Band also sued the state under both the 1837 and 1854 treaties (the band was a signatory on both).

In 1994, a U.S. District Court decision upheld the Mille Lacs Band treaty rights in the 1837 Ceded Territory; a 1996 ruling also found that the Fond du Lac Band retained their treaty rights to hunt, fish, and gather in the 1854 Ceded Territory (Great Lakes Indian Fish and Wildlife Commission [GLIFWC] 1992). Most recently, in 1999, the U.S. Supreme Court upheld the rights of the Mille Lacs Band and other signatory Bands within the 1837 Ceded Territory. These legal rulings have confirmed that tribal communities do retain rights to hunt, fish, and gather in ceded territories including tribal and public lands (Edwards et al, 2004:26).

1854 Treaty Authority

To assist in managing the treaty rights within the 1854 Ceded Territory, negotiations between the Bois Forte, Grand Portage, and Fond du Lac Bands and the state of Minnesota resulted in the formation of the 1854 Treaty Authority in 1988. Today the 1854 Treaty Authority acts as an inter-tribal natural resource management agency that manages the off-reservation hunting, fishing, and gathering rights of the Grand Portage and Bois Forte Bands of the Lake Superior and Minnesota Chippewa Tribes in the territory ceded under the Treaty of 1854. Fond du Lac withdrew from the 1854 Treaty Authority, but continues to consult and cooperate with the state on harvest regulations for its own Band members. Notable collaborative efforts among the 1854 Treaty Authority, tribal community, and state and federal government can be found in ongoing cooperative moose management programs.

Natural Resource Use

In traditional tribal culture and cosmology, natural resources bear a great significance. Therefore, natural resources impacts have the potential to impact traditional cultures.

These impacts can manifest themselves in myriad ways, such as the loss of significant cultural landscapes, the loss of ancestral and/or sacred sites, and deterioration in the health or availability of animal and plant populations culturally associated with traditional diets, hunting practices, or spiritual practices.

As discussed above, no traditional cultural properties within or adjacent to the Project site have been identified during tribal consultation. However, potential tribal activities involving the use of natural resources of concern to tribal representatives include hunting, fishing, and gathering. Concern over impacts on and access to plant resources have been emphasized during tribal consultation. Tribal use of 384 species of plants has been documented (Meeker et al. 1993). These plants occur in a broad range of habitats, and at least some occur at the Project site. In the course of consultation, tribes have expressed concern that wetlands and other water resources would be impacted by the Project, which could modify the natural resources available for exploitation. Specific tribal use of any specific areas within the Project site or immediately adjacent area for natural resource exploitation has not been documented; however, the tribes are entitled to use these natural resources to the extent rights are afforded by the 1854 Treaty.

4.8.2 Impact Criteria

Impacts to cultural resources, including historic structures, archaeological sites, and traditional cultural properties, would be considered significant if they result in adverse effects to historic properties that are eligible for listing on the NRHP. Once a cultural resource is identified, the historic significance of the property must be evaluated in terms of its ability to meet the National Register criteria (36 CFR 800.4 (c)(1)). A cultural resource that meets the criteria is considered an historic property entitled to the consideration afforded by Section 106 of the National Historic Preservation Act, as outlined in the Advisory Council on Historic Preservation’s implementing regulations (36 CFR 800).

Historic properties types defined in section 106 include districts, sites, buildings, structures, or objects that possess integrity of location, design, setting, materials, workmanship, feeling, and association, and are found to meet one or more of the following criteria:

- associated with events that have made a significant contribution to the broad patterns of our history;
- associated with the lives of persons significant in our past;

- embodies the distinctive characteristics of a type, period, or method of construction, or that represent the work of a master, or that possess high artistic values, or that represent a significant and distinguishable entity whose components may lack individual distinction; or
- yielded, or may be likely to yield, information important in prehistory or history.

A traditional cultural property must consist of a tangible property such as a district, site, building, structure, or object, and must meet the criteria listed above to be considered an historic property per the National Historic Preservation Act (NHPA). For natural resources to qualify for protection under the NHPA, they would have to constitute a definable traditional cultural property, that is, a specific site or district associated with traditional events, activities, or observances, of a significance warranting inclusion on the National Register of Historic Places (Parker and King 1998). Impact to a traditional cultural property would be evaluated in terms of the specific significance of the resource, and the potential for the proposed project to detract from that significance. No traditional cultural properties have been identified during research, field studies, or tribal consultation.

The impact criteria should also recognize the importance of natural resources to tribal cultural practices, even when tribal use of natural resources does not qualify those resources as traditional cultural properties. Access to certain natural resources for hunting, fishing, and gathering is protected by the 1854 Treaty. Limitation or elimination of access to natural resources for these purposes as provided by the Treaty, without appropriate replacement, would be considered an impact.

4.8.3 Environmental Consequences

Proposed Action

If a cultural resource can be demonstrated to meet the criteria for listing on the NRHP, impacts to that cultural resource must be avoided or mitigated appropriately. The Area of Potential Effect (APE) is the area within which the proposed development has the potential to either directly or indirectly impact historic properties that may be present. Potential historic properties identified to be within the direct APE (the area that would be directly affected by site disturbance activities) include LTVSMC structures and associated railroad and one prehistoric archaeological site, the NorthMet Site (located near the proposed mine site). In addition to the direct APE, an area of potential indirect effects would include those areas beyond the direct APE that may be indirectly affected by mining activities, including hydrologic impacts to wetlands. The extent of the indirect APE is uncertain as groundwater modeling does not accurately predict hydrologic impacts to wetlands. Just outside of the direct APE, the Knot Camp, an historic logging camp, was also identified and may be within the indirect APE. However, as the Knot Camp site will not be affected by the proposed undertaking, no further consideration is warranted. No other historic properties have been identified within the Project Area that could be within the indirect APE.

USACE has conducted consultation with SHPO (USACE, 2007; SHPO, 2007) regarding potential impacts to cultural resources. Based on strategic sampling of the Project site, the SHPO and USACE concur that no further efforts are required to identify cultural resources within the area of the Mine Site. SHPO has concurred with USACE's findings that no historic properties will be affected by the proposed undertaking. Even though the NorthMet Site does not appear to be eligible for listing on the NRHP, PolyMet proposes avoidance.

The Erie Mining Company Concentration Plant and Railroad are considered potentially eligible for listing on the NRHP. The proposed reuse of the LTVSMC plant site and some of its associated facilities by PolyMet would avoid the demolition scheduled in the reclamation agreement with MnDNR for the closed facility. These former LTVSMC facilities, including those that appear to be potentially eligible for listing on the NRHP, would retain much of their integrity through reuse by the Project.

Therefore, pursuant to Section 106 of the NHPA, it is concluded that the Project would have no adverse effect on any historic properties eligible for inclusion in the National Register, assuming that the former Erie Mining Company Concentration Plant and Railroad are reevaluated at the time of mine closure and prior to facility demolition.

Beyond potential impact to historic properties, impacts to cultural use of some natural resources would occur. Public or tribal access to natural resources within the Project site, which has been limited at least at the Plant Site since initial LTVSMC mine development, would continue to be prohibited for the lifetime of the Project. Further, the Project would impact some of the natural resources within the Mine Site that the 1854 Treaty makes available for traditional use by Ojibwe people, including plants, wetlands, and game. Although wetlands impacts would be mitigated, most of the proposed compensatory wetlands mitigation would be located outside the ceded 1854 Treaty area. These natural resource impacts are evaluated elsewhere in this document. A potential land exchange is currently being considered by the USFS for National Forest System lands proposed to be used by the Project; should this occur, access to natural resources on the additional land by 1854 signatory tribes may be made available, although it is unknown whether or not this would compensate for or result in a net loss of access rights to ceded territory.

A potential mitigation measure for the loss of hunting, gathering, and fishing at the Project site is the proposed land exchange or purchase in which new land would be acquired for inclusion in the USFS lands in exchange for the USFS land occupied by the NorthMet Project. The extent to which this measure would be effective in offsetting these natural and cultural resource impacts depends on the location of the exchanged or acquired lands and the type and degree of specific resources that would be made available. The effects of this land exchange/acquisition will be evaluated in a separate analysis prepared by the USFS. The USFS is consulting with the tribes regarding this land access issue.

Of particular concern to tribal representatives is the potential impact to wild rice beds. The Embarrass River has been identified as one of approximately 1,200 water bodies in Minnesota where wild rice is or has been recently located; according to inventory information as reported by the MnDNR. The closest wild rice bed on the Embarrass River is located downstream of the Project approximately 5.5 miles west of the proposed Tailings Basin (MnDNR, February 2008). As indicated in Section 4.1, predicted impacts to the Embarrass River include an increase in aluminum concentration that exceeds the surface water quality criterion; however, recent measured background concentrations also exceed this standard. Other modeled constituents met applicable standards. Predicted hydrologic impacts are uncertain but likely to be small. As a result, the impact to this wild rice bed is unknown but not likely to be significantly adversely affected.

No Action Alternative

The No Action Alternative would provide no benefit to cultural resources. The Northmet archaeological site would be avoided by the Project, so the No Action Alternative would not provide any additional benefits. The No Action Alternative would require the complete dismantling of the existing processing facilities under the LTVSMC reclamation plan, while the Proposed Action would retain and reuse the facility, which is preferable from an historic preservation standpoint. However, demolition of the processing facilities would still occur under the Proposed Action at some point in the future.

Under the No Action Alternative, the LTVSMC site would be restored and potentially access to the area could be reestablished allowing the traditional use of natural resources within the Project site by Ojibwe people to occur sooner than it would under the Proposed Action.

Subaqueous Disposal of Reactive Waste Rock

The subaqueous disposal of reactive waste rock alternative would not modify the direct APE, nor would it result in added benefit or impact to cultural resources as compared to the Proposed Action. No significant cultural resources would be impacted by the footprint of this alternative, and no impact would be avoided that would otherwise occur. Under this alternative, the impact to natural resources with the potential for traditional use by Ojibwe people pursuant to the 1854 Treaty would be similar to the Proposed Action.

Section 3.2.2.3 describes several potential mitigation measures for impacts from the Project. One of these measures would benefit cultural resources. Under the currently proposed Project Closure Plan, the key buildings and structures of the Erie Mining Company Concentration Plant and Railroad, both considered potentially eligible for listing on the NRHP, would be demolished. It is recommended that the cultural resources associated with these structures should be recorded prior to demolition.

4.8.4 Cumulative Impacts

During the EIS scoping process (see Section 2.1 of the Final SDD), no cumulative impact issues associated with cultural resources were identified.

4.9. COMPATIBILITY WITH PLANS AND LAND USE REGULATIONS

4.9.1. Existing Conditions

The Project area falls under a variety of land use jurisdictions, including federal (USFS Superior National Forest Plan), state (Minnesota Forest Resource Council Landscape Management Plan), county (St. Louis County Comprehensive Plan), and municipal (City of Babbitt Comprehensive Plan and zoning ordinance and the Hoyt Lakes zoning ordinance) land management plans (see Figure 4.9-1).

4.9.1.1 Federal Land Management

The Superior National Forest Plan was published by the USFS in July 2004 to guide "all natural resource management activities for the Superior National Forest." The Plan identifies the "forest-wide" desired management conditions for all social, environmental, and economic resources within the Superior National Forest. Accordingly, the "exploration and development of mineral and mineral material resources is allowed on National Forest System land, except for federally-owned minerals in designated wilderness, such as the BWCA, and the Mining Protection Area (MPA)" (Forest Plan, Desired Condition D-MN-1, pg. 2-9). Further, the Superior National Forest-wide conditions include that reclamation would begin "as soon as practicable…and generally reflect the landscape character and processes of the surrounding landscape" (Forest Plan, Guideline G-MN-1, p. 2-10).

Within the Superior National Forest, the Project area is included in the General Forest – Longer Rotation Management Area, which emphasizes "conditions that provide wood products, other commercial products, scenic quality, developed and dispersed recreation opportunities, and habitat for a diversity of terrestrial and aquatic wildlife and fish species" (Forest Plan, p. 3-10). The Superior National Forest Plan applies to those portions of the Project occurring within the Superior National Forest, including the Mine Site and portions of the transportation corridor (approximately 3,000 acres). While the USFS controls the surface land rights within the area proposed for mining, most of the mineral rights are severed and owned by RGGS, Inc. PolyMet leases those mineral and mining rights from RGGS.

There are roads used by the USFS throughout the Project area. The main road is the privately-owned Dunka Road, along the south border of the Mine Site, which would be used for site access for vehicles and equipment. Several USFS logging roads including Road 108 (branches A, B, D, AA, BA, BB, BC, and BD) and Road 109 (branches A, B, and C) lie within the proposed lease property for the Mine Site. The roads are also currently used to access Minnesota state lands to the northeast of the Mine Site.

4.9.1.1 State Land Management

The Minnesota Forest Resource Council (MFRC) Landscape Management Plan was published in March 2003 and identifies the desired conditions for the forests of northeastern Minnesota (Northeast Landscape Region). The goals of the plan include moving toward the potential range of variability for natural plant communities; achieving spatial structure consistent with the ecology of northeastern Minnesota; and providing diverse habitat to maintain natural communities and viable populations for the plant and animal species in northeastern Minnesota.

4.9.1.1 Local Land Management

St. Louis County has a comprehensive land use plan, which includes the St. Louis County Water Plan (Section 20), that was adopted in January 1996 and sets general development goals for those portions of the county outside of incorporated municipalities. The majority of the Project area is within the incorporated limits of the cities of Hoyt Lakes and Babbitt; however, a small portion of the tailings basin is within the unincorporated Waasa Township and therefore subject to jurisdiction under this plan.

The Mine Site and portions of the Project transportation corridors are within the incorporated limits of the City of Babbitt, whose comprehensive plan includes provisions for the development of mineral resources within its borders.

The Plant Site and portions of the Project transportation corridors are within the incorporated limits of the City of Hoyt Lakes. Within these limits,the local planning commissions regulate land use by means of zoning ordinances, including areas specifically zoned for mining operations and mining-related activities. Hoyt Lakes has not developed a comprehensive plan.

4.9.2. Impact Criteria

Impacts to land management would occur if the Proposed Action is incompatible or inconsistent with existing land use plans, regulations, or policies adopted by local, state, or federal governments.

4.9.3. Environmental Consequences

4.9.3.1 Proposed Action

Federal Land Management

Open-pit mineral exploration and development within the Superior National Forest is inconsistent with USFS surface management practices. It is the position of the United States that the mineral rights alone do not include the right to open pit mine the National Forest Land. The USFS and PolyMet have been working together to complete a land exchange to resolve the current divided ownership. The USFS has identified approximately 6,700 acres of National Forest land (including the NorthMet Project lands) to exchange to PolyMet for yet to be determined non-federal land such that there would be no net loss of USFS land. A separate EIS will be prepared for this land exchange in compliance with all applicable rules and regulations. A land exchange for land adjustment is consistent with the Superior National Forest Land and Resource Management Plan (Forest Plan, USDA Forest Service 2004, pages 2-51 - 2-52). The Project would clear vegetation at the Mine Site and new transportation corridors during active operations, making these areas unavailable for the life of the mine for timber harvesting and other recreational uses identified in the Superior National Forest Plan and the Longer Rotation Management Area guidelines. The Project includes a comprehensive reclamation program, however, designed to restore original watersheds, revegetate the site, and minimize runoff from the waste rock stockpiles.

Development of the proposed Mine Site would require removal of USFS Roads 108 and 109, including their branches. These roads are primarily used for logging purposes and are not accessible to the public. Development of the Mine Site would involve logging in preparation for mining activities; therefore, there would not be an immediate need for logging roads in this area. The Dunka Road is jointly owned by PolyMet, Cliffs Erie, and Minnesota Power and those entities have agreed to grant each other mutual access and keep the Dunka Road private; therefore, there would be no change in terms of access to State land. The State of Minnesota has also indicated that NorthMet Project would not create any access hardships to State lands (personal communication via email, Mike Magnusun, July 25, 2008). The USFS states that it has no objection to the elimination of USFS Roads 108 and 109 following a land exchange due to the clearing of the proposed Mine Site and the availability of alternate access to the Minnesota state lands north of the proposed Project area (personal communication via e-mail, Loretta Carter, USFS, October 24, 2007).

State Land Management

The Project would require clearing of uplands and wetlands, which would prevent the Project area from meeting the goals of the MFRC Landscape Management Plan to promote diverse floral and faunal habitat and maintain a spatial structure consistent with northeastern Minnesota ecology at least for the lifetime of the mine. Following the active mining period, the reclamation plan would revegetate the Project area with natural vegetation consistent with the surrounding landscape.

Local Land Management

The Mine Site, Plant Site, and portions of the transportation corridors are within the incorporated limits of the cities of Babbitt and Hoyt Lakes. The mining activities and transportation (along the existing road and railroad corridors) of ore from the mine to the plant are consistent with the Babbitt comprehensive plan (Pers. Comm. Jim Lasi, City of Babbitt, as cited in the EAW 2005). These activities are proposed in the portion of Babbitt zoned for mineral mining activities, including exploration, extraction, processing, and tailings disposal. The portion of the Project area within the City of Hoyt Lakes is currently zoned for mining and mining-related activities; therefore, the Project is consistent with the Hoyt Lakes planning regulations.

The proposed tailings basin area in Waasa Township is currently zoned for industrial use under the St. Louis County Comprehensive Land Use Plan. According to the plan, industrial use includes mining and all associated processing and transportation activities; therefore, use of the area for the Project is consistent with the County comprehensive land use plan, including the St. Louis County Water Plan.

Summary

The Project would be consistent with the Superior National Forest Plan, St. Louis County Comprehensive Plan, City of Babbitt Comprehensive Plan, and Hoyt Lakes zoning ordinance; and, therefore, would be compatible with land management plans and regulations. However, it is the position of the federal government that the Project would be inconsistent with USFS surface management practices. The USFS is working to complete a land exchange, which is consistent with the Superior National Forest Land and Resource Management Plan.

During active mining operations, the Project area would not be available for timber harvesting and other recreational and ecological uses identified in the SNF Plan and the MFRC Landscape Management Plan, however the mine reclamation plans would ultimately revegetate much of the site allowing it to meet the overall MFRC goals in the long-term.

4.9.3.1 Alternatives

No Action Alternative

Continued current uses and activities at the NorthMet Site under the No-Action Alternative would be compatible and consistent with existing land management plans, regulations, and practices.

Subaqueous Disposal Alternative

Similar to the Proposed Action, this alternative would be consistent with the SNF Plan and would limit the ability of the Project area to comply with the goals of the MFRC Landscape Management Plan throughout the life of the mine. However, the mine reclamation plans would allow the site to meet MFRC goals in the long-term. As with the Proposed Action, this alternative would be considered inconsistent with USFS surface management practices.

During reclamation, the subaqueous disposal area would be revegetated to a natural ecological state allowing it to comply with the MFRC Landscape Management Plan.

Other Mitigation Measures

Section 3.2.2.3 describes potential mitigation measures for impacts from the Project, one of which has the potential to affect Compatability with Plans and Land Use Regulations.

PolyMet currently proposes to stabilize disturbed areas during Project operations and at the time of mine closure using a seed mix that includes several non-native and potentially invasive species. This seed mix has been selected in order to quickly and effectively stabilitze disturbed areas and re-establish soil nutrients. An alternative would be to reseed with native non-invasive species as long as they can perform as effectively as the non-native species. The use of a native seed mix during reclamation would be consistent with the goals of the Superior National Forest Plan and the MFRC Landscape Management Plan promoting diverse floral and faunal habitat and a spatial structure consistent with northeastern Minnesota ecology.

The following potential mitigation measures may also indirectly increase Project compatibility with plans and land use regulations:

- Chemical Modification of the Reactive Waste Rock Stockpiles – application of lime to neutralize ARD would help ensure that changes in water quality would not adversely affect vegetation; therefore, the measure would be consistent with the goals of the Superior National Forest Plan and the MFRC Landscape Management Plan by maintaining diverse floral and faunal habitat and a ecological spatial structure consisten with northeastern Minnesota.
- Use of Overburden in the East Pit – resuse of overburden to help create wetlands in the east pit would restore native habitat and promote the goals of the Superior National Forest Plan and the MFRC Landscape Management Plan.
- Maximize the Elevation of the Category 1/2 Stockpile – maximizing the height of the category 1/2 stockpile would reduce to stockpile footprint and thereby minimize direct impacts to native habitats, although the reduction in direct impacts would be small (e.g., a few acres) because the stockpile heigh is already at or close to its maximum height from a geotechnical engineering perspective.

4.9.4. Cumulative Impacts

During the EIS scoping process (see Section 2.1 of the Final SDD), no cumulative impact issues associated with local plans or land use were identified.

4.10. SOCIOECONOMICS

The NorthMet Project would be located entirely within St. Louis County and would initiate mining adjacent to and mineral processing at LTVSMC's former taconite operations. Figure 4.10-1shows the location of the Project in relation to key towns within the County. St. Louis County, the East Range (the eastern portion of the Mesabi Iron Range) communities (the cities of Aurora, Babbitt, Biwabik, Hoyt Lakes, Tower, Ely, and Soudan), and their surrounding areas would experience some portion of the Project's socioeconomic effects. Labor and materials for the Project are also projected to come from urban centers such as Duluth and Minneapolis. This assessment focuses on St. Louis County and the East Range communities.

St. Louis County has a long mining heritage. Portions of the county are commonly referred to as the Iron Range. The East Range communities were established as a result of numerous iron mining operations in the area dating back to the 1800s. In response to a marked drop in employment in the Iron Range between the 1920s and 1932, former Minnesota Governor Harold Stassen and the Minnesota legislature formed the Iron Range Resources and Rehabilitation Board (IRRRB) in 1941. The organization has subsequently changed its name to Iron Range Resouces (IRR). The objective of the IRR is to help diversify the economy of the region away from its initial high dependence on high-grade ore mining by public funding of social and economic development projects with a focus on taconite mining, timber, tourism, and technology-related education. Funded by taxes on mining operations, the IRR provides grants and other programs to foster community redevelopment in the Iron Range region.

The Project would be the first non-ferrous mine and process plant permitted in Minnesota. There are several similar known deposits in the State. While no other deposits are currently in the environmental review or permitting phase, many are in advanced stages of exploration, which may reflect an expansion of mining in the region in addition to the existing taconite iron mining industry.

4.10.1. Existing Conditions

4.10.1.1. Population and Population Trends

The population of St. Louis County is centered in Duluth, with smaller, secondary centers in the central Iron Range communities of Hibbing and Virginia. Duluth is located approximately 65 miles south of the Project, and Virginia, approximately 20 miles west of the Project. The population trends for the East Range communities are somewhat similar to the population trends of St. Louis County. As the population data in Table 4.10-1 illustrates, the county and the communities have experienced a population decline since 1980, but the county decline is less than one-quarter that of the East Range communities.

In addition to a decline in population since 1980, the East Range communities have experienced an increase in median age relative to St. Louis County and the State of Minnesota (Table 4.10-2).

In terms of racial distribution the East Range communities are predominantly Caucasian (Table 4.10-3). This is somewhat consistent with the racial composition of St. Louis County and the State; however, other races in the communities are underrepresented by comparison.

Table 4.10-4 includes the household/family size of the East Range cities, St. Louis County, and the State for 2000. The average household and family size of the cities are smaller than that of the county and the state, while the percentage of married adults over the age of 15 is higher. This can be attributed to the higher percentage of persons 65 and older in the communities than in the State (Table 4.10-2). Married persons in this age range are less likely to have children living in the home, lowering the average household size.

Education levels in the East Range communities were lower than that of St. Louis County and the State in 2000 (Table 4.10-5). Individuals over 25 years of age who achieved a high school diploma in the communities are approximately 2% less than that of the County and the State. Those with bachelor's degrees or above in the East Range communities are 24% lower than the County and 39% lower than the State.

4.10.1.2. Income

Table 4-62 presents income characteristics for the selected East Range communities, St. Louis County, and the State. The median income of the East Range communities is 21% lower than that of the County and 34% lower than that of the State. In addition, the East Range communities have 49% more families below the poverty level than the State, and the number of persons in the labor force in the region is lower than that of the County and State. The U.S. Bureau of Economic Analysis reports the average earnings per job in St. Louis County for 2004 as $38,364.

Table 4.10-1 Population of St. Louis County and Select East Range Communities, MN 1980 to 2004

	St. Louis County, MN	Select East Range Communities, MN						
		Aurora	Babbitt	Biwabik	Ely	Hoyt Lakes	Soudan	Tower
1980	222,229	2,670	2,435	1,428	N/A	3,186	N/A	640
1990	193,433	1,965	1,562	1,097	3,968	2,348	502	502
2000	200,528	1,850	1,670	954	3,724	2,082	372	469
2001	200,431	1,831	1,661	943	N/A	2,070	N/A	476
2002	200,854	1,815	1,651	934	N/A	2,055	N/A	473

	St. Louis County, MN	Select East Range Communities, MN						
		Aurora	Babbitt	Biwabik	Ely	Hoyt Lakes	Soudan	Tower
2003	199,887	1,791	1,642	905	N/A	1,987	N/A	504
2004	198,799	1,777	1,630	904	N/A	1,961	N/A	504

Source: U.S. Bureau of the Census, Population Estimates and Population Distribution Branches, CO-EST2003-01 as reported in Employment, Economic and Social Impacts of PolyMet Mining, Inc.'s NorthMet Project and other Industrial Projects of Minnesota's East Range Communities, February 2006, PolyMet Mining, Inc.
Note: Data for Soudan and Ely, MN was not found for years other than the 1990 and 2000 decennial census.

Table 4.10-2 Age of Residents of Selected East Range Cities in St. Louis County, MN, in 2000

	Aurora	Babbitt	Biwabik	Ely	Hoyt Lakes	Tower	All Cities	St. Louis County	State of Minnesota
Median age	45.2	46.8	41.5	40.8	45.6	45.3	44.2	39	35.4
18 years and over	1,483	1,320	756	3,061	1,669	390	8,679	155,699	3,632,585
Percentage	80.2%	79.0%	79.2%	82.20 %	80.2%	81.4%	80.4%	77.6%	73.8%
65 years and over	442	479	192	803	444	119	2,479	32,274	594,266
Percentage	23.9%	28.7%	20.1%	21.60 %	21.3%	24.8%	23.4%	16.1%	12.1%

Source: U.S. Bureau of the Census, Census 2000 Demographic Profile Highlights as reported in Employment, Economic and Social Impacts of PolyMet Mining, Inc.'s NorthMet Project and other Industrial Projects of Minnesota's East Range Communities, February 2006, PolyMet Mining, Inc., modified for inclusion of the city of Ely, Minnesota. Data unavailable for the city of Soudan, Minnesota.

Table 4.10-3 Racial Characteristics of Residents of Selected East Range Cities in St. Louis County, Minnesota, in 2000

	Aurora	Babbitt	Biwabik	Ely	Hoyt Lakes	Tower	All Cities	St. Louis County	State of Minnesota
White	1,820	1,651	931	3,607	2,064	468	10,541	190,211	4,400,282
Percentage	98.4%	98.9%	97.6%	96.9%	99.1%	97.7%	98.0%	94.9%	89.4%
African American	1	2	0	32	6	0	41	1,704	171,731
Percentage	0.1%	0.1%	0.0%	0.9%	0.3%	0.0%	0.5%	0.8%	3.5%
American Indian	8	5	20	20	4	7	64	4,074	54,967
Percentage	0.4%	0.3%	2.1%	0.5%	0.2%	1.5%	0.6%	2.0%	1.1%
Asian	7	2	1	7	2	0	19	1,333	141,968
Percentage	0.4%	0.1%	0.1%	0.2%	0.1%	0.0%	0.2%	0.7%	2.9%
Hispanic or Latino	6	0	0	25	4	9	44	1,597	143,382
Percentage	0.3%	0.0%	0.0%	0.7%	0.2%	1.9%	0.5%	0.8%	2.9%
Other	14	10	1	58	6	4	93	3,206	150,531

	Aurora	Babbitt	Biwabik	Ely	Hoyt Lakes	Tower	All Cities	St. Louis County	State of Minnesota
Percentage	0.8%	0.6%	0.1%	7.9%	0.3%	0.8%	1.2%	1.6%	3.1%
Foreign born	26	13	15	36	26	0	116	3,897	260,463
Percentage	1.4%	0.8%	1.6%	1.0%	1.2%	0.0%	1.1%	1.9%	5.3%

Source: U.S. Bureau of the Census, Census 2000 Demographic Profile Highlights as reported in Employment, Economic and Social Impacts of PolyMet Mining, Inc.'s NorthMet Project and other Industrial Projects of Minnesota's East Range Communities, February 2006, PolyMet Mining, Inc., modified for inclusion of the city of Ely, Minnesota. Data unavailable for the city of Soudan, Minnesota.

Table Error! No text of specified style in document.**.10-4 Household/Family Size of Selected East Range Cities in St. Louis County, MN, in 2000**

	Aurora	Babbitt	Biwabik	Ely	Hoyt Lakes	Tower	All Cities	St. Louis County	State of Minnesota
Average household size	2.19	2.27	2.09	2.05	2.27	2.06	2.16	2.32	2.52
Average family size	2.79	2.67	2.69	2.72	2.71	2.69	2.71	2.9	3.09
Married males (15 years and over)	467	468	207	695	569	101	2,507	44,387	1,089,778
Percentage	63.2%	69.5%	55.1%	42.6%	66.2%	54.0%	58.4%	55.6%	57.7%
Married females (15 years and over)	450	481	189	713	597	104	2,534	43,645	1,082,898
Percentage	56.5%	67.6%	45.2%	45.2%	66.2%	52.8%	55.6%	51.5%	55.0%

Source: U.S. Bureau of the Census, Census 2000 Demographic Profile Highlights as reported in Employment, Economic, and Social Impacts of PolyMet Mining, Inc.'s
NorthMet Project and other Industrial Projects of Minnesota's East Range Communities, February 2006, PolyMet Mining, Inc., modified for inclusion of the city of Ely, Minnesota. Data unavailable for the city of Soudan, Minnesota.

Table** Error! No text of specified style in document.**.10-5 Education Characteristics of Residents of Selected East Range Cities in St. Louis County, MN (Population 25 years and older), in 2000

	Aurora	Babbitt	Biwabik	Ely	Hoyt Lakes	Tower	All Cities	St. Louis County	State of Minnesota
High school graduate or higher	1,084	1,024	595	2,107	1,354	283	6,447	115,861	2,783,000
Percentage	80.8%	83.0%	87.5%	86.0%	88.2%	88.4%	85.3%	87.2%	87.9%
Bachelor's degree or higher	247	98	68	540	279	36	1,268	29,040	868,082
Percentage	18.4%	7.9%	10.0%	22.0%	18.2%	11.3%	16.8%	21.9%	27.4%

Source: U.S. Bureau of the Census, Census 2000 Demographic Profile Highlights as reported in Employment, Economic and Social Impacts of PolyMet Mining, Inc.'s NorthMet Project and other Industrial Projects of Minnesota's East Range Communities, February 2006, PolyMet Mining, Inc., modified for inclusion of the city of Ely, Minnesota. Data unavailable for the city of Soudan, Minnesota.%

4.10.1.3. Income

Table 4.10-6 presents income characteristics for the selected East Range communities, St. Louis County, and the State. The median income of the East Range communities is 21% lower than that of the County and 34% lower than that of the State. In addition, the East Range communities have 49% more families below the poverty level than the State, and the number of persons in the labor force in the region is lower than that of the County and State. The U.S. Bureau of Economic Analysis reports the average earnings per job in St. Louis County for 2004 as $38,364.

Table 4.10-6 Income Characteristics of Families and Residents of Selected East Range Cities in

	Aurora	Babbitt	Biwabik	Ely	Hoyt Lakes	Tower	All Cities	St. Louis County	State of Minnesota
Median family income in 1999	$43,095	$37,137	$37,386	$36,047	$45,603	$37,500	$37,443	$47,134	$56,874
Families below poverty level	44	19	31	88	42	5	229	3,731	64,181
Percentage	8.5%	3.6%	11.7%	9.5%	6.6%	3.7%	7.6%	7.2%	5.1%
In labor force (16 years and older)	833	662	388	1,806	1,003	242	4,934	101,258	2,691,709
Percentage	55.0%	48.6%	50.1%	57.1%	57.8%	64.0%	55.3%	62.7%	71.2%

Source: U.S. Bureau of the Census, Census 2000 Demographic Profile Highlights as reported in Employment, Economic and Social Impacts of PolyMet Mining, Inc.'s NorthMet Project and other Industrial Projects of Minnesota's East Range Communities, February 2006, PolyMet Mining, Inc., modified for inclusion of the city of Ely, Minnesota. Data unavailable for the city of Soudan, Minnesota.

4.10.1.4. Employment

Employment trends for St. Louis County show a decline in mining since 1980 and an increase in the service sector (Tables 4.10-7 and 4.10-8). Data from 1980 through 1999 are reported by Standard Industrial Classification codes (SIC), while as of 2000 data are reported by the new and different sectors of the North American Industrial Classification Codes (NAICS). The major sectors of employment for St. Louis County for 1980 to 1999 are provided by SIC code in Table 4.10-7 and for 2000 to 2004 by NAICS code in Table 4.10-8. In 2004, the top three employment sectors were health care and social assistance; retail trade; and accommodation and food services. Mining employment fell from the seventh-ranked sector in 2000 to the twelfth-ranked sector in the County in 2004, with an average employment of 2,752.

In 2005 unemployment in St. Louis County was 4.9%, compared with 4.0% for the State (U.S. Census Bureau Map Stats, ___2005).

Table 4.10-7 St. Louis County, Employment by Major SIC Industry in 1980 and 1990

SIC Title	1980		1990	
	Average Employment	**Percent**	**Average Employment**	**Percent**
Agriculture	223	0.3%	318	0.4%
Mining	**10,973**	**15%**	**5,326**	**7%**
Construction	3,939	5%	3,465	4%
Manufacturing	7,462	10%	6,868	9%
Transportation, Com., and Elec.	3,448	5%	4,733	6%
Finance, Insurance, and Real Estate	1,364	2%	2,820	4%
Services	22,525	30%	30,472	38%
Public Administration	5,838	8%	5,968	7%
Trade, Total	**19,332**	**26%**	**19,680**	**25%**
Total, all industries*	**75,104**		**79,650**	

Source: Employment, Economic and Social Impacts of PolyMet Mining, Inc.'s NorthMet Project and other Industrial Projects of Minnesota's East Range Communities, February 2006, PolyMet Mining, Inc. *Due to rounding, the percentages reported may not add up to 100 percent

Industry classifications for the selected Iron Range Communities are summarized in Table 4.10-9 and suggest that education, health, and social services make up the largest percentage of each locale's employment. In four of the six towns, agriculture, forestry, fishing and hunting, and mining make up the second highest percentage of employment as classified by NAICS. To provide an additional frame of reference, occupational categories are provided for each of the towns per the Standard Occupational Classification System (SOC). Farming, fishing, and forestry occupations make up extremely small percentages of the total occupations for each town, suggesting that mining is a prevalent constituent of the NAICS agriculture, forestry, fishing and hunting and mining industry classification within the communities.

Certain industries, particularly mining and utilities, are more concentrated in St. Louis County than in the State generally. Sector concentration can be measured by the location quotient, which is the ratio between the local economy and the economy of a reference unit. For this analysis, the location quotient was calculated using St. Louis County as the local economy and the State as the reference unit. As illustrated by Table 4.10-10, the location quotient for the mining industry is 14.9, meaning that in St. Louis County mining employment is over fourteen times that of the state.

Table** Error! No text of specified style in document.**.10-8 St. Louis County, Employment by Major NAICS Industry in 2000 and 2004

NAICS Title	2000		2004	
	Average Employment	**Percent**	**Average Employment**	**Percent**
Health Care and Social Assistance	17,916	19%	20,566	22%
Retail Trade	13,046	14%	12,183	13%
Accommodation and Food Services	8,781	9%	8,907	10%
Educational Services	7,735	8%	7,737	8%
Public Administration	5,783	6%	5,919	6%
Manufacturing	6,389	7%	5,504	6%
Construction	4,127	4%	3,926	4%
Finance and Insurance	3,040	3%	3,733	4%
Transportation and Warehousing	3,948	4%	3,313	4%
Administrative Waste Services	2,780	3%	3,242	3%
Other Services	3,293	3%	3,191	3%
Mining	**4,570**	**5%**	**2,752**	**3%**
Professional and Technical Services	2,776	3%	2,585	3%
Information	2,871	3%	2,356	3%
Wholesale Trade	2,755	3%	2,072	2%
Arts, Entertainment, and Recreation	2,251	2%	983	1%
Utilities	999	1%	942	1%
Real Estate and Rental and Leasing	963	1%	912	1%
Management of Companies and Entpr.	955	1%	662	1%
Agriculture, Forestry, Fishing & Hunting	248	0.3%	249	0.3%
Total, all industries*	95,157		92,668	

Table Error! No text of specified style in document.**.10-9 Employment Characteristics of Selected East Range Cities in St. Louis County, 2000**

		Aurora	Babbitt	Biwabik	Ely	Hoyt Lakes	Tower	All Cities	St. Louis County	State of Minnesota
		Percent	**Percent**	**Percent**	**Percent**	**Percent**	**Percent**	**Percent**	**Percent**	**Percent**
Occupation (SOC Title)	Management, professional, and related occupations	29%	19%	24.90%	30%	21.90%	16.20%	25.57%	30.50%	35.80%
	Service occupations	20.50%	18.20%	24.10%	21.40%	18.60%	23.40%	20.56%	18.20%	13.70%
	Sales and office occupations	15.90%	25.70%	16.20%	23.80%	20.40%	27.70%	21.66%	26.20%	26.50%
	Farming, fishing, and forestry occupations		0.30%		0.40%			0.20%	0.50%	0.70%
	Construction, extraction, and maintenance occupations	14.80%	12.70%	19.60%	14.60%	18%	16.60%	15.55%	11.90%	8.40%
	Production, transportation, and material moving occupations	19.70%	24.10%	15.10%	9.80%	21.10%	16.20%	16.45%	12.80%	14.90%
Occupation (SOC Title)	Management, professional, and related occupations	29%	19%	24.90%	30%	21.90%	16.20%	25.57%	30.50%	35.80%
	Service occupations	20.50%	18.20%	24.10%	21.40%	18.60%	23.40%	20.56%	18.20%	13.70%
	Sales and office occupations	15.90%	25.70%	16.20%	23.80%	20.40%	27.70%	21.66%	26.20%	26.50%
	Farming, fishing, and forestry occupations		0.30%		0.40%			0.20%	0.50%	0.70%
	Construction, extraction, and maintenance occupations	14.80%	12.70%	19.60%	14.60%	18%	16.60%	15.55%	11.90%	8.40%
	Production, transportation, and material moving	19.70%	24.10%	15.10%	9.80%	21.10%	16.20%	16.45%	12.80%	14.90%

		Aurora	**Babbitt**	**Biwabik**	**Ely**	**Hoyt Lakes**	**Tower**	**All Cities**	**St. Louis County**	**State of Minnesota**
		Percent	**Percent**	**Percent**	**Percent**	**Percent**	**Percent**	**Percent**	**Percent**	**Percent**
	occupations									
Industry NAICS Title)	Agriculture, forestry, fishing and hunting, and mining	19.10%	16.90%	16.80%	10.30%	19.70%	7.20%	14.92%	5.70%	2.60%
	Construction	3.70%	2.90%	7%	6.70%	4.70%	8.90%	5.43%	5.90%	5.90%
	Manufacturing	7.10%	14.80%	9.50%	5%	15.40%	10.60%	9.43%	7.80%	16.30%
	Wholesale trade	2.10%	2.30%	1.70%	1.30%	0.80%	1.30%	1.47%	3.10%	3.60%
	Retail trade	11.20%	13%	10.40%	13.60%	10.50%	14%	12.25%	13.00%	11.90%
	Transportation and warehousing, and utilities	4.60%	5%	3.60%	2%	4.70%	6.40%	3.74%	6.50%	5.10%
	Information	1%	1.10%	1.70%	3.20%	1.50%		1.93%	2.80%	2.50%
	Finance, insurance, real estate, and rental and leasing	4.10%	4.70%	2.20%	5.80%	2.40%	3.80%	4.29%	4.60%	7.20%
	Professional, scientific, management, administrative, and waste management services	0.90%	2.90%	4.20%	6.50%	5.10%	1.30%	4.35%	5.20%	8.80%
	Educational, health and social services	25.90%	17.90%	18.80%	25.90%	20.30%	13.20%	22.47%	25.70%	20.90%
	Arts, entertainment, recreation, accommodation and food services	11.60%	7.80%	13.20%	12.50%	9.60%	22.10%	11.68%	10.10%	7.20%
	Other services (except public administration)	6.40%	5.90%	7%	4.10%	3.30%	7.20%	4.97%	5.00%	4.60%
	Public administration	2.40%	4.70%	3.90%	3.20%	1.90%	3.80%	3.08%	4.60%	3.40%

Source: U.S. Census Data, 2000. Data unavailable for the city of Soudan, Minnesota

Table 4.10-10 St. Louis County Industries Employment Compared to the State of Minnesota in 2004

2004 Data	State	County	Location Quotient
Total, All Industries	**2,577,178**	**92,668**	
Mining	5,182	2,780	14.9
Utilities	13,195	951	2.0
Health Care and Social Assistance	358,214	20,772	1.6
Public Administration	115,739	5,978	1.4
Accommodation and Food Services	203,091	8,996	1.2
Retail Trade	297,772	12,305	1.1
Educational Services	196,587	7,814	1.1
Other Services	85,026	3,223	1.1
Information	63,786	2,380	1.0
Transportation and Warehousing	98,921	3,346	0.9
Construction	132,521	3,965	0.8
Finance and Insurance	136,280	3,770	0.8
Administrative and Waste Services	120,537	3,274	0.8
Real Estate and Rental and Leasing	37,874	921	0.7
Professional and Technical Services	117,780	2,611	0.6
Arts, Entertainment, and Recreation	46,635	993	0.6
Wholesale Trade	127,476	2,093	0.5
Manufacturing	341,024	5,559	0.5
Agriculture, Forestry, Fishing & Hunting	16,380	251	0.4
Management of Companies and Enterprises	63,161	669	0.3

.Source: Employment, Economic and Social Impacts of PolyMet Mining, Inc.'s NorthMet Project and other Industrial Projects of Minnesota's East Range Communities, February 2006, PolyMet Mining, Inc

4.10.1.5. Public Finance

Sales and use tax revenues from St. Louis County by all industries and the mining industry are summarized in Table 4.10-11. This table outlines information compiled by the Minnesota Department of Revenue and illustrates the relative sales and use tax contribution from the mining industry in the State

The mining and processing of base and precious metals in the State are not currently subject to production tax. However, this activity is subject to ad valorem tax; net proceeds tax; occupation tax; sales and use tax (6.5% sales and use on all purchases that do not qualify for an exemption); severed mineral interest (if applicable); and withholding tax on royalty payments (if applicable). Ad valorem taxes are established by the county, local communities, and school districts according to Minnesota State law. The Project would be subject to this tax. Occupation tax is equal to 2.45% of the taxable amount. The starting taxable amount for the occupation tax is the mine value as determined by the Minnesota Department of Revenue. Revenue generated through the occupation tax is credited to the general fund, where 10% supports the University of Minnesota, 40% supports elementary and secondary schools, and 50% remains in the state's general fund.

Table 4.10-11 Select St. Louis County Sales and Use Tax Statistics

	Total Tax (Sales and Use)(in $1,000)	
Year	**All Industries**	**Mining**
1986*	Not Reported	Not Reported
1996	$97,492	$5,584
2000	$114,011	$4,155
2003	$146,182	$4,508
2004	$155,227	$4,356
2005	$163,022	$5,544

Source: Minnesota Department of Revenue: *Minnesota Sales and Use Tax Statistics, County by Industry Annual*. Total taxes for 1986 were not reported. Data prior to 1986 was not available. Mining data reported for 1986 as "metal mining", for 1996 and 2000 as the combination of "metal mining" and "mining, nonmetallic". Data reported for 2003 through 2005 as "mining – all other" and "mining – support activity"

Table 4.10-12 Housing Characteristics of Selected East Range Cities

	Aurora	Babbitt	Biwabik	Ely	Hoyt Lakes	Tower	All Cities	St. Louis County	State of Minnesota
Total housing units	**893**	**801**	**492**	**1,912**	**995**	**295**	**5,388**	**95,800**	**2,065,946**
Occupied housing units	812	735	454	1,694	916	233	4,844	82,619	1,895,127
Percentage	90.9%	91.8%	92.3%	88.6%	92.1%	79.0%	89.9%	86.2%	91.7%
Owner-occupied	654	656	376	1,209	840	171	3,906	61,683	1,412,865
Percentage	80.5%	89.3%	82.8%	71.4%	91.7%	73.4%	80.6%	74.7%	74.6%
Renter-occupied	158	79	78	485	76	62	938	20,936	482,262
Percentage	19.5%	10.7%	17.2%	28.6%	8.3%	26.6%	19.4%	25.3%	25.4%
Vacant housing units	81	66	38	218	79	62	544	13,181	170,819
Percentage	9.1%	8.2%	7.7%	11.4%	7.9%	21.0%	10.1%	13.8%	8.3%
Median value*	$46,900	$44,200	$43,400	$56,900	$39,100	$55,800	$45,550	$75,000	$122,400

Source: U.S. Bureau of the Census, Census 2000 Demographic Profile Highlights as reported in Employment, Economic and Social Impacts of PolyMet Mining, Inc.'s NorthMet Project and other Industrial Projects of Minnesota's East Range Communities, February 2006, PolyMet Mining, Inc., modified for inclusion of the city of Ely, Minnesota. Data unavailable for the city of Soudan, Minnesota.

Note: *Single-family owner-occupied home

4.10.1.6. Housing

Table 4.10-12 illustrates the housing characteristics of the East Range communities, St. Louis County, and the State. Though the population of these communities has declined (Table 4.10-1), the East Range communities have a lower percentage of available housing than the County. This percentage is supported by the demographic trends of aging population and lower household size. The elevated percentages of owner-occupied housing units versus renter-occupied units over the County and State are also indicative of these trends.

In addition to available housing, representatives of individual cities in the East Range have suggested that there is capacity for housing expansion (Employment, Economic and Social Impacts of PolyMet Mining, Inc.'s NorthMet Project and other Industrial Projects of Minnesota's East Range Communities, February 2006, PolyMet Mining, Inc.).

4.10.1.7. Public Services

Water and Sewer

Most of the infrastructure supporting the East Range communities was constructed to accommodate a larger population than currently resides in the area. All of the East Range communities have public water and wastewater systems, with varying degrees of available capacity. The wastewater treatment facility in the City of Babbitt has a total capacity of 500,000 gallons per day (gpd) with an actual daily load of 200,000 to 300,000 gpd, according to the manager of the facility. According to representatives of the Hoyt Lakes Wastewater Treatment facility, the design capacity of the facility was 1.2 million gpd, while the current maximum daily load of the facility was 670,000 gpd with average daily loads ranging between 250,000 and 300,000 gpd.

Police

The East Range communities are served with police protection either through their own department or via contract with St. Louis County. Local communities provide continuous police service at the following staffing levels:

- Aurora – one sergeant, four deputies
- Babbitt – one officer
- Biwabik – four officers
- Hoyt Lakes – five full-time and five part-time officers
- Ely – seven officers

- Tower and Soudan – two full-time and four part-time officers

Fire Protection

The East Range cities all have volunteer fire departments. Officials from the City of Babbitt indicate that they have state-of-the-art fire-fighting equipment and that they currently provide emergency service to the Northshore Mine. The volunteer fire department for the City of Ely includes over 30 volunteers and provides fire and rescue services for approximately 400 square miles of northeastern Minnesota.

Medical Services

There is available ambulance service to each of the assessed East Range communities. The City of Aurora contracts with the City of Hoyt Lakes for this service.

The East Range communities are served by both medical clinic and hospital facilities. The nearest emergency center to the City of Hoyt Lakes is the White Community Hospital. This facility is located in Aurora and has 16 hospital beds. The nearest trauma facility to the City of Babbitt is the Ely Bloomenson Community Hospital located in Ely. The City of Babbitt officials indicate that response time for emergencies is generally five minutes, with a 15-minute trip to the emergency room.

For services not provided by these facilities, residents travel to Ely, Virginia, or Duluth, Minnesota. The Virginia Regional Medical Center in Virginia, Minnesota has 83 hospital beds.

Schools and Libraries

The area school systems were originally constructed to accommodate a greater population than is currently living in the region, so there is capacity for growth. The City of Aurora has closed schools and combined them with adjacent communities. The City of Babbitt is using former education buildings to house municipal facilities. The City of Ely contains an elementary school, high school, and the Vermilion Community College. The selected East Range communities have available library services, though most libraries share building space with municipal or education facilities.

4.10.1.8. Commercial/Retail Centers

Commercial and retail activities occur in all of the East Range communities, but only to a limited extent, and the success of these operations has declined in recent years. Residents obtain basic goods and services in their communities and in the

Project area, and travel to Duluth or Virginia to purchase items that cannot be acquired locally.

4.10.1.9. Recreational Facilities/Gathering Places

The Superior National Forest including the BWCAW, and Voyageurs National Park are important recreation areas in the region. The Superior National Forest includes approximately 3 million acres and provides recreation opportunities for camping, boating, fishing, hiking, viewing scenery, off-highway vehicle (OHV) riding, wilderness related recreation, snowmobiling and cross country skiing. Located 20 miles to the north of the East Range communities, the million–plus-acre BWCAW is protected as part of the National Wilderness Preservation System. The National Wilderness Preservation System prohibits the use of motorized vehicles with the exception of limited motor craft use on certain, designated lakes.

Each of the East Range communities has access to at least one large and several smaller parks for recreational use. These parks, as well as area beaches, teen centers, gyms, and athletic arenas serve as both recreational facilities and gathering places for the local communities.

Tourism provides a significant percentage of the economies of some of the East Range communities, especially Biwabik and Tower. According to the 2000 census, 22.1% of employment in the City of Tower was attributed to the NAICS category including, “arts, entertainment, recreation, accommodation and food services” while 7.2% was attributed to the category including “agriculture, forestry, fishing and hunting, and mining.”

The Iron Range region affords various outdoor tourism activities including cross-country skiing, hiking, biking, water sports, OHV/ ATV paths, snowmobiling, fishing, hunting and camping.

Computer Access Facilities

Computers are available for use through educational facilities, libraries, and municipal facilities. The communities also have access to private internet service providers.

4.10.1.10. Community Structure

East Range cities use one of two types of government structures, as described below:

- Plan A City – City council including an elected mayor and four to six elected council members. A clerk and treasurer are appointed; neither serve on the city council. The cities of Babbitt, Hoyt Lakes, and Aurora have this form of government.

- Home Rule Charter City – Design own government through the adoption of a charter. The cities of Biwabik, Tower, and Ely have this form of government.

Participation in Voluntary Associations

City administrators and clerks of the East Range Cities provided the following partial list of organizations in which residents in the area may participate. This list is not exhaustive and may not include additional small organizations and business groups.

- Rotary Club
- Civic Association
- Veterans of Foreign Wars (VFW)
- Lions Club
- Knights of Columbus
- American Legion
- Lions – Leo Club
- Church groups
- Chamber of Commerce
- East Range Readiness Committee
- East Range Women of Today
- Athletic clubs
- Garden clubs
- Seasonal/community events committees

4.10.2. Impact Criteria

Socioeconomic aspects assessed to evaluate potential beneficial and adverse effects of the proposed Project on the local region include the following:

- Changes in local population, employment, or earnings associated with Project operations.
- Changes in demand for temporary or permanent housing during Project construction, operation, and closure periods.
- Changes in long-term demands on public services and infrastructure that consume capacities in these systems, either triggering the need for capital

expansion or resulting in a discernable reduction in the level of service provided.

- Changes in public sector revenues or expenditures, or the underlying fiscal conditions of local governments.
- Displacement or other use of property that affects residences or businesses.
- Changes induced in the social or business community that can cause important changes in organizational structures, local government, or traditional lifestyles of the community.
- Disproportionate effects on minority or low-income populations, including human health or environmental effects.

4.10.3. Socioeconomic Consequences

This section describes potential effects on population, income, employment, public finance, housing, and public services, which include water and sewer, fire protection, medical services, schools, libraries, commerce/retail centers, and community structure.

The economic multiplier effect for St. Louis County was estimated using the IMPLAN model completed by the University of Minnesota Duluth (UMD) Labovitz School of Business and Economics Bureau. Economic baseline conditions are based on the economic activity reported in the most recent tax year available in St. Louis County for IMPLAN data (2002) and the 2000 census. Direct, indirect, and induced effects are included in the overall economic impact, which was converted from 2004 to 2007 data. The UMD model defined effects in the following way:

- Direct effects - Initial new spending in the study area resulting from the Project.
- Indirect effects - Additional inter-industry spending from the direct impacts.
- Induced effects - Impact of additional household expenditure resulting from the direct and indirect impacts.

Because the nature and magnitude of construction and operation activities are different, the effects of these activities on the communities will differ. For instance, it is assumed that a greater percentage of local labor would be used during the operations phase than during construction. These differences are reflected in the IMPLAN calculated multiplier for the two phases of the Project.

4.10.3.1. Proposed Action

Environmental Justice

The Project was evaluated for effects relating to the social, cultural, and economic well-being and health of minorities and low-income groups through a review of socioeconomic and demographic data compiled from the 2000 U.S. Census. Such effects are termed environmental justice issues, and none were identified for the NorthMet Project. Minority populations in the affected communities do not comprise over 50 percent, In addition, in 2000 (US Census) the Native American population was 2.1% of St Louis County, Minnesota. The same census reported 1.2% Native American across the State of Minnesota. Therefore the Proposed Action and alternatives would not adversely affect minority groups disproportionately. While there are an elevated percentage of families below the poverty level in the East Range communities as compared with the State, the Project would create an economic benefit to the community and would not appear to create significant adverse social impacts.

As discussed in section 4.8.3.1, the proposed Project area overlaps the 1854 Ceded Territory, where certain tribal communities retain rights to hunt, fish, and gather on public lands. With 2.1% of Native Americans living in St Louis County, Minnesota, few members of these tribal communities live in the immediate vicinity. Further discussion of tribal use of Project area resources is provided in Section 4.8.

Population

<u>Construction Period</u>

Construction activities are estimated to create an average of 347 full-time equivalent (FTE) direct construction jobs over an 18-month period. The projected peak labor force for the construction activities is 800 individuals. Typical construction involves fluctuating work flows, as specialized crews may be employed for short duration tasks. Any population increases during construction would be temporary (18 months or less). It is anticipated that the majority of the labor force would be from Minnesota.

Due to proximity to population centers such as Duluth, it is estimated that 60% of construction labor would commute on a daily or weekly basis. It is estimated that approximately 15% would seek more permanent residence and the remaining jobs would be filled by local residents. Given the short duration of the construction, it is assumed that non-local workers would not relocate their families. In-migrating construction workers are estimated at approximately 50 to 100 individuals. This represents less than a 2% increase to the 2004 population of the East Range communities.

Operating Period

Current operating period labor force projections are estimated at 448 employees. Due to the estimated 20-year operating life of the facility, it is estimated that approximately 55% of labor for operations would be non-local and would relocate to the East Range; 20% would commute daily or weekly from centers such as Duluth; and the remaining labor would be local. In-migrating operations workers are estimated at approximately 247 individuals. In order to estimate the number of individuals relocating to the area to fill direct jobs, of these in-migrating workers, 25% are assumed to be single or married without families present, and 10% of the married households are assumed to be two-worker families. As a conservative estimate, married households are assumed to be equivalent to the Minnesota State average of 3.09 persons per household. This suggests that an additional 351 family members would relocate to the East Range for a total direct population influx of 598 individuals.

IMPLAN modeling suggests that approximately 553 indirect and induced jobs would be created by the Project. In order to estimate the number of individuals relocating to the area to fill indirect and induced jobs, it is assumed that 70% of the indirect labor force would be second persons in a direct labor household or current resident of the East Range. Of the remaining 30% percent, it is estimated that 10% would commute daily or weekly from other population centers, and 20% would be non-local and seek to relocate to the East Range. Relocating operations workers are estimated at approximately 111 individuals. Of these individuals, 40% are assumed to be single or married without families present, and half of the married households are assumed to be two-worker families. Utilizing an average family size of 3.09 persons suggests that an additional 88 family members will relocate to the East Range, for a total indirect and induced population influx of 199 individuals.

The total estimated population influx from direct, indirect, and induced employment would be 797 people.

Closure Period

After closure of the mine, it is estimated that a reduced number of employees and contractors would remain employed for a few years to perform post-mining activities such as demolition and reclamation. These activities would likely be followed by several years of operations and maintenance of reclamation activities. Unless new industry is developed in the East Range area prior to completion of these activities, it is assumed that 95 percent of working-age people formerly employed by the NorthMet Project would need to secure alternative local employment or would leave the area after this time. Approximately five percent of working-age people formerly employed by the NorthMet Project would remain to help with long-term closure activities.

Housing

Construction Period

It is anticipated that demand for temporary housing during the construction period would increase. The majority of the labor force would likely either commute from nearby city centers or would be existing members of the East Range community. It is estimated that on average between 100 and 200 individuals would seek temporary accommodations. The cities of Hoyt Lakes and Biwabik both have available temporary accommodations in the form of hotels and lodges. The hotel in Hoyt Lakes has 40 rooms, while Biwabik has at least 129 units. The adjacent communities of Virginia and Eveleth each have several hotels. Availability of hotels in the East Range communities and surrounding areas should be sufficient to meet demand given the total number of available rooms.

Operating Period

Demand for permanent housing is likely to increase during the operating period. Based upon population estimates previously presented, there would be approximately 247 in-migrating workers, all but 10%[1] of whom would seek independent housing. As previously discussed, the total population influx for direct, indirect, and induced employment effects is estimated at 797. This translates into an estimated increase in households of 358; the actual number may be lower than this due to two-worker in-migrating households. In addition to existing housing vacancies, East Range cities' staff and officials indicate that there is sufficient land to accommodate such growth. New home construction would increase demand for construction labor; this demand may exceed the local area's construction capacity and as such it would be necessary to bring labor in from outlying metropolitan areas (e.g., Duluth).

Closure Period

During the closure period, it is likely that the demand for housing would drop as workers migrate from the area, leaving a portion of available housing vacant. In

[1] Assumed 10% of workers will commute weekly from larger centers and stay in hotels / motels, rather than seek independent housing

addition, new housing built to originally accommodate the employment generated by the Project would have high vacancy rates as well. After some time, the baseline vacancy rate for existing properties should return. Given the duration of the Project and the difficulty in predicting other economic development and conditions that would occur in the area during and after the operation of the Project, a post-closure vacancy rate has not been established.

Income and Employment

Construction Period

As noted previously, the construction labor force is estimated at approximately 347 FTE positions, peaking at 800 individuals for a short period of time. Local labor is estimated to fill approximately 25% of the direct Project jobs. IMPLAN modeling conducted for the Project suggests that approximately 233 indirect and induced jobs would be created during the construction phase, for a total of 580 FTE jobs generated.

Total labor costs for the construction activities (local and non-local) over the estimated 18 month period are estimated to be $50 million in 2007 dollars. In addition to labor expenditures, an estimated $165 million is projected to be spent for capital equipment (local and non-local).

Operating Period

The projected labor force for the steady state operating period is estimated at 448 FTE. Table 4.10-13 illustrates the employment levels by trade. IMPLAN modeling conducted for the Project suggests approximately 553 FTE indirect and induced jobs would be created, for a total of 1,003 FTE jobs generated.

Table 4.10-13 Anticipated steady state operation employment levels

Area	Total Number
Management	13
Mine Operations – Contract supervision, operators, maintenance	149
Mine technical – Geology, grade control, planning	18
Railroad operations	25
Plant operations	199
Sample preparation and analytical laboratory	19
Finance, purchasing, marketing, environmental, HR	25
Total	**448**

Based upon data provided by PolyMet, an estimated $130 million would be spent per year of operation on wages, consumables, power, maintenance, and contract services. IMPLAN modeling estimates an additional $58.5 million would be spent in the region for a total of $188.5 million.

Closure Period

As mentioned previously, during closure and reclamation it is assumed that a reduced number of jobs and materials would be required; the remainder of the 448 jobs would be terminated and additional expenditures related to mining activity would cease.

Public Finance

The NorthMet Project would be subject to the Minnesota net proceeds tax, which is a 2% tax on net proceeds. The net proceeds are calculated as the gross proceeds, less allowable deductions. Net proceeds taxes are distributed as follows:

- 5% to the city or town where the minerals are mined or extracted
- 10% to the Municipal Aid Account (distributed to qualifying cities and townships)
- 10% to the school district where mining or extraction occurred
- 20% to the Regular School Fund (split between 15 school districts in the Taconite Relief Area)
- 20% to the county where mining or extraction occurred
- 20% to Taconite Property Tax Relief, using St. Louis County as a fiscal agent (distributed to qualifying owner-occupied homes and farms in the taconite relief area)
- 5% to Iron Range Resources (IRR)
- 5% to the Douglas J. Johnson Economic Protection Trust Fund
- 5% to the Taconite Environmental Protection Fund

Mining and processing organizations are subject to a 6.5% tax on all purchases that do not qualify for the industrial production exemption.

NorthMet tax impacts are based upon IMPLAN model estimates as described for the various Project phases as well as available information for the State's tax system as described in Section 4.10.1.4. The IMPLAN model assumes typical business operation and excludes tax structures such as net proceeds. Tax impacts from direct and induced effects included in the model are personal income taxes, indirect business taxes, and other taxes paid by the affected sector.

Construction Period

IMPLAN modeling estimates the Federal Government would receive approximately $5.4 million and the State and Local Government would receive $2.5 million in taxes for the construction of the NorthMet Project. Sales and use taxes paid on items purchased for new mining and processing facilities in the State qualify for refund.

Operating Period

The majority of economic benefits to the local community through taxes would be realized during the operating period. IMPLAN modeling estimates that after an initial operation ramp up, during a typical year of operation the Federal Government would receive $17.3 million and the State and Local Governments would receive $14.5 million in taxes from the operation of the NorthMet Project, excluding net proceeds tax. PolyMet estimates that total taxes throughout the operating period would vary from $22 to $47 million per year.

The 2% net proceeds tax collected during the operations phase would be distributed as described in Section 4.10.1.4. Tax dollars collected would benefit communities throughout the Iron Range in addition to the city and school district where the mining occurs.

Minnesota mining and processing organizations are subject to a 6.5% tax on all purchases that do not qualify for the industrial production exemption. The majority of items used or consumed for mining and processing (e.g., chemicals, fuels, lubricants, explosives), however, are subject to this exemption.

Closure Period

It is assumed that after closure of the facility is complete, the public finance through taxes paid would return to baseline values.

Transportation

The Project has two access points: the Main Gate at the end of County Road (CR) 666 and the North Gate on MN 135. Many of the building materials and some labor for Project construction and operation are expected to be transported from Minneapolis/St. Paul. These goods would be transported along Interstate 35, MN 33, US 53, MN 37, MN 135, CR 110, and CR 666 to the Main Gate. Heavy loads would bypass Hoyt Lakes (CR 110 and CR 666) and use the North Gate on MN 135. Some materials will be transferred via Lake Superior and through the ports of Duluth and Superior. These goods will likely be transported along US 53, MN 37, MN 135 or CR 4, MN 135, and the rest of the route to the Main Gate or North Gate described above. Refer to figure 4.10-2 showing mapped routes. The East Range communities may be affected by increased travel times over baseline times due to the increased amount of traffic on the roadways; however, projected traffic values are less than traffic associated with former LTVSMC operations and the Project would use the same road infrastructure. Since there are no significant impacts anticipated with traffic, a traffic study has not been performed.

With the closure of the mine, it is anticipated that traffic would revert to current levels.

Product from the mine and some raw materials used on site would be shipped via rail. A common carrier (Canadian National) rail spur serves the Project area. A PolyMet plant switch engine would move rail cars to and from their destination within the Project, and a private railroad connects the Plant Site to the Mine Site.

Public Services

During interviews conducted by the Bureau of Business and Economic Research at UMD, city officials in the East Range indicated that they anticipate limited problems accommodating the influx of people that construction and operation of the NorthMet Project may bring. For instance, representatives of the cities of Hoyt Lakes and Babbitt indicated nearly 50% capacity is available in their wastewater treatment facilities.

Emergency and medical services are currently equipped to handle similar area operations and East Range communities have mutual aid agreements in place to cooperatively respond to major emergencies. The addition of police, fire, and ambulance staff may be required to service an expanded population.

Renovations of existing school buildings and additional teachers may be needed to accommodate additional school-age children in the area.

With the closure of the mine, it is anticipated that demands on public service would decrease to current or slightly elevated levels because of a potential decrease in population. Some individuals may choose to remain in the area, maintaining a slightly elevated demand.

Commerce/Retail Centers

The Project would not displace any existing residences or businesses. On the contrary, commercial and retail businesses are expected to expand to meet increased market demand. This translates into the increased size of existing businesses and addition of new commercial and retail enterprises.

Post-closure and reclamation activities are expected to generate 20 to 50 jobs for many years, so local business would continue to be used; however, subsequent complete closure would likely result in a reduction in retail spending to baseline levels.

Recreation

The area directly impacted by the Project is part of the Superior National Forest. The project will reduce access to the site for hiking, fishing, and hunting. Limited hunting activities occur in this area. The proposed Project area is not heavily used for tourism or recreation. During both construction and operations phases, the project will generate some noise and light which may impact the recreational experience. Boating impacts associated with water level changes in both the Embarrass and Partridge Rivers should be minor; some impacts may be experienced by recreational users of Whitewater Reservoir due to water level reductions.

Community Structure

The construction and operation of the proposed NorthMet Project is unlikely to significantly affect community structure. A potential 797 person population increase may prompt the addition of a few additional city staff, but participation in community groups and functions is expected to remain similar to the baseline period.

4.10.3.2. Alternatives

No Action

Under the No-Action alternative, current trends of declining employment in the mining industry, population decline, underutilized housing, and aging population in St. Louis County and the East Range communities would likely continue. There is evidence, however, that increased non-ferrous mining, iron mining, and steel production are entering the area now, which may reverse these negative trends.

Subaqueous Disposal of Reactive Waste Rock

The alternative of subaqueous disposal of the most reactive waste rock would have no discernible socioeconomic impacts on the local community.

4.10.4. Cumulative Impacts

An assessment of both economic and social cumulative effects evaluated the combined impacts of past, present, and future projects on the East Range and St. Louis County (Table 4.10-14). Cumulative economic impacts were initially assessed through IMPLAN modeling of the baseline economic activity, average annual employment projections (year by year), and estimated construction costs (year by year) for the past and future actions identified in the Final Scoping Document (FSD) (Tables 4.10-15 and 4.10-16). These quantitative results were then evaluated in the context of additional reasonably foreseeable future projects identified subsequent to the FSD to describe both economic and social effects.

Table 4.10-14 Summary of Economic and Social Cumulative Effects

Project[2]	Temporal Scale	Potential Cumulative Effect
Projects Identified in FSD [3]		
Shutdown of LTVSMC mine	Past	In 2000, LTV Steel Company, Inc., a subsidiary of the LTV Corporation, announced its intent to close all operations due to blast furnaces experiencing lower levels of productivity and high costs as a result of poor taconite pellet quality. Approximately 1,400 people were employed by the company at this time. The shutdown of the facility decreased employment needs in the area, thereby influencing the economic condition of the region.
MACT standards	Present	St. Louis County has a significant taconite mining presence and has three coal-fired power plants. These facilities are currently subject to MACT standards that may increase the price of their products. These economic impacts may be felt by the community at large, particularly if utility prices increase as a result of the standards.
Proposed NorthMet Project	Future	Cumulative impacts for these projects were quantified using the IMPLAN model for years one through five. Table 4.10-15 illustrates estimated impacts from the construction of each project. Maximum employment effects are estimated at 1,874 jobs in year two; employment is considered the primary driver for social impacts to the community. Table 4.10-16 illustrates estimated impacts from the operation of each project. Maximum direct employment effects are estimated at 1,641 jobs in year five.
Proposed Mesabi Nugget Plant Phase I	Future	
Proposed Cliffs-Erie Railroad Pellet Transfer Facility	Present	
Proposed NO*v*A Off-Axis Detector	Future	
Proposed expansions of existing taconite plants	Future	
Projects identified subsequent to the FSD		
Establishment of the Erie Mining Company (aka LTVSMC) (1950s)	Past	The Erie Mining Company peaked in 1970 employing over 3,000. The LTV Corporation acquired full ownership in 1986 and modernized the operations, thereby increasing efficiency and production. The establishment of this company and its evolution in the Hoyt Lakes area helped launch a community based on mining, thereby affecting economic and social conditions of the region.
Northshore Mining Company mine site crusher operations	Present	The Northshore Mining Company crusher operations in Babbitt reduce boulder-size chunks of taconite to small pieces. This project contributes to cumulative economic benefits to the local community as an employment provider.
Minnesota Power Syl Laskin Energy Center operations	Present	This facility, located on Colby Lake, adds employment to the local communities, thereby representing an additional economic benefit that would contribute cumulatively with others activities.
Ispat Inland Mine Pit (Mittal mine)	Present	This project would extend the life of Mittal's existing ore processing facility through 2024 and extend the existing employment and tax benefits to the community.
Proposed Cliffs Erie Railroad Pellet Transfer Facility	Future	This facility would store and transfer taconite iron pellets at Hoyt Lakes from the Hibbing and United Taconite mines before being shipped to docks at Taconite Harbor. This facility would contribute to cumulative economic benefits to the local community through employment and increased tax base.

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[2] The economic impact modeling (IMPLAN) was conducted prior to February 2006. Projects that were proposed and in the public domain at the time of modelling are included in the economic modeling.

[3] For additional information on these projects, refer to the Employment, Economic and Social Impacts of PolyMet's NorthMet Project and other Industrial Projects of Minnesota's East Range Communities, February 2006, PolyMet Mining, Inc (RS72). Because the cumulative effects were modeled in IMPLAN, this initial analysis was limited to economic impacts only and did not take into account cumulative social impacts, such as housing, community services, and family effects.

Project[2]	Temporal Scale	Potential Cumulative Effect
NO*v*A Off-Axis Detector	Future	This project would construct a facility to study electron neutrino oscillations. This facility would contribute to cumulative economic benefits to the local community through employment and increased tax base.
Proposed Mesaba Energy power generation (coal gasification station)	Future	The Mesaba Energy Project proposes a 606 megawatt (MW) integrated gasification combined-cycle (IGCC) power plant in Taconite, Minnesota. This project would create over 1,000 construction jobs during the four-year construction phase and over 100 jobs during plant operation. Approximately 290 additional indirect jobs are expected during plant operation. The plant will also expand the tax base in Itasca County and provide a significant source of property tax revenue. Itasca County is immediately west of St. Louis County and its economic impacts would provide beneficial cumulative effects to the region. This project was initially looking at Hoyt Lakes for a potential site in addition to Taconite. When IMPLAN modeled cumulative effects, the preferred site was in Hoyt Lakes. Since then the preferred site has become Taconite with Hoyt Lakes as an alternate. Because of this change, the modeled cumulative impacts are higher than expected for the modeled projects.
Proposed Minnesota Steel DRI/ steel plant	Future	Minnesota Steel is developing a $1.6 billion fully integrated mining through steelmaking project in Nashwauk, Minnesota. This project will employ 2,000 skilled workers for two years during construction and 700 employees during operation. Approximately 2,100 indirect and induced jobs should be created because of the facility's construction and operation.
Proposed Minnesota Steel taconite mine and tailings basin	Future	Minnesota Steel also proposes to reactivate the former Butler Taconite open mine pit approximately three miles southwest of Nashwauk. Ore from the mine would be hauled to the ore processing facility and tailings would be transported via pipeline to the existing Butler Taconite tailings basin two miles southeast of the mine. This project would employ approximately 700 full-time employees. Because both this project and Minnesota's Steel's new steel project are located near the St. Louis County border and would have such a significant economic impact on its local community, regional effects are expected that would cumulatively impact the NorthMet project.
Proposed Mesabi Nugget Phase II (mining operation)	Future	Mesabi Nugget Mining L.L.C. proposes to reactivate the LTVSMC Area 2WX and 6 mines and install a new crusher and concentrator with magnetic separation and flotation (Phase II Project) on the former LTVSMC property north of Hoyt Lakes. The project would produce iron oxide concentrate at the existing nugget plant on the former LTVSMC property. The project would employ approximately 250 skilled workers during construction and 124 during operation. This project would have an economic benefit on the local community and synergistic economic impacts with the effects of the NorthMet project through increased employment and tax base.
Proposed US Steel Keewatin taconite mine and plant expansion	Future	U.S. Steel proposes to reactivate an idled production line and expand the mine pit at its Keetac taconite mine and processing facility north of the Keewatin on the St. Louis County border. This project would increase Keetac's iron pellet production output by 3.6 million tons per year (total of 9.6 million tons per year). This project would employ approximately 500 skilled workers during construction and 70 workers during facility operation. This project would have a strong economic benefit on the local community and synergistic economic impacts with the effects of the NorthMet project through increased employment and tax base.

Table 4.10-15 Total Impacts from Construction, by Project, by Measure, by Year (2008 Dollars)

Year	Project Phase	Project[4]	Value Added	Employment	Output
Year 1	Construction	Mesabi Nugget	$16,010,014	299	$29,714,385
		Expansion Plants	$49,530,982	926	$91,928,877
		Total	**$65,540,996**	**1,225**	**$121,643,262**
		NorthMet	**$40,242,870**	**752**	**$74,690,351**
Year 2	Construction				
		Mesabi Nugget	$16,010,014	299	$29,714,385
		NOvA	$20,012,520	374	$37,142,981
		Expansion Plants	$24,015,022	449	$44,571,578
		Total	**$100,280,426**	**1,874**	**$186,119,294**
Year 3	Construction	NOvA	$20,012,520	374	$37,142,981
Year 4	Installation	NOvA	$6,766,708	128	$12,242,354
Year 5	Installation	NOvA	$6,766,708	128	$12,242,354

Source: Employment, Economic and Social Impacts of PolyMet Mining, Inc.'s NorthMet Project and other Industrial Projects of Minnesota's East Range Communities, February 2006, PolyMet Mining, Inc., modified using the U.S. Department of Labor Bureau of Labor Statistics Consumer Pricing Index Inflation Calculator (http://www.bls.gov/cpi/#overview) to adjust 2004 dollars to 2008 dollars.

4 The economic impact modeling (IMPLAN) was conducted prior to February 2006. Projects that were proposed and in the public domain at the time of modelling are included in the economic modeling.

Table 4.10-16 Total Impacts from Operations, by Project, by Measure, by Year (2008 Dollars)

Year	Project Phase	Project[5]	Value Added	Employment	Output
Year 1	Operation	Mesabi Nugget	$7,096,833	83	$21,559,937
		Expansion Plants	$15,921,736	177	$41,829,027
		Total	**$23,018,569**	**260**	**$63,388,964**
Year 2	Operation	**NorthMet**	**$106,588,271**	**529**	**$183,818,215**
		Mesabi Nugget	$42,580,994	158	$129,359,620
		Expansion Plants (1)	$15,921,736	177	$41,829,027
		Expansion Plants (2)	$37,150,713	236	$97,601,060
		Total	**$202,241,714**	**1,100**	**$452,607,922**
Year 3	Operation	**NorthMet**	**$160,274,310**	**1,058**	**$276,403,198**
		Mesabi Nugget	$42,580,994	158	$129,359,620
		Expansion Plants (1)	$15,921,736	177	$41,829,027
		Expansion Plants (2)	$37,150,713	236	$97,601,060
		Total	**$255,927,753**	**1,629**	**$545,192,906**
Year 4	Operation	**NorthMet**	**$160,274,310**	**1,058**	**$276,403,198**
		Mesabi Nugget	$42,580,994	158	$129,359,620
		Expansion Plants (1)	$15,921,736	177	$41,829,027
		Expansion Plants (2)	$37,150,713	236	$97,601,060
		Total	**$255,927,753**	**1,629**	**$545,192,906**
Year 5	Operation	**NorthMet**	**$160,274,310**	**1,058**	**$276,403,198**
		Mesabi Nugget	$42,580,994	158	$129,359,620
		Expansion Plants (1)	$15,921,736	177	$41,829,027
		Expansion Plants (2)	$37,150,713	236	$97,601,060
		NOvA	$1,094,915	12	$1,942,732
		Total	**$257,022,668**	**1,641**	**$547,135,638**

Source: Employment, Economic and Social Impacts of PolyMet Mining, Inc.'s NorthMet Project and other Industrial Projects of Minnesota's East Range Communities, February 2006, PolyMet Mining, Inc., modified using the U.S. Department of Labor Bureau of Labor Statistics Consumer Pricing Index Inflation Calculator (http://www.bls.gov/cpi/#overview) to adjust 2004 dollars to 2008 dollars

Conclusions

The degree of potential cumulative social and economic impacts from construction and operation of the above-mentioned projects depend on project timing. The beneficial effects include increased employment opportunities, a larger tax base, and increased county revenue from property taxes.

However, potential increases in construction and other related employment, as well as population, would increase pressure on housing, schools, and hospitals, and other community services and infrastructure. Employment and population

5 The economic impact modeling (IMPLAN) was conducted prior to February 2006. Projects that were proposed and in the public domain at the time of modelling are included in the economic modeling.

changes during a single construction event typically follow a bell curve, with the peak of the curve coinciding with the peak of construction activities. However, when multiple projects occur within the same time period, the magnitude of the peak is significantly increased over a relatively short duration, causing more disruptive impacts and increased stresses on existing infrastructure.

Potential social impacts from construction activities are typically temporary and localized. As with the demand on public services, if multiple construction projects occur within the same time period there may be a more intense period of social disruption due to rapid increases in population. In the case of the operations described above, it is less likely that construction workers with families would relocate (or that the workers would relocated their families to the region). This demography suggests an increased risk of a significant change to population and social dynamics with the likely influx of single, transient males.

However, it is more likely that heavy construction activity associated with the projects described above would be staggered, and that the disruption period may be less intense over a longer duration, allowing for infrastructure and resources to expand to accommodate growth. With staggered construction activities there is also a greater opportunity for incoming workers to provide their services to multiple projects over a longer period of time. This would reduce the total number of new workers needed for the projects described above. It also increases the likelihood that construction workers would relocate their families and become active participants in the community.

The operations phase typically provides a more stable and sustainable work force than the construction phase. Impacts from the operation of a project are typically longer term, also allowing the community to respond to expand infrastructure and services over time. Operations employees are more likely to relocate their families to neighboring communities for the life of the project and become integral members of the community. While the influx of employees would place pressure on housing, schools, hospitals, and other infrastructure, the East Range communities have historically had higher levels of employment than currently exists today suggesting that these communities already have some capacity to accommodate increased activity without increasing pressure on public services. In addition, any capacity building during the construction phase would serve to reduce pressure posed during operations.

4.10. SOCIOECONOMICS

The NorthMet Project would be located entirely within St. Louis County and would initiate mining adjacent to and mineral processing at LTVSMC's former taconite operations. Figure 4.10-1shows the location of the Project in relation to key towns within the County. St. Louis County, the East Range (the eastern portion of the Mesabi Iron Range) communities (the cities of Aurora, Babbitt, Biwabik, Hoyt Lakes, Tower, Ely, and Soudan), and their surrounding areas would experience some portion of the Project's socioeconomic effects. Labor and materials for the Project are also projected to come from urban centers such as Duluth and Minneapolis. This assessment focuses on St. Louis County and the East Range communities.

St. Louis County has a long mining heritage. Portions of the county are commonly referred to as the Iron Range. The East Range communities were established as a result of numerous iron mining operations in the area dating back to the 1800s. In response to a marked drop in employment in the Iron Range between the 1920s and 1932, former Minnesota Governor Harold Stassen and the Minnesota legislature formed the Iron Range Resources and Rehabilitation Board (IRRRB) in 1941. The organization has subsequently changed its name to Iron Range Resouces (IRR). The objective of the IRR is to help diversify the economy of the region away from its initial high dependence on high-grade ore mining by public funding of social and economic development projects with a focus on taconite mining, timber, tourism, and technology-related education. Funded by taxes on mining operations, the IRR provides grants and other programs to foster community redevelopment in the Iron Range region.

The Project would be the first non-ferrous mine and process plant permitted in Minnesota. There are several similar known deposits in the State. While no other deposits are currently in the environmental review or permitting phase, many are in advanced stages of exploration, which may reflect an expansion of mining in the region in addition to the existing taconite iron mining industry.

4.10.1. Existing Conditions

4.10.1.1. Population and Population Trends

The population of St. Louis County is centered in Duluth, with smaller, secondary centers in the central Iron Range communities of Hibbing and Virginia. Duluth is located approximately 65 miles south of the Project, and Virginia, approximately 20 miles west of the Project. The population trends for the East Range communities are somewhat similar to the population trends of St. Louis County. As the population data in Table 4.10-1 illustrates, the county and the communities have experienced a population decline since 1980, but the county decline is less than one-quarter that of the East Range communities.

In addition to a decline in population since 1980, the East Range communities have experienced an increase in median age relative to St. Louis County and the State of Minnesota (Table 4.10-2).

In terms of racial distribution the East Range communities are predominantly Caucasian (Table 4.10-3). This is somewhat consistent with the racial composition of St. Louis County and the State; however, other races in the communities are underrepresented by comparison.

Table 4.10-4 includes the household/family size of the East Range cities, St. Louis County, and the State for 2000. The average household and family size of the cities are smaller than that of the county and the state, while the percentage of married adults over the age of 15 is higher. This can be attributed to the higher percentage of persons 65 and older in the communities than in the State (Table 4.10-2). Married persons in this age range are less likely to have children living in the home, lowering the average household size.

Education levels in the East Range communities were lower than that of St. Louis County and the State in 2000 (Table 4.10-5). Individuals over 25 years of age who achieved a high school diploma in the communities are approximately 2% less than that of the County and the State. Those with bachelor's degrees or above in the East Range communities are 24% lower than the County and 39% lower than the State.

4.10.1.2. Income

Table 4-62 presents income characteristics for the selected East Range communities, St. Louis County, and the State. The median income of the East Range communities is 21% lower than that of the County and 34% lower than that of the State. In addition, the East Range communities have 49% more families below the poverty level than the State, and the number of persons in the labor force in the region is lower than that of the County and State. The U.S. Bureau of Economic Analysis reports the average earnings per job in St. Louis County for 2004 as $38,364.

Table 4.10-1 Population of St. Louis County and Select East Range Communities, MN 1980 to 2004

	St. Louis County, MN	Select East Range Communities, MN						
		Aurora	Babbitt	Biwabik	Ely	Hoyt Lakes	Soudan	Tower
1980	222,229	2,670	2,435	1,428	N/A	3,186	N/A	640
1990	193,433	1,965	1,562	1,097	3,968	2,348	502	502
2000	200,528	1,850	1,670	954	3,724	2,082	372	469
2001	200,431	1,831	1,661	943	N/A	2,070	N/A	476
2002	200,854	1,815	1,651	934	N/A	2,055	N/A	473

	St. Louis County, MN	Select East Range Communities, MN						
		Aurora	Babbitt	Biwabik	Ely	Hoyt Lakes	Soudan	Tower
2003	199,887	1,791	1,642	905	N/A	1,987	N/A	504
2004	198,799	1,777	1,630	904	N/A	1,961	N/A	504

Source: U.S. Bureau of the Census, Population Estimates and Population Distribution Branches, CO-EST2003-01 as reported in Employment, Economic and Social Impacts of PolyMet Mining, Inc.'s NorthMet Project and other Industrial Projects of Minnesota's East Range Communities, February 2006, PolyMet Mining, Inc.
Note: Data for Soudan and Ely, MN was not found for years other than the 1990 and 2000 decennial census.

Table 4.10-2 Age of Residents of Selected East Range Cities in St. Louis County, MN, in 2000

	Aurora	Babbitt	Biwabik	Ely	Hoyt Lakes	Tower	All Cities	St. Louis County	State of Minnesota
Median age	45.2	46.8	41.5	40.8	45.6	45.3	44.2	39	35.4
18 years and over	1,483	1,320	756	3,061	1,669	390	8,679	155,699	3,632,585
Percentage	80.2%	79.0%	79.2%	82.20 %	80.2%	81.4%	80.4%	77.6%	73.8%
65 years and over	442	479	192	803	444	119	2,479	32,274	594,266
Percentage	23.9%	28.7%	20.1%	21.60 %	21.3%	24.8%	23.4%	16.1%	12.1%

Source: U.S. Bureau of the Census, Census 2000 Demographic Profile Highlights as reported in Employment, Economic and Social Impacts of PolyMet Mining, Inc.'s NorthMet Project and other Industrial Projects of Minnesota's East Range Communities, February 2006, PolyMet Mining, Inc., modified for inclusion of the city of Ely, Minnesota. Data unavailable for the city of Soudan, Minnesota.

Table 4.10-3 Racial Characteristics of Residents of Selected East Range Cities in St. Louis County, Minnesota, in 2000

	Aurora	Babbitt	Biwabik	Ely	Hoyt Lakes	Tower	All Cities	St. Louis County	State of Minnesota
White	1,820	1,651	931	3,607	2,064	468	10,541	190,211	4,400,282
Percentage	98.4%	98.9%	97.6%	96.9%	99.1%	97.7%	98.0%	94.9%	89.4%
African American	1	2	0	32	6	0	41	1,704	171,731
Percentage	0.1%	0.1%	0.0%	0.9%	0.3%	0.0%	0.5%	0.8%	3.5%
American Indian	8	5	20	20	4	7	64	4,074	54,967
Percentage	0.4%	0.3%	2.1%	0.5%	0.2%	1.5%	0.6%	2.0%	1.1%
Asian	7	2	1	7	2	0	19	1,333	141,968
Percentage	0.4%	0.1%	0.1%	0.2%	0.1%	0.0%	0.2%	0.7%	2.9%
Hispanic or Latino	6	0	0	25	4	9	44	1,597	143,382
Percentage	0.3%	0.0%	0.0%	0.7%	0.2%	1.9%	0.5%	0.8%	2.9%
Other	14	10	1	58	6	4	93	3,206	150,531

	Aurora	Babbitt	Biwabik	Ely	Hoyt Lakes	Tower	All Cities	St. Louis County	State of Minnesota
Percentage	0.8%	0.6%	0.1%	7.9%	0.3%	0.8%	1.2%	1.6%	3.1%
Foreign born	26	13	15	36	26	0	116	3,897	260,463
Percentage	1.4%	0.8%	1.6%	1.0%	1.2%	0.0%	1.1%	1.9%	5.3%

Source: U.S. Bureau of the Census, Census 2000 Demographic Profile Highlights as reported in Employment, Economic and Social Impacts of PolyMet Mining, Inc.'s NorthMet Project and other Industrial Projects of Minnesota's East Range Communities, February 2006, PolyMet Mining, Inc., modified for inclusion of the city of Ely, Minnesota. Data unavailable for the city of Soudan, Minnesota.

Table Error! No text of specified style in document.**.10-4 Household/Family Size of Selected East Range Cities in St. Louis County, MN, in 2000**

	Aurora	Babbitt	Biwabik	Ely	Hoyt Lakes	Tower	All Cities	St. Louis County	State of Minnesota
Average household size	2.19	2.27	2.09	2.05	2.27	2.06	2.16	2.32	2.52
Average family size	2.79	2.67	2.69	2.72	2.71	2.69	2.71	2.9	3.09
Married males (15 years and over)	467	468	207	695	569	101	2,507	44,387	1,089,778
Percentage	63.2%	69.5%	55.1%	42.6%	66.2%	54.0%	58.4%	55.6%	57.7%
Married females (15 years and over)	450	481	189	713	597	104	2,534	43,645	1,082,898
Percentage	56.5%	67.6%	45.2%	45.2%	66.2%	52.8%	55.6%	51.5%	55.0%

Source: U.S. Bureau of the Census, Census 2000 Demographic Profile Highlights as reported in Employment, Economic, and Social Impacts of PolyMet Mining, Inc.'s
NorthMet Project and other Industrial Projects of Minnesota's East Range Communities, February 2006, PolyMet Mining, Inc., modified for inclusion of the city of Ely, Minnesota. Data unavailable for the city of Soudan, Minnesota.

Table *Error! No text of specified style in document.****.10-5 Education Characteristics of Residents of Selected East Range Cities in St. Louis County, MN (Population 25 years and older), in 2000***

	Aurora	Babbitt	Biwabik	Ely	Hoyt Lakes	Tower	All Cities	St. Louis County	State of Minnesota
High school graduate or higher	1,084	1,024	595	2,107	1,354	283	6,447	115,861	2,783,000
Percentage	80.8%	83.0%	87.5%	86.0%	88.2%	88.4%	85.3%	87.2%	87.9%
Bachelor's degree or higher	247	98	68	540	279	36	1,268	29,040	868,082
Percentage	18.4%	7.9%	10.0%	22.0%	18.2%	11.3%	16.8%	21.9%	27.4%

Source: U.S. Bureau of the Census, Census 2000 Demographic Profile Highlights as reported in Employment, Economic and Social Impacts of PolyMet Mining, Inc.'s NorthMet Project and other Industrial Projects of Minnesota's East Range Communities, February 2006, PolyMet Mining, Inc., modified for inclusion of the city of Ely, Minnesota. Data unavailable for the city of Soudan, Minnesota.%

4.10.1.3. Income

Table 4.10-6 presents income characteristics for the selected East Range communities, St. Louis County, and the State. The median income of the East Range communities is 21% lower than that of the County and 34% lower than that of the State. In addition, the East Range communities have 49% more families below the poverty level than the State, and the number of persons in the labor force in the region is lower than that of the County and State. The U.S. Bureau of Economic Analysis reports the average earnings per job in St. Louis County for 2004 as $38,364.

Table 4.10-6 Income Characteristics of Families and Residents of Selected East Range Cities in

	Aurora	Babbitt	Biwabik	Ely	Hoyt Lakes	Tower	All Cities	St. Louis County	State of Minnesota
Median family income in 1999	$43,095	$37,137	$37,386	$36,047	$45,603	$37,500	$37,443	$47,134	$56,874
Families below poverty level	44	19	31	88	42	5	229	3,731	64,181
Percentage	8.5%	3.6%	11.7%	9.5%	6.6%	3.7%	7.6%	7.2%	5.1%
In labor force (16 years and older)	833	662	388	1,806	1,003	242	4,934	101,258	2,691,709
Percentage	55.0%	48.6%	50.1%	57.1%	57.8%	64.0%	55.3%	62.7%	71.2%

Source: U.S. Bureau of the Census, Census 2000 Demographic Profile Highlights as reported in Employment, Economic and Social Impacts of PolyMet Mining, Inc.'s NorthMet Project and other Industrial Projects of Minnesota's East Range Communities, February 2006, PolyMet Mining, Inc., modified for inclusion of the city of Ely, Minnesota. Data unavailable for the city of Soudan, Minnesota.

4.10.1.4. Employment

Employment trends for St. Louis County show a decline in mining since 1980 and an increase in the service sector (Tables 4.10-7 and 4.10-8). Data from 1980 through 1999 are reported by Standard Industrial Classification codes (SIC), while as of 2000 data are reported by the new and different sectors of the North American Industrial Classification Codes (NAICS). The major sectors of employment for St. Louis County for 1980 to 1999 are provided by SIC code in Table 4.10-7 and for 2000 to 2004 by NAICS code in Table 4.10-8. In 2004, the top three employment sectors were health care and social assistance; retail trade; and accommodation and food services. Mining employment fell from the seventh-ranked sector in 2000 to the twelfth-ranked sector in the County in 2004, with an average employment of 2,752.

In 2005 unemployment in St. Louis County was 4.9%, compared with 4.0% for the State (U.S. Census Bureau Map Stats, ___2005).

Table 4.10-7 St. Louis County, Employment by Major SIC Industry in 1980 and 1990

SIC Title	1980		1990	
	Average Employment	**Percent**	**Average Employment**	**Percent**
Agriculture	223	0.3%	318	0.4%
Mining	**10,973**	**15%**	**5,326**	**7%**
Construction	3,939	5%	3,465	4%
Manufacturing	7,462	10%	6,868	9%
Transportation, Com., and Elec.	3,448	5%	4,733	6%
Finance, Insurance, and Real Estate	1,364	2%	2,820	4%
Services	22,525	30%	30,472	38%
Public Administration	5,838	8%	5,968	7%
Trade, Total	**19,332**	**26%**	**19,680**	**25%**
Total, all industries*	**75,104**		**79,650**	

Source: Employment, Economic and Social Impacts of PolyMet Mining, Inc.'s NorthMet Project and other Industrial Projects of Minnesota's East Range Communities, February 2006, PolyMet Mining, Inc. *Due to rounding, the percentages reported may not add up to 100 percent

Industry classifications for the selected Iron Range Communities are summarized in Table 4.10-9 and suggest that education, health, and social services make up the largest percentage of each locale's employment. In four of the six towns, agriculture, forestry, fishing and hunting, and mining make up the second highest percentage of employment as classified by NAICS. To provide an additional frame of reference, occupational categories are provided for each of the towns per the Standard Occupational Classification System (SOC). Farming, fishing, and forestry occupations make up extremely small percentages of the total occupations for each town, suggesting that mining is a prevalent constituent of the NAICS agriculture, forestry, fishing and hunting and mining industry classification within the communities.

Certain industries, particularly mining and utilities, are more concentrated in St. Louis County than in the State generally. Sector concentration can be measured by the location quotient, which is the ratio between the local economy and the economy of a reference unit. For this analysis, the location quotient was calculated using St. Louis County as the local economy and the State as the reference unit. As illustrated by Table 4.10-10, the location quotient for the mining industry is 14.9, meaning that in St. Louis County mining employment is over fourteen times that of the state.

Table** Error! No text of specified style in document.**.10-8 St. Louis County, Employment by Major NAICS Industry in 2000 and 2004

NAICS Title	2000		2004	
	Average Employment	**Percent**	**Average Employment**	**Percent**
Health Care and Social Assistance	17,916	19%	20,566	22%
Retail Trade	13,046	14%	12,183	13%
Accommodation and Food Services	8,781	9%	8,907	10%
Educational Services	7,735	8%	7,737	8%
Public Administration	5,783	6%	5,919	6%
Manufacturing	6,389	7%	5,504	6%
Construction	4,127	4%	3,926	4%
Finance and Insurance	3,040	3%	3,733	4%
Transportation and Warehousing	3,948	4%	3,313	4%
Administrative Waste Services	2,780	3%	3,242	3%
Other Services	3,293	3%	3,191	3%
Mining	**4,570**	**5%**	**2,752**	**3%**
Professional and Technical Services	2,776	3%	2,585	3%
Information	2,871	3%	2,356	3%
Wholesale Trade	2,755	3%	2,072	2%
Arts, Entertainment, and Recreation	2,251	2%	983	1%
Utilities	999	1%	942	1%
Real Estate and Rental and Leasing	963	1%	912	1%
Management of Companies and Entpr.	955	1%	662	1%
Agriculture, Forestry, Fishing & Hunting	248	0.3%	249	0.3%
Total, all industries*	95,157		92,668	

Table Error! No text of specified style in document.**.10-9 Employment Characteristics of Selected East Range Cities in St. Louis County, 2000**

		Aurora	Babbitt	Biwabik	Ely	Hoyt Lakes	Tower	All Cities	St. Louis County	State of Minnesota
		Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent
Occupation (SOC Title)	Management, professional, and related occupations	29%	19%	24.90%	30%	21.90%	16.20%	25.57%	30.50%	35.80%
	Service occupations	20.50%	18.20%	24.10%	21.40%	18.60%	23.40%	20.56%	18.20%	13.70%
	Sales and office occupations	15.90%	25.70%	16.20%	23.80%	20.40%	27.70%	21.66%	26.20%	26.50%
	Farming, fishing, and forestry occupations		0.30%		0.40%			0.20%	0.50%	0.70%
	Construction, extraction, and maintenance occupations	14.80%	12.70%	19.60%	14.60%	18%	16.60%	15.55%	11.90%	8.40%
	Production, transportation, and material moving occupations	19.70%	24.10%	15.10%	9.80%	21.10%	16.20%	16.45%	12.80%	14.90%
Occupation (SOC Title)	Management, professional, and related occupations	29%	19%	24.90%	30%	21.90%	16.20%	25.57%	30.50%	35.80%
	Service occupations	20.50%	18.20%	24.10%	21.40%	18.60%	23.40%	20.56%	18.20%	13.70%
	Sales and office occupations	15.90%	25.70%	16.20%	23.80%	20.40%	27.70%	21.66%	26.20%	26.50%
	Farming, fishing, and forestry occupations		0.30%		0.40%			0.20%	0.50%	0.70%
	Construction, extraction, and maintenance occupations	14.80%	12.70%	19.60%	14.60%	18%	16.60%	15.55%	11.90%	8.40%
	Production, transportation, and material moving	19.70%	24.10%	15.10%	9.80%	21.10%	16.20%	16.45%	12.80%	14.90%

		Aurora	Babbitt	Biwabik	Ely	Hoyt Lakes	Tower	All Cities	St. Louis County	State of Minnesota
		Percent	**Percent**	**Percent**	**Percent**	**Percent**	**Percent**	**Percent**	**Percent**	**Percent**
	occupations									
Industry NAICS Title)	Agriculture, forestry, fishing and hunting, and mining	19.10%	16.90%	16.80%	10.30%	19.70%	7.20%	14.92%	5.70%	2.60%
	Construction	3.70%	2.90%	7%	6.70%	4.70%	8.90%	5.43%	5.90%	5.90%
	Manufacturing	7.10%	14.80%	9.50%	5%	15.40%	10.60%	9.43%	7.80%	16.30%
	Wholesale trade	2.10%	2.30%	1.70%	1.30%	0.80%	1.30%	1.47%	3.10%	3.60%
	Retail trade	11.20%	13%	10.40%	13.60%	10.50%	14%	12.25%	13.00%	11.90%
	Transportation and warehousing, and utilities	4.60%	5%	3.60%	2%	4.70%	6.40%	3.74%	6.50%	5.10%
	Information	1%	1.10%	1.70%	3.20%	1.50%		1.93%	2.80%	2.50%
	Finance, insurance, real estate, and rental and leasing	4.10%	4.70%	2.20%	5.80%	2.40%	3.80%	4.29%	4.60%	7.20%
	Professional, scientific, management, administrative, and waste management services	0.90%	2.90%	4.20%	6.50%	5.10%	1.30%	4.35%	5.20%	8.80%
	Educational, health and social services	25.90%	17.90%	18.80%	25.90%	20.30%	13.20%	22.47%	25.70%	20.90%
	Arts, entertainment, recreation, accommodation and food services	11.60%	7.80%	13.20%	12.50%	9.60%	22.10%	11.68%	10.10%	7.20%
	Other services (except public administration)	6.40%	5.90%	7%	4.10%	3.30%	7.20%	4.97%	5.00%	4.60%
	Public administration	2.40%	4.70%	3.90%	3.20%	1.90%	3.80%	3.08%	4.60%	3.40%

Source: U.S. Census Data, 2000. Data unavailable for the city of Soudan, Minnesota

Table 4.10-10 St. Louis County Industries Employment Compared to the State of Minnesota in 2004

2004 Data	State	County	Location Quotient
Total, All Industries	**2,577,178**	**92,668**	
Mining	5,182	2,780	14.9
Utilities	13,195	951	2.0
Health Care and Social Assistance	358,214	20,772	1.6
Public Administration	115,739	5,978	1.4
Accommodation and Food Services	203,091	8,996	1.2
Retail Trade	297,772	12,305	1.1
Educational Services	196,587	7,814	1.1
Other Services	85,026	3,223	1.1
Information	63,786	2,380	1.0
Transportation and Warehousing	98,921	3,346	0.9
Construction	132,521	3,965	0.8
Finance and Insurance	136,280	3,770	0.8
Administrative and Waste Services	120,537	3,274	0.8
Real Estate and Rental and Leasing	37,874	921	0.7
Professional and Technical Services	117,780	2,611	0.6
Arts, Entertainment, and Recreation	46,635	993	0.6
Wholesale Trade	127,476	2,093	0.5
Manufacturing	341,024	5,559	0.5
Agriculture, Forestry, Fishing & Hunting	16,380	251	0.4
Management of Companies and Enterprises	63,161	669	0.3

.Source: Employment, Economic and Social Impacts of PolyMet Mining, Inc.'s NorthMet Project and other Industrial Projects of Minnesota's East Range Communities, February 2006, PolyMet Mining, Inc

4.10.1.5. Public Finance

Sales and use tax revenues from St. Louis County by all industries and the mining industry are summarized in Table 4.10-11. This table outlines information compiled by the Minnesota Department of Revenue and illustrates the relative sales and use tax contribution from the mining industry in the State

The mining and processing of base and precious metals in the State are not currently subject to production tax. However, this activity is subject to ad valorem tax; net proceeds tax; occupation tax; sales and use tax (6.5% sales and use on all purchases that do not qualify for an exemption); severed mineral interest (if applicable); and withholding tax on royalty payments (if applicable). Ad valorem taxes are established by the county, local communities, and school districts according to Minnesota State law. The Project would be subject to this tax. Occupation tax is equal to 2.45% of the taxable amount. The starting taxable amount for the occupation tax is the mine value as determined by the Minnesota Department of Revenue. Revenue generated through the occupation tax is credited to the general fund, where 10% supports the University of Minnesota, 40% supports elementary and secondary schools, and 50% remains in the state's general fund.

Table 4.10-11 Select St. Louis County Sales and Use Tax Statistics

	Total Tax (Sales and Use)(in $1,000)	
Year	**All Industries**	**Mining**
1986*	Not Reported	Not Reported
1996	$97,492	$5,584
2000	$114,011	$4,155
2003	$146,182	$4,508
2004	$155,227	$4,356
2005	$163,022	$5,544

Source: Minnesota Department of Revenue: *Minnesota Sales and Use Tax Statistics, County by Industry Annual*. Total taxes for 1986 were not reported. Data prior to 1986 was not available. Mining data reported for 1986 as "metal mining", for 1996 and 2000 as the combination of "metal mining" and "mining, nonmetallic". Data reported for 2003 through 2005 as "mining – all other" and "mining – support activity"

Table 4.10-12 Housing Characteristics of Selected East Range Cities

	Aurora	Babbitt	Biwabik	Ely	Hoyt Lakes	Tower	All Cities	St. Louis County	State of Minnesota
Total housing units	**893**	**801**	**492**	**1,912**	**995**	**295**	**5,388**	**95,800**	**2,065,946**
Occupied housing units	812	735	454	1,694	916	233	4,844	82,619	1,895,127
Percentage	90.9%	91.8%	92.3%	88.6%	92.1%	79.0%	89.9%	86.2%	91.7%
Owner-occupied	654	656	376	1,209	840	171	3,906	61,683	1,412,865
Percentage	80.5%	89.3%	82.8%	71.4%	91.7%	73.4%	80.6%	74.7%	74.6%
Renter-occupied	158	79	78	485	76	62	938	20,936	482,262
Percentage	19.5%	10.7%	17.2%	28.6%	8.3%	26.6%	19.4%	25.3%	25.4%
Vacant housing units	81	66	38	218	79	62	544	13,181	170,819
Percentage	9.1%	8.2%	7.7%	11.4%	7.9%	21.0%	10.1%	13.8%	8.3%
Median value*	$46,900	$44,200	$43,400	$56,900	$39,100	$55,800	$45,550	$75,000	$122,400

Source: U.S. Bureau of the Census, Census 2000 Demographic Profile Highlights as reported in Employment, Economic and Social Impacts of PolyMet Mining, Inc.'s NorthMet Project and other Industrial Projects of Minnesota's East Range Communities, February 2006, PolyMet Mining, Inc., modified for inclusion of the city of Ely, Minnesota. Data unavailable for the city of Soudan, Minnesota.

Note: *Single-family owner-occupied home

4.10.1.6. Housing

Table 4.10-12 illustrates the housing characteristics of the East Range communities, St. Louis County, and the State. Though the population of these communities has declined (Table 4.10-1), the East Range communities have a lower percentage of available housing than the County. This percentage is supported by the demographic trends of aging population and lower household size. The elevated percentages of owner-occupied housing units versus renter-occupied units over the County and State are also indicative of these trends.

In addition to available housing, representatives of individual cities in the East Range have suggested that there is capacity for housing expansion (Employment, Economic and Social Impacts of PolyMet Mining, Inc.'s NorthMet Project and other Industrial Projects of Minnesota's East Range Communities, February 2006, PolyMet Mining, Inc.).

4.10.1.7. Public Services

Water and Sewer

Most of the infrastructure supporting the East Range communities was constructed to accommodate a larger population than currently resides in the area. All of the East Range communities have public water and wastewater systems, with varying degrees of available capacity. The wastewater treatment facility in the City of Babbitt has a total capacity of 500,000 gallons per day (gpd) with an actual daily load of 200,000 to 300,000 gpd, according to the manager of the facility. According to representatives of the Hoyt Lakes Wastewater Treatment facility, the design capacity of the facility was 1.2 million gpd, while the current maximum daily load of the facility was 670,000 gpd with average daily loads ranging between 250,000 and 300,000 gpd.

Police

The East Range communities are served with police protection either through their own department or via contract with St. Louis County. Local communities provide continuous police service at the following staffing levels:

- Aurora – one sergeant, four deputies
- Babbitt – one officer
- Biwabik – four officers
- Hoyt Lakes – five full-time and five part-time officers
- Ely – seven officers

- Tower and Soudan – two full-time and four part-time officers

Fire Protection

The East Range cities all have volunteer fire departments. Officials from the City of Babbitt indicate that they have state-of-the-art fire-fighting equipment and that they currently provide emergency service to the Northshore Mine. The volunteer fire department for the City of Ely includes over 30 volunteers and provides fire and rescue services for approximately 400 square miles of northeastern Minnesota.

Medical Services

There is available ambulance service to each of the assessed East Range communities. The City of Aurora contracts with the City of Hoyt Lakes for this service.

The East Range communities are served by both medical clinic and hospital facilities. The nearest emergency center to the City of Hoyt Lakes is the White Community Hospital. This facility is located in Aurora and has 16 hospital beds. The nearest trauma facility to the City of Babbitt is the Ely Bloomenson Community Hospital located in Ely. The City of Babbitt officials indicate that response time for emergencies is generally five minutes, with a 15-minute trip to the emergency room.

For services not provided by these facilities, residents travel to Ely, Virginia, or Duluth, Minnesota. The Virginia Regional Medical Center in Virginia, Minnesota has 83 hospital beds.

Schools and Libraries

The area school systems were originally constructed to accommodate a greater population than is currently living in the region, so there is capacity for growth. The City of Aurora has closed schools and combined them with adjacent communities. The City of Babbitt is using former education buildings to house municipal facilities. The City of Ely contains an elementary school, high school, and the Vermilion Community College. The selected East Range communities have available library services, though most libraries share building space with municipal or education facilities.

4.10.1.8. Commercial/Retail Centers

Commercial and retail activities occur in all of the East Range communities, but only to a limited extent, and the success of these operations has declined in recent years. Residents obtain basic goods and services in their communities and in the

Project area, and travel to Duluth or Virginia to purchase items that cannot be acquired locally.

4.10.1.9. Recreational Facilities/Gathering Places

The Superior National Forest including the BWCAW, and Voyageurs National Park are important recreation areas in the region. The Superior National Forest includes approximately 3 million acres and provides recreation opportunities for camping, boating, fishing, hiking, viewing scenery, off-highway vehicle (OHV) riding, wilderness related recreation, snowmobiling and cross country skiing. Located 20 miles to the north of the East Range communities, the million–plus-acre BWCAW is protected as part of the National Wilderness Preservation System. The National Wilderness Preservation System prohibits the use of motorized vehicles with the exception of limited motor craft use on certain, designated lakes.

Each of the East Range communities has access to at least one large and several smaller parks for recreational use. These parks, as well as area beaches, teen centers, gyms, and athletic arenas serve as both recreational facilities and gathering places for the local communities.

Tourism provides a significant percentage of the economies of some of the East Range communities, especially Biwabik and Tower. According to the 2000 census, 22.1% of employment in the City of Tower was attributed to the NAICS category including, “arts, entertainment, recreation, accommodation and food services” while 7.2% was attributed to the category including “agriculture, forestry, fishing and hunting, and mining.”

The Iron Range region affords various outdoor tourism activities including cross-country skiing, hiking, biking, water sports, OHV/ ATV paths, snowmobiling, fishing, hunting and camping.

Computer Access Facilities

Computers are available for use through educational facilities, libraries, and municipal facilities. The communities also have access to private internet service providers.

4.10.1.10. Community Structure

East Range cities use one of two types of government structures, as described below:

- Plan A City – City council including an elected mayor and four to six elected council members. A clerk and treasurer are appointed; neither serve on the city council. The cities of Babbitt, Hoyt Lakes, and Aurora have this form of government.

- Home Rule Charter City – Design own government through the adoption of a charter. The cities of Biwabik, Tower, and Ely have this form of government.

Participation in Voluntary Associations

City administrators and clerks of the East Range Cities provided the following partial list of organizations in which residents in the area may participate. This list is not exhaustive and may not include additional small organizations and business groups.

- Rotary Club
- Civic Association
- Veterans of Foreign Wars (VFW)
- Lions Club
- Knights of Columbus
- American Legion
- Lions – Leo Club
- Church groups
- Chamber of Commerce
- East Range Readiness Committee
- East Range Women of Today
- Athletic clubs
- Garden clubs
- Seasonal/community events committees

4.10.2. Impact Criteria

Socioeconomic aspects assessed to evaluate potential beneficial and adverse effects of the proposed Project on the local region include the following:

- Changes in local population, employment, or earnings associated with Project operations.
- Changes in demand for temporary or permanent housing during Project construction, operation, and closure periods.
- Changes in long-term demands on public services and infrastructure that consume capacities in these systems, either triggering the need for capital

expansion or resulting in a discernable reduction in the level of service provided.

- Changes in public sector revenues or expenditures, or the underlying fiscal conditions of local governments.
- Displacement or other use of property that affects residences or businesses.
- Changes induced in the social or business community that can cause important changes in organizational structures, local government, or traditional lifestyles of the community.
- Disproportionate effects on minority or low-income populations, including human health or environmental effects.

4.10.3. Socioeconomic Consequences

This section describes potential effects on population, income, employment, public finance, housing, and public services, which include water and sewer, fire protection, medical services, schools, libraries, commerce/retail centers, and community structure.

The economic multiplier effect for St. Louis County was estimated using the IMPLAN model completed by the University of Minnesota Duluth (UMD) Labovitz School of Business and Economics Bureau. Economic baseline conditions are based on the economic activity reported in the most recent tax year available in St. Louis County for IMPLAN data (2002) and the 2000 census. Direct, indirect, and induced effects are included in the overall economic impact, which was converted from 2004 to 2007 data. The UMD model defined effects in the following way:

- Direct effects - Initial new spending in the study area resulting from the Project.
- Indirect effects - Additional inter-industry spending from the direct impacts.
- Induced effects - Impact of additional household expenditure resulting from the direct and indirect impacts.

Because the nature and magnitude of construction and operation activities are different, the effects of these activities on the communities will differ. For instance, it is assumed that a greater percentage of local labor would be used during the operations phase than during construction. These differences are reflected in the IMPLAN calculated multiplier for the two phases of the Project.

4.10.3.1. Proposed Action

Environmental Justice

The Project was evaluated for effects relating to the social, cultural, and economic well-being and health of minorities and low-income groups through a review of socioeconomic and demographic data compiled from the 2000 U.S. Census. Such effects are termed environmental justice issues, and none were identified for the NorthMet Project. Minority populations in the affected communities do not comprise over 50 percent, In addition, in 2000 (US Census) the Native American population was 2.1% of St Louis County, Minnesota. The same census reported 1.2% Native American across the State of Minnesota. Therefore the Proposed Action and alternatives would not adversely affect minority groups disproportionately. While there are an elevated percentage of families below the poverty level in the East Range communities as compared with the State, the Project would create an economic benefit to the community and would not appear to create significant adverse social impacts.

As discussed in section 4.8.3.1, the proposed Project area overlaps the 1854 Ceded Territory, where certain tribal communities retain rights to hunt, fish, and gather on public lands. With 2.1% of Native Americans living in St Louis County, Minnesota, few members of these tribal communities live in the immediate vicinity. Further discussion of tribal use of Project area resources is provided in Section 4.8.

Population

Construction Period

Construction activities are estimated to create an average of 347 full-time equivalent (FTE) direct construction jobs over an 18-month period. The projected peak labor force for the construction activities is 800 individuals. Typical construction involves fluctuating work flows, as specialized crews may be employed for short duration tasks. Any population increases during construction would be temporary (18 months or less). It is anticipated that the majority of the labor force would be from Minnesota.

Due to proximity to population centers such as Duluth, it is estimated that 60% of construction labor would commute on a daily or weekly basis. It is estimated that approximately 15% would seek more permanent residence and the remaining jobs would be filled by local residents. Given the short duration of the construction, it is assumed that non-local workers would not relocate their families. In-migrating construction workers are estimated at approximately 50 to 100 individuals. This represents less than a 2% increase to the 2004 population of the East Range communities.

Operating Period

Current operating period labor force projections are estimated at 448 employees. Due to the estimated 20-year operating life of the facility, it is estimated that approximately 55% of labor for operations would be non-local and would relocate to the East Range; 20% would commute daily or weekly from centers such as Duluth; and the remaining labor would be local. In-migrating operations workers are estimated at approximately 247 individuals. In order to estimate the number of individuals relocating to the area to fill direct jobs, of these in-migrating workers, 25% are assumed to be single or married without families present, and 10% of the married households are assumed to be two-worker families. As a conservative estimate, married households are assumed to be equivalent to the Minnesota State average of 3.09 persons per household. This suggests that an additional 351 family members would relocate to the East Range for a total direct population influx of 598 individuals.

IMPLAN modeling suggests that approximately 553 indirect and induced jobs would be created by the Project. In order to estimate the number of individuals relocating to the area to fill indirect and induced jobs, it is assumed that 70% of the indirect labor force would be second persons in a direct labor household or current resident of the East Range. Of the remaining 30% percent, it is estimated that 10% would commute daily or weekly from other population centers, and 20% would be non-local and seek to relocate to the East Range. Relocating operations workers are estimated at approximately 111 individuals. Of these individuals, 40% are assumed to be single or married without families present, and half of the married households are assumed to be two-worker families. Utilizing an average family size of 3.09 persons suggests that an additional 88 family members will relocate to the East Range, for a total indirect and induced population influx of 199 individuals.

The total estimated population influx from direct, indirect, and induced employment would be 797 people.

Closure Period

After closure of the mine, it is estimated that a reduced number of employees and contractors would remain employed for a few years to perform post-mining activities such as demolition and reclamation. These activities would likely be followed by several years of operations and maintenance of reclamation activities. Unless new industry is developed in the East Range area prior to completion of these activities, it is assumed that 95 percent of working-age people formerly employed by the NorthMet Project would need to secure alternative local employment or would leave the area after this time. Approximately five percent of working-age people formerly employed by the NorthMet Project would remain to help with long-term closure activities.

Housing

Construction Period

It is anticipated that demand for temporary housing during the construction period would increase. The majority of the labor force would likely either commute from nearby city centers or would be existing members of the East Range community. It is estimated that on average between 100 and 200 individuals would seek temporary accommodations. The cities of Hoyt Lakes and Biwabik both have available temporary accommodations in the form of hotels and lodges. The hotel in Hoyt Lakes has 40 rooms, while Biwabik has at least 129 units. The adjacent communities of Virginia and Eveleth each have several hotels. Availability of hotels in the East Range communities and surrounding areas should be sufficient to meet demand given the total number of available rooms.

Operating Period

Demand for permanent housing is likely to increase during the operating period. Based upon population estimates previously presented, there would be approximately 247 in-migrating workers, all but 10%[1] of whom would seek independent housing. As previously discussed, the total population influx for direct, indirect, and induced employment effects is estimated at 797. This translates into an estimated increase in households of 358; the actual number may be lower than this due to two-worker in-migrating households. In addition to existing housing vacancies, East Range cities' staff and officials indicate that there is sufficient land to accommodate such growth. New home construction would increase demand for construction labor; this demand may exceed the local area's construction capacity and as such it would be necessary to bring labor in from outlying metropolitan areas (e.g., Duluth).

Closure Period

During the closure period, it is likely that the demand for housing would drop as workers migrate from the area, leaving a portion of available housing vacant. In

[1] Assumed 10% of workers will commute weekly from larger centers and stay in hotels / motels, rather than seek independent housing

addition, new housing built to originally accommodate the employment generated by the Project would have high vacancy rates as well. After some time, the baseline vacancy rate for existing properties should return. Given the duration of the Project and the difficulty in predicting other economic development and conditions that would occur in the area during and after the operation of the Project, a post-closure vacancy rate has not been established.

Income and Employment

Construction Period

As noted previously, the construction labor force is estimated at approximately 347 FTE positions, peaking at 800 individuals for a short period of time. Local labor is estimated to fill approximately 25% of the direct Project jobs. IMPLAN modeling conducted for the Project suggests that approximately 233 indirect and induced jobs would be created during the construction phase, for a total of 580 FTE jobs generated.

Total labor costs for the construction activities (local and non-local) over the estimated 18 month period are estimated to be $50 million in 2007 dollars. In addition to labor expenditures, an estimated $165 million is projected to be spent for capital equipment (local and non-local).

Operating Period

The projected labor force for the steady state operating period is estimated at 448 FTE. Table 4.10-13 illustrates the employment levels by trade. IMPLAN modeling conducted for the Project suggests approximately 553 FTE indirect and induced jobs would be created, for a total of 1,003 FTE jobs generated.

Table 4.10-13 Anticipated steady state operation employment levels

Area	Total Number
Management	13
Mine Operations – Contract supervision, operators, maintenance	149
Mine technical – Geology, grade control, planning	18
Railroad operations	25
Plant operations	199
Sample preparation and analytical laboratory	19
Finance, purchasing, marketing, environmental, HR	25
Total	**448**

Based upon data provided by PolyMet, an estimated $130 million would be spent per year of operation on wages, consumables, power, maintenance, and contract services. IMPLAN modeling estimates an additional $58.5 million would be spent in the region for a total of $188.5 million.

Closure Period

As mentioned previously, during closure and reclamation it is assumed that a reduced number of jobs and materials would be required; the remainder of the 448 jobs would be terminated and additional expenditures related to mining activity would cease.

Public Finance

The NorthMet Project would be subject to the Minnesota net proceeds tax, which is a 2% tax on net proceeds. The net proceeds are calculated as the gross proceeds, less allowable deductions. Net proceeds taxes are distributed as follows:

- 5% to the city or town where the minerals are mined or extracted
- 10% to the Municipal Aid Account (distributed to qualifying cities and townships)
- 10% to the school district where mining or extraction occurred
- 20% to the Regular School Fund (split between 15 school districts in the Taconite Relief Area)
- 20% to the county where mining or extraction occurred
- 20% to Taconite Property Tax Relief, using St. Louis County as a fiscal agent (distributed to qualifying owner-occupied homes and farms in the taconite relief area)
- 5% to Iron Range Resources (IRR)
- 5% to the Douglas J. Johnson Economic Protection Trust Fund
- 5% to the Taconite Environmental Protection Fund

Mining and processing organizations are subject to a 6.5% tax on all purchases that do not qualify for the industrial production exemption.

NorthMet tax impacts are based upon IMPLAN model estimates as described for the various Project phases as well as available information for the State's tax system as described in Section 4.10.1.4. The IMPLAN model assumes typical business operation and excludes tax structures such as net proceeds. Tax impacts from direct and induced effects included in the model are personal income taxes, indirect business taxes, and other taxes paid by the affected sector.

Construction Period

IMPLAN modeling estimates the Federal Government would receive approximately $5.4 million and the State and Local Government would receive $2.5 million in taxes for the construction of the NorthMet Project. Sales and use taxes paid on items purchased for new mining and processing facilities in the State qualify for refund.

Operating Period

The majority of economic benefits to the local community through taxes would be realized during the operating period. IMPLAN modeling estimates that after an initial operation ramp up, during a typical year of operation the Federal Government would receive $17.3 million and the State and Local Governments would receive $14.5 million in taxes from the operation of the NorthMet Project, excluding net proceeds tax. PolyMet estimates that total taxes throughout the operating period would vary from $22 to $47 million per year.

The 2% net proceeds tax collected during the operations phase would be distributed as described in Section 4.10.1.4. Tax dollars collected would benefit communities throughout the Iron Range in addition to the city and school district where the mining occurs.

Minnesota mining and processing organizations are subject to a 6.5% tax on all purchases that do not qualify for the industrial production exemption. The majority of items used or consumed for mining and processing (e.g., chemicals, fuels, lubricants, explosives), however, are subject to this exemption.

Closure Period

It is assumed that after closure of the facility is complete, the public finance through taxes paid would return to baseline values.

Transportation

The Project has two access points: the Main Gate at the end of County Road (CR) 666 and the North Gate on MN 135. Many of the building materials and some labor for Project construction and operation are expected to be transported from Minneapolis/St. Paul. These goods would be transported along Interstate 35, MN 33, US 53, MN 37, MN 135, CR 110, and CR 666 to the Main Gate. Heavy loads would bypass Hoyt Lakes (CR 110 and CR 666) and use the North Gate on MN 135. Some materials will be transferred via Lake Superior and through the ports of Duluth and Superior. These goods will likely be transported along US 53, MN 37, MN 135 or CR 4, MN 135, and the rest of the route to the Main Gate or North Gate described above. Refer to figure 4.10-2 showing mapped routes. The East Range communities may be affected by increased travel times over baseline times due to the increased amount of traffic on the roadways; however, projected traffic values are less than traffic associated with former LTVSMC operations and the Project would use the same road infrastructure. Since there are no significant impacts anticipated with traffic, a traffic study has not been performed.

With the closure of the mine, it is anticipated that traffic would revert to current levels.

Product from the mine and some raw materials used on site would be shipped via rail. A common carrier (Canadian National) rail spur serves the Project area. A PolyMet plant switch engine would move rail cars to and from their destination within the Project, and a private railroad connects the Plant Site to the Mine Site.

Public Services

During interviews conducted by the Bureau of Business and Economic Research at UMD, city officials in the East Range indicated that they anticipate limited problems accommodating the influx of people that construction and operation of the NorthMet Project may bring. For instance, representatives of the cities of Hoyt Lakes and Babbitt indicated nearly 50% capacity is available in their wastewater treatment facilities.

Emergency and medical services are currently equipped to handle similar area operations and East Range communities have mutual aid agreements in place to cooperatively respond to major emergencies. The addition of police, fire, and ambulance staff may be required to service an expanded population.

Renovations of existing school buildings and additional teachers may be needed to accommodate additional school-age children in the area.

With the closure of the mine, it is anticipated that demands on public service would decrease to current or slightly elevated levels because of a potential decrease in population. Some individuals may choose to remain in the area, maintaining a slightly elevated demand.

Commerce/Retail Centers

The Project would not displace any existing residences or businesses. On the contrary, commercial and retail businesses are expected to expand to meet increased market demand. This translates into the increased size of existing businesses and addition of new commercial and retail enterprises.

Post-closure and reclamation activities are expected to generate 20 to 50 jobs for many years, so local business would continue to be used; however, subsequent complete closure would likely result in a reduction in retail spending to baseline levels.

Recreation

The area directly impacted by the Project is part of the Superior National Forest. The project will reduce access to the site for hiking, fishing, and hunting. Limited hunting activities occur in this area. The proposed Project area is not heavily used for tourism or recreation. During both construction and operations phases, the project will generate some noise and light which may impact the recreational experience. Boating impacts associated with water level changes in both the Embarrass and Partridge Rivers should be minor; some impacts may be experienced by recreational users of Whitewater Reservoir due to water level reductions.

Community Structure

The construction and operation of the proposed NorthMet Project is unlikely to significantly affect community structure. A potential 797 person population increase may prompt the addition of a few additional city staff, but participation in community groups and functions is expected to remain similar to the baseline period.

4.10.3.2. Alternatives

No Action

Under the No-Action alternative, current trends of declining employment in the mining industry, population decline, underutilized housing, and aging population in St. Louis County and the East Range communities would likely continue. There is evidence, however, that increased non-ferrous mining, iron mining, and steel production are entering the area now, which may reverse these negative trends.

Subaqueous Disposal of Reactive Waste Rock

The alternative of subaqueous disposal of the most reactive waste rock would have no discernible socioeconomic impacts on the local community.

4.10.4. Cumulative Impacts

An assessment of both economic and social cumulative effects evaluated the combined impacts of past, present, and future projects on the East Range and St. Louis County (Table 4.10-14). Cumulative economic impacts were initially assessed through IMPLAN modeling of the baseline economic activity, average annual employment projections (year by year), and estimated construction costs (year by year) for the past and future actions identified in the Final Scoping Document (FSD) (Tables 4.10-15 and 4.10-16). These quantitative results were then evaluated in the context of additional reasonably foreseeable future projects identified subsequent to the FSD to describe both economic and social effects.

Table 4.10-14 Summary of Economic and Social Cumulative Effects

Project[2]	Temporal Scale	Potential Cumulative Effect
Projects Identified in FSD[3]		
Shutdown of LTVSMC mine	Past	In 2000, LTV Steel Company, Inc., a subsidiary of the LTV Corporation, announced its intent to close all operations due to blast furnaces experiencing lower levels of productivity and high costs as a result of poor taconite pellet quality. Approximately 1,400 people were employed by the company at this time. The shutdown of the facility decreased employment needs in the area, thereby influencing the economic condition of the region.
MACT standards	Present	St. Louis County has a significant taconite mining presence and has three coal-fired power plants. These facilities are currently subject to MACT standards that may increase the price of their products. These economic impacts may be felt by the community at large, particularly if utility prices increase as a result of the standards.
Proposed NorthMet Project	Future	Cumulative impacts for these projects were quantified using the IMPLAN model for years one through five. Table 4.10-15 illustrates estimated impacts from the construction of each project. Maximum employment effects are estimated at 1,874 jobs in year two; employment is considered the primary driver for social impacts to the community. Table 4.10-16 illustrates estimated impacts from the operation of each project. Maximum direct employment effects are estimated at 1,641 jobs in year five.
Proposed Mesabi Nugget Plant Phase I	Future	
Proposed Cliffs-Erie Railroad Pellet Transfer Facility	Present	
Proposed NO*v*A Off-Axis Detector	Future	
Proposed expansions of existing taconite plants	Future	
Projects identified subsequent to the FSD		
Establishment of the Erie Mining Company (aka LTVSMC) (1950s)	Past	The Erie Mining Company peaked in 1970 employing over 3,000. The LTV Corporation acquired full ownership in 1986 and modernized the operations, thereby increasing efficiency and production. The establishment of this company and its evolution in the Hoyt Lakes area helped launch a community based on mining, thereby affecting economic and social conditions of the region.
Northshore Mining Company mine site crusher operations	Present	The Northshore Mining Company crusher operations in Babbitt reduce boulder-size chunks of taconite to small pieces. This project contributes to cumulative economic benefits to the local community as an employment provider.
Minnesota Power Syl Laskin Energy Center operations	Present	This facility, located on Colby Lake, adds employment to the local communities, thereby representing an additional economic benefit that would contribute cumulatively with others activities.
Ispat Inland Mine Pit (Mittal mine)	Present	This project would extend the life of Mittal's existing ore processing facility through 2024 and extend the existing employment and tax benefits to the community.
Proposed Cliffs Erie Railroad Pellet Transfer Facility	Future	This facility would store and transfer taconite iron pellets at Hoyt Lakes from the Hibbing and United Taconite mines before being shipped to docks at Taconite Harbor. This facility would contribute to cumulative economic benefits to the local community through employment and increased tax base.

[2] The economic impact modeling (IMPLAN) was conducted prior to February 2006. Projects that were proposed and in the public domain at the time of modelling are included in the economic modeling.

[3] For additional information on these projects, refer to the Employment, Economic and Social Impacts of PolyMet's NorthMet Project and other Industrial Projects of Minnesota's East Range Communities, February 2006, PolyMet Mining, Inc (RS72). Because the cumulative effects were modeled in IMPLAN, this initial analysis was limited to economic impacts only and did not take into account cumulative social impacts, such as housing, community services, and family effects.

Project[2]	Temporal Scale	Potential Cumulative Effect
NO*v*A Off-Axis Detector	Future	This project would construct a facility to study electron neutrino oscillations. This facility would contribute to cumulative economic benefits to the local community through employment and increased tax base.
Proposed Mesaba Energy power generation (coal gasification station)	Future	The Mesaba Energy Project proposes a 606 megawatt (MW) integrated gasification combined-cycle (IGCC) power plant in Taconite, Minnesota. This project would create over 1,000 construction jobs during the four-year construction phase and over 100 jobs during plant operation. Approximately 290 additional indirect jobs are expected during plant operation. The plant will also expand the tax base in Itasca County and provide a significant source of property tax revenue. Itasca County is immediately west of St. Louis County and its economic impacts would provide beneficial cumulative effects to the region. This project was initially looking at Hoyt Lakes for a potential site in addition to Taconite. When IMPLAN modeled cumulative effects, the preferred site was in Hoyt Lakes. Since then the preferred site has become Taconite with Hoyt Lakes as an alternate. Because of this change, the modeled cumulative impacts are higher than expected for the modeled projects.
Proposed Minnesota Steel DRI/ steel plant	Future	Minnesota Steel is developing a $1.6 billion fully integrated mining through steelmaking project in Nashwauk, Minnesota. This project will employ 2,000 skilled workers for two years during construction and 700 employees during operation. Approximately 2,100 indirect and induced jobs should be created because of the facility's construction and operation.
Proposed Minnesota Steel taconite mine and tailings basin	Future	Minnesota Steel also proposes to reactivate the former Butler Taconite open mine pit approximately three miles southwest of Nashwauk. Ore from the mine would be hauled to the ore processing facility and tailings would be transported via pipeline to the existing Butler Taconite tailings basin two miles southeast of the mine. This project would employ approximately 700 full-time employees. Because both this project and Minnesota's Steel's new steel project are located near the St. Louis County border and would have such a significant economic impact on its local community, regional effects are expected that would cumulatively impact the NorthMet project.
Proposed Mesabi Nugget Phase II (mining operation)	Future	Mesabi Nugget Mining L.L.C. proposes to reactivate the LTVSMC Area 2WX and 6 mines and install a new crusher and concentrator with magnetic separation and flotation (Phase II Project) on the former LTVSMC property north of Hoyt Lakes. The project would produce iron oxide concentrate at the existing nugget plant on the former LTVSMC property. The project would employ approximately 250 skilled workers during construction and 124 during operation. This project would have an economic benefit on the local community and synergistic economic impacts with the effects of the NorthMet project through increased employment and tax base.
Proposed US Steel Keewatin taconite mine and plant expansion	Future	U.S. Steel proposes to reactivate an idled production line and expand the mine pit at its Keetac taconite mine and processing facility north of the Keewatin on the St. Louis County border. This project would increase Keetac's iron pellet production output by 3.6 million tons per year (total of 9.6 million tons per year). This project would employ approximately 500 skilled workers during construction and 70 workers during facility operation. This project would have a strong economic benefit on the local community and synergistic economic impacts with the effects of the NorthMet project through increased employment and tax base.

Table 4.10-15 Total Impacts from Construction, by Project, by Measure, by Year (2008 Dollars)

Year	Project Phase	Project[4]	Value Added	Employment	Output
Year 1	Construction	Mesabi Nugget	$16,010,014	299	$29,714,385
		Expansion Plants	$49,530,982	926	$91,928,877
		Total	**$65,540,996**	**1,225**	**$121,643,262**
Year 2	Construction	**NorthMet**	**$40,242,870**	**752**	**$74,690,351**
		Mesabi Nugget	$16,010,014	299	$29,714,385
		NOvA	$20,012,520	374	$37,142,981
		Expansion Plants	$24,015,022	449	$44,571,578
		Total	**$100,280,426**	**1,874**	**$186,119,294**
Year 3	Construction	NOvA	$20,012,520	374	$37,142,981
Year 4	Installation	NOvA	$6,766,708	128	$12,242,354
Year 5	Installation	NOvA	$6,766,708	128	$12,242,354

Source: Employment, Economic and Social Impacts of PolyMet Mining, Inc.'s NorthMet Project and other Industrial Projects of Minnesota's East Range Communities, February 2006, PolyMet Mining, Inc., modified using the U.S. Department of Labor Bureau of Labor Statistics Consumer Pricing Index Inflation Calculator (http://www.bls.gov/cpi/#overview) to adjust 2004 dollars to 2008 dollars.

4 The economic impact modeling (IMPLAN) was conducted prior to February 2006. Projects that were proposed and in the public domain at the time of modelling are included in the economic modeling.

Table 4.10-16 Total Impacts from Operations, by Project, by Measure, by Year (2008 Dollars)

Year	Project Phase	Project[5]	Value Added	Employment	Output
Year 1	Operation	Mesabi Nugget	$7,096,833	83	$21,559,937
		Expansion Plants	$15,921,736	177	$41,829,027
		Total	**$23,018,569**	**260**	**$63,388,964**
Year 2	Operation	**NorthMet**	**$106,588,271**	**529**	**$183,818,215**
		Mesabi Nugget	$42,580,994	158	$129,359,620
		Expansion Plants (1)	$15,921,736	177	$41,829,027
		Expansion Plants (2)	$37,150,713	236	$97,601,060
		Total	**$202,241,714**	**1,100**	**$452,607,922**
Year 3	Operation	**NorthMet**	**$160,274,310**	**1,058**	**$276,403,198**
		Mesabi Nugget	$42,580,994	158	$129,359,620
		Expansion Plants (1)	$15,921,736	177	$41,829,027
		Expansion Plants (2)	$37,150,713	236	$97,601,060
		Total	**$255,927,753**	**1,629**	**$545,192,906**
Year 4	Operation	**NorthMet**	**$160,274,310**	**1,058**	**$276,403,198**
		Mesabi Nugget	$42,580,994	158	$129,359,620
		Expansion Plants (1)	$15,921,736	177	$41,829,027
		Expansion Plants (2)	$37,150,713	236	$97,601,060
		Total	**$255,927,753**	**1,629**	**$545,192,906**
Year 5	Operation	**NorthMet**	**$160,274,310**	**1,058**	**$276,403,198**
		Mesabi Nugget	$42,580,994	158	$129,359,620
		Expansion Plants (1)	$15,921,736	177	$41,829,027
		Expansion Plants (2)	$37,150,713	236	$97,601,060
		NOvA	$1,094,915	12	$1,942,732
		Total	**$257,022,668**	**1,641**	**$547,135,638**

Source: Employment, Economic and Social Impacts of PolyMet Mining, Inc.'s NorthMet Project and other Industrial Projects of Minnesota's East Range Communities, February 2006, PolyMet Mining, Inc., modified using the U.S. Department of Labor Bureau of Labor Statistics Consumer Pricing Index Inflation Calculator (http://www.bls.gov/cpi/#overview) to adjust 2004 dollars to 2008 dollars

Conclusions

The degree of potential cumulative social and economic impacts from construction and operation of the above-mentioned projects depend on project timing. The beneficial effects include increased employment opportunities, a larger tax base, and increased county revenue from property taxes.

However, potential increases in construction and other related employment, as well as population, would increase pressure on housing, schools, and hospitals, and other community services and infrastructure. Employment and population

5 The economic impact modeling (IMPLAN) was conducted prior to February 2006. Projects that were proposed and in the public domain at the time of modelling are included in the economic modeling.

changes during a single construction event typically follow a bell curve, with the peak of the curve coinciding with the peak of construction activities. However, when multiple projects occur within the same time period, the magnitude of the peak is significantly increased over a relatively short duration, causing more disruptive impacts and increased stresses on existing infrastructure.

Potential social impacts from construction activities are typically temporary and localized. As with the demand on public services, if multiple construction projects occur within the same time period there may be a more intense period of social disruption due to rapid increases in population. In the case of the operations described above, it is less likely that construction workers with families would relocate (or that the workers would relocated their families to the region). This demography suggests an increased risk of a significant change to population and social dynamics with the likely influx of single, transient males.

However, it is more likely that heavy construction activity associated with the projects described above would be staggered, and that the disruption period may be less intense over a longer duration, allowing for infrastructure and resources to expand to accommodate growth. With staggered construction activities there is also a greater opportunity for incoming workers to provide their services to multiple projects over a longer period of time. This would reduce the total number of new workers needed for the projects described above. It also increases the likelihood that construction workers would relocate their families and become active participants in the community.

The operations phase typically provides a more stable and sustainable work force than the construction phase. Impacts from the operation of a project are typically longer term, also allowing the community to respond to expand infrastructure and services over time. Operations employees are more likely to relocate their families to neighboring communities for the life of the project and become integral members of the community. While the influx of employees would place pressure on housing, schools, hospitals, and other infrastructure, the East Range communities have historically had higher levels of employment than currently exists today suggesting that these communities already have some capacity to accommodate increased activity without increasing pressure on public services. In addition, any capacity building during the construction phase would serve to reduce pressure posed during operations.

4.11. VISUAL RESOURCES

4.11.1. Existing Conditions

The NorthMet Project lies within, and adjacent to, the SNF in northeastern Minnesota. The SNF provides over three million acres of rich and varied resources, including timber for the forest products industry, over 445,000 acres of surface waterways for recreational use, and historical mining and logging operations (USFS, 2007). The visual character of the Project area varies between upland forests and bog wetlands to developed industrial areas. There are several mines near the Project. The Plant Site is fully contained within the operating area of the former LTVSMC taconite processing facility.

4.11.1.1. Visual Character of the Project Area

Mine Site

The Mine Site is located along the south flank of the Mesabi Iron Range, immediately south of the Giants Range formation (see Figure 4.11-1). The site is relatively flat, with elevations between 1,570 feet and 1,600 feet mean sea level (MSL). The Giants Range formation is the dominant landscape feature and rises steeply to an average elevation of approximately 1,700 feet MSL along the ridgeline and declines approximately 150 to 200 feet on its northern flank. The ‘100 Mile Swamp’, Partridge River, and the Peter Mitchell Mine lie to the north between the Mine Site and the Giants Range formation. The Mine Site is surrounded by wetlands and mixed deciduous and coniferous upland forests to the east, south, and west. The average canopy height in the upland forest is 30 to 60 feet with occasional white pine and white spruce in excess of 70 feet. In the wetland areas, the coniferous canopy is approximately 30 to 40 feet while the deciduous growth is less than 20 feet tall. The Partridge River makes a horseshoe bend and is immediately north, east, and south of the Mine Site.

The nearest potential visual receptors are rural homes and USFS campsites approximately five miles to the south near the unincorporated village of Skibo. Additional residences are located approximately 7 miles to the east along Lake County Road 2 within the incorporated limits of the City of Babbitt. The Babbitt city center is located approximately 7 miles north of the Mine Site. To the immediate west of the Mine Site are uninhabited forests, wetlands, and open land. The City of Hoyt Lakes is approximately 10 miles to the southwest of the Mine Site.

Plant Site

The Plant Site is located at the inactive former LTVSMC taconite processing facility. Topography at the Plant Site rises from approximately 1,550 feet MSL near the railroad at the south end of the plant to approximately 1,780 feet MSL at the north end adjacent to the tailings basin. The inactive LTVSMC industrial processing buildings dominate the visual landscape at the Plant Site including crushing, grinding, concentrating, and maintenance and pellet storage/rail loading facilities. The LTVSMC tailings basin is located to the north of the buildings with mine pits and waste rock stockpile sites to the south and east, and a railroad to the west. Second Creek and its headwater wetland also border the site immediately to the south. The nearest potential visual receptors are residences approximately five miles south of the Plant Site in the City of Hoyt Lakes.

The proposed tailings basin is located at the former LTVSMC tailings basin on the northern portion of the Plant Site. The tailings basin ranges in elevation from approximately 1,650 feet MSL bordering the Plant Site to approximately 1,730 feet MSL along its northern border. The basin is surrounded by wetlands and low, forested (mixed coniferous and deciduous) uplands to the north, east, and west. The nearest potential visual receptors to the tailings basin are residences approximately one mile north on County Road 358 and additional residences approximately two miles north along County Road 615. These are rural residences within the Superior National Forest boundary and outside the incorporated limits of Babbitt and Hoyt Lakes.

4.11.1.2. Management Class

The Management Classification System (MCS) was developed by the USACE to provide general guidelines as to the degree and nature of visual change acceptable in a landscape (USACE, 1988). Based on the assessment of features in Sections 4.11.1.1, the Mine Site falls into the “Modification Management Class” of areas not noted for their distinct qualities and often considered to be of average quality. The Plant Site is in the “Rehabilitation Class”, or areas noted for their minimal visual quality due to historic use as a mining material processing center. In the planning and design of projects in this type of landscape, the USACE has determined that “project activity may attract attention and dominate the existing visual resource. However, the project should exhibit good design and visual compatibility with its surroundings” (USACE, 1988).

4.11.2. Impact Criteria

The primary issues related to visual resources, and therefore the potential for impacts, would include:

- The number of sensitive viewpoints affected by the Project;
- Significant increases in the extent or scale of visible mining disturbances; and
- The ultimate appearance of the Project at full reclamation versus current and interim stages of active mining.

4.11.3. Environmental Consequences

4.11.3.1. Proposed Action

At the Mine Site, the waste rock stockpiles would range from approximately 1,750 feet MSL (Category 4 waste rock stockpile) to 2,100 feet MSL (Category 1/2 waste rock stockpile) above the ground surface (Golder, 2008). The ridgeline rises sharply to the north of the Mine Site before dropping off, so receptors to the north, including the BWCAW, would not see the stockpiles or safety lights from stockpiling activities atop these piles.

The upland forest communities surrounding the Mine Site to the east, south, and west would shield ground-level views of the Mine Site in those areas. These forest stands are a mix of coniferous and deciduous forests and would provide screening year-round. Potential users on elevated terrain to the east, north, or west would have a limited view of the mine and stockpiles. There are no major trails within the SNF adjacent to the Mine Site that would expose recreational users to the mine. The Project would increase the scale of disturbance in the region; however, mining activity is a traditional aspect of the local landscape and the addition of the proposed mining facilities would not introduce visual elements to surrounding viewpoints that are in stark contrast to the regional visual character.

The Mine Site would be in operation 24 hours per day; therefore, nighttime safety lighting of the stockpiles would potentially contribute to a localized “glow” effect in the night sky. Similar to the daytime impacts, the Giants Range ridgeline and Northshore mine site would shield night lighting for residences to the north. PolyMet does not propose specific mitigation measures with respect to light impacts.

No significant changes are anticipated to the visual character of the Plant Site during Project operations. The proposed hydrometallurgical process buildings would be smaller and shorter than the existing infrastructure. The Project would use the existing infrastructure, including the tailings basin, for processing operations; therefore, the Project would be in keeping with the existing, modified, industrial landscape, and consistent with the USACE’s management objectives for the “modification” landscape management class.

The tailings basin is potentially visible to rural residences on County Road 358, located approximately one mile to the north. However, the basin has been previously used for storing tailings. The continued use of the tailings basin would increase the silhouette of the low mound on the southern horizon as the tailings basin and hydromet elevations would increase approximately 40 feet to 50 feet. However, this would be consistent with the current visual landscape and not have significant visual impacts due to the pre-existing mining characteristics of the surrounding area.

The Project would not increase the number of affected sensitive viewpoints or significantly increase the extent or scale of visible disturbance. Following the completion of the mining activities, PolyMet proposes to complete a reclamation plan to remove all buildings and facilities at the Mine and Plant sites and revegetate the Project site with appropriate species consistent with the regional visual landscape. The Mine and Plant sites would be distinct from the surrounding natural landscape while the vegetation cover develops; however, the revegetated areas would not introduce visual elements in contrast with the regional visual landscape.

4.11.3.2. Alternatives

No-Action Alternative

Under the No-Action Alternative, the Project would not be developed, the hydrometallurgical process buildings would not be constructed, and the former LTVSMC processing facility would be demolished as required by existing Minnesota reclamation rules. Cliffs Erie would reclaim the processing plant and all buildings on the property would be demolished. The reclamation activities would have the potential for a short-term disruption of the visual landscape due to the demolition and revegetation activities. Long-term visual effects would be beneficial as the LTVSMC processing plant would be revegetated with appropriate species.

Subaqueous Disposal of Reactive Waste Rock

Under this alternative, the most-reactive waste rock (all Category 2/3/4 waste rock) would be disposed subaqueously in the East Pit thereby eliminating the permanent Category 2/3/4 stockpile and increasing the size of the Category 1 stockpile. The Category 2/3/4 waste rock would be temporarily stockpiled at the Mine Site until the East Pit was available for disposal. Similar to the Proposed Action, the ridgeline north of the mine site would obscure the stockpiles from visual receptors north of the ridgeline and the surrounding upland forest communities would shield ground-level views of the mine site to the east, south, and west. This alternative would increase the overall scale of disturbance in the region due to the presence of the temporary stockpiles and slight increase in the Category 1 stockpile height; however, relative to the Proposed Action this alternative would be less intrusive from surrounding viewpoints as the temporary stockpiles would be removed as the East Pit becomes available for storage. During reclamation, the Mine Site (including the Category 1 stockpile) would be revegetated with appropriate species; therefore, no significant permanent visual impacts are predicted from mining operations.

The impacts of this alternative relative to the Plant Site would be the same as the Proposed Action.

Other Mitigation Measures

Section 3.2.2.35 describes potential mitigation measures for impacts from the Project, one of which has the potential to affect visual resources.

To mitigate the potential visual effects from the Project, an alternative would be directing operating lights downward and shielding light sources to reduce the potential for glow effects.

4.11.4. Cumulative Impacts

During the EIS scoping process (see Section 2.1 of the Final SDD), no cumulative impact issues associated with visual resources were identified.

4.12 HAZARDOUS MATERIALS

The Project would use or generate as waste the following hazardous materials:

- Fuels – diesel fuel, gasoline, oils, greases, anti-freeze, and solvents used for equipment operation and maintenance
- Plant Reagents – sodium hydrosulphide, sodium hydroxide, acids, flocculants and anti-scalants used in processing plant applications
- Blasting Agents – ammonium nitrate, fuel oil, ANFO, emulsions, blasting caps, initiators and fuses, and other high explosives used in blasting
- Others – assay chemicals, and other hazardous waste classified as by-products

Issues relating to the presence of hazardous materials may include the accidental releases of these materials during transportation, storage, handling, and use at the Project and their potential impacts on the environment. The environmental resources that could be potentially affected by these hazardous materials if they are accidentally released include air, water, soil and ecological resources.

There are several federal and state regulations that establish management and reporting requirements for hazardous materials that would be applicable to the Project. The statutes to be followed would include, but not be limited to:

- 40 CFR 112 – (Oil Pollution Prevention)
- 49 CFR Subchapter A – (Hazardous Material and Oil Transportation)
- Section 112 of the Clean Air Act – (Hazardous Air Pollutants)
- Minnesota State Law Chapter 115.061 – (Minnesota State Guidelines for responding to Spills and Releases)
- Minnesota State Law Chapter 7151 (Aboveground Storage of Liquid Materials)

4.12.1 Existing Conditions

With the exception of two-gallon gasoline containers at the Main Gate fueling station, there are currently no known hazardous materials or waste at the Project. All hazardous materials generated or used at the sites including used oils, explosive wastes, plant reagents, and assay wastes associated with the prior LTVSMC mine have been either shipped off site for recycling or proper disposal.

4.12.2 Impact Criteria

Several criteria define the impacts from the accidental spill, release, or discharge of contaminants or hazardous material on the environment. The basic principle of these criteria is the protection of people and the environment. Based on this principle, the Project would have a significant environmental impact if the following were to occur:

Transportation

- A spill, release, or discharge of any hazardous or other material during transportation which, if not recovered in a timely manner, may cause pollution of waters of the state or cause other harm to the environment or to the public.

Handling and Use

- A spill, release, or discharge of a hazardous or other material during handling or use which may cause pollution of waters of the state or cause other harm to the environment or to the public.
- Hazardous emissions or handling of hazardous or acutely hazardous materials that has the potential to cause harm to the public or the environment.

Storage

- A spill, release or discharge from storage facilities on the site exceeding the volumes of the primary and secondary containment structures and which could not be recovered in a timely manner and thus pollutes waters of the state or causes other harm to the environment or to the public.

4.12.3 Environmental Consequences

4.12.3.1 Proposed Action

Operation of the Project would involve the transportation, storage, handling, use and disposal of process consumables and wastes, some of which are hazardous wastes. A list of materials and their classifications that would be used during Project construction, operations, and closure are provided in Table 4.12-1. The estimated delivery frequency and volumes and estimated annual use of these materials are also listed in Table 4.12-1.

Table 4.12-1 Materials

			Deliveries			Annual Use
Substance	**Classifications & Precautions**	**Storage Capacity**	**Means**	**Origin**	**Proposed Action** **Monthly Delivery**	**Proposed Action**
ANFO & Boosters *(Mixture of ammonium nitrate, fuel oil, and guar gum)*	Flammable: Irritant to skin and eyes. May cause nausea if ingested and irritation to nose and throat if ingested	No onsite manager	Vendor/Truck	To be confirmed	Approximately 56 Trucks	15,117,538 tons/yr
Diesel Fuel	Flammable: Continued exposure to vapors can irritate eyes and lungs. Potentially fatal if ingested.	<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	To be confirmed	74 loads (Truck)	<u>Mine:</u> 5,910,000 gal/yr <u>Plant:</u> Uncertain, but relatively minor <u>Locomotives:</u> 473,040 gal/yr
Grease	Mild skin irritant, ingestion may cause discomfort	Existing Bulk Tank	Bulk Tank	To be confirmed	Less than 1 truck per month	<u>Mine:</u> unknown <u>Plant:</u> Uncertain, but relatively minor <u>Locomotives:</u> 16 lb/yr – each locomotive
Lubricating Oil	Minimal health hazards	<u>Mine:</u> 2,000 gal <u>Plant:</u> 2 – 7,000 gal 2 – 12,000 gal 1 – 12,338 gal	Tanker Truck	To be confirmed	2 loads per month	<u>Mine:</u> 47,000 gal/yr <u>Plant:</u> Uncertain, but relatively minor <u>Locomotives:</u> 200 gal/yr – each locomotive
Transmission Oil	Minimal health hazards	<u>Mine:</u> 1,500 gal	Tanker Truck	To be confirme d	Less than 2 loads per month	<u>Mine:</u> 33,000 gal/yr
Hydraulic Oil	Minimal health hazards	<u>Mine:</u> 2,000 gal <u>Plant:</u> 2 – 2,500 gal	Bulk Tanker Truck	To be confirme d	Less 1 load per month	<u>Mine:</u> 13,000 gal/yr <u>Plant:</u> Uncertain, but relatively minor
Coolant *(Ethylene Glycol Mix)*	Harmful or fatal if swallowed; eye, skin, and respiratory irritant	<u>Mine:</u> 600 gal <u>Plant:</u> 6,000 gal	Drums and Bulk Tanker Truck	To be confirme d	1 delivery per month	<u>Mine:</u> 12,000 gal/yr <u>Plant:</u> Uncertain, but relatively minor
Gasoline *(Light Vehicles)*	Harmful or fatal if swallowed; eye, skin, and respiratory irritant	<u>Plant:</u> 2 - 6,000 gal	Bulk Transfer	To be confirme d	2 deliveries per month	<u>Plant:</u> 500 gal/day or 178,000 gal per ye
Degreaser	Skin and eye irritant, potential inhalation hazard	<u>Plant:</u> 1 - 400 gal 1 – 2,500 gal		To be confirme d	As needed to keep full- less than 1 delivery per month	Uncertain, likely less than 15,000 ga
Used Oils	Minimal health hazards	55 gal drums		To be confirme d		
Caustic *(NaOH)*	Skin and eye irritant, corrosive	1,100 gal	Tanker Truck	To be confirmed	Truck	66 Short Ton
Cobalt Sulfate	Health Rating Moderate (2)	1,200 lbs	Truck Deliveries of	To be confirmed	17-18 bags by common carrier	7 Short Ton

	Skin and respiratory irritant		67 lb bags			
Flocculent *(MagnaFloc 10)*	Inhalation Irritant		Truck	To be confirmed	1 truck every 2 months	16.5 Short Ton
Flocculent *(MagnaFloc 342)*	Low overall toxicity	1,875 lb bags	Bulk Containers via Truck	To be confirmed	Less than one truck per month	1 Short Ton

Transportation

All hazardous substances would be transported by commercial carriers in accordance with the hazardous substances shipping requirements of Title 49 of the Code of Federal Regulations (CFR). Carriers would be licensed and inspected as required by the Minnesota Department of Transportation. Tanker trucks would be inspected and have a Certificate of Compliance issued by the Minnesota Motor Vehicle Division. These permits, licenses, and certificates are the responsibility of the carrier. Title 49 of the CFR requires that all shipments of hazardous substances be properly identified and placarded. Shipping documents must be accessible and include Material Safety Data Sheets (MSDS) that contain information describing the hazardous substance, 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. It should be noted that hazardous wastes would also need to be transported from the project site to be properly disposed of. Transportation of these waste streams would have to adhere to all applicable state and federal regulations including requirements for Hazardous Waste Manifests with shipments, labeling and/or using placards, and emergency information requirements. With the size of the NorthMet operations, it would be necessary for the Project to either have dedicated employees to handle these tasks or hire a contractor to take care of this aspect of the Project.

As identified in Table 4.12-1, trucks would be used to transport a variety of hazardous substances to the project site. Shipments of hazardous substances would originate from various cities. The risk of accidental truck spills was evaluated using two representative hazardous substances, diesel fuel and Pax Flotation Collector (Pax FC), based on the relatively large quantity of deliveries and health risk characteristics of these materials. Approximately 74 tanker truck loads of diesel fuel and 2 truck loads of Pax FC would be delivered monthly. These quantities amount to approximately 17,800 and 480 shipments of diesel fuel and Pax FC respectively, based on an estimated 20 years of mine life.

For this evaluation, both materials were assumed to be shipped from Duluth. These materials would be transported approximately 60 miles along State Highway 53 (divided highway) from Duluth to Eveleth and then approximately 20 miles along State Highways 37 and 135 (two-lane roads) from Eveleth to the North Gate access road to the site. This route would transport the materials near towns such as Independence, Cotton, Biwabik, and Gilbert, and across rivers such as the Cloquet, Embarrass, and Whiteface.

The impact of an accidental release would depend on the location of the release in relation to populations and local activities, the quantity released, and the nature of the released material. The possibility of accidental release during delivery depends on factors such as skill and state of mind of the driver, type and condition of vehicle used for delivery, and traffic conditions and road type. Most of these factors are qualitative and even incidental. For the present evaluation, however, only quantitative factors are considered.

The probability of an accidental release of hazardous substance during transportation was calculated using the Federal Highway Administration truck accident statistics model (Rhyne 1994) as presented in Table 4.12-2. According to these statistics, the average rate of truck accidents for transport along a rural interstate freeway is 0.64 per million miles traveled. For rural two-lane roads, the average truck accident rate is 2.19 accidents per million miles traveled. All access roads to the Project are paved.

The probability of a release or spill was based on accident statistics for liquid tankers carrying hazardous substances. These statistics indicate that on the average, 18.8 percent of accidents involving liquid tankers carrying hazardous substances resulted in a spill or release.

Using the accident and liquid tanker spill statistics, the probability evaluation indicates that the potential for an accidental release of liquids with truck transport during the life of the proposed Project is less than one accident involving a spill of each of the materials considered. Specifically, there is about a 0.7 percent chance that an accident resulting in a release of Pax FC and a 27.5 percent chance that an accident resulting in a release of diesel fuel could occur over the entire 20-year life of the Project. Together, there is an approximately 28 percent chance that an accident involving either one of these substances or both would occur at some point during Project operations.

Including the other shipments listed in Table 4.12-1 would incrementally increase the odds of a potential release of hazardous materials during a transport accident. The event of an accidental release could range from a minor oil spill on the Project site where cleanup equipment would be readily available, to a severe spill during transport involving a large release of diesel fuel or other hazardous substance. Some of the

Table 4.12-3 Materrial Transported

	Rural Freeway						Rural Two Lane Road						
Material Transported	**No. of Truck Delivery**	**Freeway Haul Distance (Miles)**	**Accident Rate Per Million Miles Traveled**	**Calculated Number of Accidents**	**Probability of Release Given an Accident (%)**	**Calculated Number of Spill**	**No. of Truck Delivery**	**Freeway Haul Distance (Miles)**	**Accident Rate Per Million Miles Traveled**	**Calculated Number of Accidents**	**Probability of Release Given an Accident (%)**	**Calculated Number of Spill**	**Combined Total Estimated Release (Freeway and Rural Two-Lane)**
Diesel Fuel	17,800	60	0.64	0.68352	18.8	0.12850176	17,800	20	2.19	.077964	18.8	0.14657232	0.275
Pax FC	480	60	0.64	0.018432	18.8	0.003465216	480	20	2.19	0.021054	18.8	0.003952512	.007
Total						0.13						0.15	0.282

Note:
A compound event is any event that combines any two simple events. The notion is:
P(A and B) = 0.275 x 0.007 = 0.002
P(A) + P (B) = 0.275 + 0.007 = 0.282
Thus
P(A or B) = [P(A) + P(B)] – [P (A and B)] = 0.282 – 0.002 = 0.28

chemicals could have immediate adverse effects on water quality and aquatic resources if a spill were to enter a surface water body. However, considering the anticipated transport routes, the probability of a spill into a waterway is low. An alternative transportation route, shorter by about 17 miles, was rejected because of its close proximity to water bodies such as Wild Rice and Island Lakes. The selected transportation route for this evaluation is longer but is further away from water bodies, so that in the unlikely event that a spill or a release of materials should occur, it could be managed in a timely manner to reduce the likelihood of a significant impact.

A large-scale release of hazardous liquids delivered to the site by tanker truck (7,500 gallon capacity), such as diesel fuel, acid, or other hazardous substances, could have implications for public health and safety. The location of the release would again be the primary factor in determining its importance. As indicated, the probability of a release anywhere along a proposed transportation route was calculated to be low, and the probability of a release within a populated area would be lower yet. In addition to location, the potential hazard presented by the material released is a factor in determining the significance of a release. A qualitative evaluation of the substances to be shipped indicates that the probability of causing significant harm is low for most substances. For example, though ANFO is an explosive, it will only detonate under specific conditions such as when ignited with detonators, heat, or sudden shock wave in a confined space. Caustic is corrosive and can be fatal if ingested or has prolonged contact with the skin; however, in a spill situation, necessary response would be made to prevent or minimize any exposure from occurring, 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 and fire protection agencies also may be involved initially to secure the site and protect public safety.

In the event of an accident involving the release of hazardous material, Title 49 of the CFR requires that the carrier notify local emergency response personnel, the National Response Center (for discharge of reportable quantities of hazardous materials to navigable waters), and the U.S Department of Transportation (DOT). PolyMet and its contractors would be required to comply with these and similar regulatory requirements.

Storage

The capacities of hazardous substance storage tanks at the Project are listed in Table 4.12.1. Mobile tanker trucks would be used on site to fuel and maintain haul trucks. The number of these trucks and their capacities would be based on Project-specific requirements. Tanks and vessels would be positioned on an approved containment surface with interior sumps to route any spilled process solutions to lined collection areas. Most of the storage tanks would be double walled. In addition, all hazardous substance storage tanks would 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 oils and spent hazardous substances would be shipped off site for recycling. In addition, fire assay wastes, including cupels, crucibles, and slag, would be shipped off site for recycling or disposal at a licensed facility. Certain materials may be stored on site for a period of time before shipment. These materials would be stored in compliance with safety storage requirements as dictated by both state and the federal requirements. The storage period would also be in compliance with any state and federal timeline stipulations. All such stored wastes would be labeled and dated for timeline inspection purposes.

Handling and Use

Over the life of the Project, the probability of minor spills of oils and lubricants would be relatively high. These releases could occur during operations, for example, as a result of a bad connection on an oil supply line or from equipment failure. Impacts of such minor spills could include contamination of surface waters. However, spills of this nature would most likely be small, localized, and contained. The requirements for storage of oils and lubricants including the requirement for spill prevention control and countermeasure planning (SPCC plan) are found in the Oil Pollution Prevention Act (40 CFR 112). The main aim of this plan is to develop strategies to prevent oil spills from reaching state and U.S. waters. An SPCC Plan is thus specific to each project and facility, providing site-specific information such as a description of facilities, storage information, preventative measures, response action, equipment, and contact information. The facility would prepare an SPCC plan to address oil stored at the facility. Other incidents involving process solutions or flammable or explosive or other hazardous substances also could occur during mine operations. To reduce the likelihood of incidental spills of these materials at the mine site, a preliminary Emergency Response Plan (ERP) document has been prepared for both the mine and the process facility. The plan is developed to identify potential emergencies that may arise during operation of project facilities or an activity on the premises of a Project. The plan establishes a framework to respond effectively to the identified potential emergencies. The ERP may include situations involving hazardous substances. In addition to the ERP, a Hazardous Materials Management Plan would be prepared. This plan would be a framework or mechanism for handling, storage and disposal of materials that are used or generated so that they do not cause harm or impact the environment adversely.

The SPCC plan would include procedures, methods, equipment and other requirements to prevent discharges of oil from facilities and to contain such discharges. The SPCC Plan would also contain a detailed, facility-specific, written description of how a facility's operations comply with the requirements of the Oil Pollution Prevention regulation (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, and liquid level devices. An SPCC Plan must be certified by a Professional Engineer (PE) that:

- The SPCC Plan is adequate for the facility
- Technical standards have been considered
- Inspections and tests are adequate for the facility
- The SPCC Plan has been prepared in accordance with good engineering practice, including consideration of applicable industry practice

Completion of an SPCC Plan that would allow PE certification is not possible for the Project until construction has been completed. However, a preliminary SPCC Plan, including a site map for the Project, has been prepared (See ER04 Preliminary Spill Prevention, Countermeasures and Control Plan – Plant Site and ER05 Preliminary Spill Prevention, Countermeasures and Control Plan –Mine Site). The preliminary SPCC Plan was prepared in accordance with the requirements set forth in 40 CFR 112. Since the Project would have less than 1,000,000 gallons of tank capacity on site it falls under these rules and regulations. The policies and procedures set forth in this document, and a separate PolyMet Standard Procedure for Storage Tank Management, would be prepared to comply with Minnesota State Law, Chapter 7151, Aboveground Storage of Liquid Materials.

The SPCC Plan would be finalized and certified by a PE as required, when petroleum storage and handling facilities have been constructed. Based on current planning and information, the SPCC Plan would need to address at least the following areas or activities involving petroleum oil:

- A truck fueling station
- Remote fueling activities (i.e., at the equipment operating location)
- Above ground storage tanks
- Oil filled equipment

The truck 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 and/or license and transported to a recycling, treatment or disposal facility. One station would consolidate all truck fueling activities. Portable spill clean up kits would be installed at the truck fueling station. Remote fueling would be conducted for equipment located within mine pits and at material stockpiles (e.g., front end loaders and bulldozers). Standard operating procedures, including spill response plans, would be prepared and associated training would be conducted for fueling operations. Equipment would not be left unattended during fueling operations. When possible, remote fueling should not be performed within the perimeter of sensitive areas where if a release were to occur, surface water could be impacted. At final design stage an updated version of the current SPCC plan would be prepared for the Project facilities to address specific spill responses and cleanup, release notifications, etc. For oil-filled equipment, a containment system including walls and floor would be constructed so that any 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 and documented that would require inspections or a monitoring program to detect equipment failure and/or a discharge. Aboveground storage tanks would be located at the truck fueling station where fuel storage would meet secondary containment standards. The tanks would have either a containment dike with a membrane or a concrete enclosure to contain leaks or spills.

The SPCC or ERP documents along with manufacturer MSDS sheets would be available in all areas where hazardous substances are expected to be used or produced and at all areas of fuel storage. These plans include procedures for evacuating personnel, maintaining safety, cleanup and neutralization activities, emergency contacts, internal and external notifications to regulatory authorities, and incident documentation. Proper implementation of the ERP is expected to minimize the impacts associated with any potential release of hazardous substances.

Table 4.12-3 HAZARDOUS MATERIAL MANAGEMENT PLANS

Plans	Applicable Statute	Materials/Applications
SPCC Plan	40 CFR 112	Oil Spills
Hazardous Materials Management Plan	40 CFR 260 – 279 DOT 49 CFR	Handling, storage, disposal of oils, chemicals, fluids, other wastes. Transportation of hazardous materials
Emergency Response Plan	29 CFR 1910.120	Hazardous material release response guidance
Spill Response Plan	29 CFR 1910.120/CAA Section 112 Minnesota Statute Chapter 115	General guidance Minnesota state guideline for responding to spills and releases

Mitigation of hazardous material release would follow the principle of prevention, minimization and treatment. Prevention would be achieved when any hazardous material is avoided, where possible, by replacing it with a substitute material that is not hazardous. Since this is not possible in most cases, precautions would be taken to keep the release and the potential risk of exposure to a minimum. Any accidentally released hazardous material would be treated quickly and in accordance with the SPCC plan. In addition, the mitigation process would include the following:

- Hazardous Materials Management Plan – with communication and training programs
- Overfill Protection Procedures
- Provision for Secondary Containment
- Establishment of Leak Detection System
- Preventative Inspection and Maintenance Procedures
- Emergency Response Plan

These measures would be designed to ensure that accidental releases are prevented or minimized, and when they do occur they are responded to quickly and properly.

The monitoring activities proposed for prevention of incidental releases, mitigation or quick removal of the effects if hazardous materials are released include:

- Regular visual inspection 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
- Keeping MSDS sheets at visible locations for easy access at all times
- Regular monitoring of surface and ground water quality

Monitoring would be an integral part of the hazardous material management process at the site.

No Action Alternative

The No Action alternative involves demolishing the existing facilities. All remaining hazardous substances, including lead-based paints, a considerable amount of asbestos containing materials, and any other potentially hazardous substances, would be removed in compliance with relevant regulations. Thus, there is no expected accidental spill, release or discharge of these materials, and the environment would not be impacted by the existing facilities or sites. Under the Proposed Action, the buildings would also be demolished at the end of mine life, and the risk of a spill or release of hazardous materials causing significant impact is low. Therefore, the No Action alternative does not present a significant environmental benefit as compared to the Proposed Action.

Subaqueous Disposal of Reactive Waste Rock

The subaqueous disposal of reactive waste rock alternative would have similar requirements for hazardous substance transportation, storage, and handling as the Proposed Action. Therefore, this alternative does not present a significant environmental benefit as compared to the Proposed Action.

4.13 CUMULATIVE EFFECTS

The Council on Environmental Quality (CEQ) defines cumulative effects as "the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-federal) or person undertakes such other actions" (40 CFR § 1508.7). In 1997, the CEQ published *Considering Cumulative Effects under the National Environmental Policy Act* as a comprehensive guidance document for cumulative analyses. The methodologies recommended in this guidance document were used by the U.S. Environmental Protection Agency (EPA) in their *Final Protocol to Assess Expanded Cumulative Effects on Native Americans* (2007) and were recommended by the Minnesota Environmental Quality Board (MEQB) as providing "the best source of guidance on cumulative impacts" (MEQB, 1998). Therefore, the 1997 CEQ guidance document was used in this EIS to assess the potential cumulative impacts of the proposed NorthMet Project in combination with other past, present, and reasonably foreseeable future actions in the greater project vicinity[1].

This section is intended to summarize the resource-specific cumulative effects analyses (Refer to Sections 4.1 to 4.12) and provide an overall, synergistic analysis of the system-level cumulative effects resulting from the combined influence of the resource-specific effects to the regional airshed, watershed, and land cover surrounding the Project. In addition, this section also discusses the influence of these synergistic effects on uniquely-affected communities in the region.

Methodology for Cumulative Effects Assessment

The 1997 CEQ guidelines recommend analyzing cumulative effects according to a tiered approach among specific resources, interconnected systems, and human communities. This hierarchical approach allows for a quantitative, resource-specific analysis as well as a synergistic, additive discussion of the system-level influence of regional actions. Under the resource-specific lens, the resources considered were identified during the scoping process as those having the potential for cumulative effects by the Proposed Action or Alternatives. If the Proposed Action or Alternatives did not result in direct or secondary impacts on a resource, then that resource was eliminated from the cumulative impact evaluation (CEQ, 1997). Cumulative effects generally do not occur within

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[1] The greater project vicinity varies dependent upon the resource under discussion (e.g., water resources, air quality, uniquely-affected communities, etc). The specific geographic scope for each resource is further discussed within the appropriate subsection of this analysis.

predetermined political or administrative boundaries, and as such, the analysis should encompass a geophysical boundary appropriate to that resource or system. The Final Scoping Document (October 25, 2005) identified 12 resource-specific areas of concern related to cumulative effects. Table 4.13-1 provides a summary of the resource-specific concerns identified during scoping, and the spatial and temporal scales considered in this cumulative effects analysis.

Table 4.13-1 Resource-Specific Scope of Cumulative Effect Subject Areas

Subject Area	Spatial Scale	Temporal Scale
Hoyt Lakes Area Projects and Air Concentration in Class II Areas	NorthMet site boundary with a 10-km buffer	Existing conditions (inclusive of historic influences) through the life of the mine, including closure.
Class I Areas PM_{10} Increment	Arrowhead Region (Koochiching) Airshed	Current emissions baseline and potential outlook through 2020.
Ecosystem Acidification Resulting from Deposition of Air Pollutants	Itasca, St. Louis, Lake, and Cook Counties	Current emissions baseline and potential outlook through 2020.
Mercury Deposition and Bioaccumulation in Fish	Itasca, St. Louis, Lake, and Cook Counties (used emissions data from state and US)	Current emissions baseline and potential outlook through 2020.
Visibility Impairment	Iron Range	Existing conditions (inclusive of historic influences) through the life of the mine, including closure.
Loss of Threatened and Endangered Plant Species	State of Minnesota	Current or historic projects with "taking" permits from MnDNR and future projects through the life of the mine, including closure.
Loss of Wetlands	Partridge River Watershed	Historic conditions from the 1930s to current. Future conditions through the life of the mine, including closure.
Loss or Fragmentation of Wildlife Habitat	Arrowhead Region for habitat; Mesabi Iron Range plus 15-mile buffer for wildlife travel corridors	Historical trends over the last ~100 years, and future through the life of the mine, including closure.
Streamflow and Lake Level Changes	Upper Partridge River including Colby Lake	Upper Partridge River: current conditions the life of the mine, including closure. Colby Lake/Whitewater Reservoir: Historic conditions from the 1950s the life of the mine, including closure.
Water Quality Changes	Upper Partridge River (including Colby Lake) and Upper Embarrass River	2004 conditions (inclusive of historic influences) through operation and post closure (independent scenarios)
Economic Impacts	St. Louis County and the East Range (municipalities of Aurora, Babbitt, Biwabik, Ely, Hoyt Lakes, Soudan, Tower, and the surrounding areas)	1980 (or closest available data) through closure of reasonably foreseeable projects (as defined in the Scoping Decision Document)
Social Impacts	East Range (municipalities of Aurora, Babbitt, Biwabik, Ely, Hoyt Lakes, Soudan, Tower, and the surrounding areas)	2002 conditions (inclusive of historic influences) through closure of reasonably foreseeable projects (as defined in the Scoping Decision Document)

Resource-Specific Scale

At the resource-specific scale, cumulative effects on individual resources (e.g., air quality in Class I areas or surface water quality) are analyzed to determine if the proposed Project, in combination with other actions, would adversely affect specific resources. Table 4.13-2 summarizes the findings of the resource-specific cumulative effects analyses. For a detailed analysis of each subject area, refer to the individual resource analyses (Sections 4.1 through 4.12).

Table 4.13-2 Findings of the Resource-Specific Cumulative Effects Analysis

Cumulative Effect Subject Area	**Section in CPDEIS**	**Cumulative Effects Summary**
Hoyt Lakes Area Projects and Air Concentration in Class II Areas	Air Quality (Section 4.6)	The Project area is in attainment for all NAAQS. The Project and past, current, and future actions, while increasing emissions, would cumulatively comply with the Federal and state increment limits. Therefore there would be no significant cumulative effect on Class II areas.
Class I Areas PM_{10} Increment	Air Quality (Section 4.6)	The Project area is in attainment for all NAAQS. The Cumulative Class I PM_{10} Increment Analysis determined that there would be no significant impacts associated with the Project and other past, current, and future actions. Cumulatively, there would be an increase in PM_{10} emissions; however, these emissions would not exceed the PSD increment limits. Therefore, there would be no significant cumulative impact.
Ecosystem Acidification Resulting from Deposition of Air Pollutants	Air Quality (Section 4.6)	The Project and past, current, and future actions would increase deposition of SO_2 and NO_2; however, the deposition rate would be below Federal and state threshold values. In combination with the overall reduction in sulfate and nitrate-producing emissions since 2000, there would be a net decrease in emissions and therefore no adverse cumulative impact.
Mercury Deposition and Bioaccumulation in Fish	Air Quality (Section 4.6)	The Project and future actions would add new mercury emitting sources; however, the implementation of mercury reducing legislation will cause a reduction in existing mercury emissions in the region. This reduction will serve to off-set the new mercury sources and result in a net decrease in mercury emissions. Therefore, there would be no cumulative impact to fish from mercury deposition and bioaccumulation.
Visibility Impairment	Air Quality (Section 4.6)	The Project and future actions would add new emissions sources in the region; however, these emissions would be offset by the emissions reductions at past and current projects. There would be an overall net reduction in visibility degrading emissions; therefore, the Project and past, current, and future actions would have no cumulative impact on visibility.
Loss of Threatened and Endangered Plant Species	Vegetation (Section 4.3)	Future cumulative impacts to ETSC plant species from the Project and other past, current, and future actions range from 2% to 21% of the known populations of these species. The ETSC plant species known to occur in the Project area exhibit preferences for disturbed sites and therefore will likely not experience adverse cumulative effects for the Project and past, current, and future projects.
Loss of Wetlands	Wetlands (Section 4.2)	The Project would result in the loss of 1,197 acres of primarily high quality wetland habitat; however, over 97% of the existing wetlands in the Partridge River watershed would remain in the foreseeable future. Additionally, wetland mitigation would occur on site and primarily outside of the watershed.

Loss or Fragmentation of Wildlife Habitat	Wildlife (Section 4.4)	Largest impact is due to forestry. Habitat will be increased for species requiring older forests and forests with a significant conifer component, and decreased for species that utilize young forests and non-forested habitats. Mining adds to the impact on a temporary basis (prior to closure).
Wildlife Travel Corridors	Wildlife (Section 4.4)	Impacts from new and future projects are anticipated to 8 of the 13 wildlife travel corridors; the proposed project would affect one of those. This impact is temporary and should largely be mitigated following mine closure and reclamation.
Streamflow and Lake Level Changes	Water Resources (Section 4.1)	**Under review**
Water Quality Changes	Water Resources (Section 4.1)	**Under review**
Economic Impacts	Socioeconomics (Section 4.1)	The Project and past, present, and future development along the Iron Range would increase regional employment and spending, thereby having a beneficial impact on the regional economy
Social Impacts	Socioeconomics (Section 4.10)/ Cultural Resources (Section 4.7)	Potential for cumulative effects to indigenous land use practices. See discussion below for additive/synergistic assessment of cumulative effects to uniquely-affected communities.

System Scale

At the system level, relationships among resource-specific cumulative affect subject areas were analyzed to determine if the impacts to system components would combine for synergistic/additive effects on regional natural systems. In this EIS, three natural systems, regional airshed, watershed, and ecoregion, were analyzed for additive and synergistic cumulative effects.

Regional Airshed

The Arrowhead Region airshed includes the seven counties in northeastern Minnesota including St. Louis County and the proposed Project area (Figure 4.13-1). The Arrowhead Region extends across the Mesabi Range mining areas where past and present mining activities have contributed to increased air and fugitive dust emissions from construction, extraction, and processing operations and increased vehicular traffic in support of the commercial operations. The Arrowhead Region is currently in attainment for all NAAQS and the proposed project would not violate these standards or contribute to a regional nonattainment situation or violate state air quality regulations (refer to Section 4.6, Air Quality, for a detailed discussion of these standards). The Clean Air Act standards regulate project-specific emissions; and these project-specific regulations presumptively act to protect and preserve regional air quality. As described in Table 4.13-2, the Project and other past, current, and future actions would have no significant cumulative effects on the regional airshed. Relative to mercury deposition and ecosystem acidification, the region is expected to experience a cumulative decline in the mercury, sulfates, and other acidifying compounds in the future due to new regulation, voluntary reductions, and technological improvements. Therefore, while the proposed Project would result in additional air emissions, the additive influence of actions in the region would not contribute to a significant cumulative effect on regional air quality.

Watershed

The St. Louis River watershed includes the Partridge and Embarrass Rivers in St. Louis County, drains the southern of the Mesabi Ridgeline, and flows south out of the Mesabi Range (Figure 4.13-2). The St. Louis River Watershed is one of several watersheds that drain the Mesabi Range, where past and present mining activities have discharged to local waterbodies; however, because the proposed Project area is solely within the St. Louis River watershed and would have no direct or indirect influence on other regional watersheds it would not contribute to any cumulative effect to those other watersheds. The St. Louis River watershed and the proposed Project comply with the water quality and discharge standards under the Clean Water Act and Minnesota state regulations (refer to Section 4.1 Water Quality, for a detailed discussion of these standards). Similar to airsheds, the Clean Water Act regulates project-level discharges as a presumptive protection measure for regional water quality. Cumulative effects are still under review.

Land Cover

The proposed Mine Site is located within the Superior National Forest and both the Plant and Mine sites are surrounded by federal, state, and local public lands (Figure 4.13-3). These areas provide large tracts of natural vegetative cover, including wild rice, and habitat for endemic aquatic and terrestrial wildlife species such as moose throughout northeastern Minnesota. The development of past and current mining operations throughout the Mesabi Range has led to a historic reduction in natural vegetative cover and habitat fragmentation throughout the region and the future mining activities (including the Project) would contribute to further declines in habitat during the life of their respective projects. However, Northeastern Minnesota currently retains large regional tracts of undisturbed habitat, such as wetlands, where despite the impacts of this and other Projects within the Partridge River watershed, more than 97% of historic wetlands still remain. Long-term reclamation plans following cessation of operations would eventually restore native habitat and promote wildlife use; however, there would be a short-term decline in habitat availability at the various project sites.

As discussed in Sections 4.3 and 4.4, the Project would impact some ETSC plant species, wetlands, and wildlife corridors used by large mammals. The ETSC affected species are disturbance tolerant and impacts would not be significant. Use of one of 13 identified wildlife travel corridors would be restricted throughout the life of the mine. Some habitat fragmentation would occur, although the impact would be largely mitigated at mine closure and overall are not expected to be significant over the long-term.

Uniquely-affected Communities

In the case of human communities, the CEQ guidelines recommend analysis along sociocultural boundaries, or human communities that would be uniquely affected, rather than arbitrary political or administrative units. The uniquely affected communities in this Project area the Native American tribes within the 1854 Ceded Territory in northeastern Minnesota. These tribes have culturally-unique ties to the natural landscape that would potentially be uniquely impacted by the proposed project and therefore has the potential for cumulative effects to the tribes with cultural ties to the natural landscape. These impacts can manifest themselves in myriad ways, such as the loss of significant cultural landscapes, the loss of ancestral and/or sacred sites, and deterioration in the health or availability of animal and plant populations culturally associated with traditional diets, hunting practices, or spiritual practices.
These communities have used lands with the Ceded Territory for traditional culture purposes including wild rice harvesting and moose hunting. Wild rice communities are found within the Embarrass River; however the Plant Site, Mine Site, and Transportation Corridors do not support wild rice communities. Moose do occur in the vicinity of the Project; however, their populations are relatively low in this area compared to other portions of the 1854 Ceded Territory. Indirect cumulative effects to natural resources of cultural importance to tribes, due to the influence of regional projects on water resources, are under review.

The Project, as currently proposed, would result in a long term (over 20 years), but temporary, loss of tribal access to public lands for traditional uses. Although it is unclear to what extent these specific Project lands have been used by tribal members in the recent past, and these lands do not support wild rice or large moose populations, which are common tribal uses of public lands, nevertheless, the loss of public access represents an adverse effect to the tribes. For the Mine Site, the USFS and PolyMet have been working together to complete a land exchange to resolve the current split estate between Federal surface overlying private mineral rights. The USFS has identified approximately 6,700 acres of National Forest land to exchange to PolyMet for yet to be determined non-federal land. However, it is currently unknown if this non-Federal land would occur within the 1854 Ceded Territory and be available to the affected tribes.

5.0 Comparison of Alternatives

Minnesota statutes and rules require that an EIS include a discussion of alternatives (Minnesota Statutes Chapter 116D Sections 04 and 045; and Minnesota Rules Chapter 4410 Section 0200 through 7500) and alternatives that incorporate reasonable mitigation measures as identified during the scoping process and public comment periods (Minnesota Rules part 4410.2300, item G). Chapter 3.2 of this CPDEIS describes the alternatives and reasonable mitigation and monitoring measures considered during the scoping process. This chapter compares the identified reasonable alternatives and potential mitigation measures.

5.1. ALTERNATIVES CONSIDERED IN THE CPDEIS

Three alternatives were carried forward for analysis in the CPDEIS: the Proposed Action, the Subaqueous Disposal Alternative, and the No-Action Alternative. The two action alternatives are differentiated by their treatment of the Category 2/3/4 waste rock. Under the Proposed Action, the Category 2/3/4 waste rock stockpiles would be revegetated as part of the Mine Site reclamation and remain permanent surface features. The Subaqueous Disposal Alternative would temporarily store the Category 2/3/4 waste rock at the surface; however, most of the Category 2 and all Category 3/4 waste rock would ultimately be disposed as backfill in the mine pits and submerged to eliminate the long-term surface stockpiles. The No-Action Alternative would result in closure of a portion of the Plant Site as per the existing LTVSMC closure plan; however, no mining activities would occur. Table 5-1 compares the anticipated impacts of the Proposed Action with the Subaqueous Disposal and No-Action Alternatives.

Table 5-1 Comparison of the Proposed Action, Subaqueous Disposal Alternative, and No-Action Alternative

Resource	Proposed Action	Subaqueous Disposal Alternative	No-Action Alternative
Water Resources	**Water Quality:** No surface water quality impacts are anticipated. Adverse impacts to groundwater would occur at all waste rock stockpiles and the tailings basin. **Water Quantity/Levels: Evaluation in progress**	**Water Quality:** No surface water impacts are anticipated. Adverse impacts to groundwater would be limited to the Category 1 waste rock and Category 4 lean ore stockpiles and the Tailings Basin. Impacts to the tailings basin would be less than under the Proposed Action. **Water Quantity/Levels : Evaluation in progress**	**Plant Site:** Current impacts to GW quality from former LTVSMC tailings. **Mine Site:** No effect
Wetlands	Direct impact to 869 acres at Mine Site, transportation corridors, and tailings basin. An additional 328 acres of iIndirect impacts are predicted due to wildlife fragmentation and hydrologic effects. Monitoring may identify the need for compensatory mitigation for any additional indirect impacts caused by hydrologic effects.	The anticipated impacts from this alternative would be similar to the Proposed Action; however, the elimination of permanent surface stockpiles due to subaqueous disposal would slightly reduce wetland impacts at the Mine Site.	No effect at the Plant or Mine sites.
Vegetation	Construction and operation of the Plant and Mine sites would result in the loss of native species cover until completion of the reclamation actions (e.g., the life of the mine plus up to 40 years depending on cover type).	The anticipated impacts from this alternative would be similar to the Proposed Action; however, the elimination of permanent surface stockpiles due to subaqueous disposal would reduce the loss of natural habitat at the Mine Site.	**Plant Site:** increased native species cover following partial closure **Mine Site:** No effect
Wildlife	Construction and operation of the Plant and Mine sites would result in the loss of natural wildlife habitat until completion of the reclamation actions (e.g., the life of the mine plus up to 40 years depending on habitat type). Potential to impact Canada Lynx (federally threatened species) at the Mine Site.	The anticipated impacts from this alternative would be similar to the Proposed Action; however, the elimination of permanent surface stockpiles due to subaqueous disposal would reduce the loss of natural habitat at the Mine Site.	**Plant Site:** limited habitat benefits following partial closure **Mine Site:** No effect
Fish and Benthic Macroinvertebrates	Limited adverse effect. Water quality impacts to aluminum would exacerbate existing aluminum stress in the Partridge River. Potential increase in the availability of methylmercury to fish.	Limited adverse effect. The anticipated impacts from this alternative would be the same as those for the Proposed Action.	No effect at the Plant or Mine sites.

Resource	Proposed Action	Subaqueous Disposal Alternative	No-Action Alternative
Air Quality	No significant effect at the Plant or Mine sites.	No significant effect at the Plant or Mine sites.	No effect at the Plant or Mine sites.
Noise	No significant effect at the Plant or Mine sites.	No significant effect at the Plant or Mine sites.	No effect at the Plant or Mine sites.
Cultural Resources	No significant effect to historic or archaeological resources. Loss of access to Mine Site would reduce tribal access to lands in the 1854 Ceded Territory.	No significant effect to historic or archaeological resources. The anticipated impacts from this alternative would be the same as those for the Proposed Action.	No effect at the Plant or Mine sites.
Compatibility with Plans and Land Use Regulations	No significant effect. Loss of access to Mine Site lands during life of the Mine would be offset by areas gained through land exchange. No long-term violation of the Federal, state, and local land management plans.	No significant effect. Loss of access to Mine Site lands during life of the Mine would be offset by areas gained through land exchange. No long-term violation of the Federal, state, and local land management plans.	No effect at the Plant or Mine sites.
Socioeconomics	Beneficial effect: Local increase in employment, taxes, and spending. The local infrastructure can support the anticipated influx of workers; therefore, there would be no significant effect on community infrastructure.	Beneficial effect. The anticipated impacts from this alternative would be the same as those for the Proposed Action.	No effect at the Plant or Mine sites.
Visual Resources	No significant effect. Visual impacts are shielded from all but those individuals immediately adjacent to the Mine Site.	No significant effect. The anticipated impacts from this alternative would be similar to the Proposed Action; however, the elimination of several permanent surface stockpiles due to subaqueous disposal would reduce visual intrusion relative to the Proposed Action.	**Plant Site:** limited beneficial effect following partial closure **Mine Site:** No effect
Hazardous Materials	No significant effect. Hazardous materials would be managed in accordance with Federal, state, and local requirements.	No significant effect. The anticipated impacts from this alternative would be the same as those for the Proposed Action.	No effect at the Plant or Mine sites.

5.2. IDENTIFICATION OF AN AGENCY PREFERRED ALTERNATIVE

The anticipated impacts of the Proposed Action would be similar to those from the Subaqueous Disposal Alternative for seven of the twelve resources identified above: Fish and Benthic Macroinverebrates; Air Quality; Noise; Cultural Resources; Compatibility with Plans and Land Use Regulations; Socioeconomics; and Hazardous Materials. The anticipated impacts to these resources would not be affected by subaqueous disposal as opposed to surface storage of Category 2/3/4 waste rock.

Subaqueous disposal of the Category 2/3/4 waste rock would reduce the permanent stockpile footprint at the Mine Site, thereby providing minor environmental benefits to wetlands, vegetation, wildlife, and visual resources relative to the Proposed Action. Subaqueous disposal would maintain a greater amount of naturally-occuring upland and wetland vegetation and wildlife habitat when compared to the Proposed Action and reduce the direct impacts of the Project on these resources. The elimination of the these surface waste rock stockpiles also limits the Mine Site’s long-term visual intrusion into the surrounding landscape, although the surface stockpiles would occur temporarily until space is available in the East Pit.

The Subaqueous Disposal Alternative would have significant environmental benefits to groundwater quality when compared to the Proposed Action. At the Mine Site, the Proposed Action would exceed the groundwater impact criteria at all waste rock and lean ore stockpiles for various constituents. The Subaqueous Disposal Alternative would also exceed the groundwater impact criteria for a subset of those constituents, but the impacts would be limited to the Category 1 and Category 4 lean ore stockpiles, respectively, and these effects could be mitigated.

At the Plant Site, the Proposed Action would exceed the groundwater impact criteria in the tailings basin for several constituents. The Subaqueous Disposal Alternative would also exceed the groundwater impact criteria at the tailings basin; however, the constituents would be liminted to arsenic and antimony. The arsenic impacts associated with the Subaqueous Disposal Alternative, while exceeding the impact criteria, would be less than the arsenic levels under the Proposed Action. No impacts to surface water are anticipated for either action alternative. Water quantity and level impacts are still under review.

The environmental effects of the Subaqueous Disposal Alternative were determined to be comparable or less significant for all resources when compared to the Proposed Action. The Proposed Action would result in significant groundwater impacts to multiple constituents at both the Plant and Mine sites, while the Subaqueous Disposal Alternative would reduce the constituents of concern at both locations and reduce the impacts to two stockpiles at the Mine Site and reduce constituent levels in the tailings basin at the Plant Site. The No-Action Alternative would have no effect on eight of the twelve resources identified above. The No-Action Alternative would have slight benefits to vegetation, wildlife, and visual resources due to the partial closure of the Plant Site under the existing LTVSMC closure plant. However, the former LTVSMC tailings basin would continue to adversely impact groundwater at the Plant Site.

The Subaqueous Disposal Alternative meets the Project purpose and need and offers significant environmental benefits over the Proposed Action with respect to water quality. Nevertheless, there are still remaining groundwater quality issues that are still undergoing evaluation and at this time, we are not prepared to identify an agency preferred alternative.

5.3. MITIGATION AND MONITORING MEASURES

During the EIS scoping process, additional mitigation measure were identified for consideration to minimize the potential impacts from the Project. A summary of these mitigation and monitoring measures are presented in the table below. Several of the mitigation measures have already been adopted as part of the Project. The table identifies wheter the mitigation measure has been incorporated in the Proposed Action (I), is an agency-identified additional measure (A), or is still under consideration (C). Refer to Section 3.2.2.2 and the resource-specific sections in Chapter 4 of the CPDEIS for a detailed description and the potential benefits of the measure.

Table 5-2 Summary of Monitoring and Mitigation Measures

Resource	Mitigation Measure	Status
4.1 - Water Resources	Fully Lined Tailings Basin	C
	Chemical Modification of Reactive Waste R	C
	Monitoring of Waste Rock Stockpiles and Ta Basin	A
	Maximize the elevation of the Category 1/2 stockpile	A
	Dry cover for Tailings Area reclamation	C
	Others under review	C
4.2 - Wetlands	Include the Tailings Basin in the wetlands monitoring program during operation and clo	A
	A wetland monitoring plan to characterize in effects on wetlands and provide for potential mitigation, including additional compensator mitigation, as needed	A

Resource	Mitigation Measure	Status
	Mitigation of indirect wetland impacts beyor 28 acres identified by PolyMet for compensa mitigation to be addressed as a permit condit	A
	Use LTVSMC taconite tailings for construct the NorthMet tailings embankment	A
	Fully-Lined Tailings Basin	C
4.3 - Vegetation	Use a fast-acting seed mix during reclamatio contains potential invasive species	I
	Use a native species seed mix to stabilize dis areas during site reclamation	A
	Fencing/Flagging ETSC plant species along Road	A
	Monitoring of Waste Rock Stockpiles and Ta Basin	A
	Chemical Modification of the Reactive Wast Stockpiles	A
	Use Overburden in the East Pit	A
	Maximize the elevation of the Category 1/2 s	A
4.4 – Wildlife	Vehicular prevention and avoidance techniqu including speed limits and driver education f Dunka Road users	A
	Use a fast-acting seed mix during reclamatio contains potential invasive species	I
	Use a native species seed mix during reclama	A
	Prohibit access to the Mine Site during reclar through signage, barriers, berms to facilitate restoration and wildlife use	A
	Monitoring of Waste Rock Stockpiles and Ta Basin	A
	Chemical Modification of the Reactive Wast Stockpiles	A
	Use Overburden in the East Pit	A
	Maximize the elevation of the Category 1/2 s	A
4.5 - Fish and Benthic Macroinvertebrates	Monitor mercury levels in overburden stockp runoff to determine need for additional mitig	A
4.6 - Air Quality	Replace locomotives with USEPA Tier-III er certified units	I
	Upgrade particulate matter controls to most s control levels, as identified by USEPA RLB(	I
	Active treatment of tailings basin roads, wor and beaches	I
	Modified road layouts and truck sizes at the Site	I
	Pre-construction and post-operation ambient monitoring for MN-fibers in Hoyt Lakes	I
4.7 - Noise	Seismic monitoring program	I
	Air blast monitoring stations adjacent to near Project structures	I
4.8 - Cultural Resources	No mitigation or monitoring measures identi	N/A
4.9 - Compatibility with P Land Use Regulations	Use a fast-acting seed mix during reclamatio contains potential invasive species	I
	Use a native species seed mix during reclama	A
	Chemical Modification of the Reactive Wast Stockpiles	A
	Use Overburden in the East Pit	A
	Maximize the elevation of the Category 1/2 s	A
4.10 - Socioeconomics	No mitigation or monitoring measures identi	N/A
4.11 - Visual Resources	Direct operating lights down and shield light to reduce glow effects	A
4.12 - Hazardous Material	Hazardous Materials Management Plan	I

Resource	Mitigation Measure	Status
	SPCC Plan	I
	Emergency Response Plan	I
	Spil Response Plan	I
	Spill mitigation procedures including: overfi protection, secondary containment, leak dete systems, and preventative inspection and maintenance	I
	Monitoring activities including: visual inspe storage facilities; inspections for vessel leaks equipment verification; emergency system re employee awareness training; surface and groundwater modeling; and accessible MSD	I

6.0 Irreversible or Irretrievable Commitment of Resources

The Proposed Action could result in the irreversible commitment of resources or the irretrievable commitment of resources. Irreversible commitment of resources refers to the loss of future options for resource development or management, especially of nonrenewable resources such as minerals and cultural resources. Irretrievable commitment of resources refers to the lost production or use of renewable natural resources during the life of the operations.

The construction and operation of the Project would result in the irreversible or irretrievable loss of minerals, vegetation, wetlands, and cultural and tribal resources. Approximately 228 million tons of base and precious metal ore and lean ore would be irreversibly lost over the life of the mine. Excavation of the mine pit would also result in the irretrievable loss of vegetation communities at the Plant and Mine sites, including wetlands, for the life of the mine. Following mine closure, significant portions of the site would be reclaimed and the land would revert to its natural state; however, a subset of these communities would be irreversibly lost due to the remaining permanent mining features such as the conversion from terrestrial to open water habitat in the West Pit. The mine site contains natural resources culturally important to tribes, including access to the land itself, that would be irretrievably lost during the life of the Project, including reclamation.

The construction and operation of the Project would also result in an irreversible and irretrievable commitment of water resources. During project operation, available ground water would irretrievably decline due to mine pit dewatering and surface water withdrawals. Additionally, groundwater quality immediately surrounding the surface stockpiles and tailings basin would decline.

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For reviewers who would like to obtain complete copies of the reports of these studies, the MDNR will provide this information on a CD upon request.

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