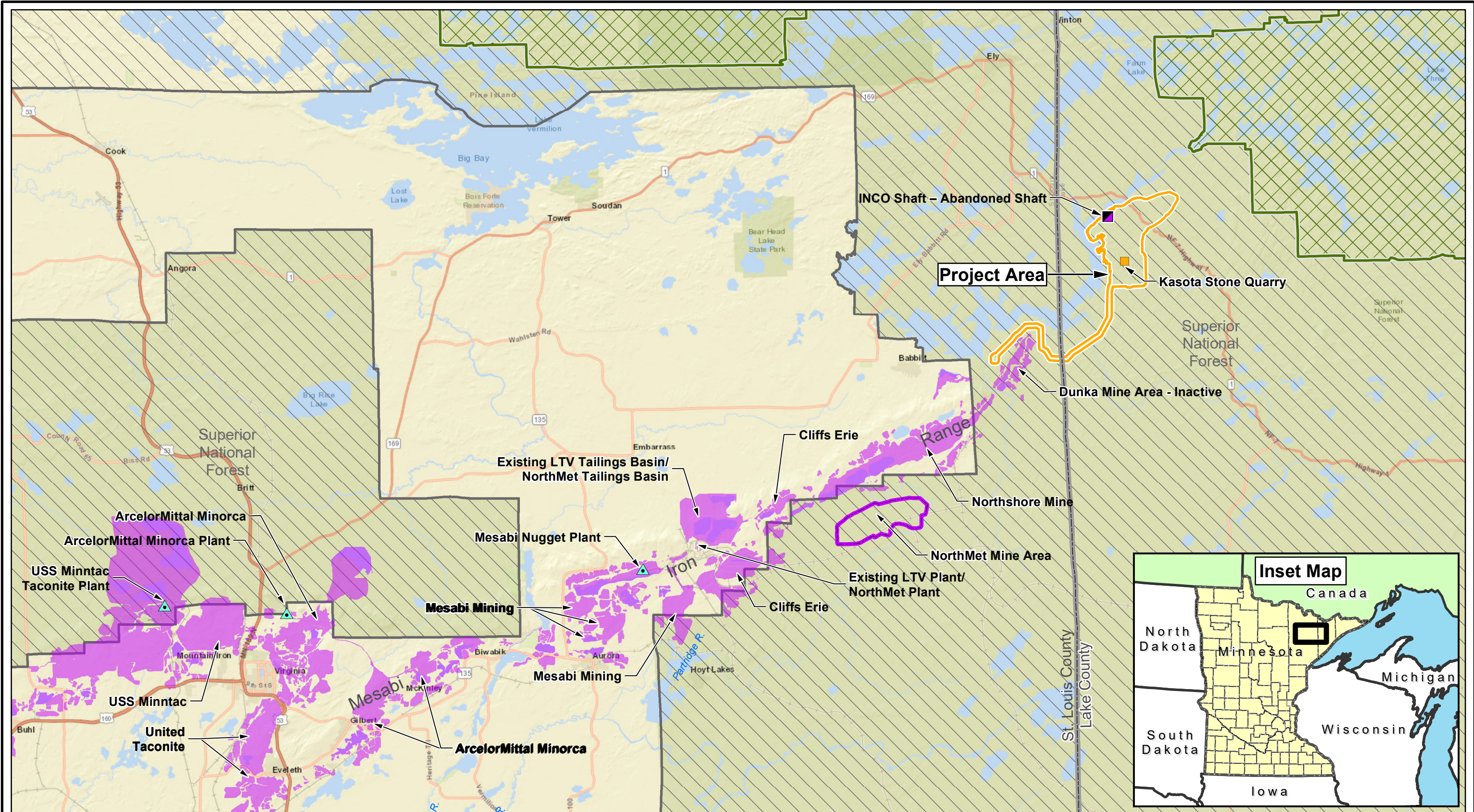




**TWIN METALS MINNESOTA PROJECT
SCOPING ENVIRONMENTAL ASSESSMENT
WORKSHEET DATA SUBMITTAL**
Environmental Review Support Document

**SCOPING ENVIRONMENTAL ASSESSMENT WORKSHEET
DATA SUBMITTAL - FIGURES**



NOTES

1. Basemap from Esri and its data suppliers.
2. Boundary data from the Minnesota Department of Natural Resources.
3. Mining related data from Minnesota Department of Natural Resources Division of Lands and Minerals via email.
4. Horizontal datum based on NAD 1983. Horizontal coordinates based on Minnesota State Plane North (feet).

LEGEND

	Inco Shaft – Abandoned Shaft		Superior National Forest Administrative Boundary (does not indicate surface ownership)
	Kasota Stone Quarry		Boundary Waters Canoe Area Wilderness
	Existing Taconite Plant		Mesabi Range Mining Features (Existing Pits, Tailings Basins, Stockpiles and other Mine Features)
	County Boundary		
	Project Area		



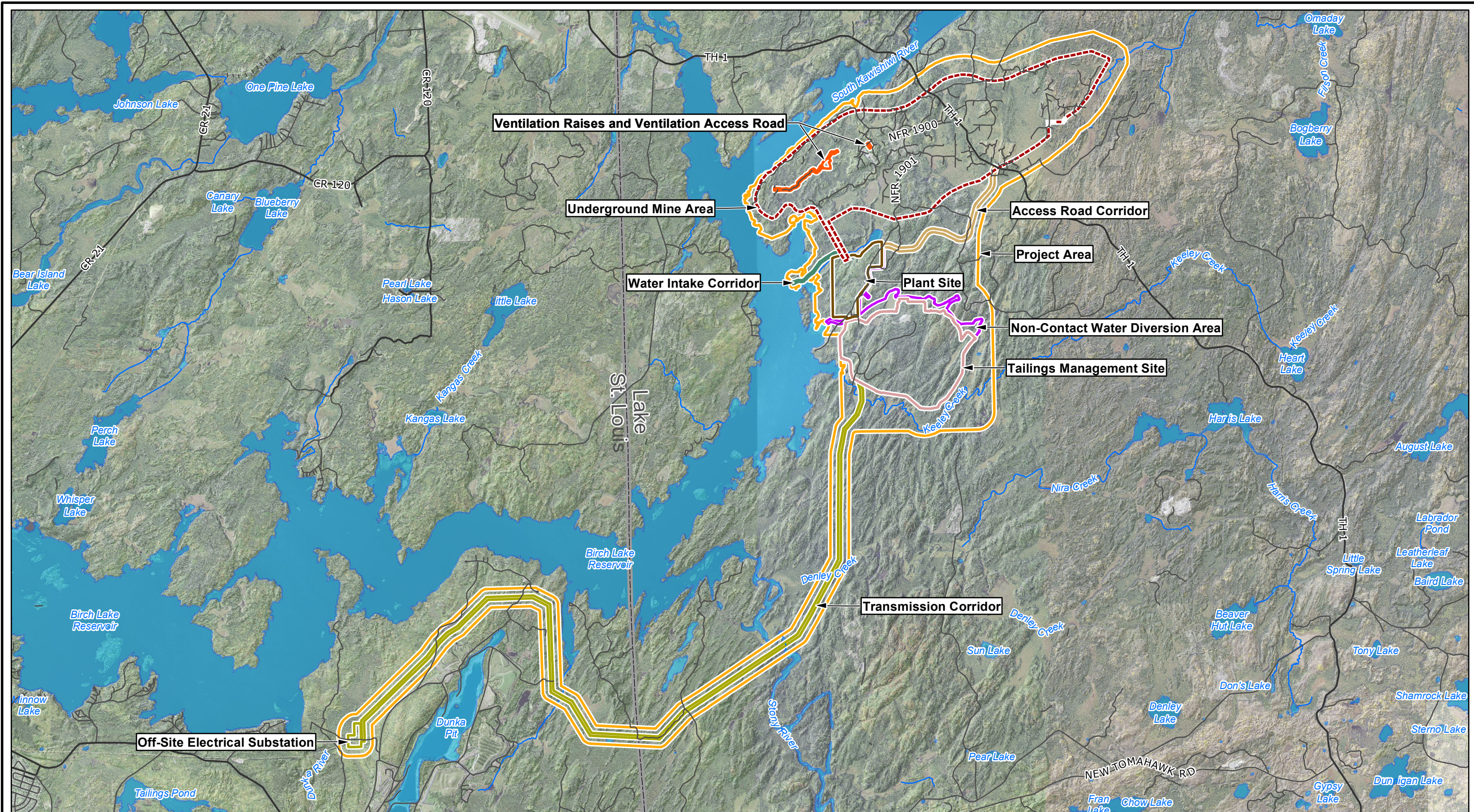
TWIN METALS MINNESOTA

FIGURE 1-1

PROJECT LOCATION

Scale: 0 2 4 Miles

Date: SEPTEMBER 2019



NOTES:

1. Base air photo from the U.S. Department of Agriculture Farm Service Agency, Aerial Photography Field Office.
2. Hydrographic data from Minnesota Department of Natural Resources.
3. Horizontal datum based on NAD 1983. Horizontal coordinates based on Minnesota State Plane North (feet).

LEGEND

— Primary Road	Project Area	Transmission Corridor
— Secondary Road	Underground Mine Area	Water Intake Corridor
— River/Stream	Plant Site	Ventilation Raises and Ventilation Access Road
— Lake/Pond	Tailings Management Site	Access Road Corridor
— County Boundary	Non-Contact Water Diversion Area	

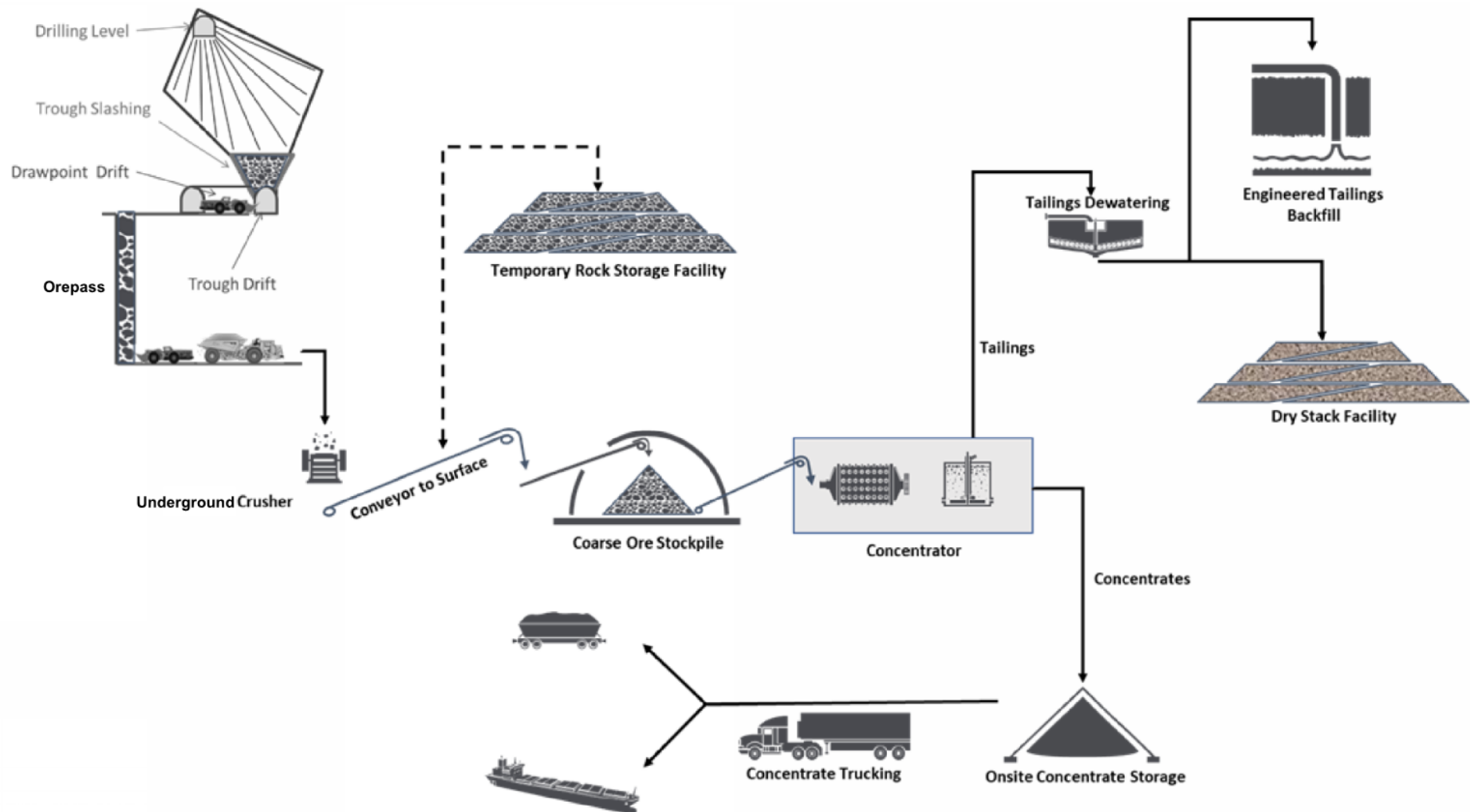
TWIN METALS MINNESOTA

FIGURE 2-1

GENERAL PROJECT LAYOUT

Scale: 0 2,500 5,000 Feet

Date: SEPTEMBER 2019



Activity	Construction										Operations	
	Year -3		Year -2				Year -1				Year 1	
	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2
Construction												
Construction start	★											
Site Development & Access Roads												
Portal and Decline Development												
Mine & Mine Infrastructure												
Concentrator												
Tailings Dewatering Plant												
Dry Stack Facility												
Commissioning												
Stope Mining Begins										★		
Commissioning & Ramp-up												
Commerical Production												★



TWIN METALS MINNESOTA

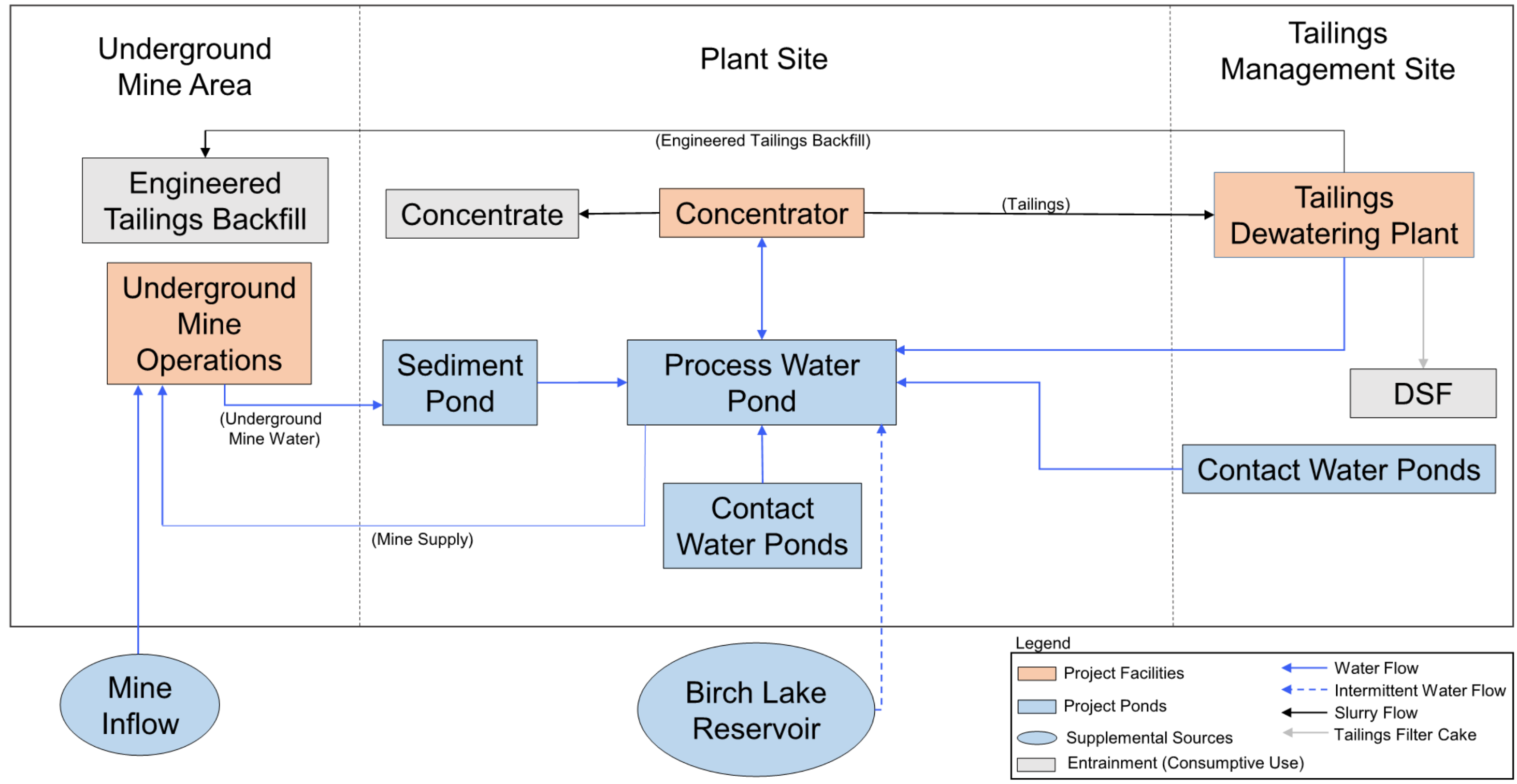
FIGURE 3-2

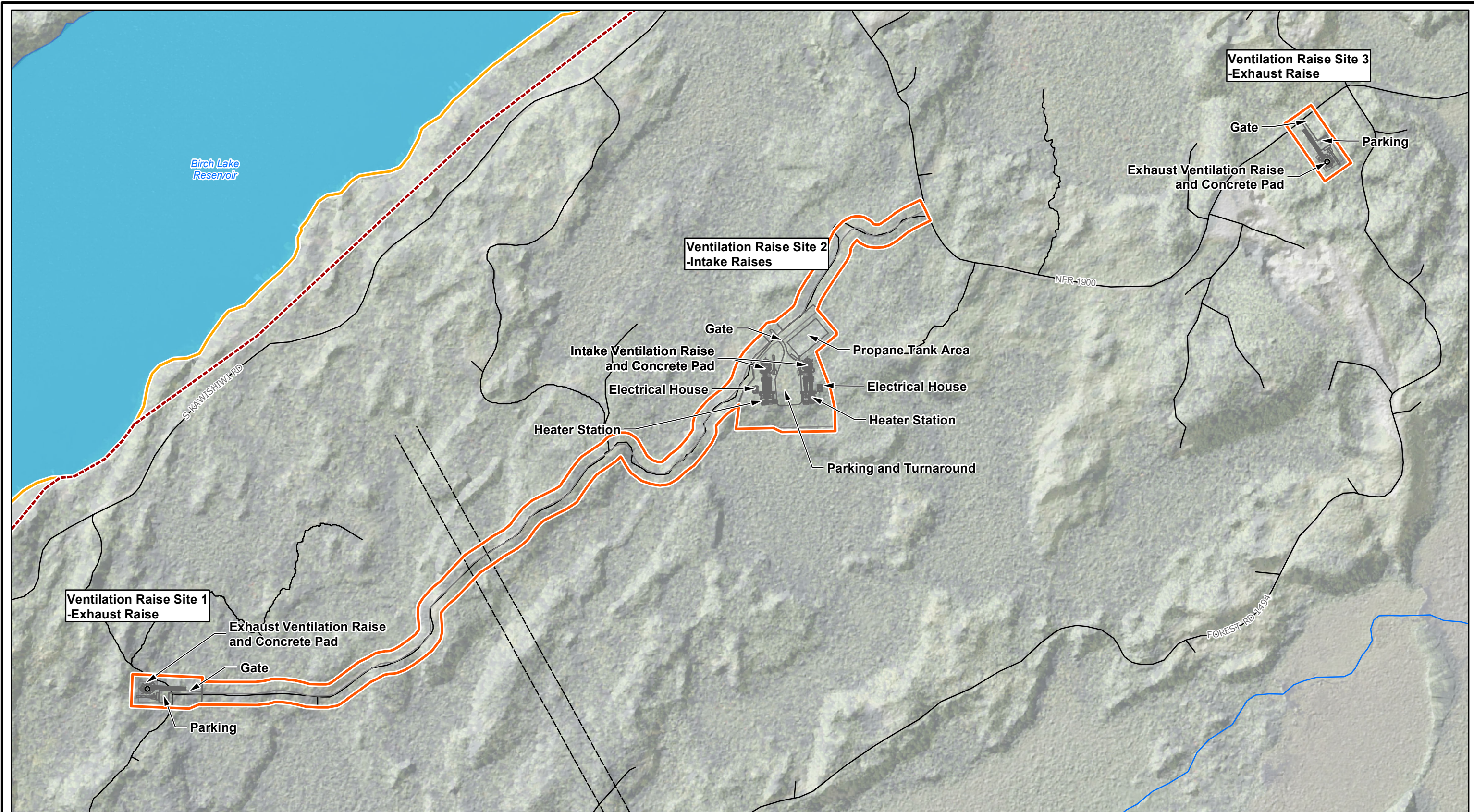
PROJECT CONSTRUCTION SCHEDULE

Scale: NOT TO SCALE

Date: SEPTEMBER 2019

Process Water Flow Schematic





NOTES:

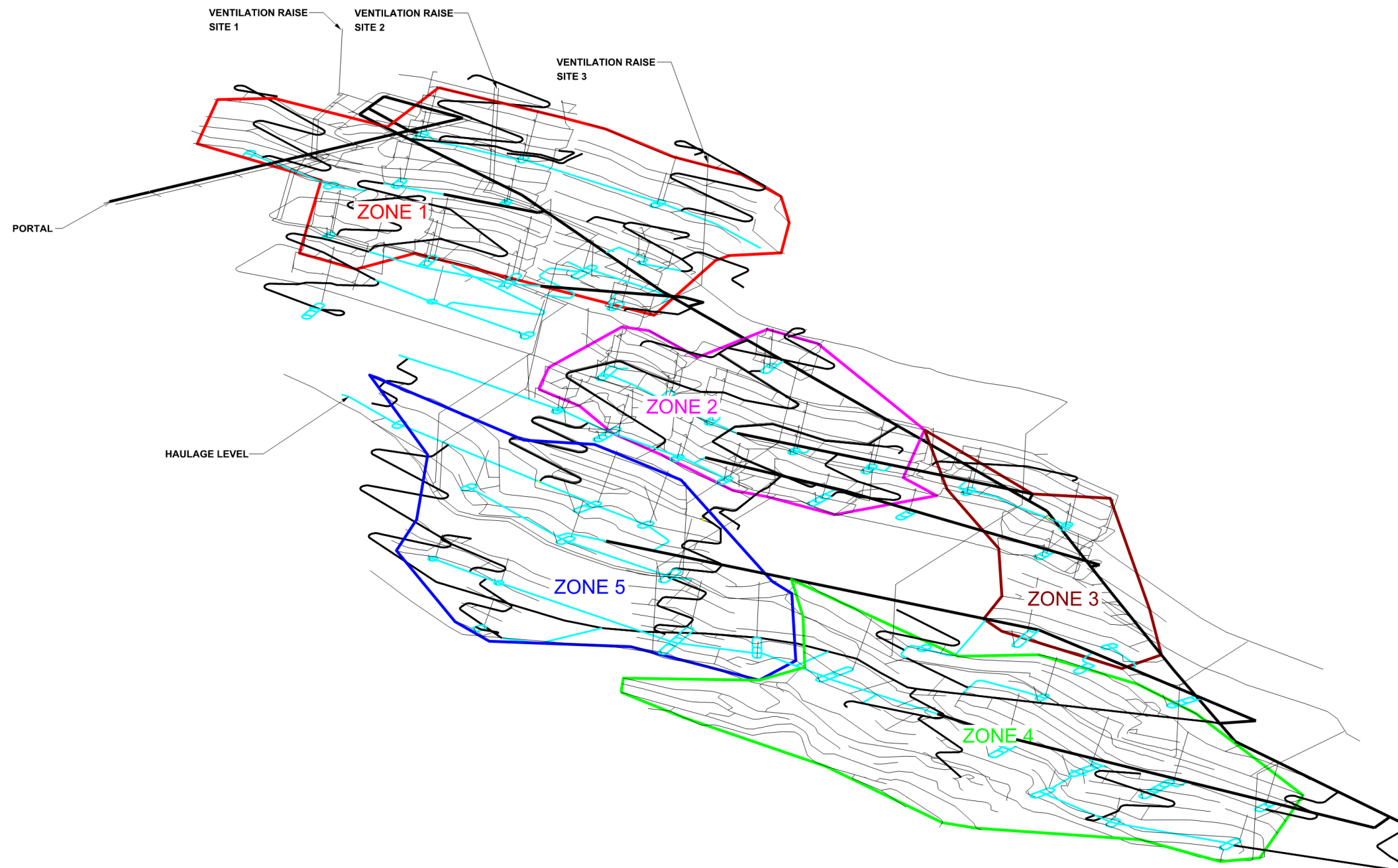
1. Base air photo from the U.S. Department of Agriculture Farm Service Agency, Aerial Photography Field Office.
2. Digital elevation model hillshade downloaded from MnTopo.
3. Hydrographic data from Minnesota Department of Natural Resources.
4. Horizontal datum based on NAD 1983. Horizontal coordinates based on Minnesota State Plane North (feet).

LEGEND

— Facilities	Ventilation Raises and Ventilation Raise Access Road
- - - Decline	Underground Mine Area
— Secondary Road	Project Area
River/Stream	
Lake/Pond	



TWIN METALS MINNESOTA	
FIGURE 3-4	
VENTILATION RAISE LAYOUTS	
Scale: 0 200 400 Feet	Date: SEPTEMBER 2019




UNDERGROUND MINE AREA DESIGN
ISOMETRIC VIEW
 200-00-206-0001-01

- LEGEND**
- ZONE 1 BOUNDARY —
 - ZONE 2 BOUNDARY —
 - ZONE 3 BOUNDARY —
 - ZONE 4 BOUNDARY —
 - ZONE 5 BOUNDARY —
 - MINE RAMP —
 - HAULAGE LEVEL —
 - CONVEYOR DRIFT —
 - DRIFT —

PRELIMINARY
NOT FOR CONSTRUCTION

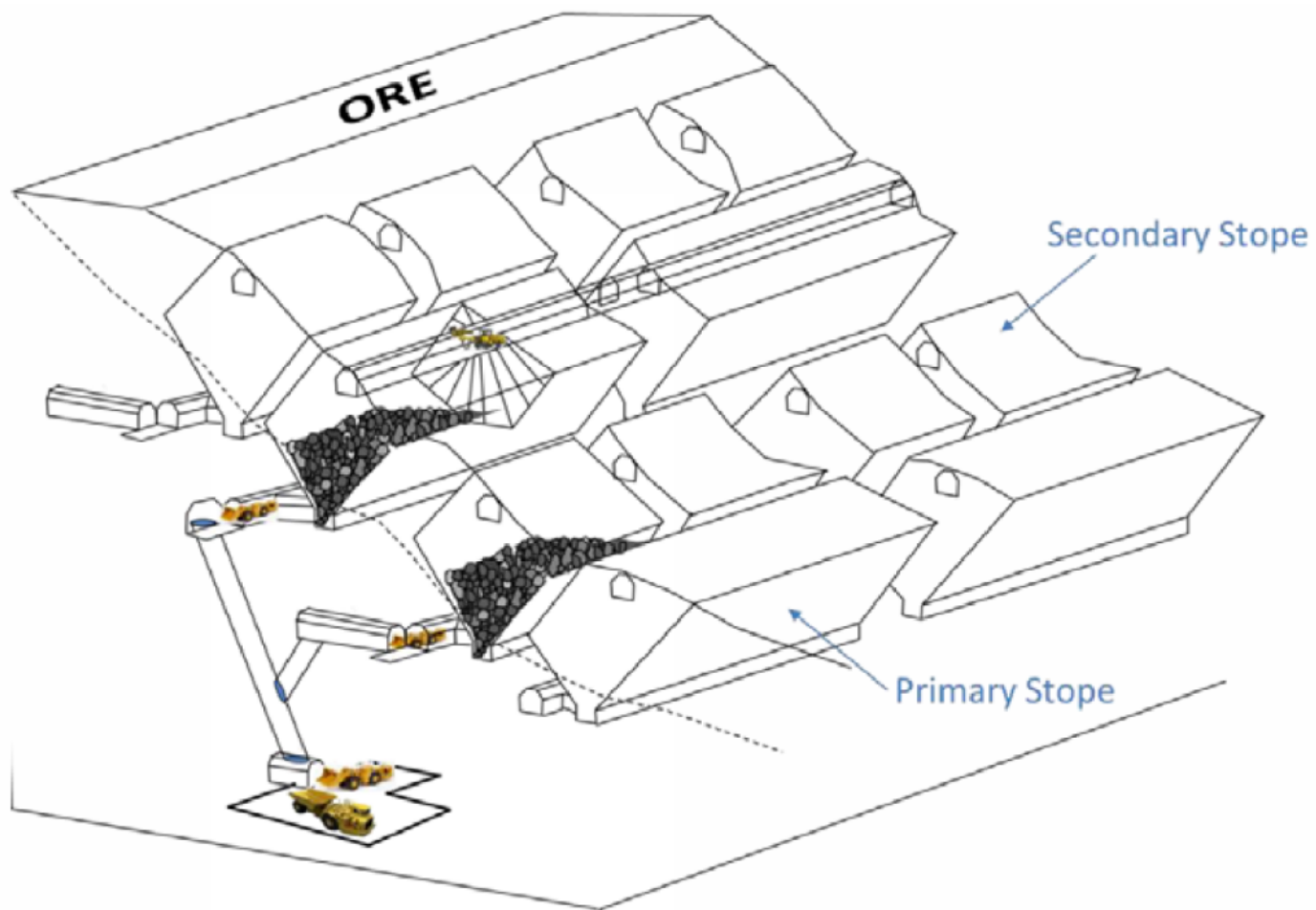


TWIN METALS MINNESOTA

FIGURE 3-5
UNDERGROUND MINE AREA DESIGN

Scale: NOT TO SCALE

Date: SEPTEMBER 2019



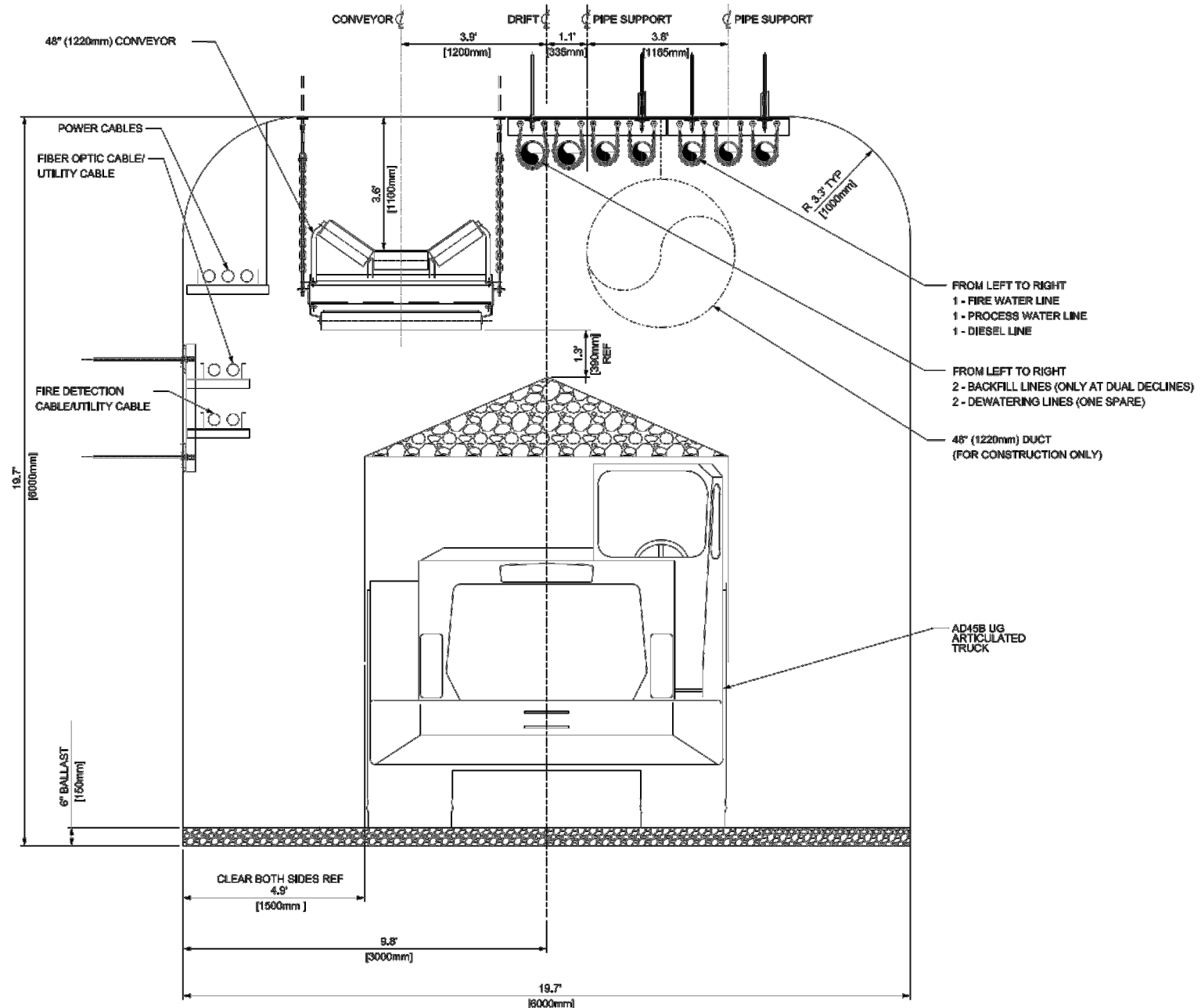
TWIN METALS MINNESOTA

FIGURE 3-6

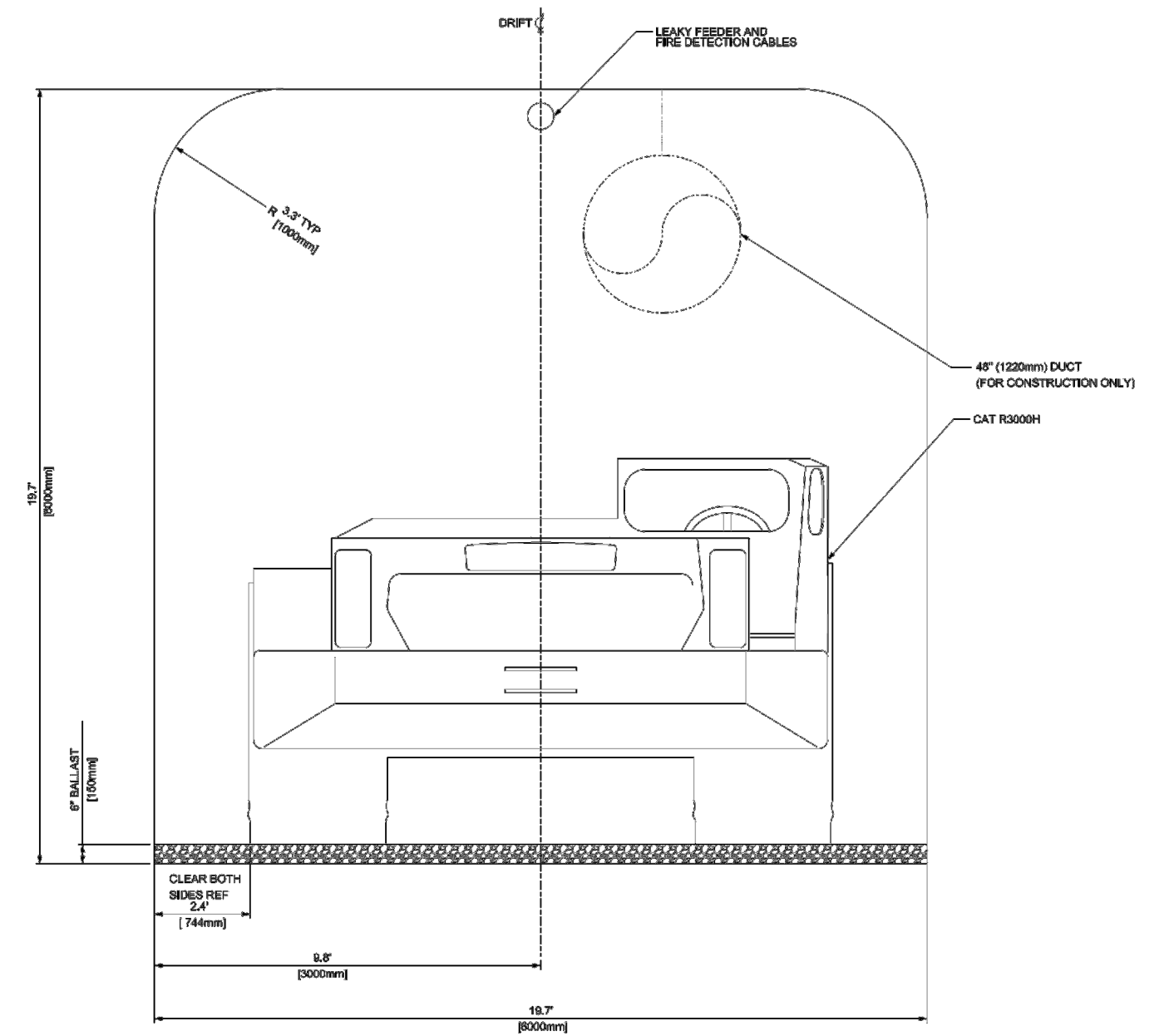
MINING METHOD SCHEMATIC

Scale: NOT TO SCALE

Date: SEPTEMBER 2019



TYPICAL CONVEYOR DRIFT - SECTION



TYPICAL TRANSPORT DRIFT - SECTION

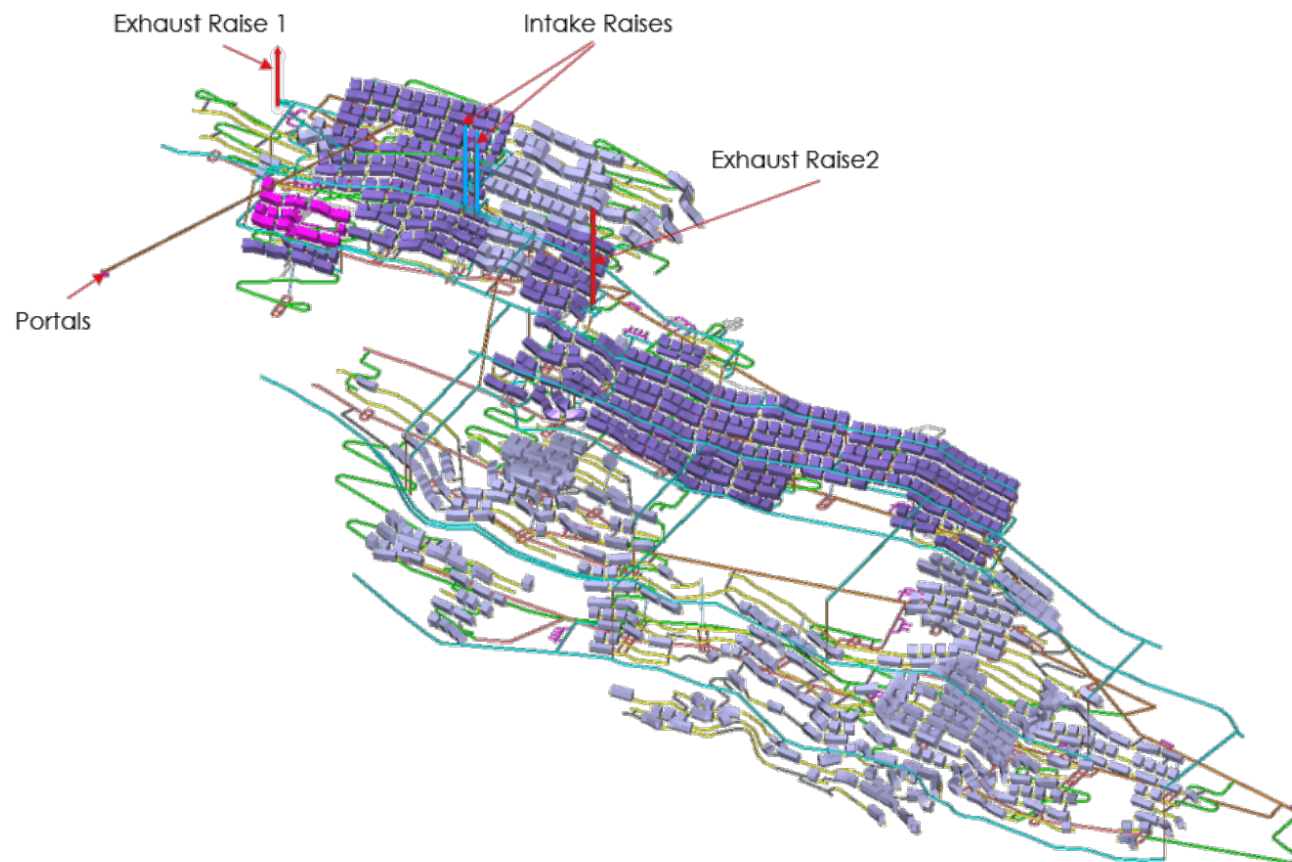
PRELIMINARY
NOT FOR CONSTRUCTION



TWIN METALS MINNESOTA

FIGURE 3-7
MINE DESIGN TYPICAL DRIFT SECTIONS

Scale: NOT TO SCALE Date: SEPTEMBER 2019



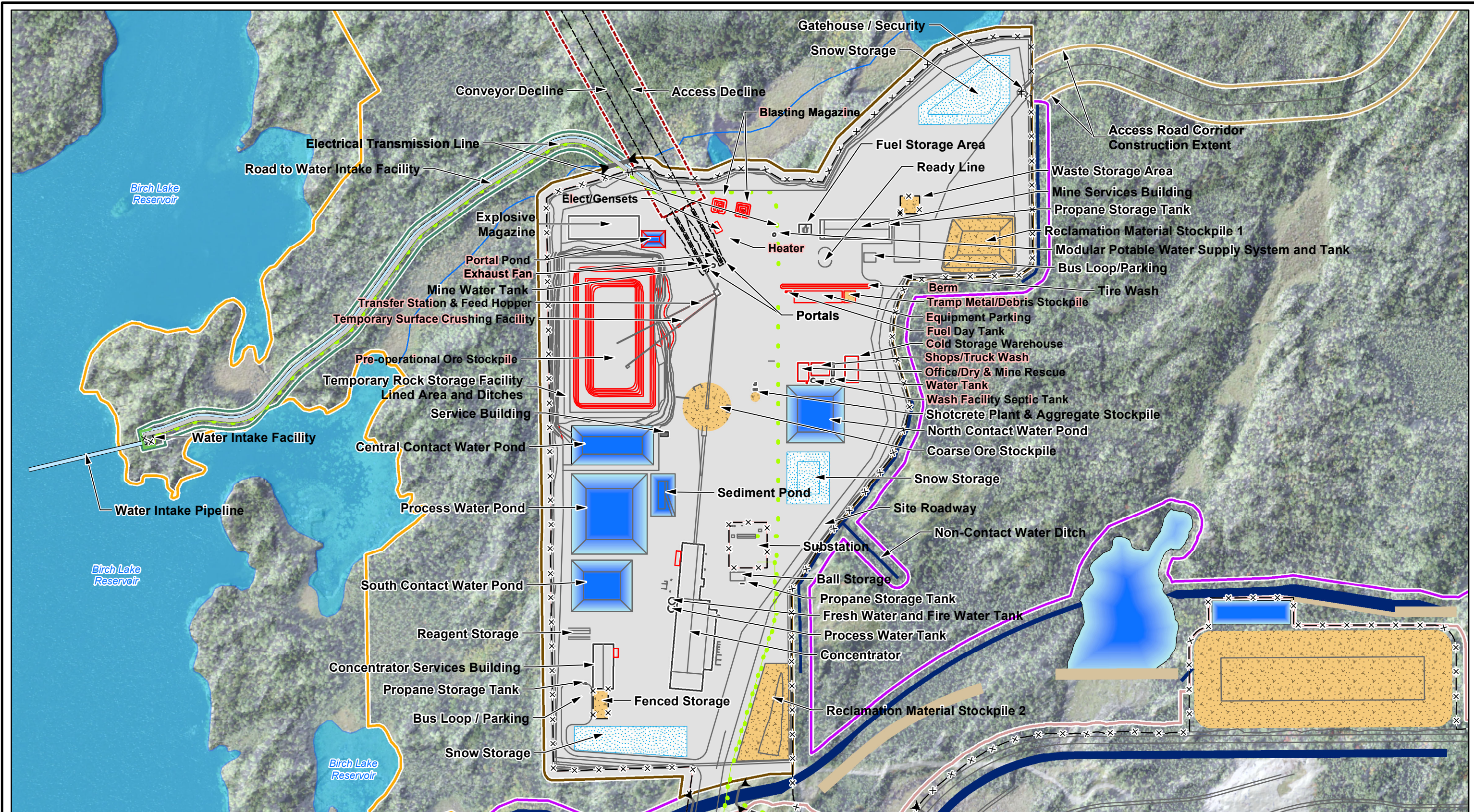
TWIN METALS MINNESOTA

FIGURE 3-8

MATURI 25-YEAR MINE DESIGN

Scale: NOT TO SCALE

Date: SEPTEMBER 2019



NOTES:

1. Base air photo from the U.S. Department of Agriculture Farm Service Agency, Aerial Photography Field Office.
2. Hydrographic data from Minnesota Department of Natural Resources.
3. Horizontal datum based on NAD 1983. Horizontal coordinates based on Minnesota State Plane North (feet).

LEGEND

— Facility	— Temporary Facilities during Construction	■ Plant Site
- - - Decline	— River/Stream	■ Tailings Management Site
— Piping	■ Lake/Pond	■ Non-Contact Water Diversion Area
— Culvert	■ Project Area	■ Water Intake Corridor
— Electrical Transmission Line	■ Underground Mine Area	■ Access Road Corridor
x — Fence		
— Vegetative Screen		

Facilities and Infrastructure:

- Gatehouse / Security
- Snow Storage
- Conveyor Decline
- Access Decline
- Blasting Magazine
- Fuel Storage Area
- Ready Line
- Waste Storage Area
- Mine Services Building
- Propane Storage Tank
- Reclamation Material Stockpile 1
- Modular Potable Water Supply System and Tank
- Bus Loop/Parking
- Explosive Magazine
- Elect/Gensets
- Heater
- Portals
- Berm
- Tramp Metal/Debris Stockpile
- Equipment Parking
- Fuel Day Tank
- Cold Storage Warehouse
- Shops/Truck Wash
- Office/Dry & Mine Rescue
- Water Tank
- Wash Facility Septic Tank
- Shotcrete Plant & Aggregate Stockpile
- North Contact Water Pond
- Coarse Ore Stockpile
- Snow Storage
- Site Roadway
- Non-Contact Water Ditch
- Ball Storage
- Propane Storage Tank
- Fresh Water and Fire Water Tank
- Process Water Tank
- Concentrator
- Reclamation Material Stockpile 2
- Fenced Storage
- Snow Storage
- Bus Loop / Parking
- Concentrator Services Building
- Propane Storage Tank
- Reagent Storage
- South Contact Water Pond
- Process Water Pond
- Central Contact Water Pond
- Service Building
- Lined Area and Ditches
- Temporary Rock Storage Facility
- Pre-operational Ore Stockpile
- Temporary Surface Crushing Facility
- Transfer Station & Feed Hopper
- Mine Water Tank
- Portal Pond Exhaust Fan
- Water Intake Facility
- Water Intake Pipeline
- Road to Water Intake Facility
- Electrical Transmission Line

TWIN METALS MINNESOTA

FIGURE 3-9

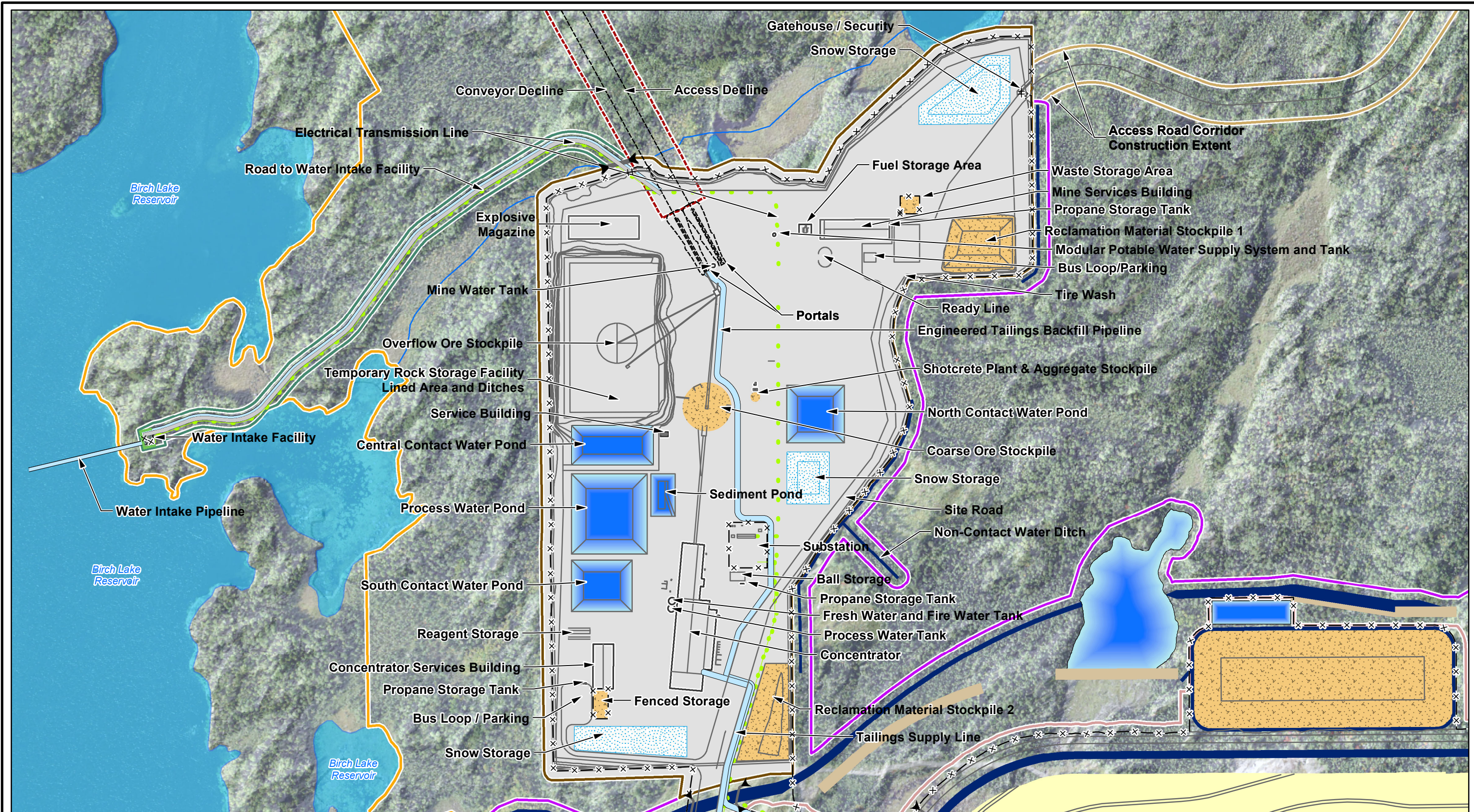
PLANT SITE CONSTRUCTION PHASE

Scale: 0 250 500 Feet

Date: SEPTEMBER 2019

Foth

N



NOTES:

1. Base air photo from the U.S. Department of Agriculture Farm Service Agency, Aerial Photography Field Office.
2. Hydrographic data from Minnesota Department of Natural Resources.
3. Horizontal datum based on NAD 1983. Horizontal coordinates based on Minnesota State Plane North (feet).

LEGEND

— Facility	— River/Stream	■ Plant Site
- - - Decline	■ Lake/Pond	■ Tailings Management Site
— Piping	■ Project Area	■ Non-Contact Water Diversion Area
— Culvert	■ Underground Mine Area	■ Water Intake Corridor
● Electrical Transmission Line		■ Access Road Corridor
x Fence		
— Vegetative Screen		

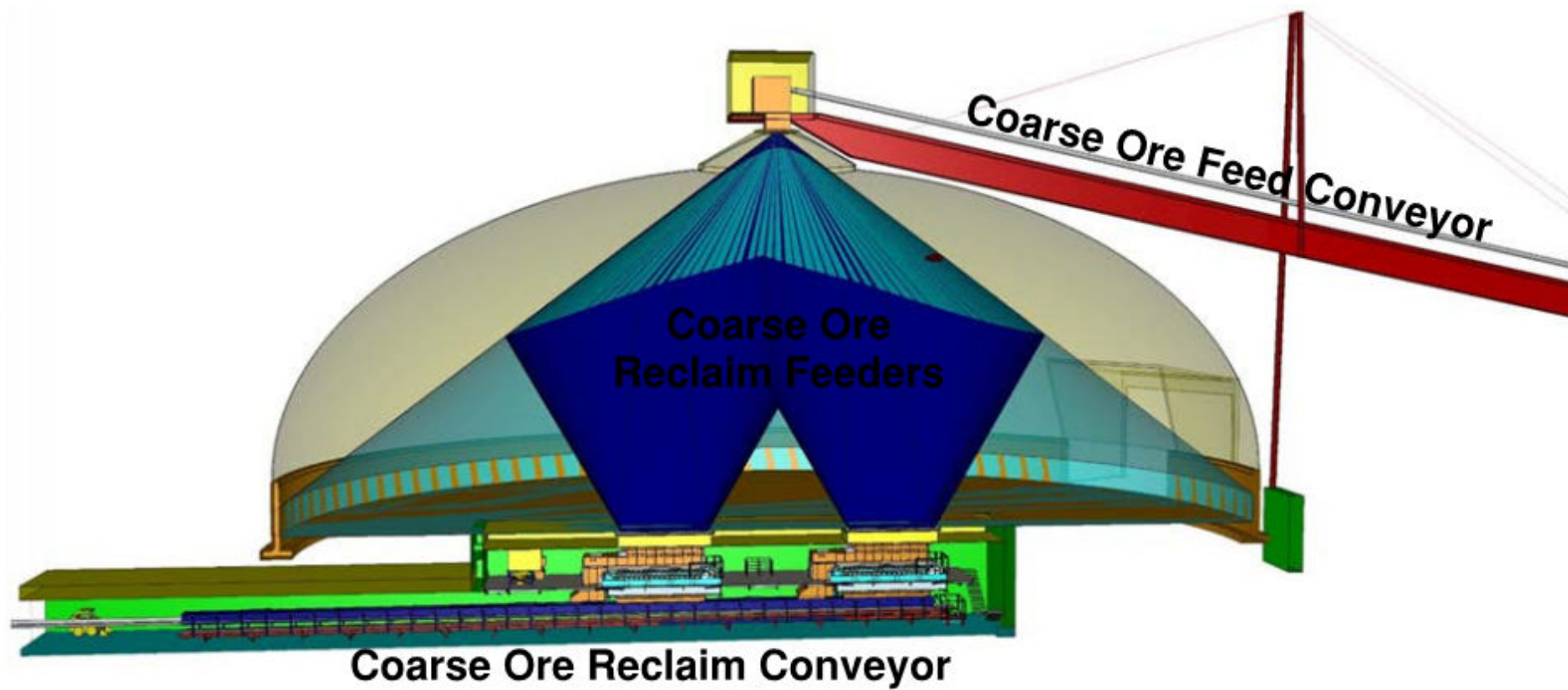
TWIN METALS MINNESOTA

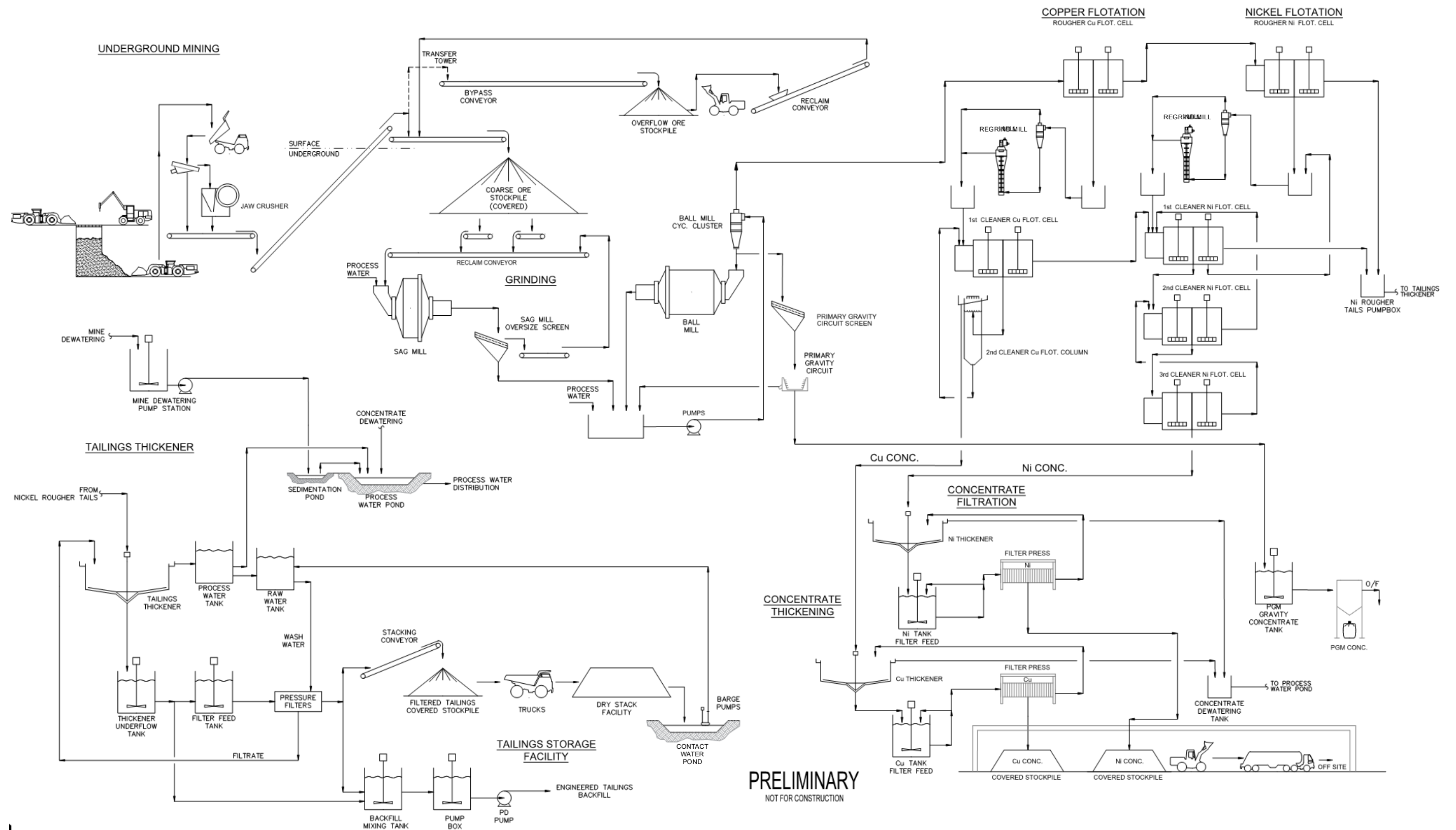
FIGURE 3-10

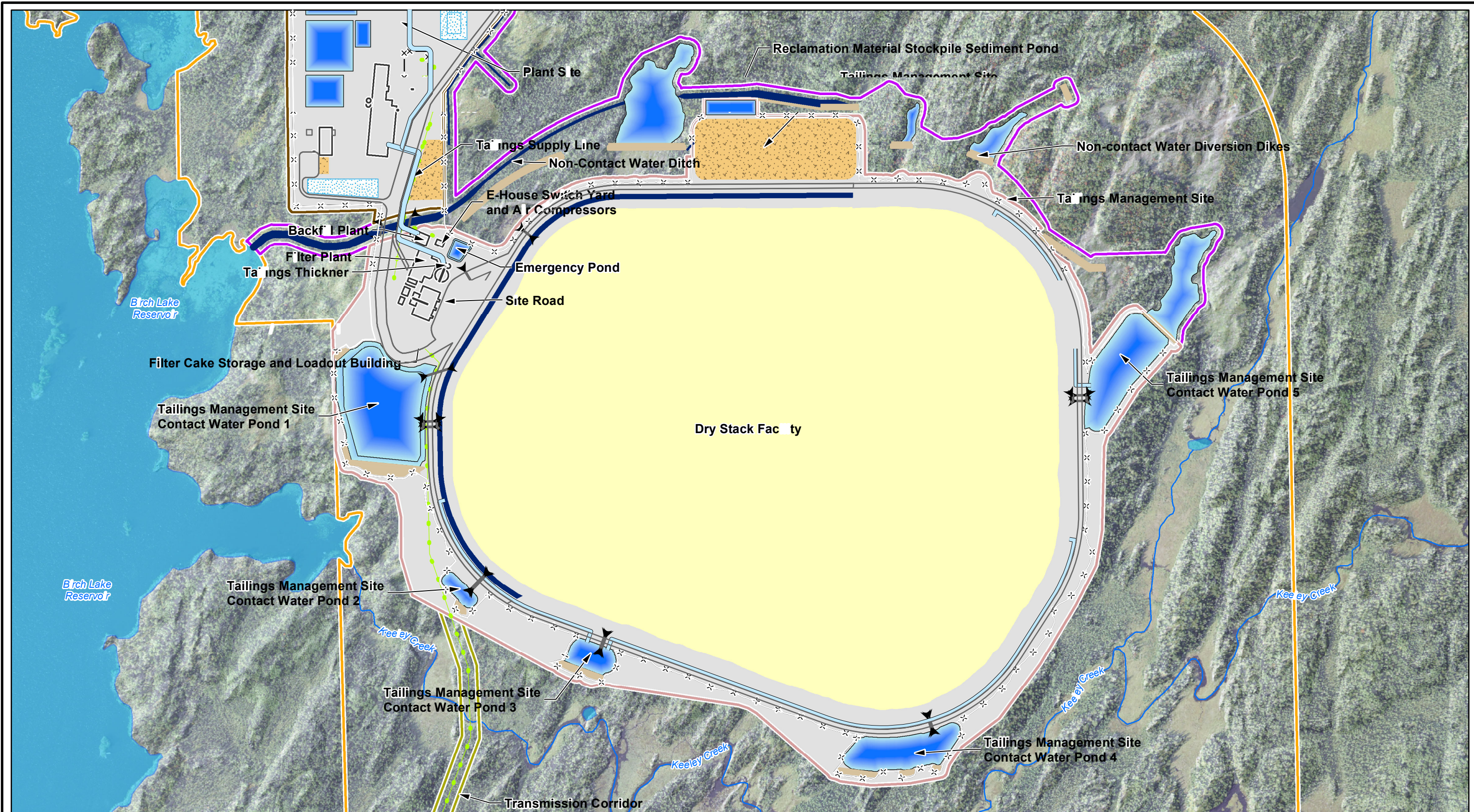
PLANT SITE LAYOUT

Scale: 0 250 500 Feet

Date: SEPTEMBER 2019







NOTES:

1. Base air photo from the U.S. Department of Agriculture Farm Service Agency, Aerial Photography Field Office.
2. Hydrographic data from Minnesota Department of Natural Resources.
3. Horizontal datum based on NAD 1983. Horizontal coordinates based on Minnesota State Plane North (feet).

LEGEND

— Facility	— River/Stream	— Plant Site
— Piping	— Lake/Pond	— Tailings Management Site
— Dike; Berm	— Project Area	— Non-Contact Water Diversion Area
— Culvert		— Transmission Corridor
— Electrical Transmission Line		
— Fence		

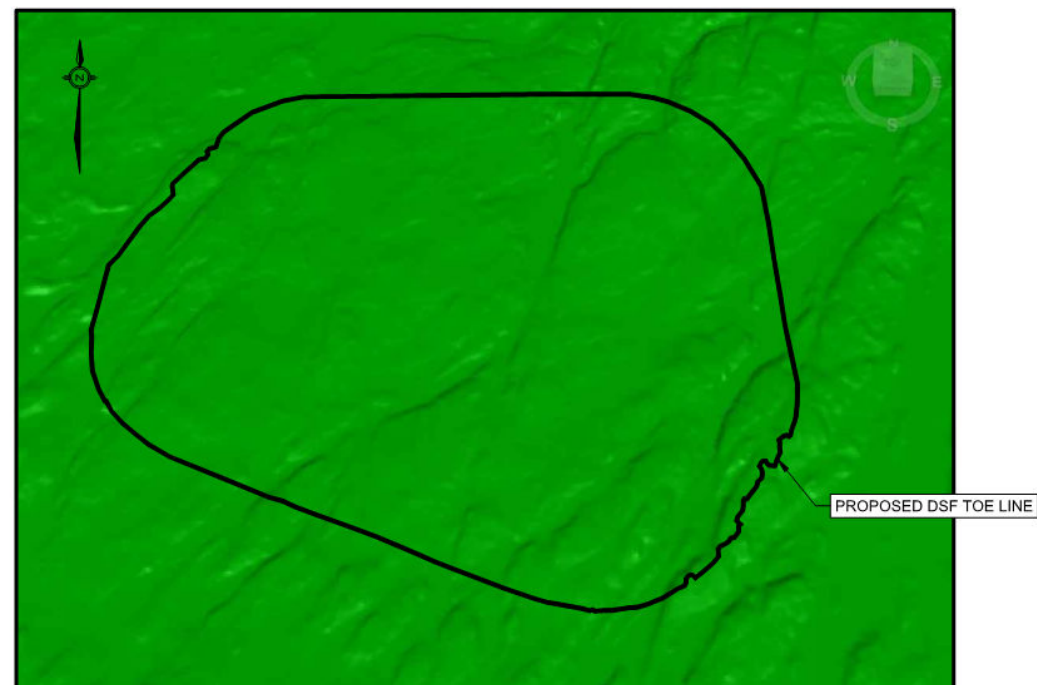
TWIN METALS MINNESOTA

FIGURE 3-13

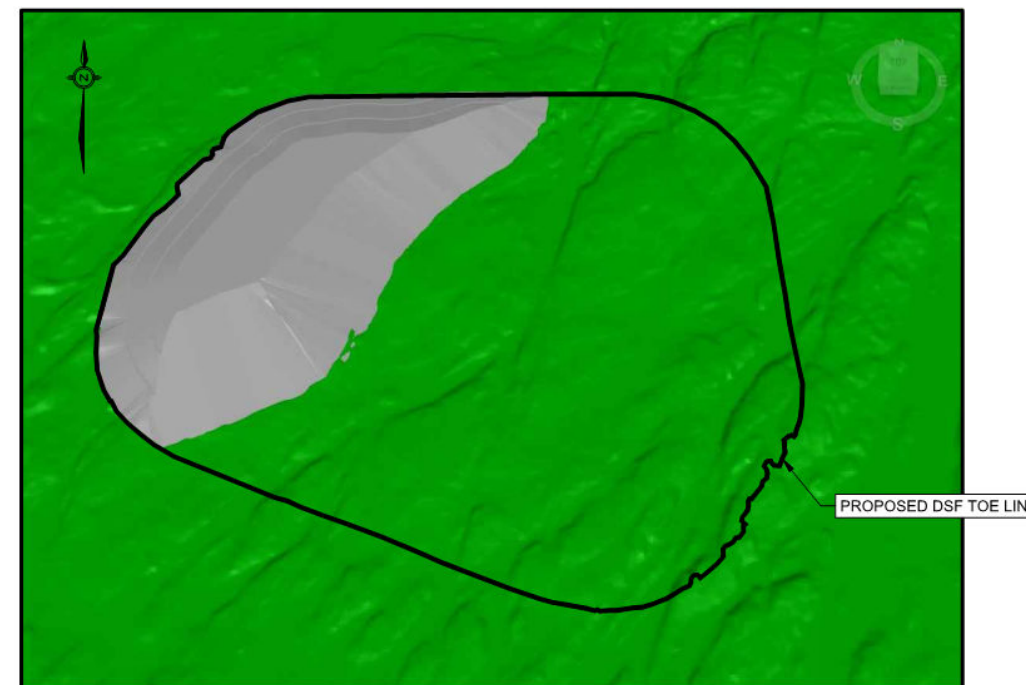
TAILINGS MANAGEMENT SITE LAYOUT

Scale: 0 400 800 Feet

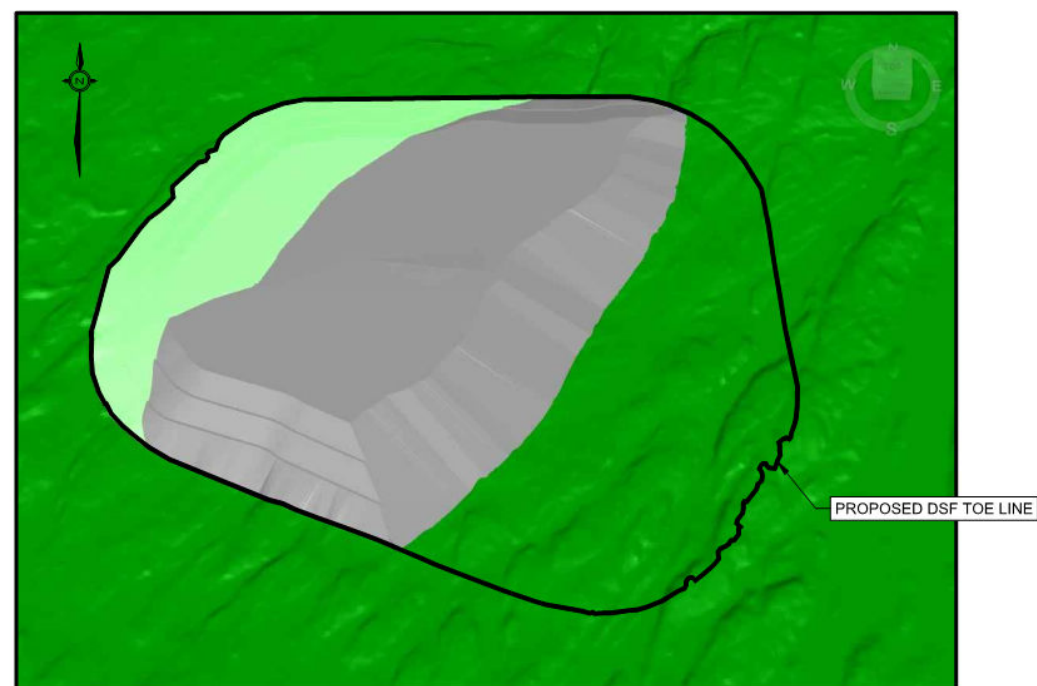
Date: SEPTEMBER 2019



ORIGINAL GROUND (PRIOR TO CONSTRUCTION)
N.T.S.



STAGE 1
(APPROXIMATELY YEAR 6 OF OPERATION)
N.T.S.



STAGE 2
(APPROXIMATELY YEAR 16 OF OPERATION)
N.T.S.



STAGE 3
(APPROXIMATELY YEAR 25 OF OPERATION)
N.T.S.

NOT FOR CONSTRUCTION

NOTES:
1. DSF - Dry Stack Facility



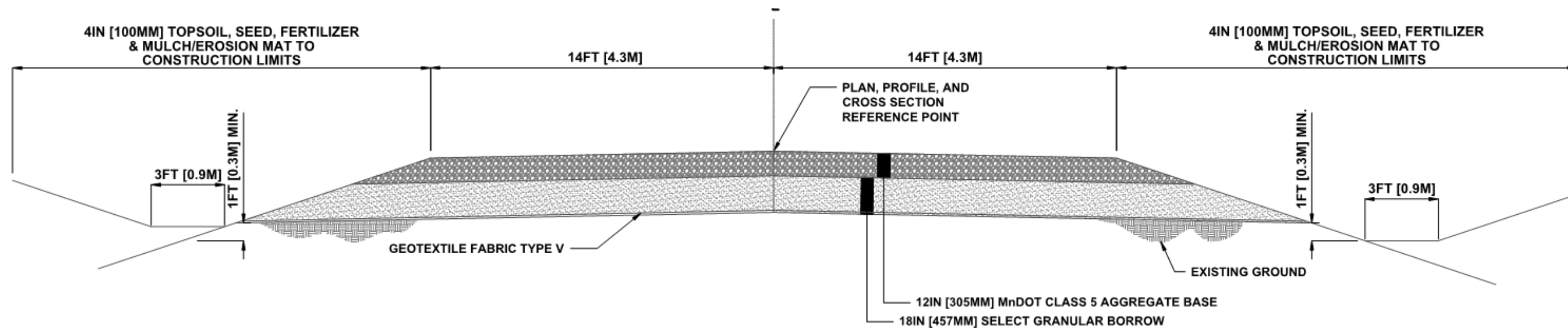
TWIN METALS MINNESOTA

FIGURE 3-14

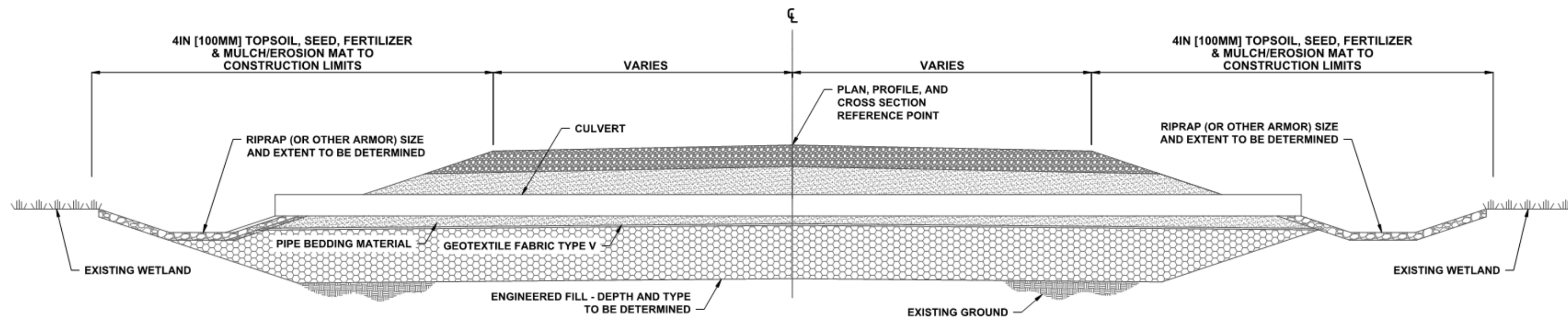
DRY STACK FACILITY CONSTRUCTION STAGES

Scale: NOT TO SCALE

Date: SEPTEMBER 2019

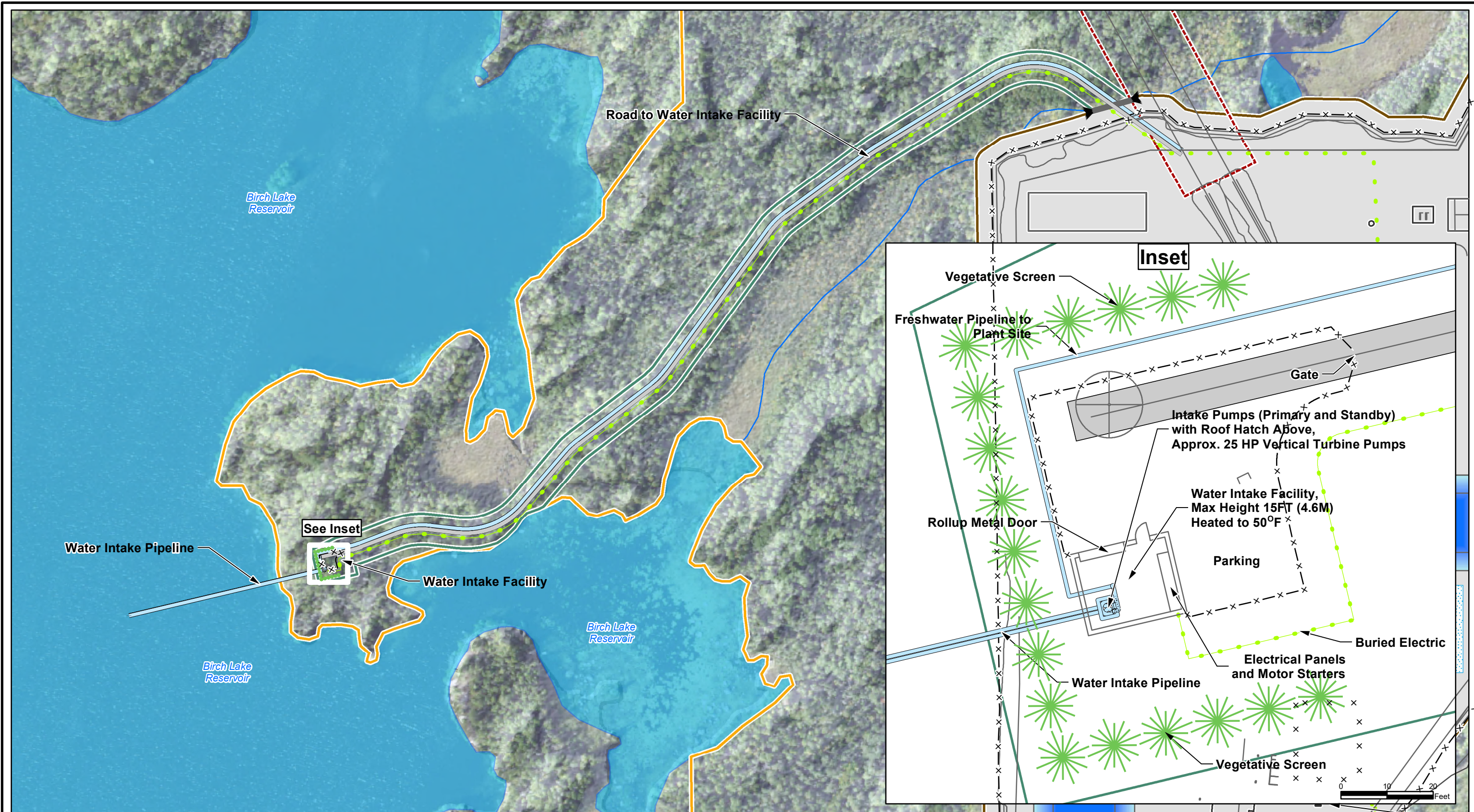


TYPICAL SECTION



TYPICAL SECTION W/CULVERT

*PRELIMINARY
NOT FOR CONSTRUCTION*



NOTES:

1. Base air photo from the U.S. Department of Agriculture Farm Service Agency, Aerial Photography Field Office.
2. Hydrographic data from Minnesota Department of Natural Resources.
3. Horizontal datum based on NAD 1983.

Horizontal coordinates based on Minnesota State Plane North (feet).

LEGEND

— Facilities	— Primary Road	Project Area
— Piping	— Secondary Road	Underground Mine Area
— Culvert	— River/Stream	Plant Site
— Electrical Transmission Line	— Lake/Pond	Water Intake Corridor
— Fence		
— Vegetative Screen		

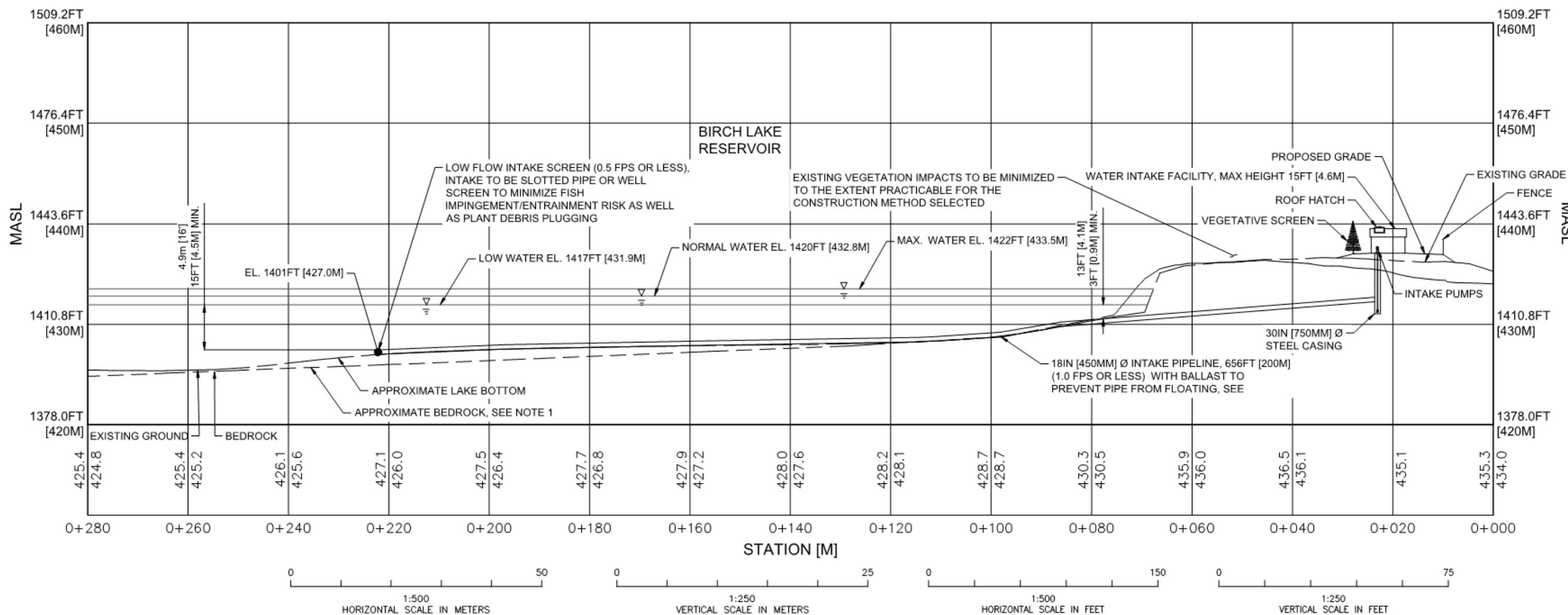
TWIN METALS MINNESOTA

FIGURE 3-16

WATER INTAKE FACILITY AND ACCESS ROAD PLAN AND GENERAL ARRANGEMENT

Scale: 0 150 300 Feet

Date: SEPTEMBER 2019



*PRELIMINARY
NOT FOR CONSTRUCTION*

Notes

1. TOP OF BEDROCK ESTIMATES SHOWN IN THE PROFILES ARE BASED ON DATA FROM THE MINNESOTA GEOLOGICAL SURVEY (OFR2016-04) DOWNLOADED FEBRUARY 12, 2018.



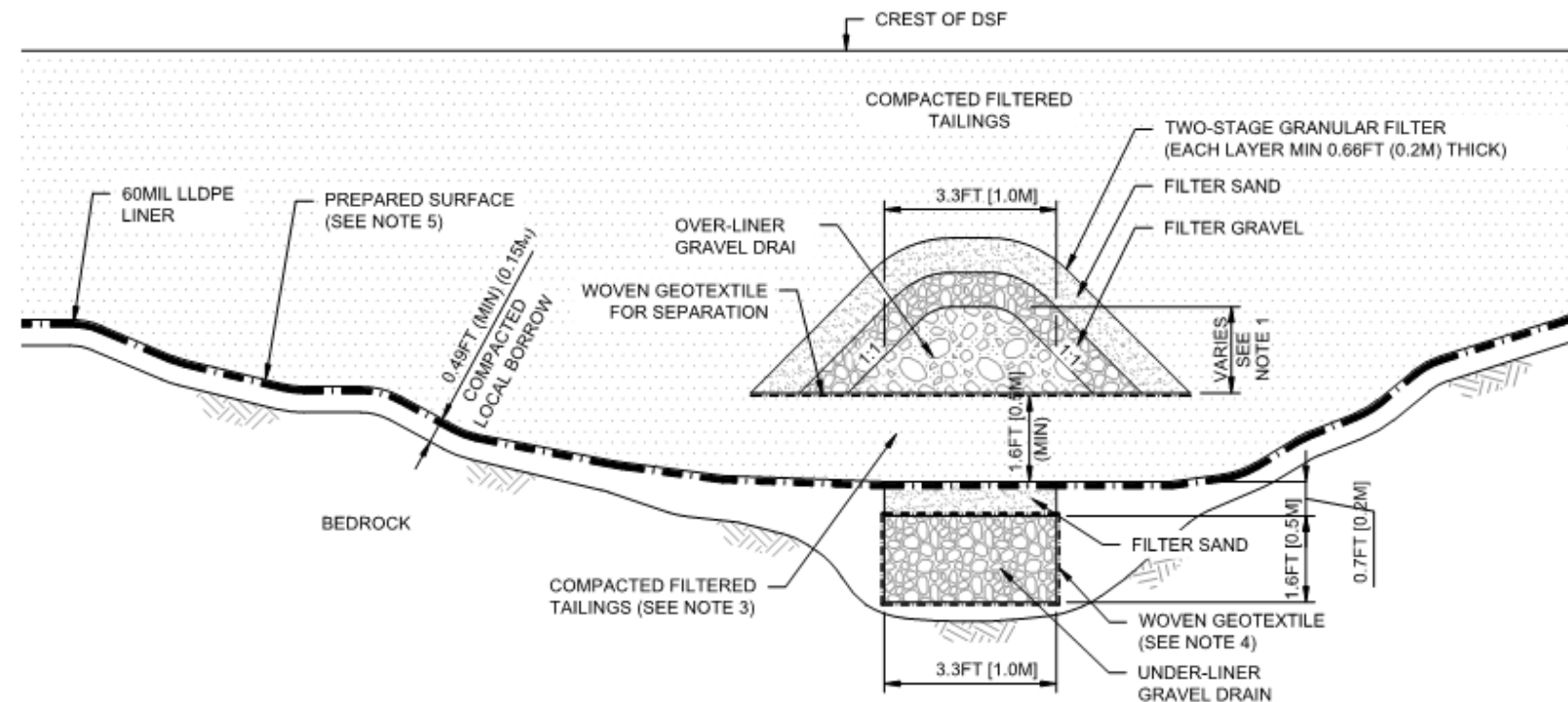
TWIN METALS MINNESOTA

FIGURE 3-17

WATER INTAKE FACILITY PLAN, PROFILE, SECTIONS, AND DETAILS





Scale: SEE ABOVE

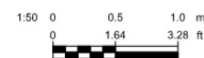
Date: SEPTEMBER 2019



TYPICAL BASE DRAIN DETAIL
SCALE = 1:50

LEGEND:

-  OVER-LINER DRAIN GRAVEL
-  UNDER-LINER DRAIN GRAVEL AND OVER-LINER DRAIN FILTER GRAVEL
-  OVER-LINER DRAIN FILTER SAND
-  COMPACTED FILTERED TAILINGS



*PRELIMINARY
NOT FOR CONSTRUCTION*

NOTES:

1. DIMENSIONS AND ELEVATIONS ARE IN FEET [METERS].
2. DIMENSIONS OF OVER-LINER DRAINS VARY. REQUIRED CROSS-SECTION OF GRAVEL FOR FEEDER DRAINS IS 5.4FT² [0.5M²] (AVERAGE WIDTH=3.3FT [1.0M], HEIGHT=1.6FT [0.5M]). ARTERIAL DRAINS HAVE LARGER CROSS-SECTIONAL AREA THAT VARIES DEPENDING ON CONTRIBUTING DRAIN CATCHMENT AREA.
3. DIMENSIONS OF UNDER-LINER DRAINS VARY. REQUIRED CROSS-SECTION OF GRAVEL FOR FEEDER DRAINS IS 5.4FT² [0.5M²] (WIDTH=3.3FT [1.0M], HEIGHT=1.6FT [0.5M]). ARTERIAL DRAINS HAVE LARGER CROSS-SECTIONAL AREA THAT VARIES DEPENDING ON CONTRIBUTING DRAIN CATCHMENT AREA.
4. 1.6FT [0.5M] THICK LAYER OF COMPACTED TAILINGS PLACED OVER THE GEOMEMBRANE PRIOR TO PLACING OVER-LINER DRAIN.
5. WOVEN GEOTEXTILE WILL BE USED FOR SEPARATION, NOT FILTRATION.
6. FOUNDATION TO BE STRIPPED OF TOPSOIL, ORGANICS AND UNSUITABLE MATERIALS. FOUNDATION SHALL HAVE AN ALLOWABLE BEARING PRESSURE OF 150 kPa TO SUPPORT LINER SYSTEM. A BEDDING LAYER OF LOCAL, SUITABLE BORROW, MINIMUM 0.5FT [0.15M] THICK WILL BE PLACED AND DENSELY COMPACTED OVER ANY EXPOSED BEDROCK.



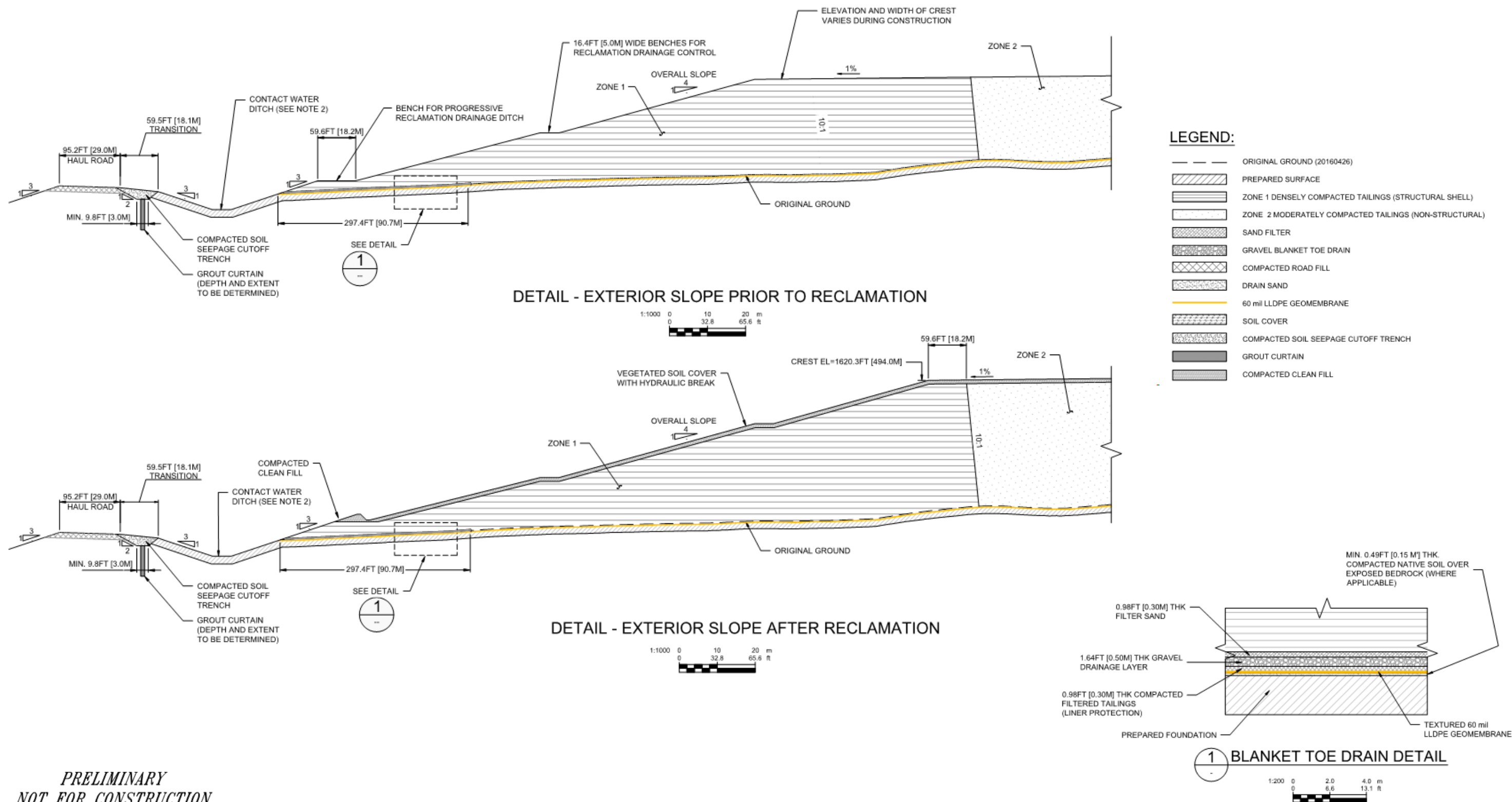
TWIN METALS MINNESOTA

FIGURE 3-18

BASE DRAIN DETAILS

Scale: AS SHOWN

Date: SEPTEMBER 2019



PRELIMINARY
NOT FOR CONSTRUCTION

Notes

1. ORIGINAL GROUND SURVEY PROVIDED BY TWIN METALS MINNESOTA, RECEIVED ON APRIL 26, 2016.
2. SEEPAGE CUTOFF SURFACE WILL HAVE GRASS VEGETATION IN SOME LOCATIONS, RIPRAP ARMOUR IN OTHERS AND EXPOSED BEDROCK IN OTHERS.



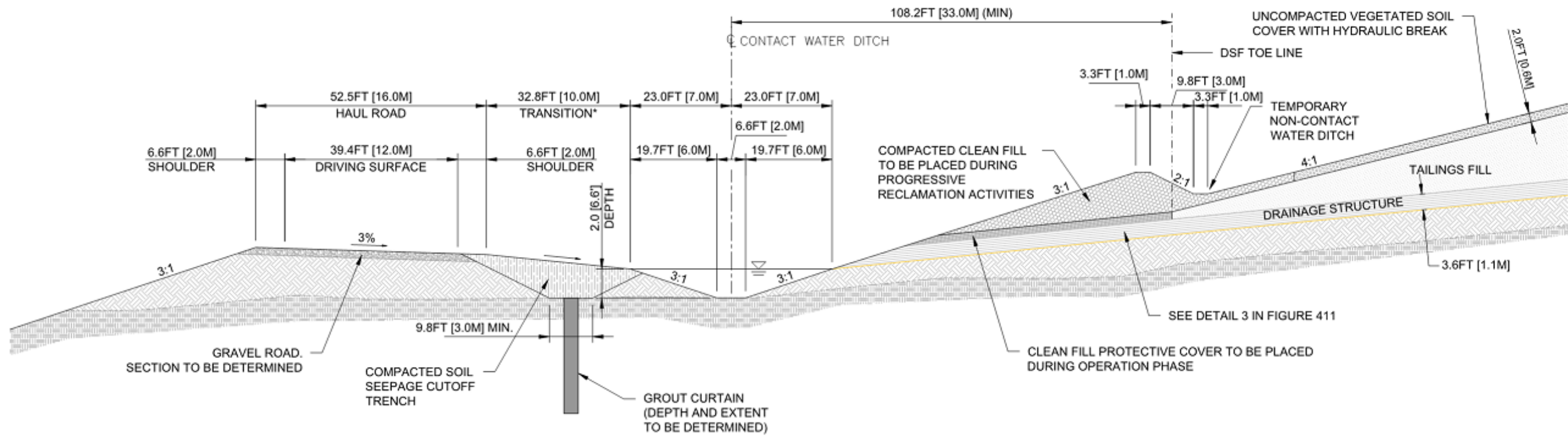
TWIN METALS MINNESOTA

FIGURE 3-19

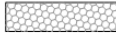









TYPICAL CROSS-SECTION OF EXTERIOR SLOPE

Scale: AS SHOWN

Date: SEPTEMBER 2019



LEGEND:

-  COMPACTED CLEAN FILL
-  CLEAN FILL PROTECTIVE COVER
-  DRAINAGE COVER
-  COMPACTED FILTERED TAILINGS
-  ROAD GRAVEL SURFACE
-  COMPACTED LOW PERMEABILITY SOIL
-  GROUT CURTAIN
-  SUITABLE FOUNDATION (PREPARED OVERBURDEN OR COMPACTED FILL)
-  BEDROCK
-  60 mil LLDPE Geomembrane

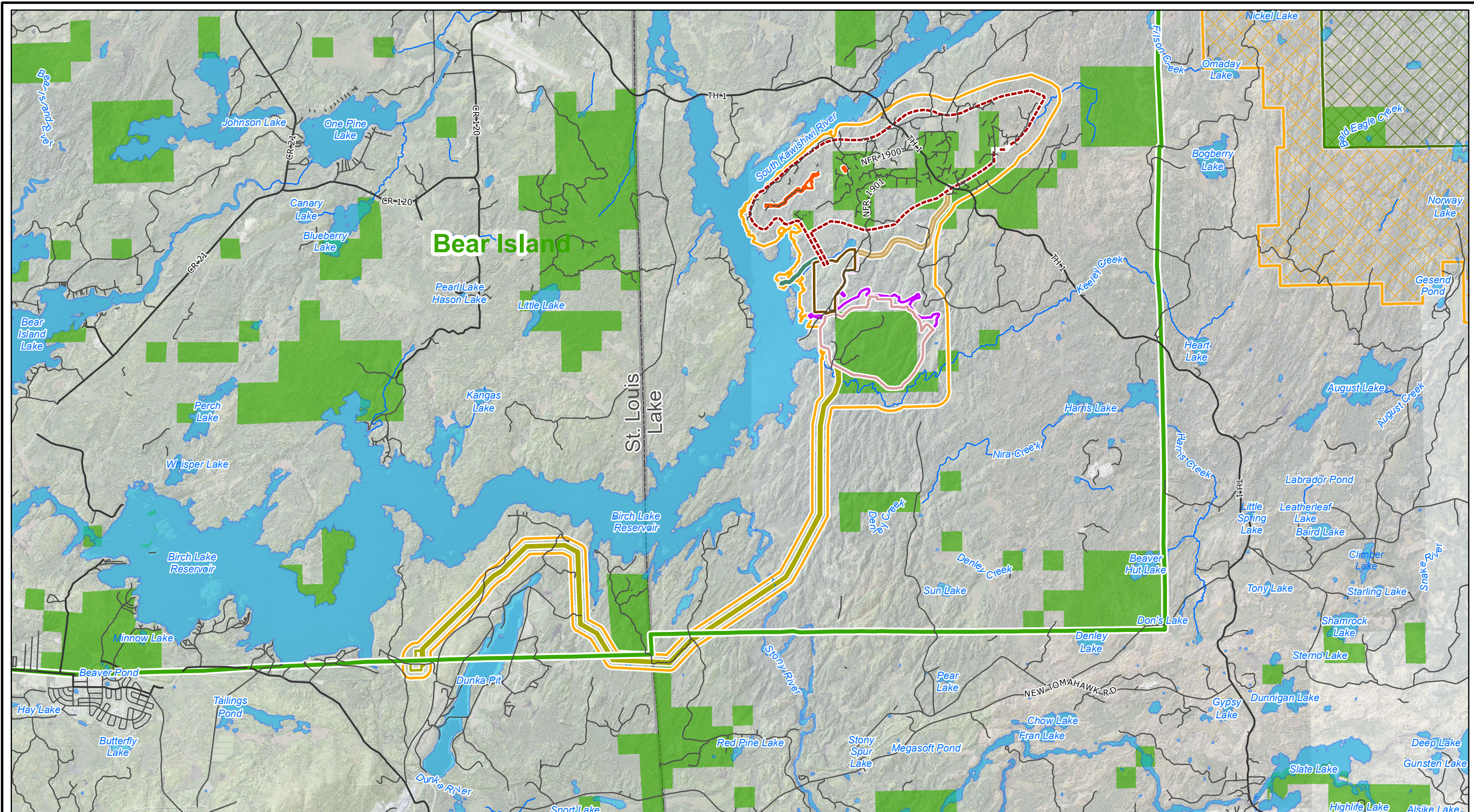
TYPICAL PERIMETER CONTACT WATER DITCH DETAIL
SCALE = 1:400

*PRELIMINARY
NOT FOR CONSTRUCTION*

- Notes**
ABOUT TRANSITION SLOPE:
SLOPES THROUGH TRANSITION WILL VARY
DEPENDING ON MATERIAL AS FOLLOWS:
1. FOR FILL CONDITION: FROM 3% TO 3(H):1(V)
2. FOR CUT CONDITION (THROUGH OVERBURDEN):
FROM 3% TO 3(H):1(V)
3. FOR CUT CONDITION (THROUGH BEDROCK):
FROM 3% TO 1(H):1(V)



TWIN METALS MINNESOTA	
FIGURE 3-20	
TYPICAL DITCH SECTIONS	
Scale: NOT TO SCALE	Date: SEPTEMBER 2019



NOTES:

- Hydrographic data from Minnesota Department of Natural Resources.
- Horizontal datum based on NAD 1983. Horizontal coordinates based on Minnesota State Plane North (feet).
- Boundary Waters Canoe Area Wilderness, Mineral Management Corridor and State Forest data from Minnesota Department of Natural Resources.

LEGEND

Primary Road	Boundary Waters Canoe Area Wilderness	Plant Site	Water Intake Corridor
Secondary Road	Boundary Waters Canoe Area Wilderness Mineral Management Corridor	Tailings Management Site	Ventilation Raises and Ventilation Raise Access Road
River/Stream	State Forests - Statutory Boundaries	Non-Contact Water Diversion Area	Access Road Corridor
Lake/Pond	State Forests - Management Units	Transmission Corridor	
Municipal Boundary	Project Area		
County Boundary	Underground Mine Area		

TWIN METALS MINNESOTA

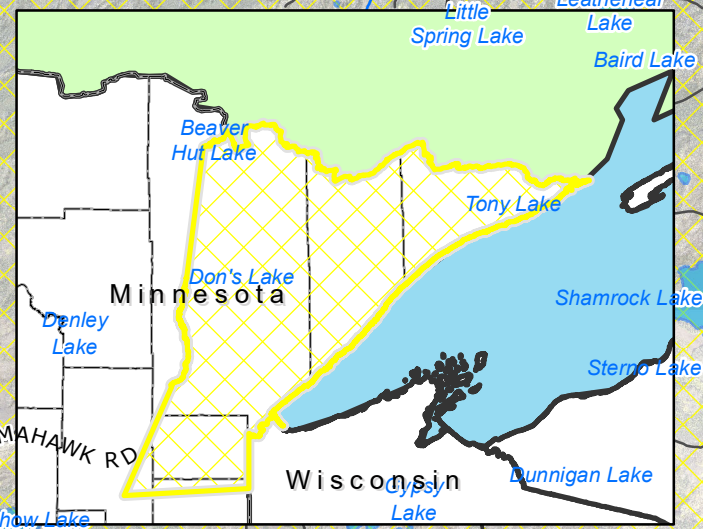
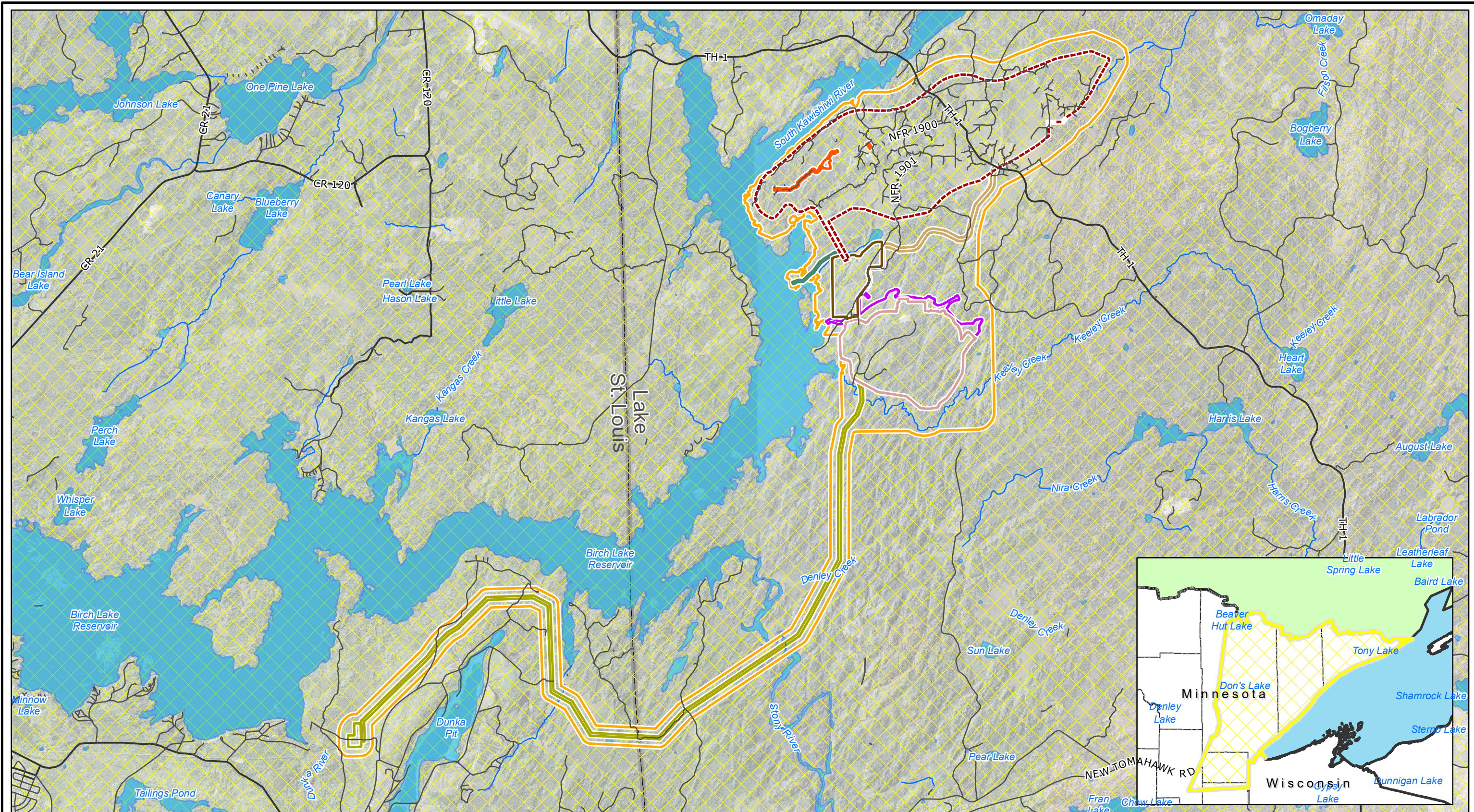
FIGURE 4-1

BWCAW MINERALS MANAGEMENT CORRIDOR AND MDNR STATE FOREST MANAGEMENT UNITS

Scale: 0 3,000 6,000 Feet

Date: SEPTEMBER 2019

Foth



NOTES:

1. Hydrographic data from Minnesota Department of Natural Resources.
2. Horizontal datum based on NAD 1983. Horizontal coordinates based on Minnesota State Plane North (feet).
3. 1854 Treaty Ceded Territory data from The Great Lakes Indian and Wildlife Commission.

LEGEND

— Primary Road	1854 Treaty Ceded Territory	Plant Site	Water Intake Corridor
— Secondary Road	County Boundary	Tailings Management Site	Ventilation Raises and Ventilation Raise Access Road
— River/Stream	Project Area	Non-Contact Water Diversion Area	Access Road Corridor
— Lake/Pond	Underground Mine Area	Transmission Corridor	

TWIN METALS MINNESOTA

FIGURE 4-2

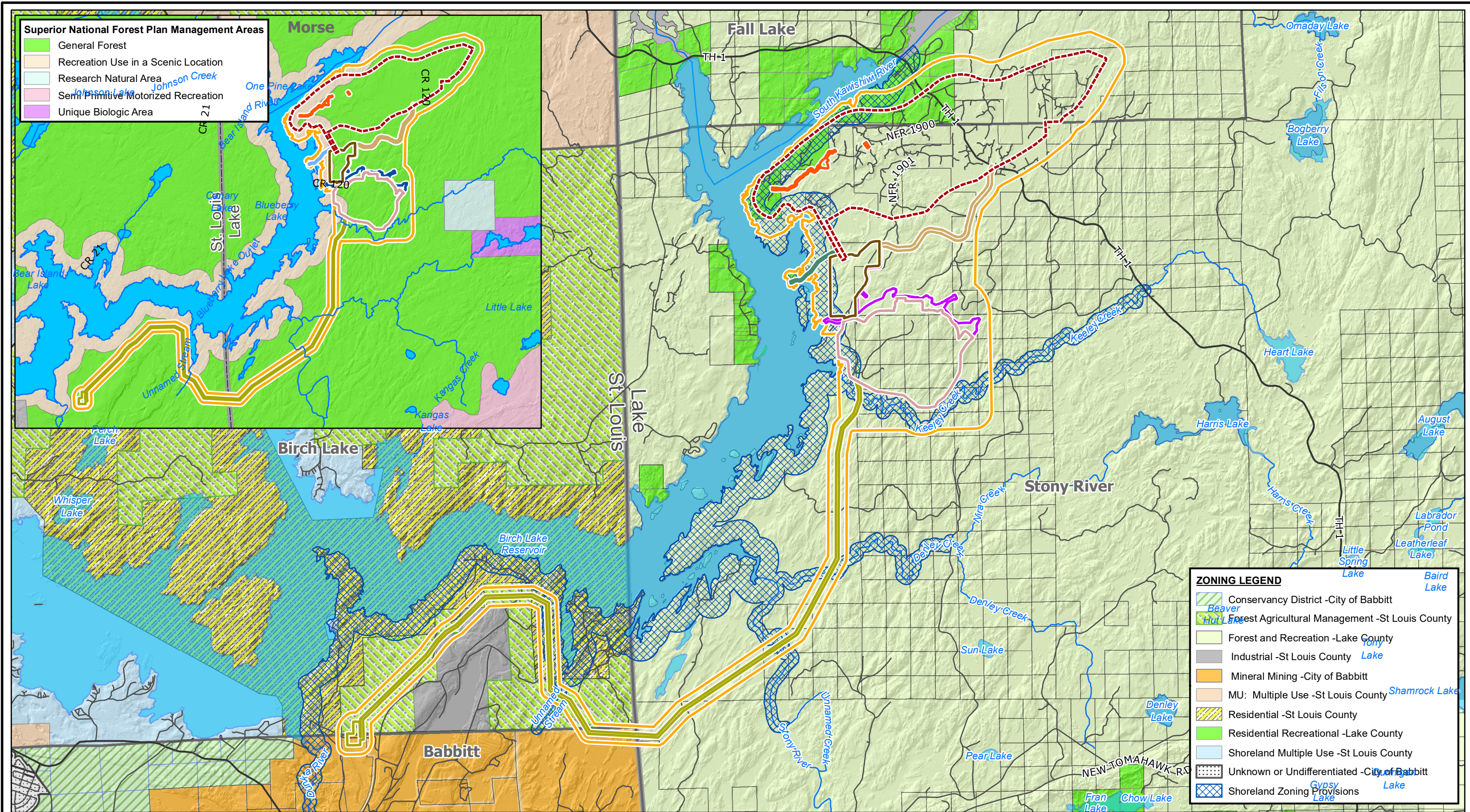
1854 TREATY CEDED TERRITORY

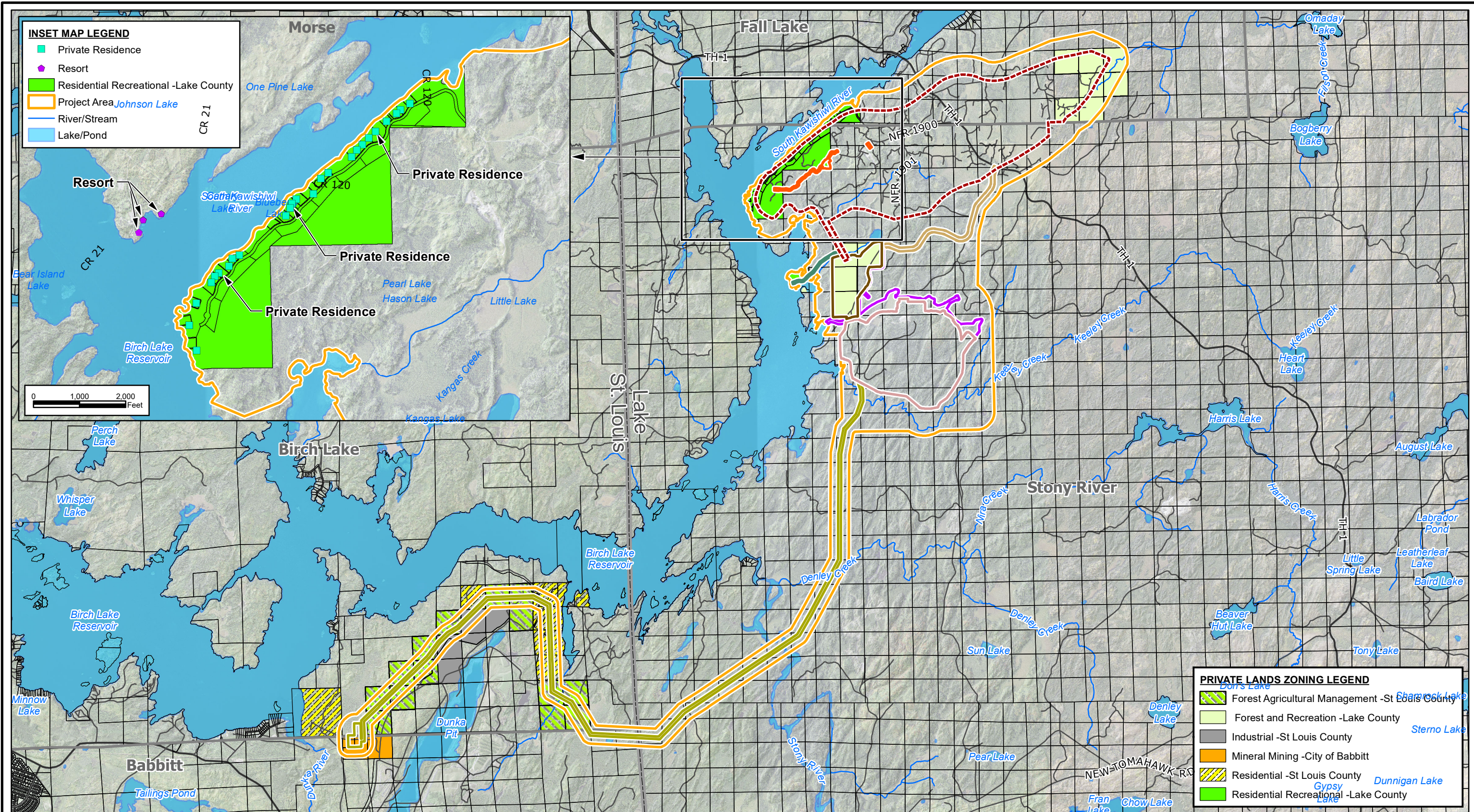
Scale: 0 2,500 5,000 Feet

Date: SEPTEMBER 2019

TWIN METALS MINNESOTA

Foth





INSET MAP LEGEND

- Private Residence
- Resort
- Residential Recreational -Lake County
- Project Area
- River/Stream
- Lake/Pond

PRIVATE LANDS ZONING LEGEND

- Forest Agricultural Management -St Louis County
- Forest and Recreation -Lake County
- Industrial -St Louis County
- Mineral Mining -City of Babbitt
- Residential -St Louis County
- Residential Recreational -Lake County

NOTES:

- Hydrographic data from Minnesota Department of Natural Resources.
- Horizontal datum based on NAD 1983. Horizontal coordinates based on Minnesota State Plane North (feet).

LEGEND

- Primary Road
- Secondary Road
- River/Stream
- Lake/Pond
- Property Boundary
- Municipal Boundary
- County Boundary
- Project Area
- Underground Mine Area
- Plant Site
- Tailings Management Site
- Non-Contact Water Diversion Area
- Transmission Corridor
- Water Intake Corridor
- Ventilation Raises and Ventilation Raise Access Road
- Access Road Corridor

TWIN METALS MINNESOTA

FIGURE 4-4

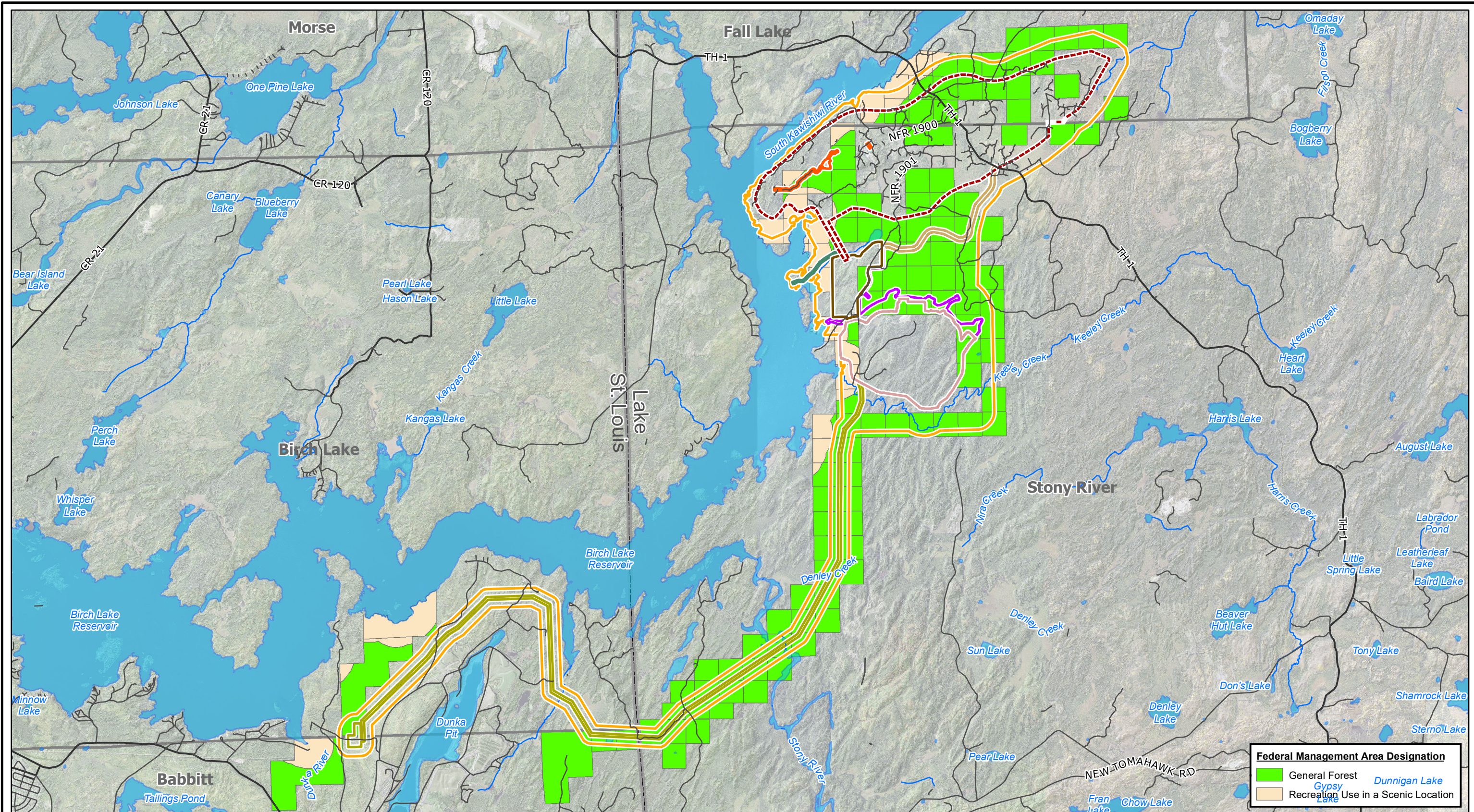
PRIVATE LANDS ZONING

Scale: 0 2,500 5,000 Feet

Date: SEPTEMBER 2019

TWIN METALS MINNESOTA

Foth



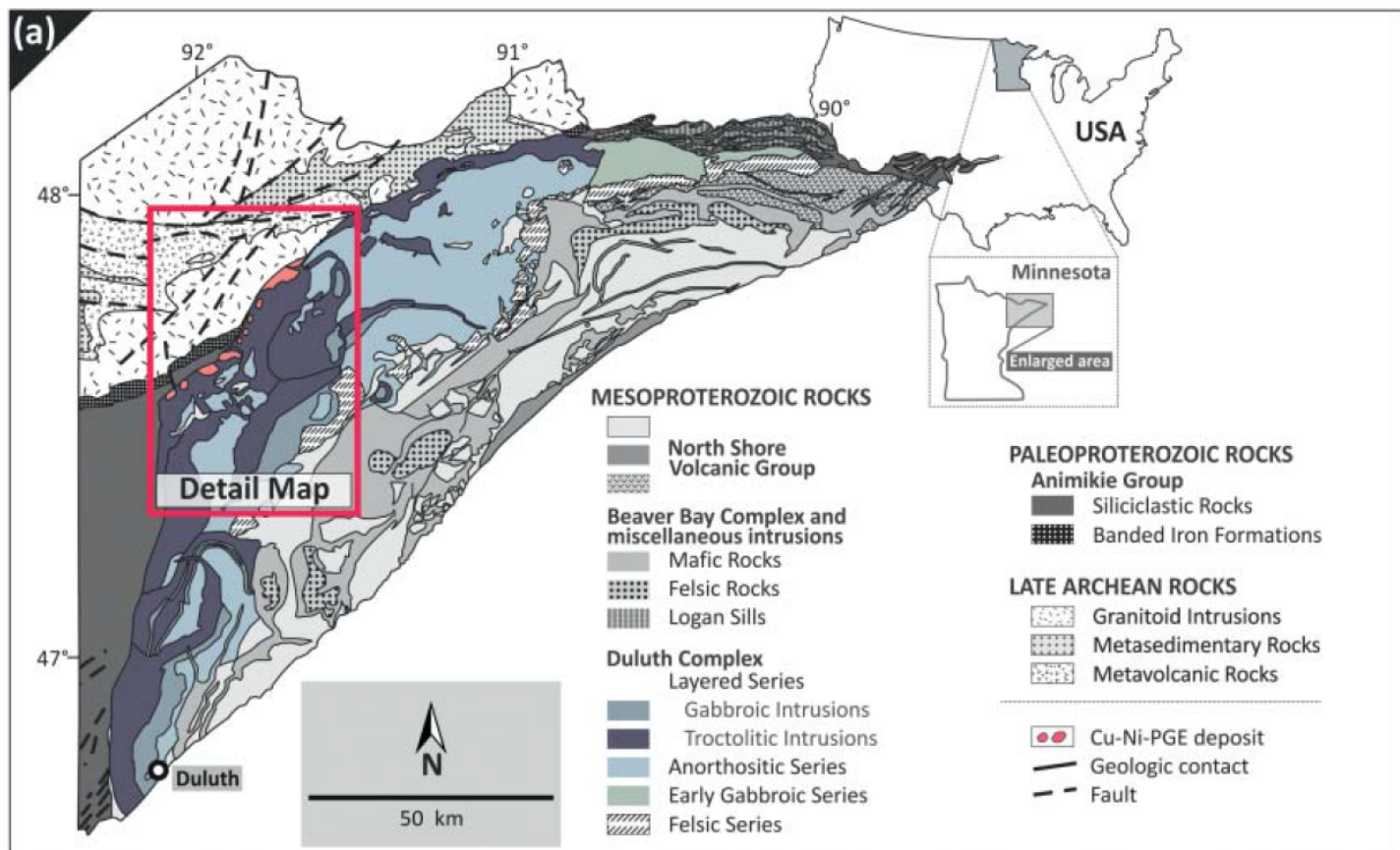
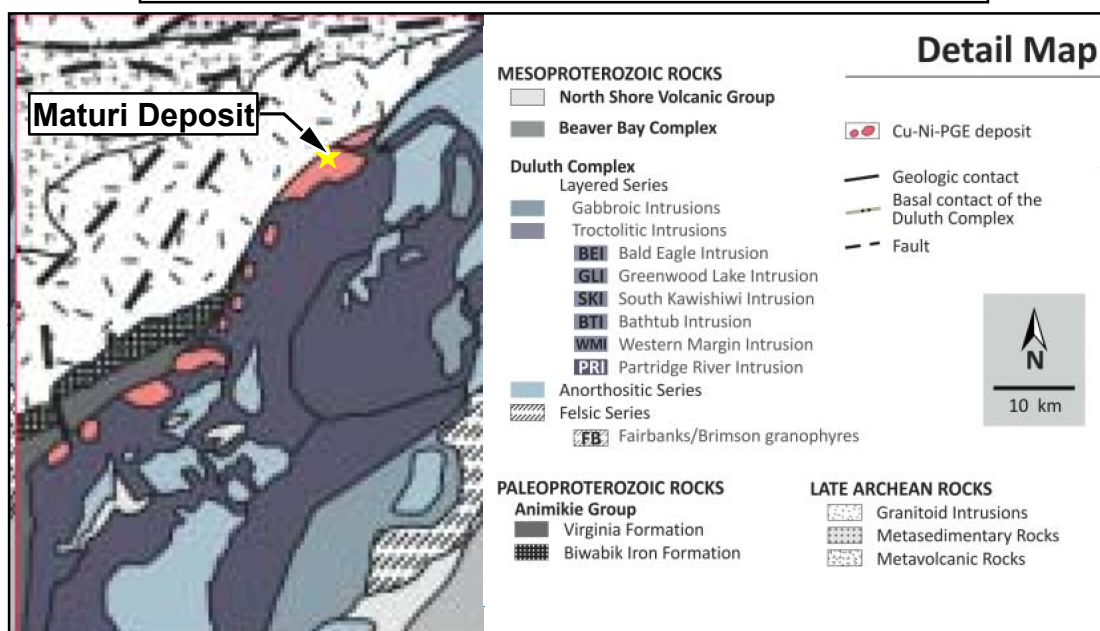


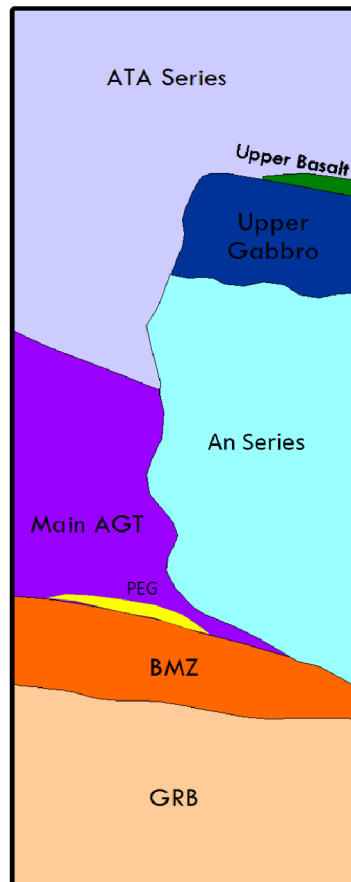
Fig 1. (a) Geologic map of northeastern Minnesota (modified from Miller *et al.* 2001) showing footwall units (Paleoproterozoic and Neoproterozoic rocks) and the Duluth Complex with its Felsic, Early Gabbroic, Anorthositic, and Layered Series and hanging wall units, which comprise basaltic rocks from the North Shore Volcanic Group.



NOTES:

1. Figure content from Raic, et al. (2015). Arsenic-Rich Cu-Ni-PGE Mineralization in Wetlegs, Duluth Complex, St. Louis County, Minnesota, USA. The Canadian Mineralogist, Vol. 53, pp. 105-132 (2015) DOI: 10.3749/canmin. 1400053

Generalized Stratigraphy of the Maturi Deposit



Keewanawan Rift-Related Package (~1.09 Ga.)

South Kawishiwi Intrusion

ATA Series: Thick upper aspect of the SKI dominated by medium-grained intergranular anorthositic troctolite and troctolitic anorthosite. Commonly weakly to moderately foliated.

Main AGT: Thick homogenous package of medium-grained ophitic augite troctolite. Interpreted to be the liquid phase of the SKI.

PEG: Pegmatoidal to coarse-grained anorthositic troctolite to anorthositic gabbro. Largely barren.

BMZ (Basal Mineralized Zone): Heterogeneous package of mineralized dominantly troctolitic rocks consisting of the UH, S3, S2, and S1 subunits.

Anorthositic Series

Upper Gabbro: Upper mafic phase of the Anorthositic Series. Typified by coarse-grained oxide olivine gabbro to anorthositic gabbro.

An Series: Lower feldspathic aspect of the Anorthositic Series typified by foliated very coarse-grained anorthosite to medium-grained ophitic gabbroic anorthosite or anorthositic gabbro.

North Shore Volcanics

Upper Basalt: Tholeiitic basalt inclusion of the extrusive phase of the Mid-Continent Rift.

GRB (Giants Range Batholith): Heterogeneous Archean (~2.68 Ga) granitoid batholith. Dominant lithologies of porphyritic quartz monzonite to diorite. Locally exhibits sulfide mineralization near the contact with and within the contact metamorphic aureole of the SKI.

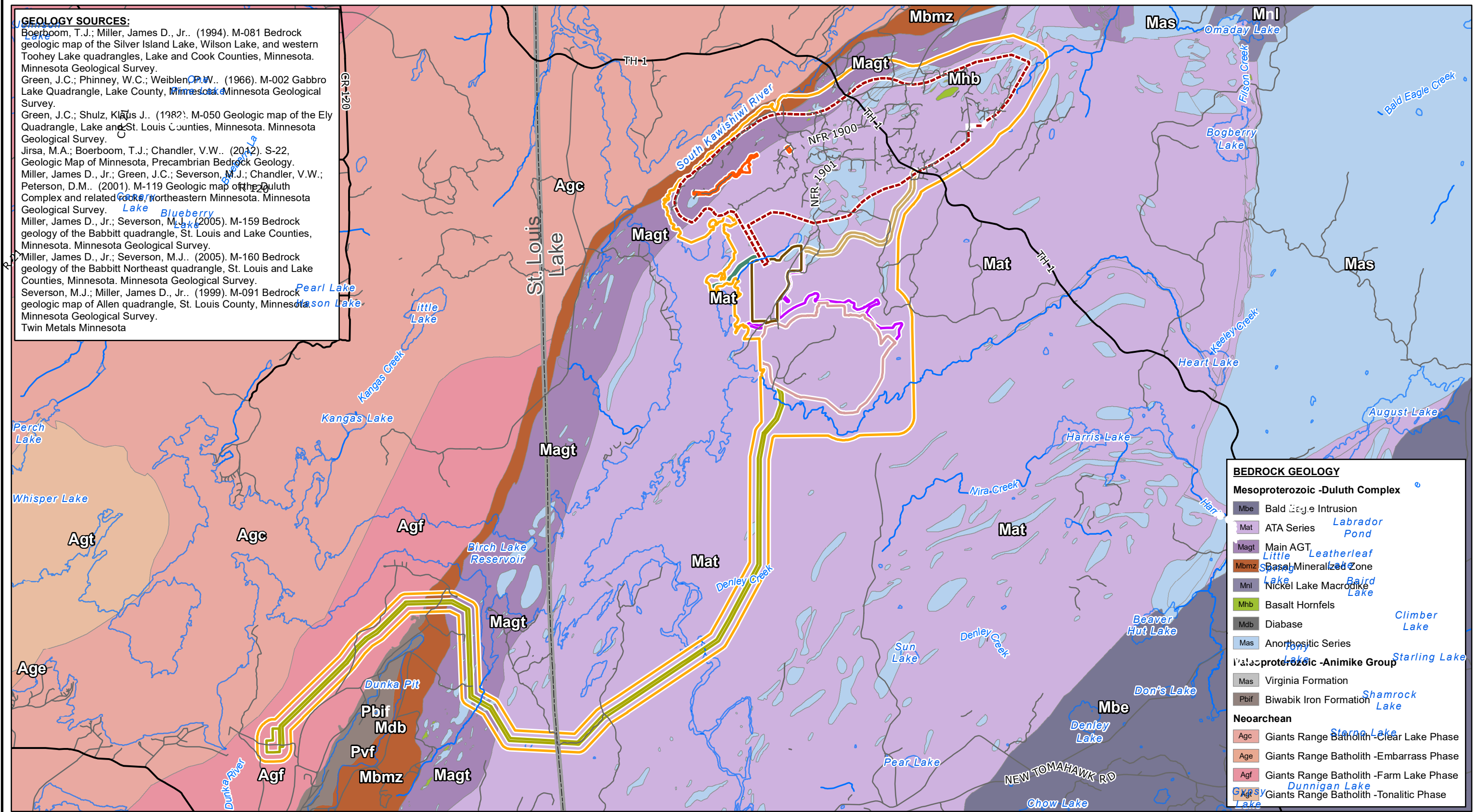


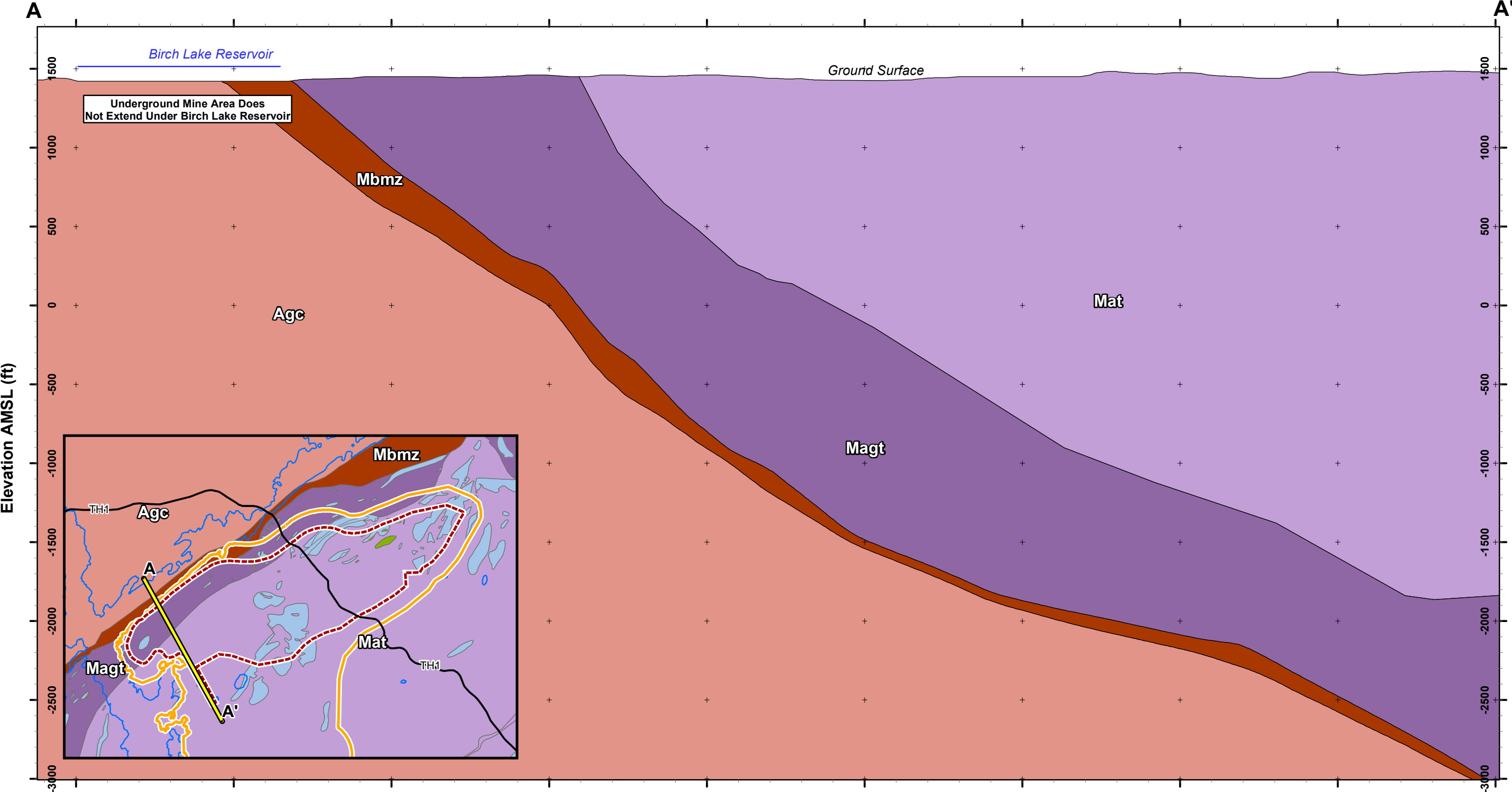
TWIN METALS MINNESOTA

FIGURE 5-2

MATURI DEPOSIT STRATIGRAPHY

Scale: NOT TO SCALE Date: SEPTEMBER 2019





NOTES:

- 1. Quaternary sediments and lake bathymetry not shown as thicknesses and depths are generally less than 20 feet and not seen at this scale.
- 2. Hydrographic data from Minnesota Department of Natural Resources.
- 3. Horizontal datum based on NAD 1983. Horizontal coordinates based on Minnesota State Plane North (feet).
- 4. Horizontal and vertical scale are as shown. Vertical exaggeration is 1.

LEGEND

- Cross Section Line
- Primary Road
- Project Area
- Underground Mine Area
- Lake/Pond

Geologic Unit

- Magt Main Augite troctolite
- Mat Anorthositic troctolite to troctolitic anorthosite
- Mbmz Basal Mineralized Zone
- Agc Giants Range Batholith



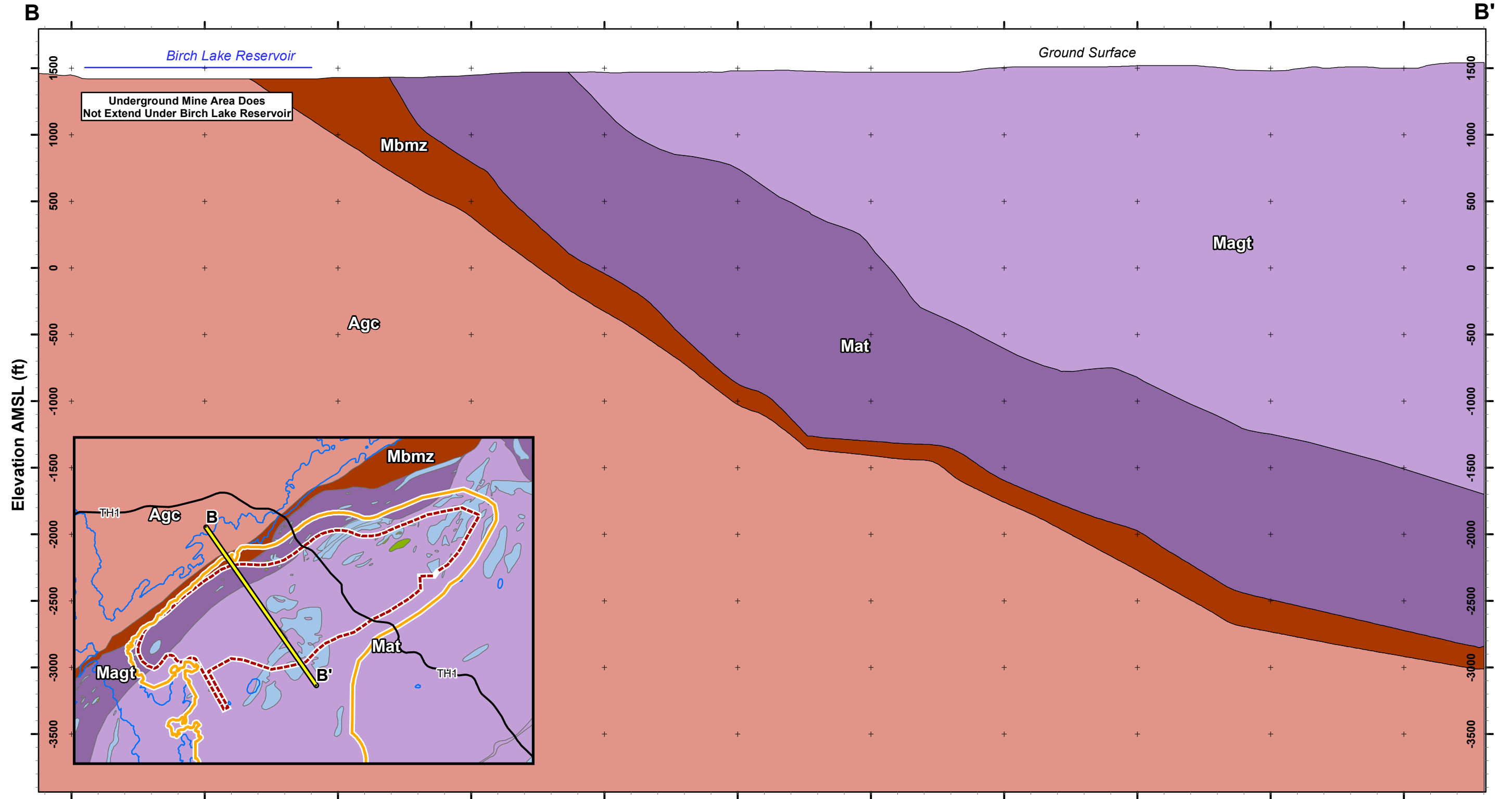
TWIN METALS MINNESOTA

FIGURE 5-4

BEDROCK CROSS SECTION A-A'
UNDERGROUND MINE AREA

Horizontal & Vertical Scale: 0 250 500 Feet

Date: SEPTEMBER 2019



NOTES:

1. Quaternary sediments and lake bathymetry not shown as thicknesses and depths are generally less than 20 feet and not seen at this scale.
2. Hydrographic data from Minnesota Department of Natural Resources.
3. Horizontal datum based on NAD 1983. Horizontal coordinates based on Minnesota State Plane North (feet).
4. Horizontal and vertical scale are as shown. Vertical exaggeration is 1.

LEGEND

- Cross Section Line
- Primary Road
- Project Area
- Underground Mine Area
- Lake/Pond

Geologic Unit

- Magt Main Augite troctolite
- Mat Anorthositic troctolite to troctolitic anorthosite
- Mbmz Basal Mineralized Zone
- Agc Giants Range Batholith



TWIN METALS MINNESOTA

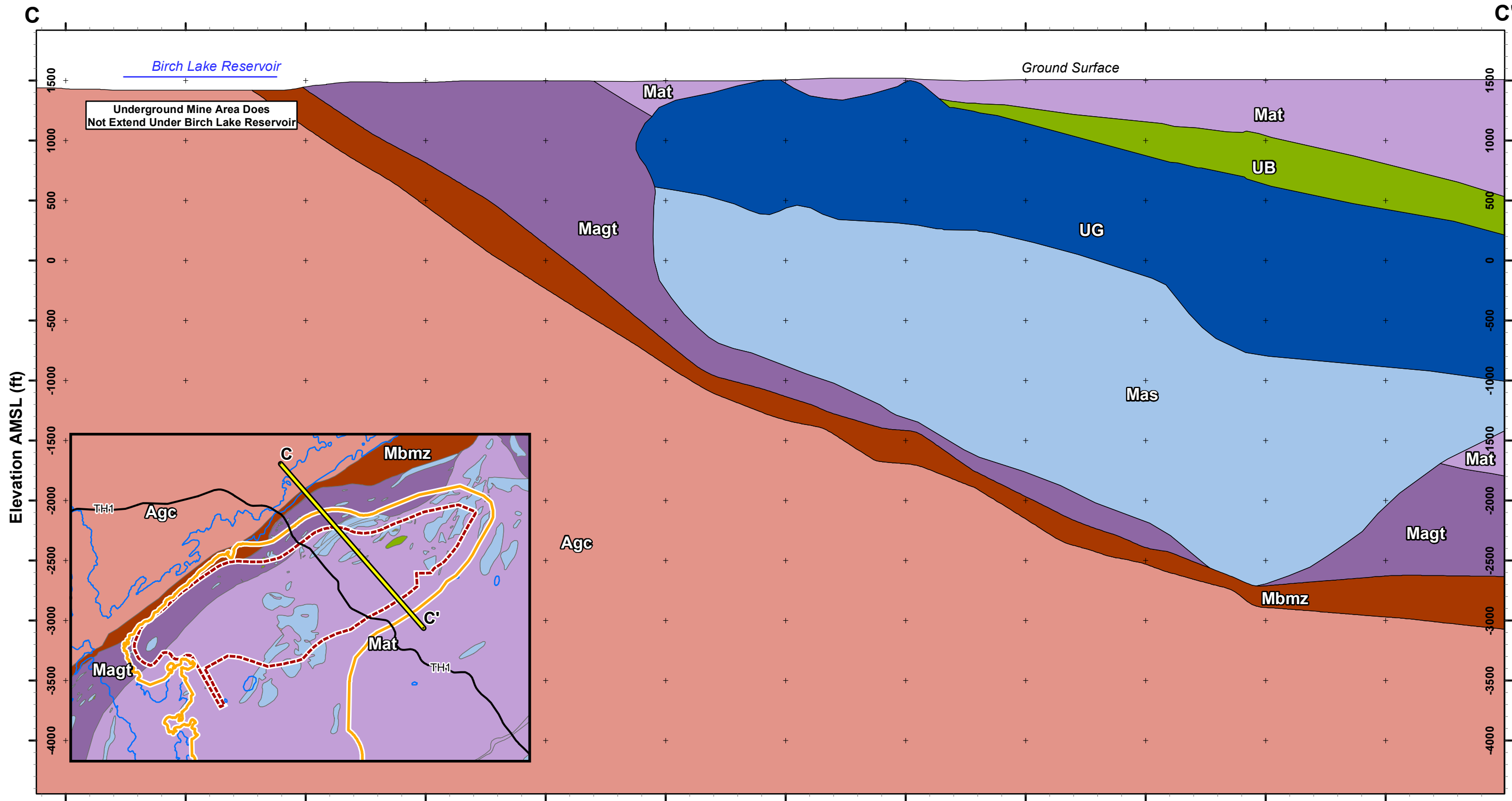
FIGURE 5-5
BEDROCK CROSS SECTION B-B'
UNDERGROUND MINE AREA

Horizontal & Vertical Scale: 0 250 500 Feet

Date: SEPTEMBER 2019

2959703 E
813457 N

2967755 E
804159 N



NOTES:

1. Quaternary sediments and lake bathymetry not shown as thicknesses and depths are generally less than 20 feet and not seen at this scale.
2. Hydrographic data from Minnesota Department of Natural Resources.
3. Horizontal datum based on NAD 1983. Horizontal coordinates based on Minnesota State Plane North (feet).
4. Horizontal and vertical scale are as shown. Vertical exaggeration is 1.

LEGEND

- Cross Section Line
- Primary Road
- Project Area
- Underground Mine Area
- Lake/Pond

Geologic Unit

- Magt Main Augite troctolite
- Mat Anorthositic troctolite to troctolitic anorthosite
- Mbmz Basal Mineralized Zone
- UG Upper Gabbro
- Mas Anorthositic Series
- UB Upper Basalt
- Agc Giants Range Batholith



TWIN METALS MINNESOTA

FIGURE 5-6

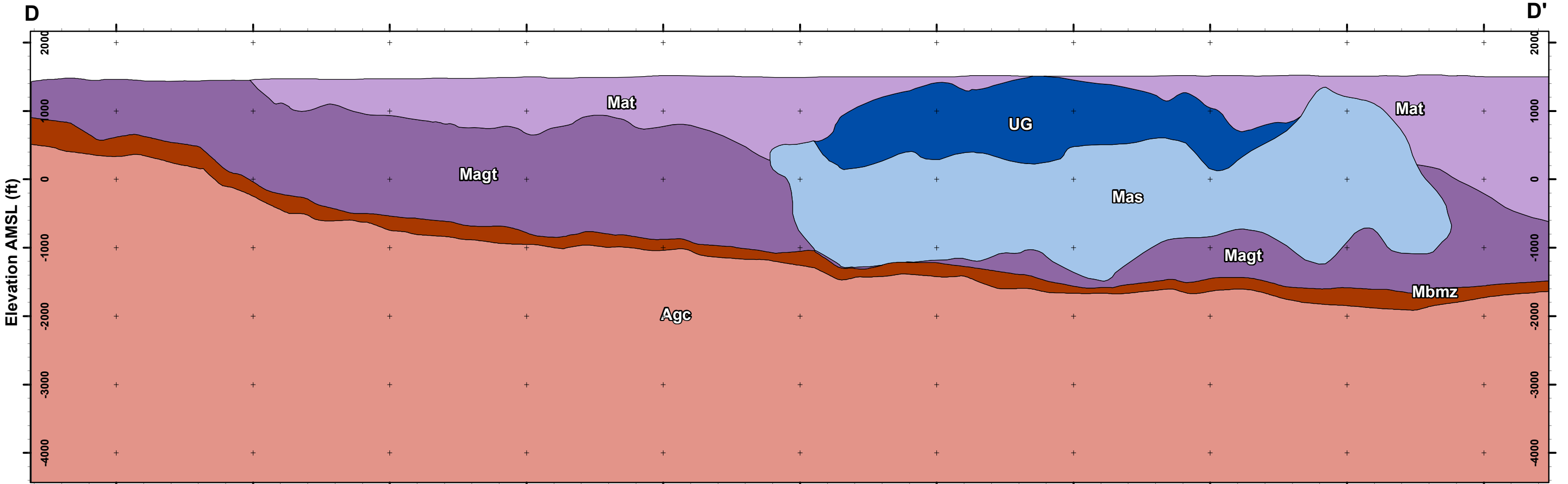
**BEDROCK CROSS SECTION C-C'
UNDERGROUND MINE AREA**

Horizontal & Vertical Scale: 0 250 500 Feet

Date: SEPTEMBER 2019

2951223 E
802812 N

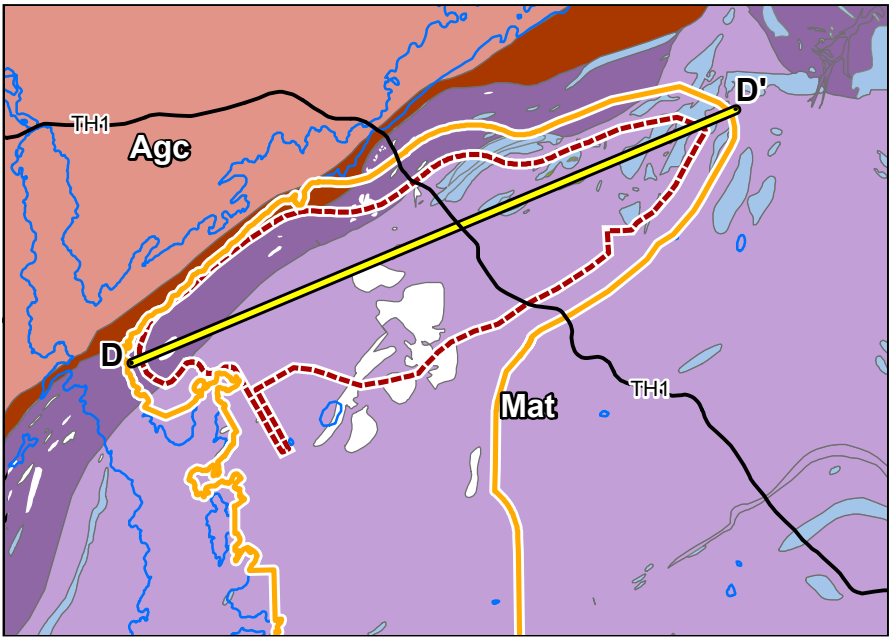
2971693 E
811443 N



- NOTES:**
1. Quaternary sediments and lake bathymetry not shown as thicknesses and depths are generally less than 20 feet and not seen at this scale.
 2. Hydrographic data from Minnesota Department of Natural Resources.
 3. Horizontal datum based on NAD 1983. Horizontal coordinates based on Minnesota State Plane North (feet).
 4. Horizontal and vertical scale are as shown. Vertical exaggeration is 1.

- LEGEND**
- Cross Section Line
 - Primary Road
 - Project Area
 - - - Underground Mine Area
 - Lake/Pond

- Geologic Unit**
- Magt Main Augite troctolite
 - Mat Anorthositic troctolite to troctolitic anorthosite
 - Mbmz Basal Mineralized Zone
 - UG Upper Gabbro
 - Mas Anorthositic Series
 - Agc Giants Range Batholith



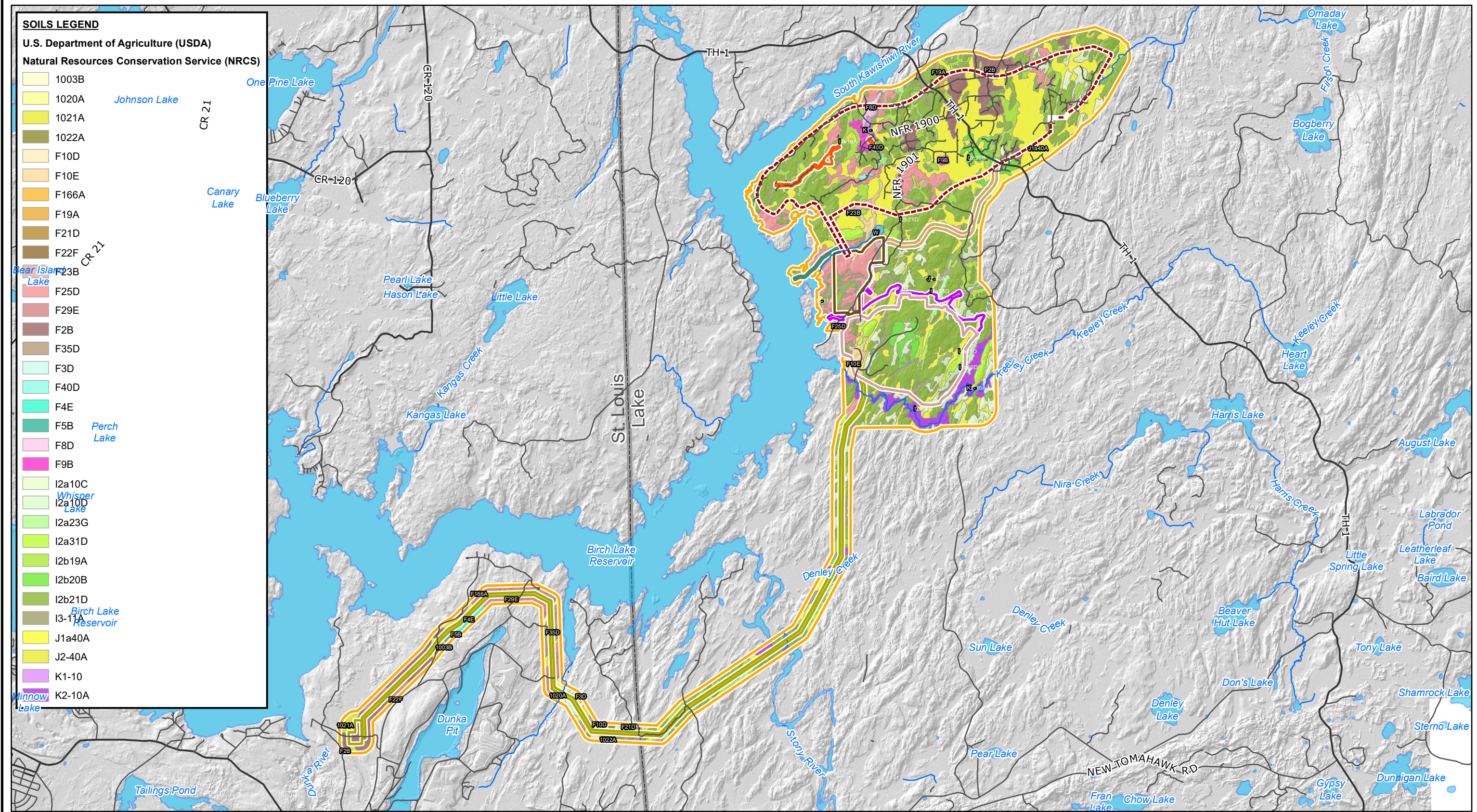
TWIN METALS MINNESOTA

FIGURE 5-7

BEDROCK CROSS SECTION D-D'
UNDERGROUND MINE AREA

Horizontal & Vertical Scale: 0 750 1,500 Feet

Date: SEPTEMBER 2019



SOILS LEGEND

- U.S. Department of Agriculture (USDA)**
Natural Resources Conservation Service (NRCS)
- 1003B
 - 1020A
 - 1021A
 - 1022A
 - F10D
 - F10E
 - F166A
 - F19A
 - F21D
 - F22F
 - F23B
 - F25D
 - F29E
 - F2B
 - F35D
 - F3D
 - F40D
 - F4E
 - F5B
 - F8D
 - F9B
 - I2a10C
 - I2a10D
 - I2a23G
 - I2a31D
 - I2b19A
 - I2b20B
 - I2b21D
 - I3-11A
 - J1a40A
 - J2-40A
 - K1-10
 - K2-10A

- NOTES:**
1. Hydrographic data from Minnesota Department of Natural Resources.
 2. Horizontal datum based on NAD 1983. Horizontal coordinates based on Minnesota State Plane North (feet).
 3. Soils data downloaded from the U.S. Department of Agriculture (<https://websoilsurvey.sc.egov.usda.gov>).
 4. See Table 5-1 for soil descriptions.

LEGEND

- | | | |
|-----------------------|----------------------------------|------------------------------------|
| Primary Road | Plant Site | Water Intake Corridor |
| Secondary Road | Tailings Management Site | Ventilation Raises and Ventilation |
| River/Stream | Non-Contact Water Diversion Area | Raise Access Road |
| County Boundary | Transmission Corridor | Access Road Corridor |
| Project Area | | |
| Underground Mine Area | | |



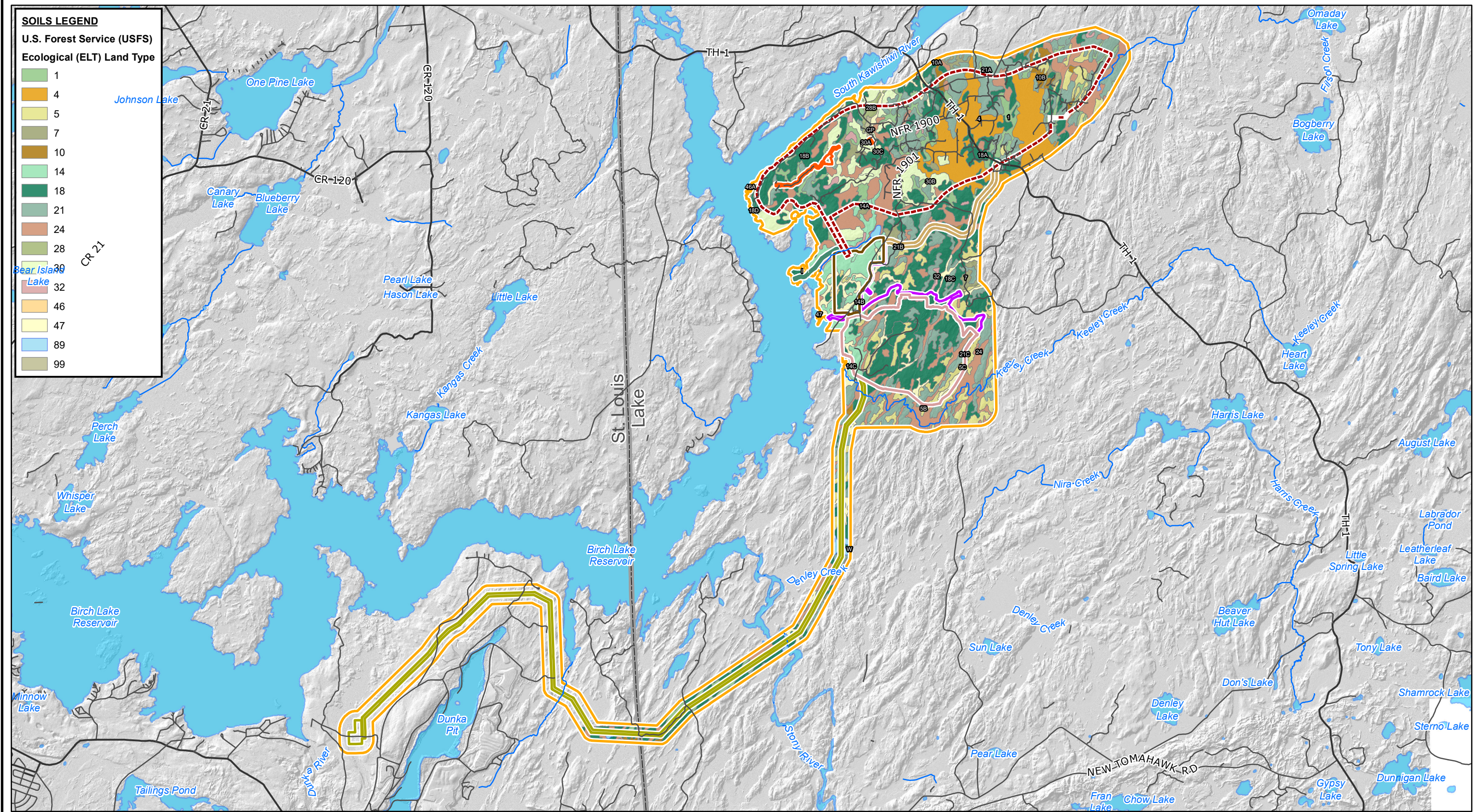
TWIN METALS MINNESOTA

FIGURE 5-8

U.S. DEPARTMENT OF AGRICULTURE
NRCS SOILS DATA

Scale: 0 2,500 5,000 Feet

Date: SEPTEMBER 2019



SOILS LEGEND
U.S. Forest Service (USFS)
Ecological (ELT) Land Type

1
4
5
7
10
14
18
21
24
28
30
32
46
47
89
99

NOTES:
1. Hydrographic data from Minnesota Department of Natural Resources.
2. Horizontal datum based on NAD 1983. Horizontal coordinates based on Minnesota State Plane North (feet).
3. Terrestrial Ecological Unit Inventory (soils) data from the United States Forest Service.
4. See Table 5-2 for soil descriptions.

LEGEND

River/Stream	Project Area	Transmission Corridor
Primary Road	Underground Mine Area	Water Intake Corridor
Secondary Road	Plant Site	Ventilation Raises and Ventilation Raise Access Road
County Boundary	Tailings Management Site	Access Road Corridor
	Non-Contact Water Diversion Area	

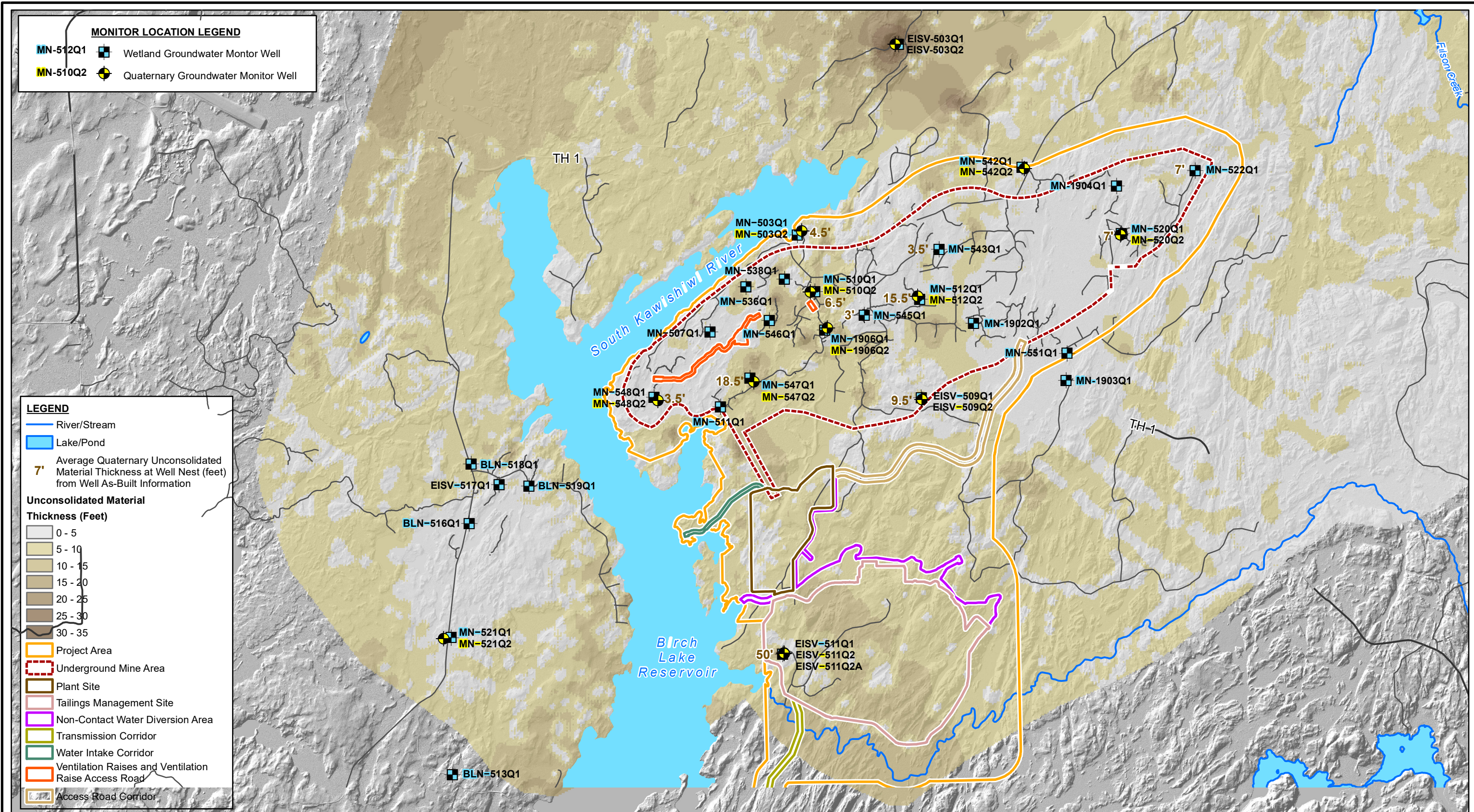


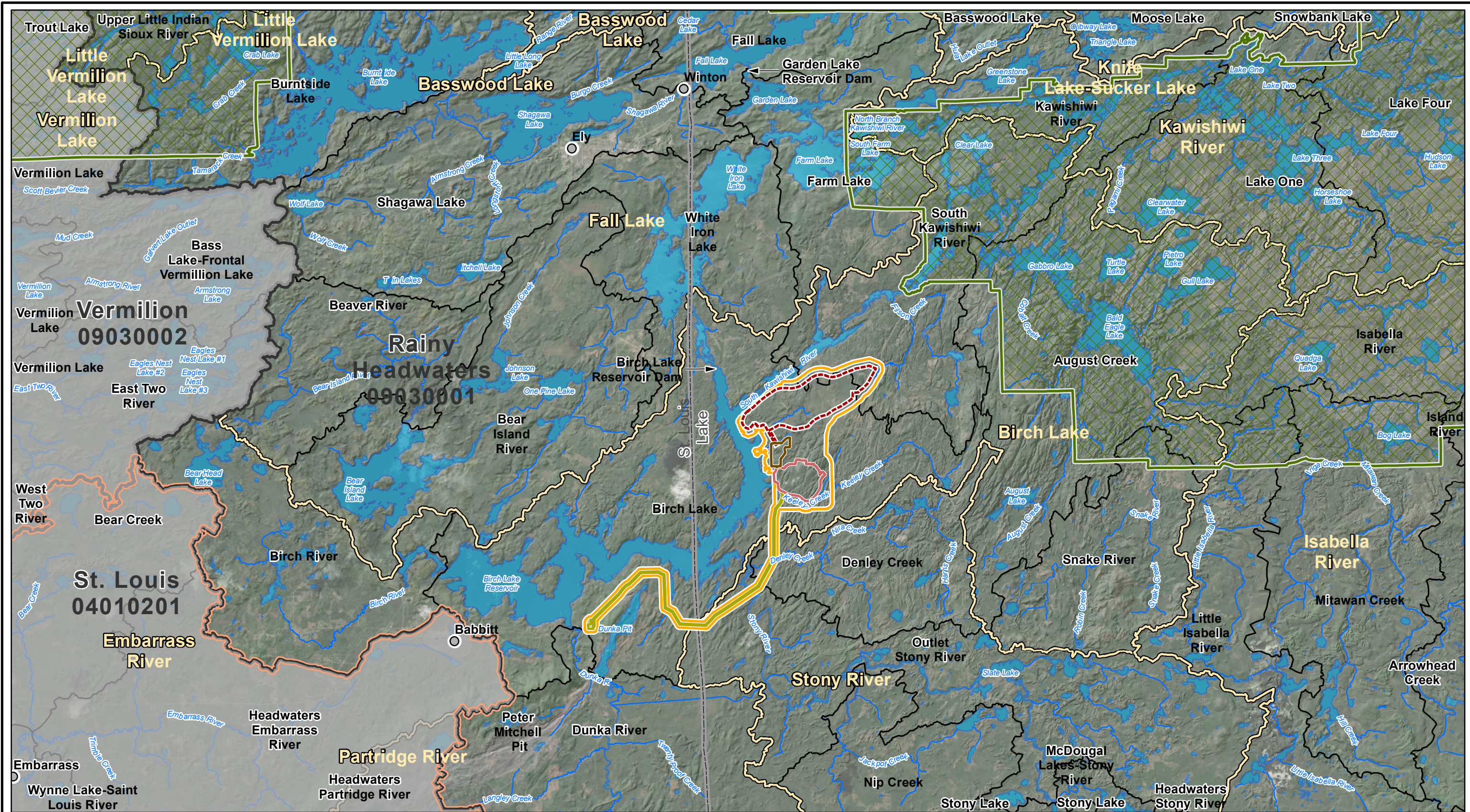
TWIN METALS MINNESOTA

FIGURE 5-9
U.S. FOREST SERVICE ELT SOILS DATA

Scale: 0 2,500 5,000 Feet

Date: SEPTEMBER 2019





NOTES:

1. Base air photo from Esri World Imagery map service.
2. Watershed data from the U.S. Geological Survey Watershed Boundary Dataset (WBD).
3. Hydrographic data from Minnesota Department of Natural Resources.
4. Horizontal datum based on NAD 1983. Horizontal coordinates based on Minnesota State Plane North (feet).

LEGEND

○ Place Name	□ Watershed Boundary Hydrological Unit Code 12	▨ Underground Mine Area
— River/Stream	— Laurentian Divide	□ Plant Site
■ Lake/Pond	▨ County Boundary	▨ Tailings Management Site
▨ Watershed Boundary Hydrological Unit Code 8	▨ Boundary Waters Canoe Area Wilderness	▨ Transmission Corridor
▨ Watershed Boundary Hydrological Unit Code 10	▨ Project Area	

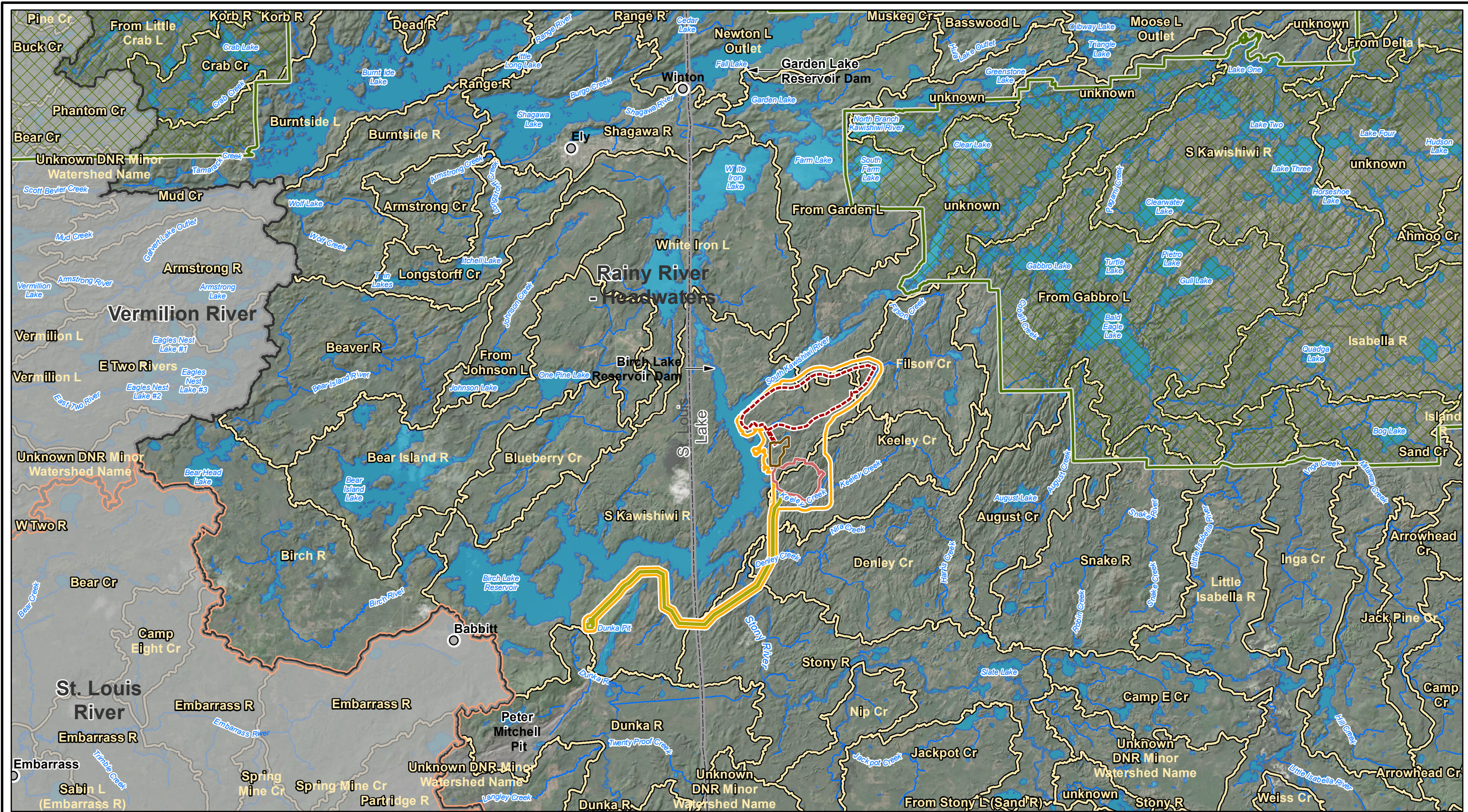
TWIN METALS MINNESOTA

FIGURE 6-1

U.S. GEOLOGICAL SURVEY
HYDROLOGICAL UNIT CODE WATERSHEDS

Scale: 0 1.25 2.5 Miles

Date: SEPTEMBER 2019



NOTES:

1. Base air photo from Esri World Imagery map service.
2. Hydrographic and watershed data from Minnesota Department of Natural Resources.
3. Horizontal datum based on NAD 1983. Horizontal coordinates based on Minnesota State Plane North (feet).

LEGEND

○ Place Name	▬ County Boundary	▬ Plant Site
▬ Major Watershed Boundary	▬ Boundary Waters Canoe Area Wilderness	▬ Tailings Management Site
▬ Minor Watershed Boundary	▬ Project Area	▬ Transmission Corridor
▬ River/Stream	▬ Underground Mine Area	
▬ Lake/Pond		
▬ Laurentian Divide		

TWIN METALS MINNESOTA

FIGURE 6-2

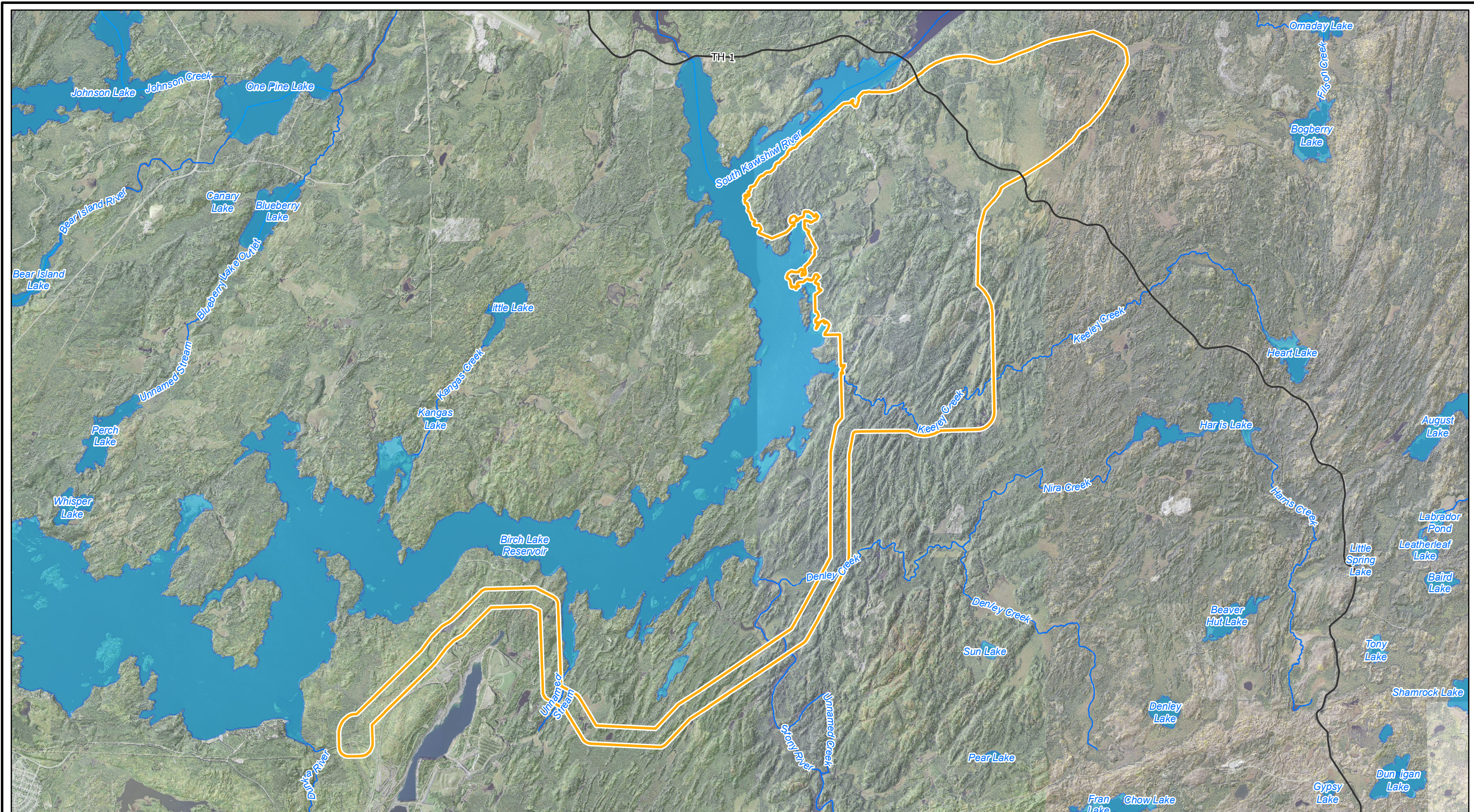
MINNESOTA DEPARTMENT OF NATURAL RESOURCES WATERSHEDS

Scale: 0 1.25 2.5 Miles

Date: SEPTEMBER 2019

TWIN METALS MINNESOTA

Foth



NOTES:

1. Base air photo from the U.S. Department of Agriculture Farm Service Agency, Aerial Photography Field Office.
2. Hydrographic data from Minnesota Department of Natural Resources.
3. Horizontal datum based on NAD 1983. Horizontal coordinates based on Minnesota State Plane North (feet).

LEGEND

- Public Waters - Watercourse Delineation
- Public Waters - Basin Delineation
- Primary Road
- Project Area

TWIN METALS MINNESOTA

N

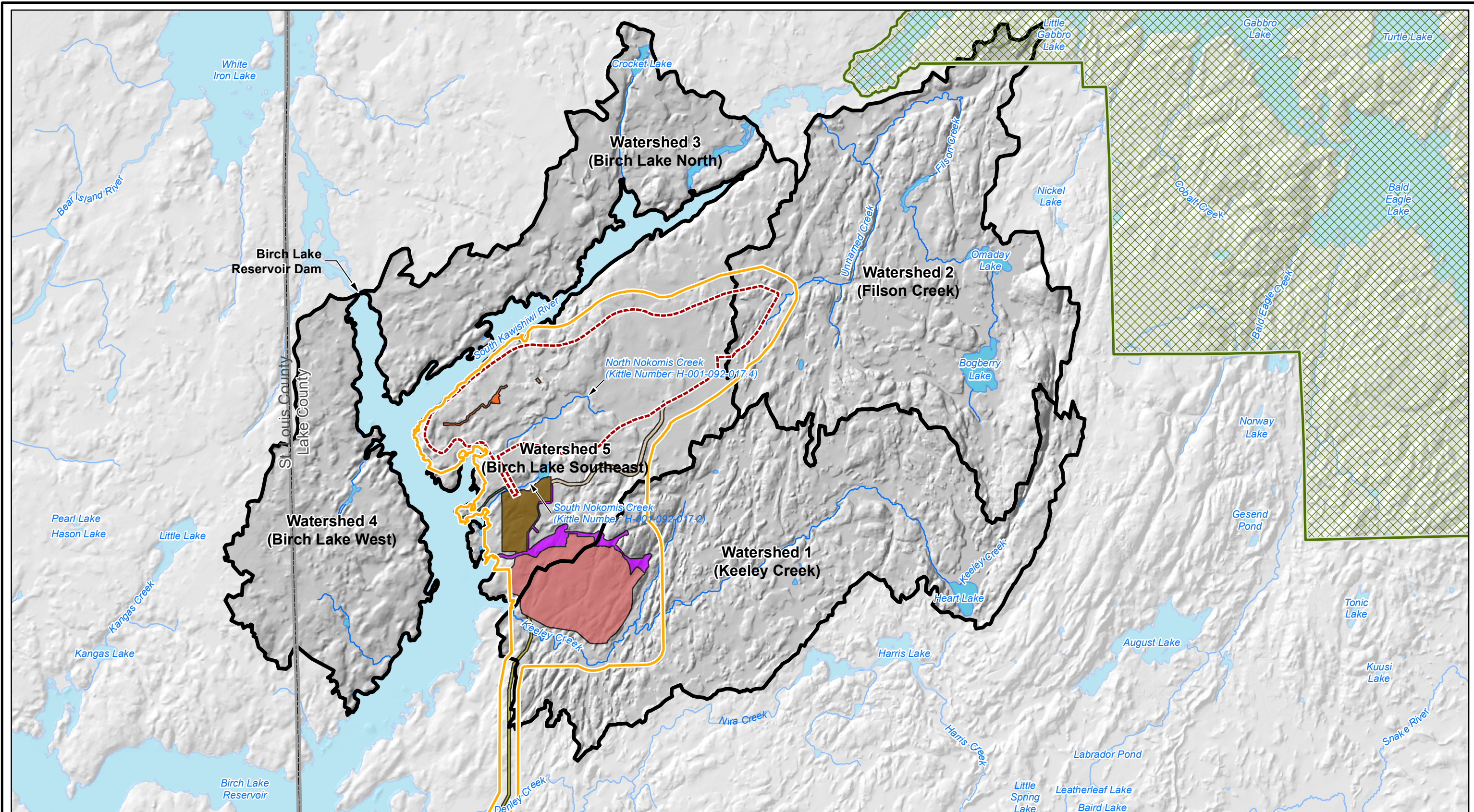
TWIN METALS MINNESOTA

FIGURE 6-3

MINNESOTA DEPARTMENT OF NATURAL RESOURCES
PUBLIC WATER INVENTORY

Scale: 0 2,500 5,000 Feet

Date: SEPTEMBER 2019



NOTES:

- Digital elevation model from the U.S. Geological Survey. (<https://viewer.nationalmap.gov/basic/>).
- Hydrographic and watershed data from Minnesota Department of Natural Resources.
- Horizontal datum based on NAD 1983. Horizontal coordinates based on Minnesota State Plane North (feet).

LEGEND

Watersheds Intersected by the Underground Mine Area, Water Intake Corridor, Plant Site and Tailings Management Site	County Boundary	Plant Site	Water Intake Corridor
River/Stream	Boundary Waters Canoe Area Wilderness	Tailings Management Site	Ventilation Raise and Ventilation Raise Access Road
Lake/Pond	Project Area	Non-Contact Water Diversion Area	Access Road Corridor
	Underground Mine Area	Transmission Corridor	

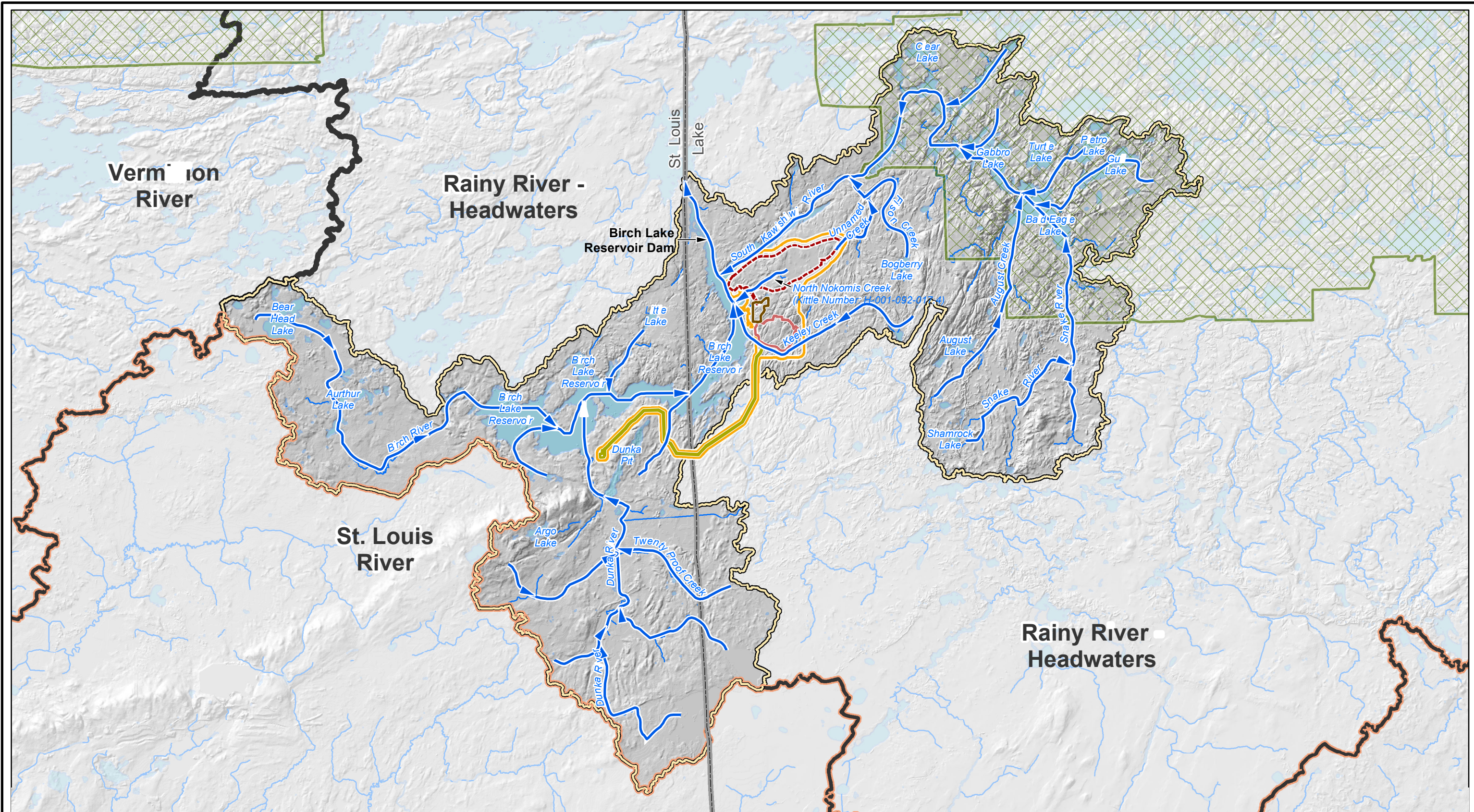
TWIN METALS MINNESOTA

FIGURE 6-4

PROJECT WATERSHEDS

Scale: 0 2,500 5,000 Feet

Date: SEPTEMBER 2019



NOTES:

- Digital elevation model from the U.S. Geological Survey. (<https://viewer.nationalmap.gov/basic/>).
- Watershed data from the U.S. Geological Survey Watershed Boundary Dataset (WBD).
- Hydrographic data from Minnesota Department of Natural Resources.
- Horizontal datum based on NAD 1983. Horizontal coordinates based on Minnesota State Plane North (feet).

LEGEND

- Generalized Surface Water Drainage
- Laurentian Divide
- Watershed Boundary Hydrological Unit Code 10
- Watershed Boundary Hydrological Unit Code 8
- Lake/Pond
- County Boundary
- Boundary Waters Canoe Area Wilderness
- Project Area
- Underground Mine Area
- Plant Site
- Tailings Management Site
- Transmission Corridor

TWIN METALS MINNESOTA

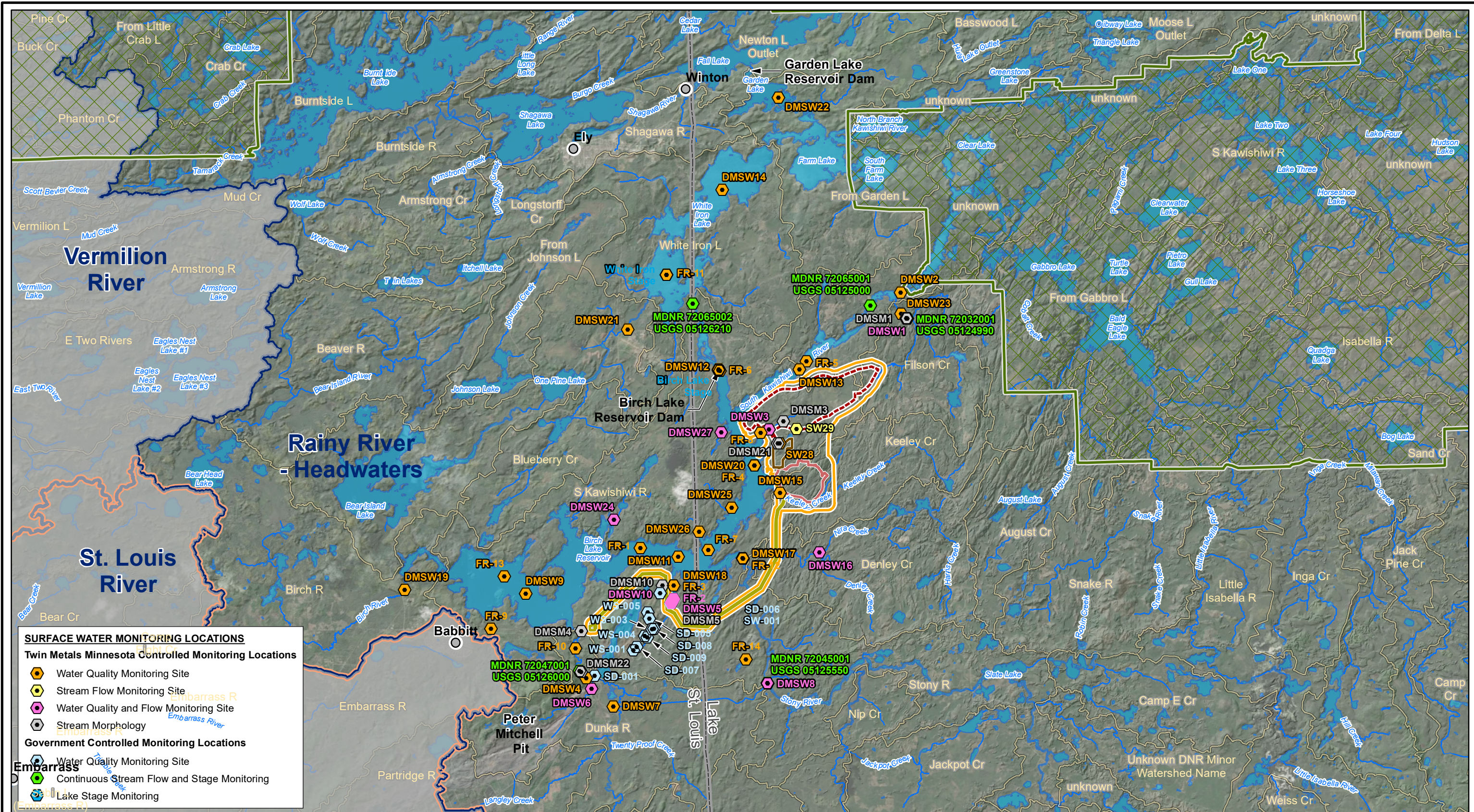
FIGURE 6-5

BIRCH LAKE RESERVOIR WATERSHED SURFACE DRAINAGE

Scale: 0 1.5 3 Miles

Date: SEPTEMBER 2019

Foth



SURFACE WATER MONITORING LOCATIONS

Twin Metals Minnesota Controlled Monitoring Locations

- Water Quality Monitoring Site
- Stream Flow Monitoring Site
- Water Quality and Flow Monitoring Site
- Stream Morphology

Government Controlled Monitoring Locations

- Water Quality Monitoring Site
- Continuous Stream Flow and Stage Monitoring
- Lake Stage Monitoring

NOTES:

1. Base air photo from Esri World Imagery map service.
2. Hydrographic and watershed data from Minnesota Department of Natural Resources.
3. Existing surface water monitoring locations from Barr Engineering Co.
4. Horizontal datum based on NAD 1983. Horizontal coordinates based on Minnesota State Plane North (feet).

LEGEND

Place Name	County Boundary	Plant Site
River/Stream	Boundary Waters Canoe Area Wilderness	Tailings Management Site
Lake/Pond	Project Area	Transmission Corridor
Minor Watershed Boundary	Underground Mine Area	
Major Watershed Boundary		
Laurentian Divide		

TWIN METALS MINNESOTA

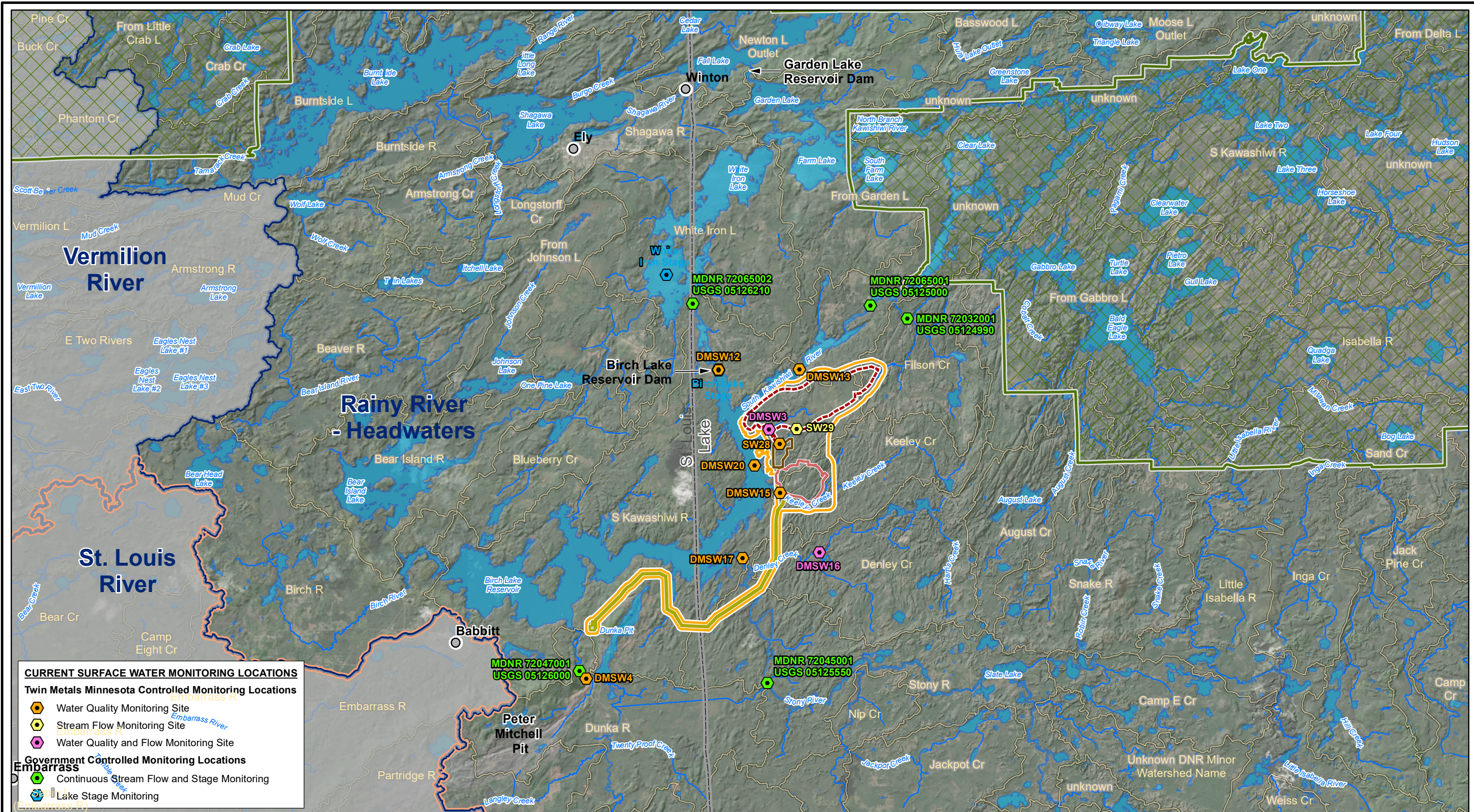
FIGURE 6-6

SURFACE WATER HYDROLOGY AND WATER QUALITY MONITORING LOCATIONS

Scale: 0 1.25 2.5 Miles

Date: SEPTEMBER 2019

Foth



CURRENT SURFACE WATER MONITORING LOCATIONS

Twin Metals Minnesota Controlled Monitoring Locations

- Water Quality Monitoring Site
- Stream Flow Monitoring Site
- Water Quality and Flow Monitoring Site

Government Controlled Monitoring Locations

- Continuous Stream Flow and Stage Monitoring
- Lake Stage Monitoring

NOTES:

1. Base air photo from Esri World Imagery map service.
2. Hydrographic and watershed data from Minnesota Department of Natural Resources.
3. Existing surface water monitoring locations from Barr Engineering Co.
4. Horizontal datum based on NAD 1983. Horizontal coordinates based on Minnesota State Plane North (feet).

LEGEND

Place Name	Boundary Waters Canoe Area Wilderness	Plant Site
River/Stream	Project Area	Tailings Management Site
Lake/Pond	Underground Mine Area	Transmission Corridor
Minor Watershed Boundary		
Major Watershed Boundary		
Laurentian Divide		
County Boundary		



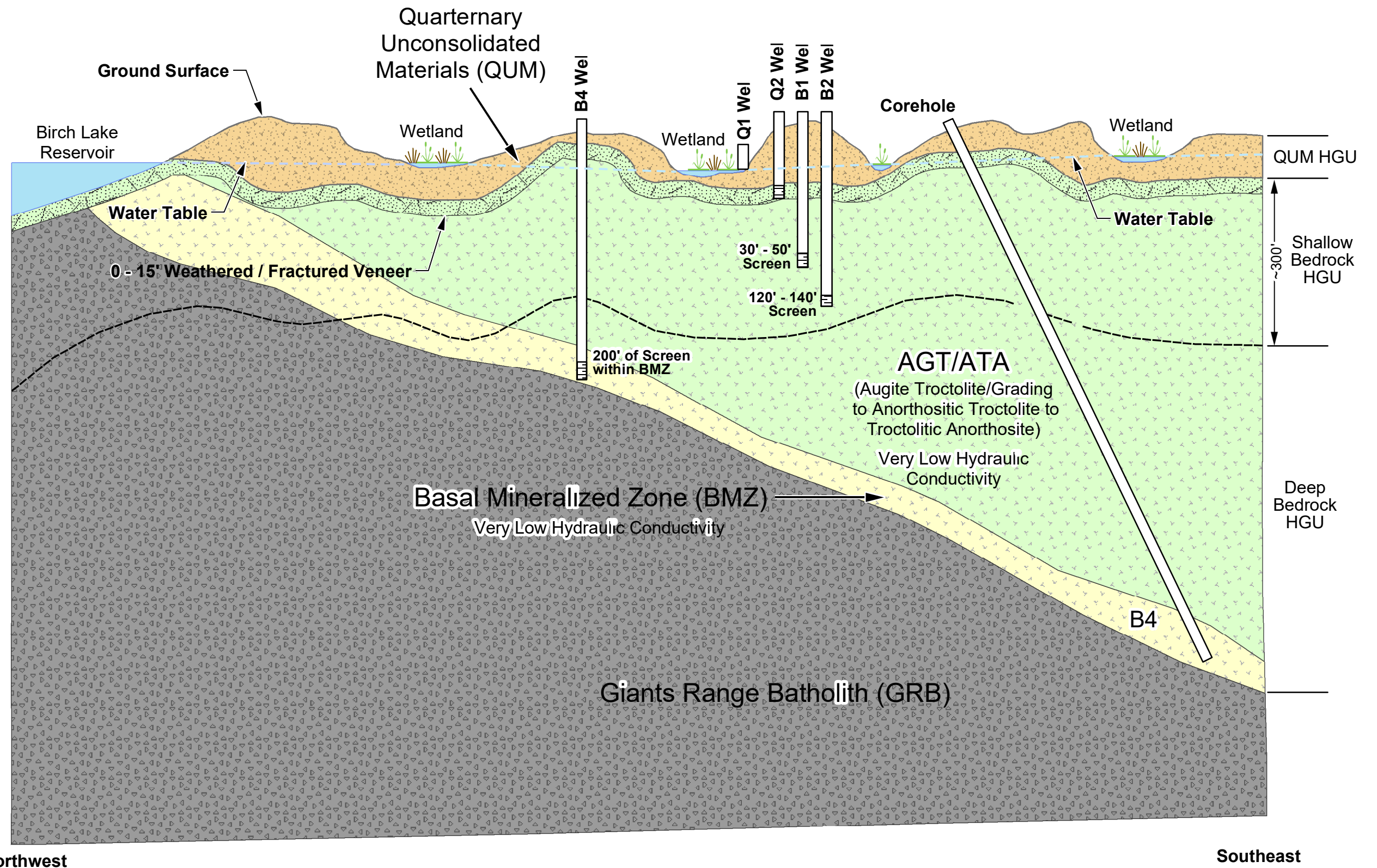
TWIN METALS MINNESOTA

FIGURE 6-7

CURRENT SURFACE WATER HYDROLOGY AND WATER QUALITY MONITORING LOCATIONS

Scale: 0 1.25 2.5 Miles

Date: SEPTEMBER 2019



NOTES:
1. Figure is conceptual, not to scale and to be used for purposes of discussion.



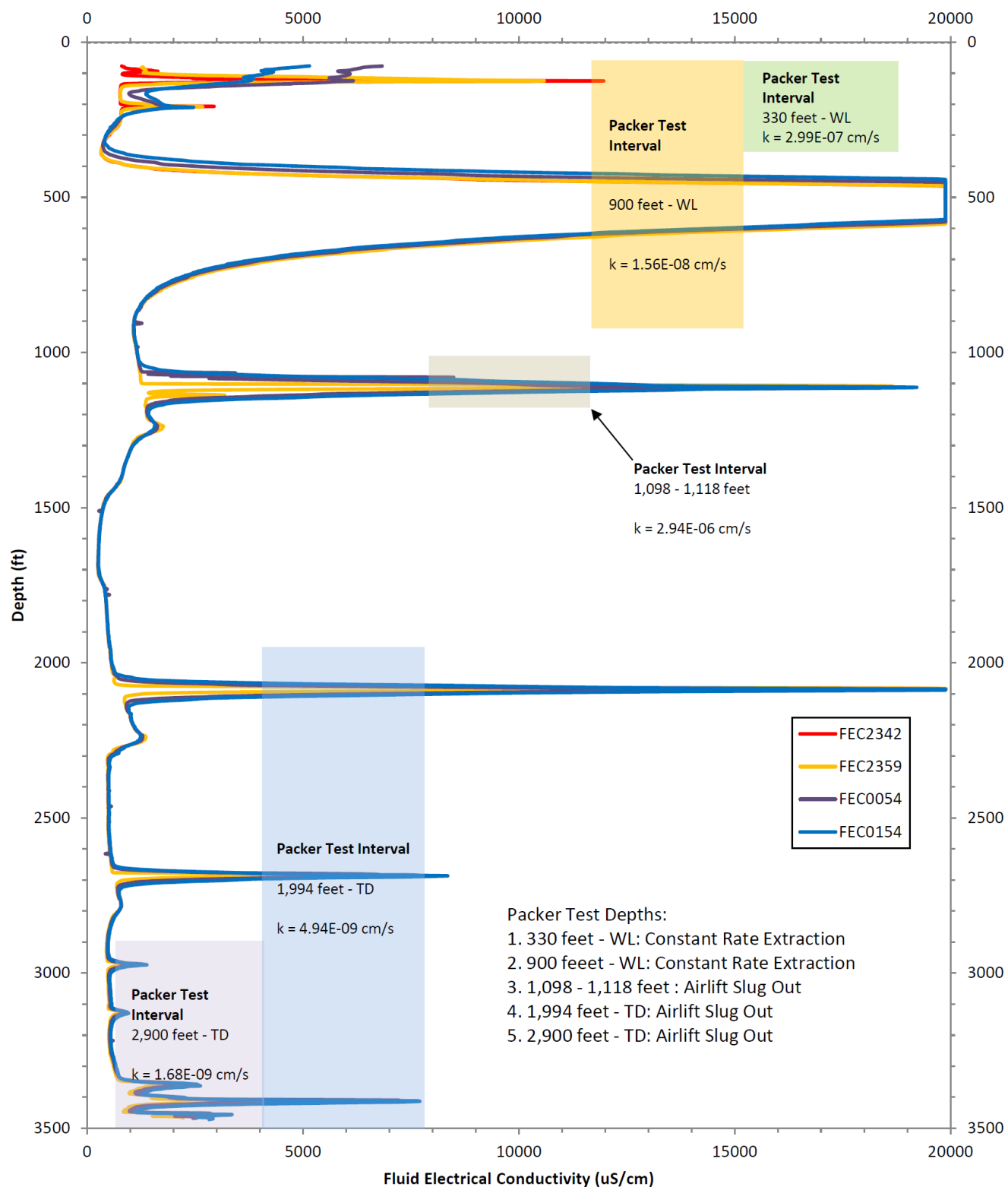
TWIN METALS MINNESOTA

FIGURE 6-8

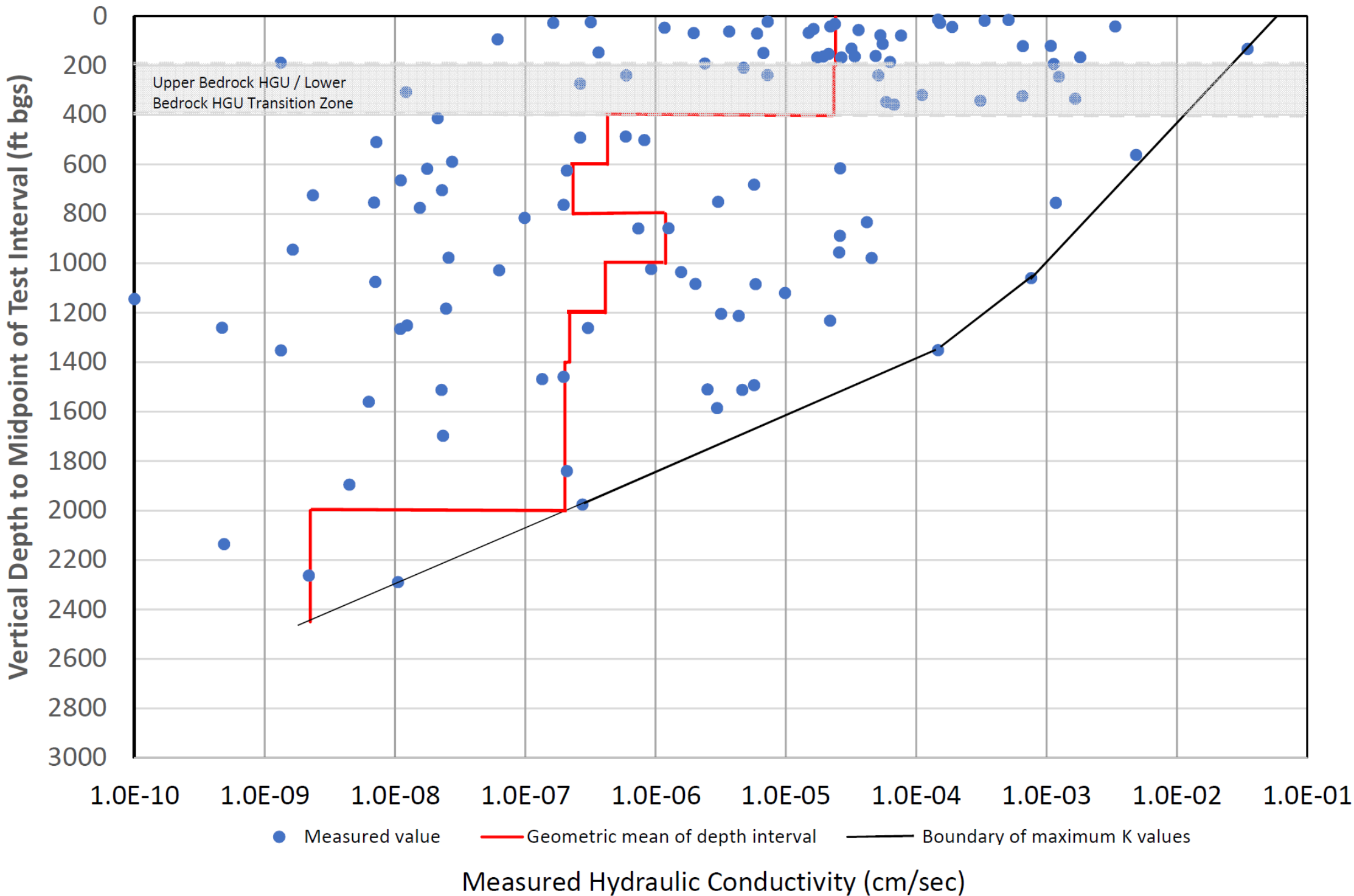
CONCEPTUAL HYDROLOGIC MODEL - HGUS

Scale: NOT TO SCALE

Date: SEPTEMBER 2019



Bedrock Hydraulic Conductivity vs Depth



NOTES:
1. Hydraulic conductivity data subject to data qualification filtering.
All tests of zones >100 ft and tests which exceeded the resolution limits of test equipment were removed from plot.
2. When additional data and analysis becomes available, that information would be used to add to or modify the plot.

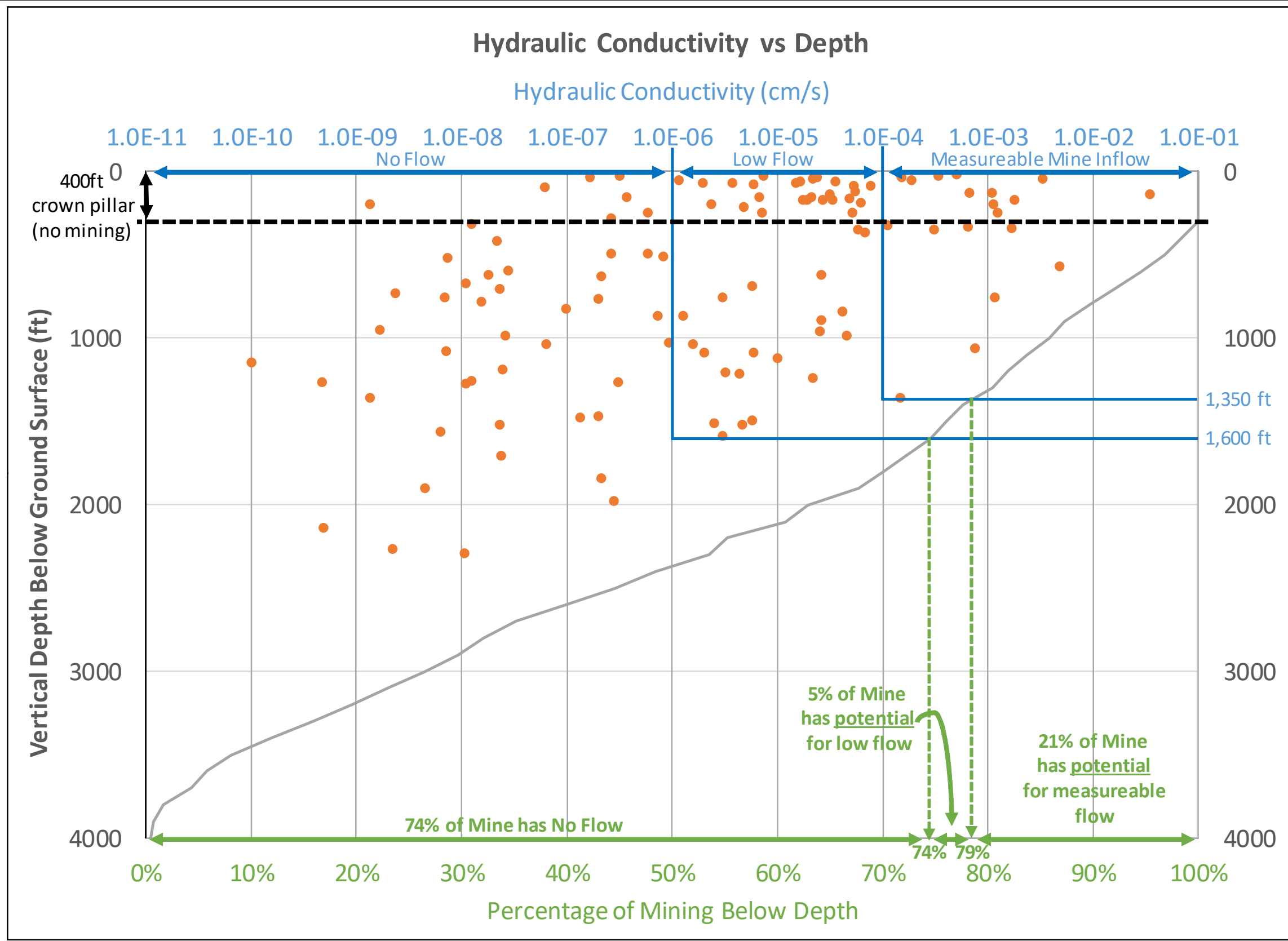


TWIN METALS MINNESOTA

FIGURE 6-12

HYDRAULIC CONDUCTIVITY DISTRIBUTION

Scale: AS SHOWN Date: SEPTEMBER 2019



LEGEND

- Hydraulic Conductivity
- Percent of Mining Below Mine Level



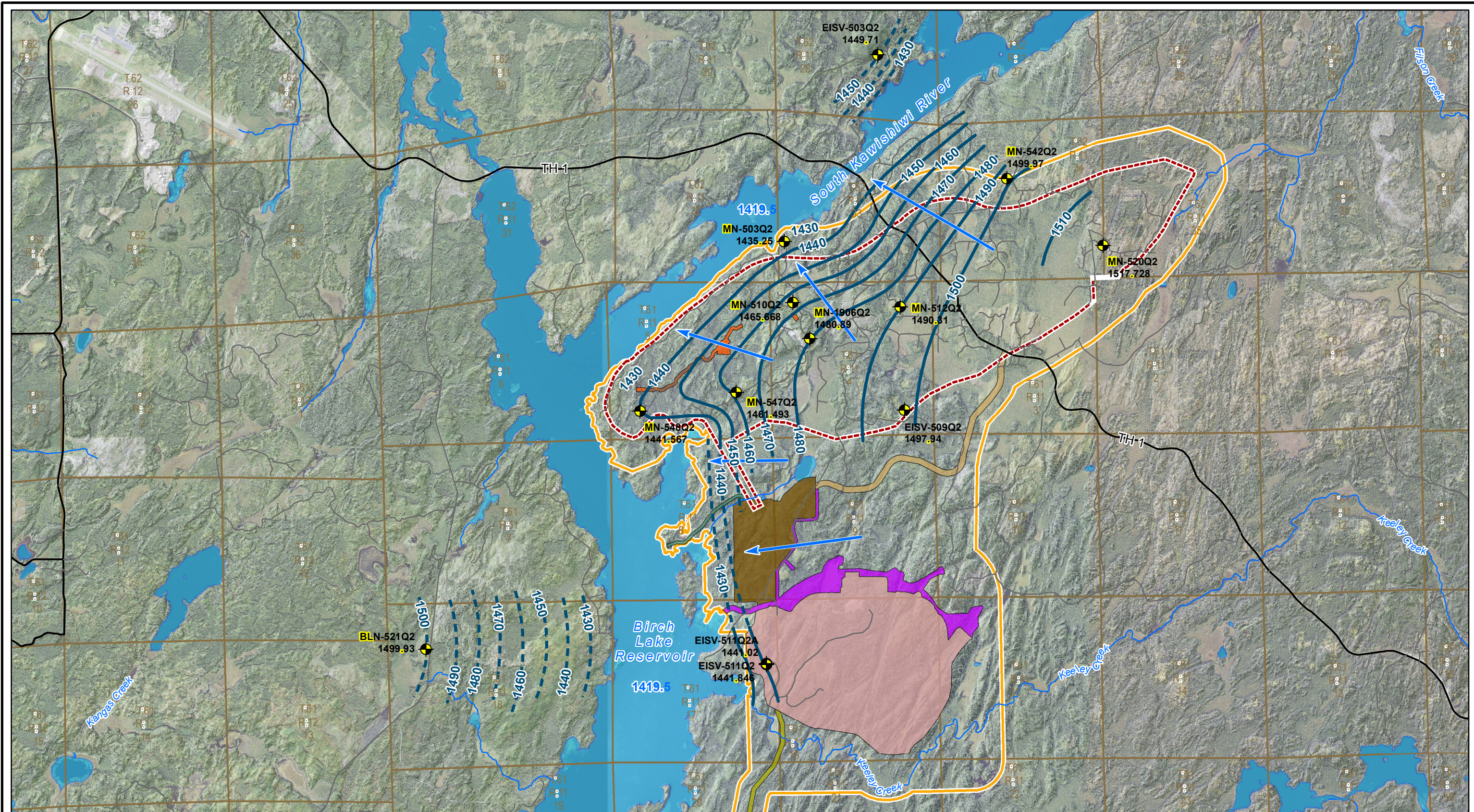
TWIN METALS MINNESOTA

FIGURE 6-13

PROJECTED GROUNDWATER INFLOW TO MINE
DEPTH VERSUS PERCENT OF MINE WORKINGS

Scale: AS SHOWN

Date: SEPTEMBER 2019



NOTES:

1. Base air photo from the U.S. Department of Agriculture Farm Service Agency, Aerial Photography Field Office.
2. Well locations surveyed by Northern Lights Surveying Co.
3. Hydrographic data from Minnesota Department of Natural Resources.
4. Horizontal datum based on NAD 1983. Horizontal coordinates based on Minnesota State Plane North (feet).
5. Birch Lake Reservoir water elevation of 1419.5 ft msl is from the Minnesota Department of Natural Resources website (6/5/2019).

LEGEND

Quaternary Groundwater Monitor Well	River/Stream	Underground Mine Area	Transmission Corridor
June 2019 Groundwater Contour	Lake/Pond	Plant Site	Water Intake Corridor
June 2019 Groundwater Inferred Contour	Section Line	Tailings Management Site	Ventilation Raises and Ventilation Raise Access Road
Groundwater Flow Direction	Project Area	Non-Contact Water Diversion Area	Access Road Corridor
Primary Road			
Secondary Road			

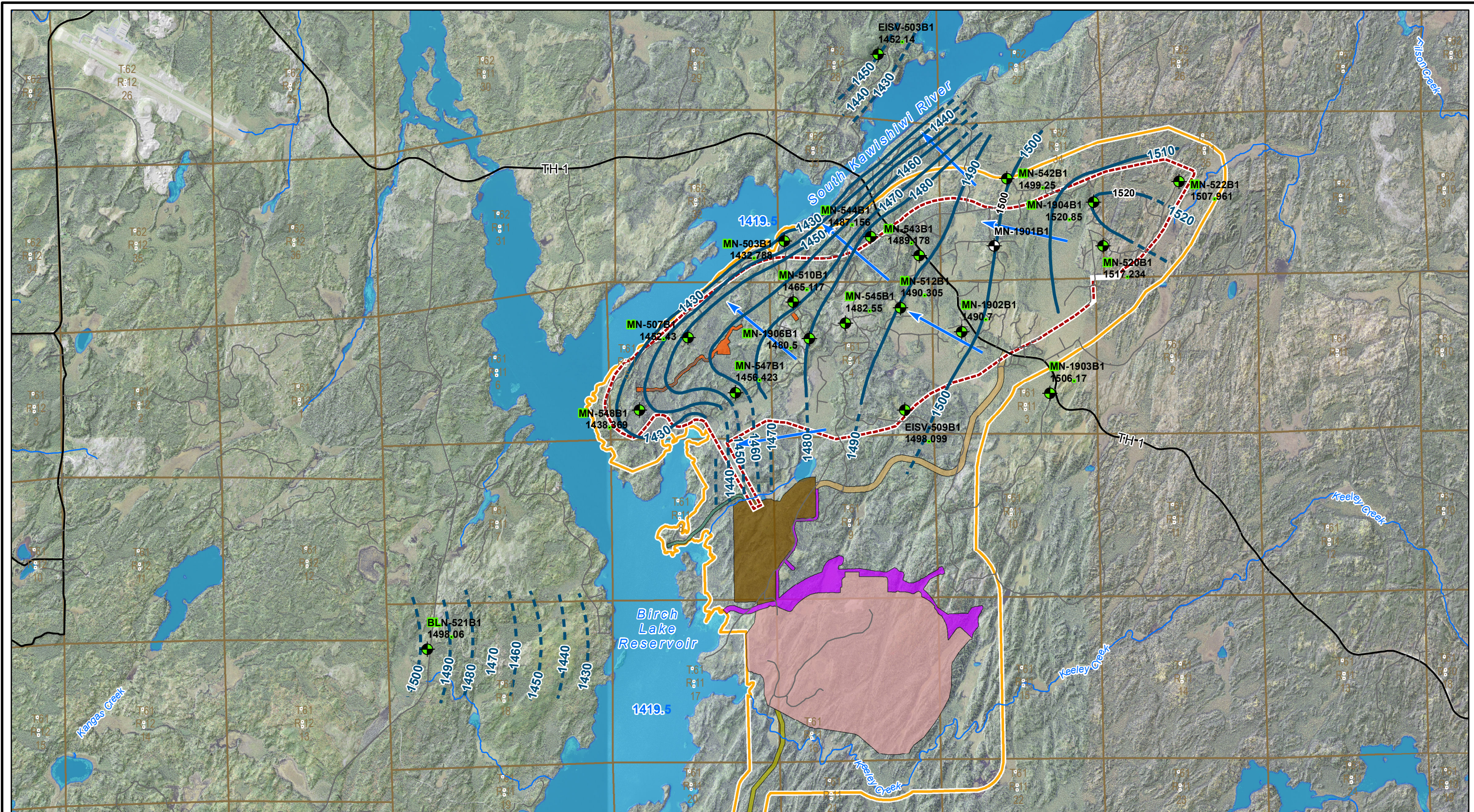
TWIN METALS MINNESOTA

FIGURE 6-14

POTENTIOMETRIC SURFACE
Q2 MONITOR WELLS QUM HGU
JUNE 2019

Scale: 0 1,500 3,000 Feet

Date: SEPTEMBER 2019



NOTES:

1. Base air photo from the U.S. Department of Agriculture Farm Service Agency, Aerial Photography Field Office.
2. Well locations surveyed by Northern Lights Surveying Co.
3. Hydrographic data from Minnesota Department of Natural Resources.
4. Horizontal datum based on NAD 1983. Horizontal coordinates based on Minnesota State Plane North (feet).
5. Birch Lake Reservoir water elevation of 1419.5 ft msl is from the Minnesota Department of Natural Resources website (6/5/2019).
6. MN-1901B1 was not measured as the well was still in recovery phase from well development.

LEGEND

Shallow Bedrock Groundwater Monitor Well	Primary Road	Plant Site
Monitor Well Not Used for Contours	Secondary Road	Tailings Management Site
June 2019 Groundwater Contour	River/Stream	Non-Contact Water Diversion Area
June 2019 Groundwater Inferred Contour	Lake/Pond	Transmission Corridor
Groundwater Flow Direction	Section Line	Water Intake Corridor
	Project Area	Ventilation Raises and Ventilation Raise Access Road
	Underground Mine Area	Access Road Corridor

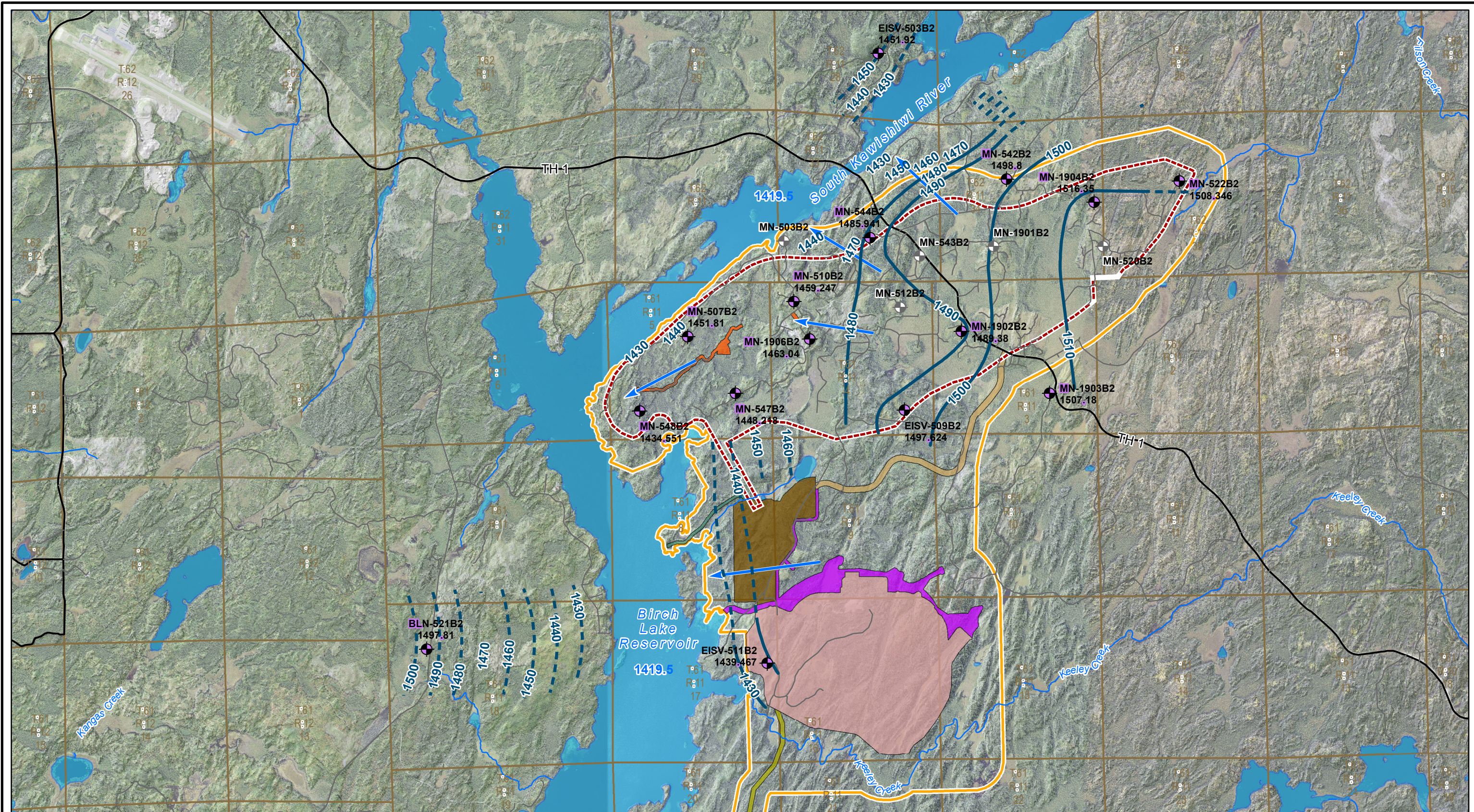
TWIN METALS MINNESOTA

FIGURE 6-15

POTENTIOMETRIC SURFACE
B1 MONITOR WELLS SHALLOW BEDROCK HGU
JUNE 2019

Scale: 0 1,500 3,000 Feet

Date: SEPTEMBER 2019



NOTES:

1. Base air photo from the U.S. Department of Agriculture Farm Service Agency, Aerial Photography Field Office.
2. Well locations surveyed by Northern Lights Surveying Co.
3. Hydrographic data from Minnesota Department of Natural Resources.
4. Horizontal datum based on NAD 1983. Horizontal coordinates based on Minnesota State Plane North (feet).
5. Birch Lake Reservoir water elevation of 1419.5 ft msl is from the Minnesota Department of Natural Resources website (6/5/2019).
6. Locations in gray were not used for contouring. Locations are still in recovery phase from previous purging events.

LEGEND

<ul style="list-style-type: none"> Deep Bedrock Groundwater Monitor Well Monitor Well Not Used for Contours June 2019 Groundwater Contour June 2019 Groundwater Inferred Contour Groundwater Flow Direction 	<ul style="list-style-type: none"> Primary Road Secondary Road River/Stream 	<ul style="list-style-type: none"> Lake/Pond Section Line Underground Mine Area Project Area Plant Site Tailings Management Site 	<ul style="list-style-type: none"> Non-Contact Water Diversion Area Transmission Corridor Water Intake Corridor Ventilation Raises and Ventilation Raise Access Road Access Road Corridor
--	--	--	--

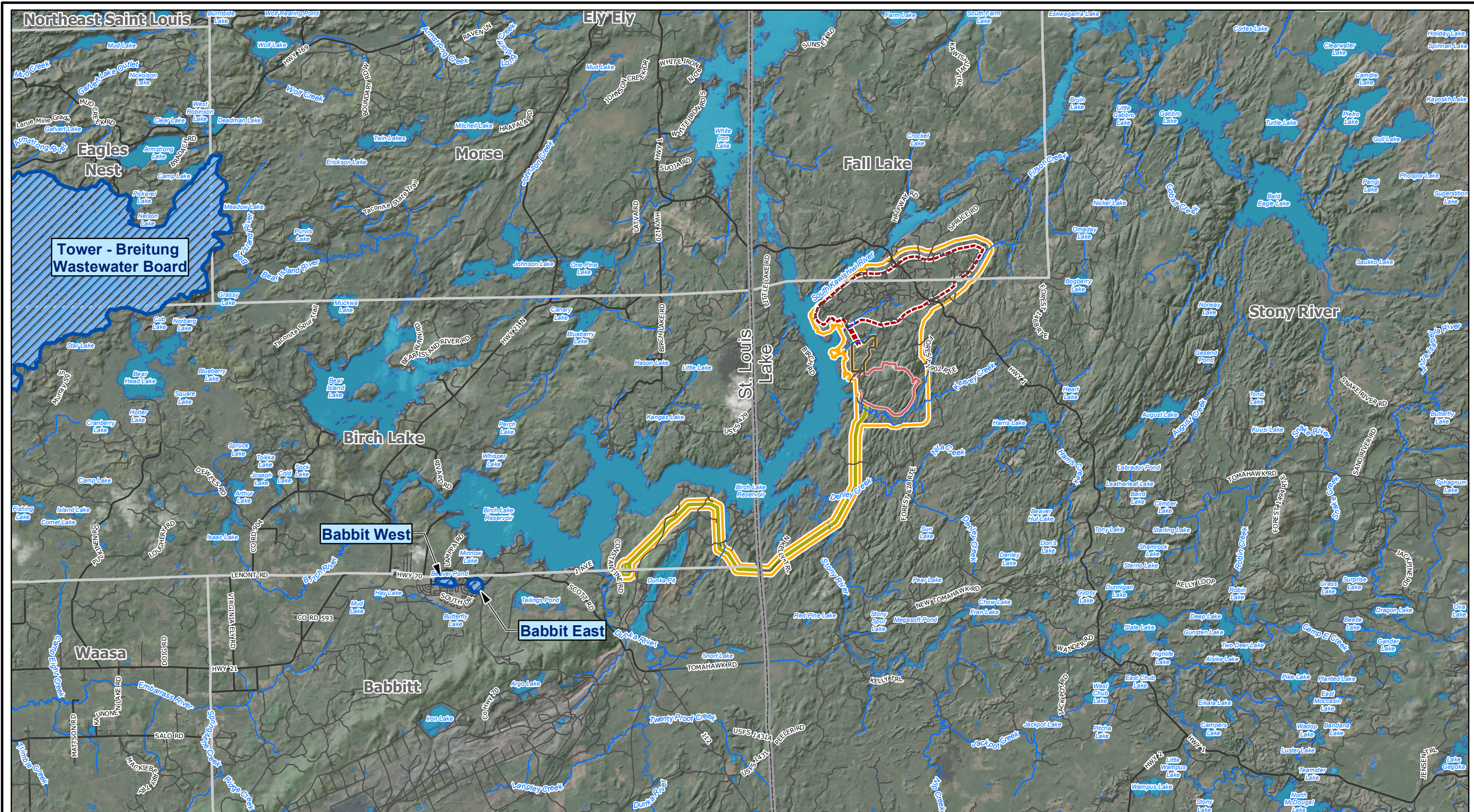
TWIN METALS MINNESOTA

FIGURE 6-16

POTENTIOMETRIC SURFACE
B2 MONITOR WELLS SHALLOW BEDROCK HGU
JUNE 2019

Scale: 0 1,500 3,000 Feet

Date: SEPTEMBER 2019



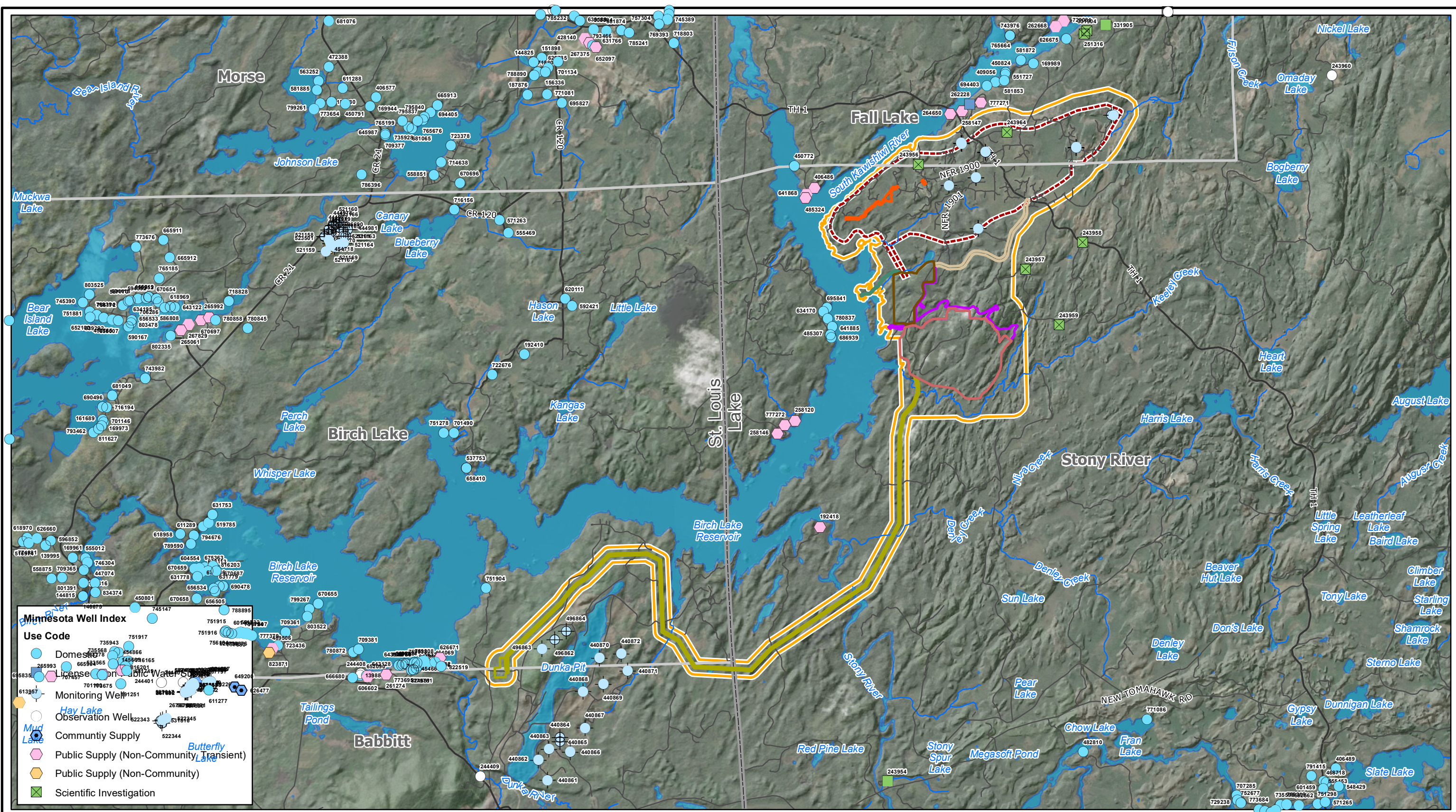
NOTES:

1. Base air photo from Esri World Imagery map service.
2. Hydrographic data from Minnesota Department of Natural Resources.
3. Horizontal datum based on NAD 1983. Horizontal coordinates based on Minnesota State Plane North (feet).
4. Wellhead protection areas from Minnesota Department of Health.

LEGEND

Wellhead Protection Area	Project Area
River/Stream	Underground Mine Area
Primary Road	Tailsings Management Site
Secondary Road	Transmission Corridor
Municipal Boundary	
County Boundary	

TWIN METALS MINNESOTA	
FIGURE 6-17	
WELLHEAD PROTECTION AREA	
Scale: 0 1 2 Miles	Date: SEPTEMBER 2019



NOTES:

1. Base air photo from Esri World Imagery map service.
2. Hydrographic data from Minnesota Department of Natural Resources.
3. Horizontal datum based on NAD 1983. Horizontal coordinates based on Minnesota State Plane North (feet).
4. Minnesota Well Index data from Minnesota Geological Survey (October 2018).

LEGEND

River/Stream	Project Area	Transmission Corridor
Primary Road	Underground Mine Area	Water Intake Corridor
Secondary Road	Plant Site	Ventilation Raise and Ventilation
Municipal Boundary	Tailings Management Site	Raise Access Road
County Boundary	Non-Contact Water Diversion Area	Access Road Corridor

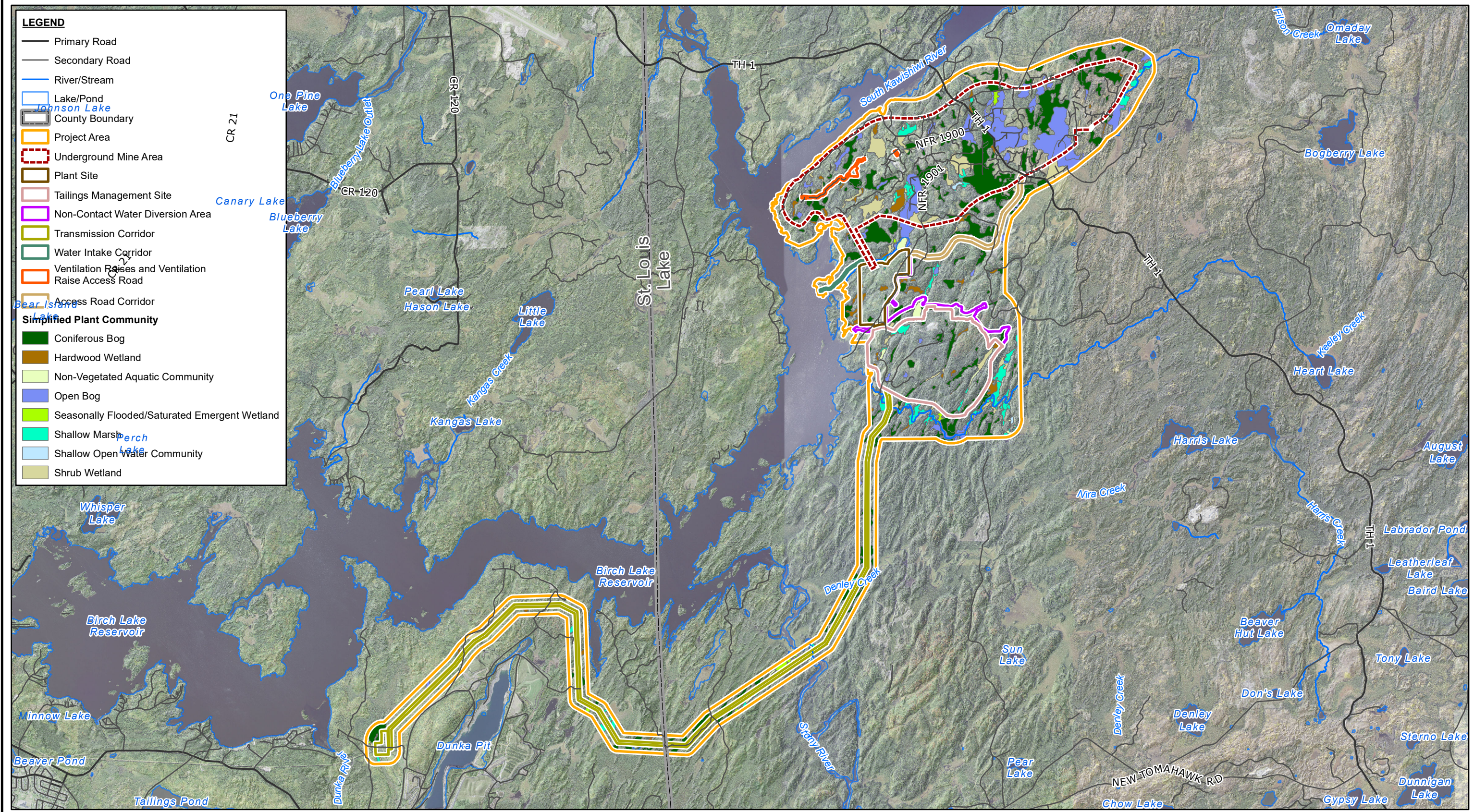
TWIN METALS MINNESOTA

FIGURE 6-18

MINNESOTA WELL INDEX MAP

Scale: 0 3,000 6,000 Feet

Date: SEPTEMBER 2019



LEGEND

Primary Road

Secondary Road

River/Stream

Lake/Pond

County Boundary

Project Area

Underground Mine Area

Plant Site

Tailings Management Site

Non-Contact Water Diversion Area

Transmission Corridor

Water Intake Corridor

Ventilation Raises and Ventilation Raise Access Road

Access Road Corridor

Simplified Plant Community

Coniferous Bog

Hardwood Wetland

Non-Vegetated Aquatic Community

Open Bog

Seasonally Flooded/Saturated Emergent Wetland

Shallow Marsh

Shallow Open Water Community

Shrub Wetland

NOTES:

1. Base air photo from the U.S. Department of Agriculture Farm Service Agency, Aerial Photography Field Office.

2. Hydrographic and National Wetlands Inventory (NWI) data from Minnesota Department of Natural Resources.

3. Horizontal datum based on NAD 1983. Horizontal coordinates based on Minnesota State Plane North (feet).



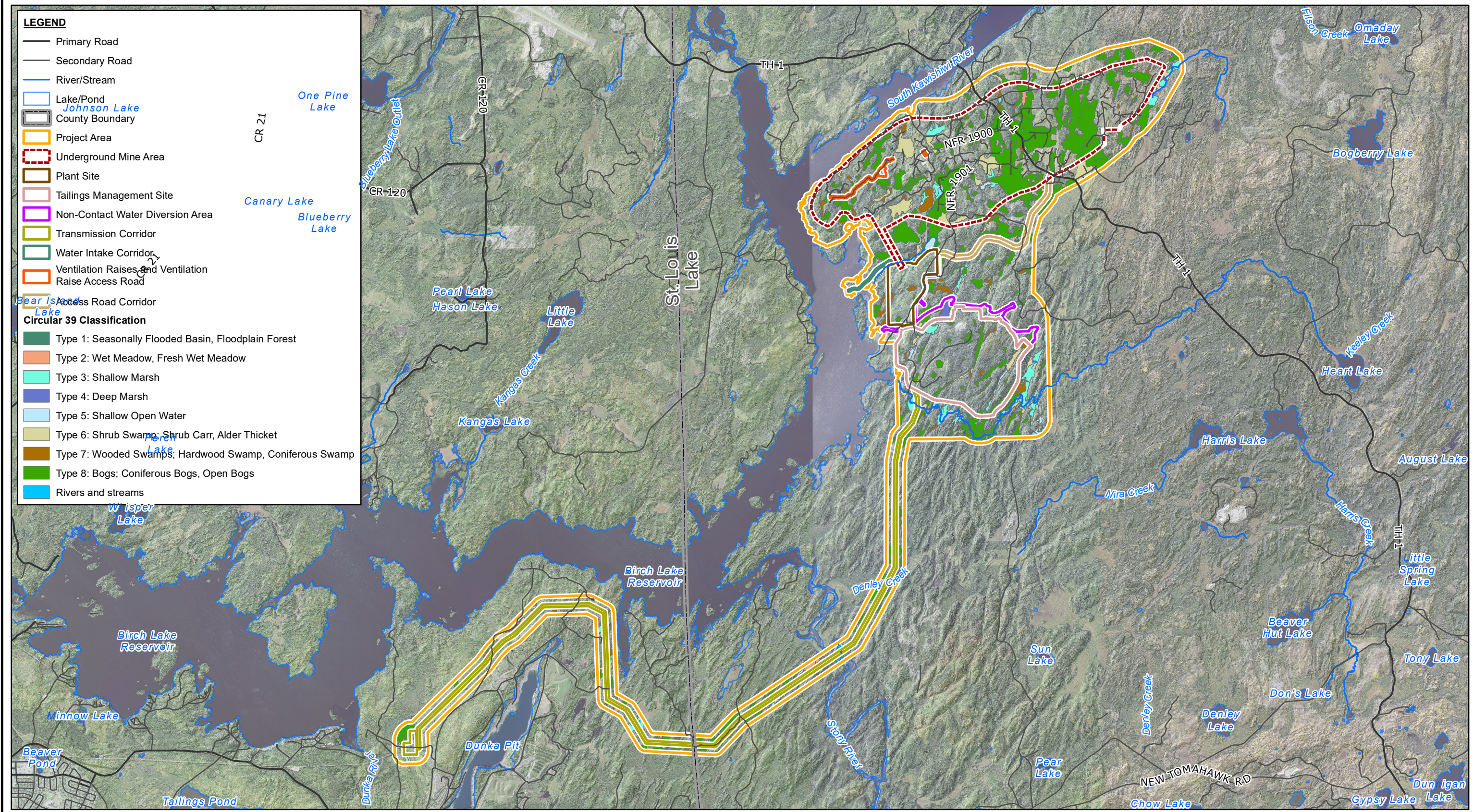
TWIN METALS MINNESOTA

FIGURE 6-19

NATIONAL WETLANDS INVENTORY
SIMPLIFIED PLANT COMMUNITY CLASSIFICATION

Scale: 0 2,500 5,000 Feet

Date: SEPTEMBER 2019



LEGEND

- Primary Road
 - Secondary Road
 - River/Stream
 - Lake/Pond
 - County Boundary
 - Project Area
 - Underground Mine Area
 - Plant Site
 - Tailings Management Site
 - Non-Contact Water Diversion Area
 - Transmission Corridor
 - Water Intake Corridor
 - Ventilation Raises and Ventilation Raise Access Road
 - Access Road Corridor
- Circular 39 Classification**
- Type 1: Seasonally Flooded Basin, Floodplain Forest
 - Type 2: Wet Meadow, Fresh Wet Meadow
 - Type 3: Shallow Marsh
 - Type 4: Deep Marsh
 - Type 5: Shallow Open Water
 - Type 6: Shrub Swamp, Shrub Carr, Alder Thicket
 - Type 7: Wooded Swamps, Hardwood Swamp, Coniferous Swamp
 - Type 8: Bogs; Coniferous Bogs, Open Bogs
 - Rivers and streams

NOTES:

1. Base air photo from the U.S. Department of Agriculture Farm Service Agency, Aerial Photography Field Office.
2. Hydrographic and National Wetlands Inventory (NWI) data from Minnesota Department of Natural Resources.
3. Horizontal datum based on NAD 1983. Horizontal coordinates based on Minnesota State Plane North (feet).



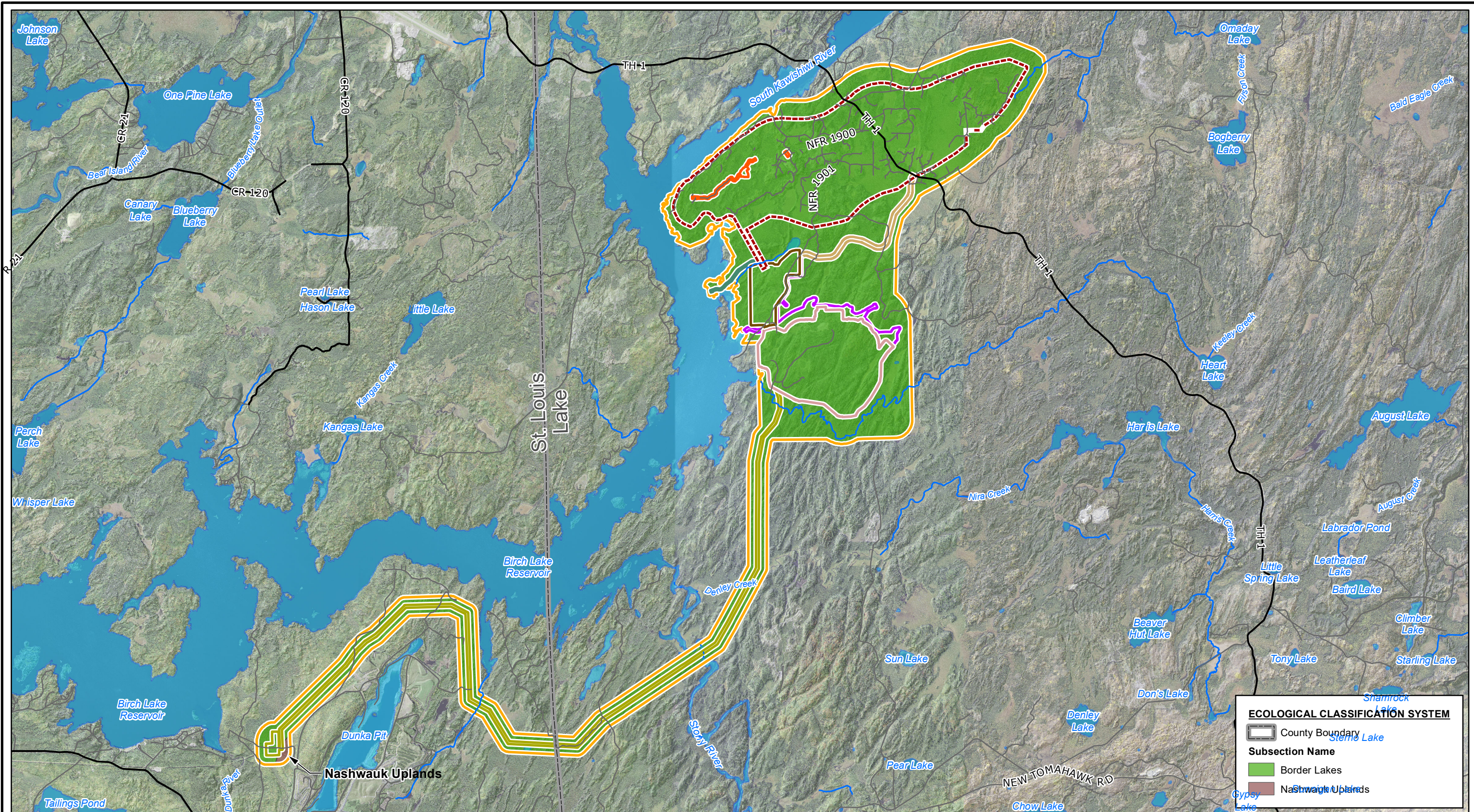
TWIN METALS MINNESOTA

FIGURE 6-20

NATIONAL WETLANDS INVENTORY
CIRCULAR 39 CLASSIFICATION

Scale: 0 2,500 5,000 Feet

Date: SEPTEMBER 2019



NOTES:

1. Base air photo from the U.S. Department of Agriculture Farm Service Agency, Aerial Photography Field Office.
2. Hydrographic and Ecological Classification System (ECS) data from Minnesota Department of Natural Resources.
3. Horizontal datum based on NAD 1983. Horizontal coordinates based on Minnesota State Plane North (feet).

LEGEND

— Primary Road	--- Underground Mine Area	— Transmission Corridor
— Secondary Road	— Plant Site	— Water Intake Corridor
— River/Stream	— Tailings Management Site	— Ventilation Raises and Ventilation Raise Access Road
— Lake/Pond	— Non-Contact Water Diversion Area	— Access Road Corridor
— County Boundary		
— Project Area		

ECOLOGICAL CLASSIFICATION SYSTEM

— County Boundary

Subsection Name

— Border Lakes

— Nashwauk Uplands



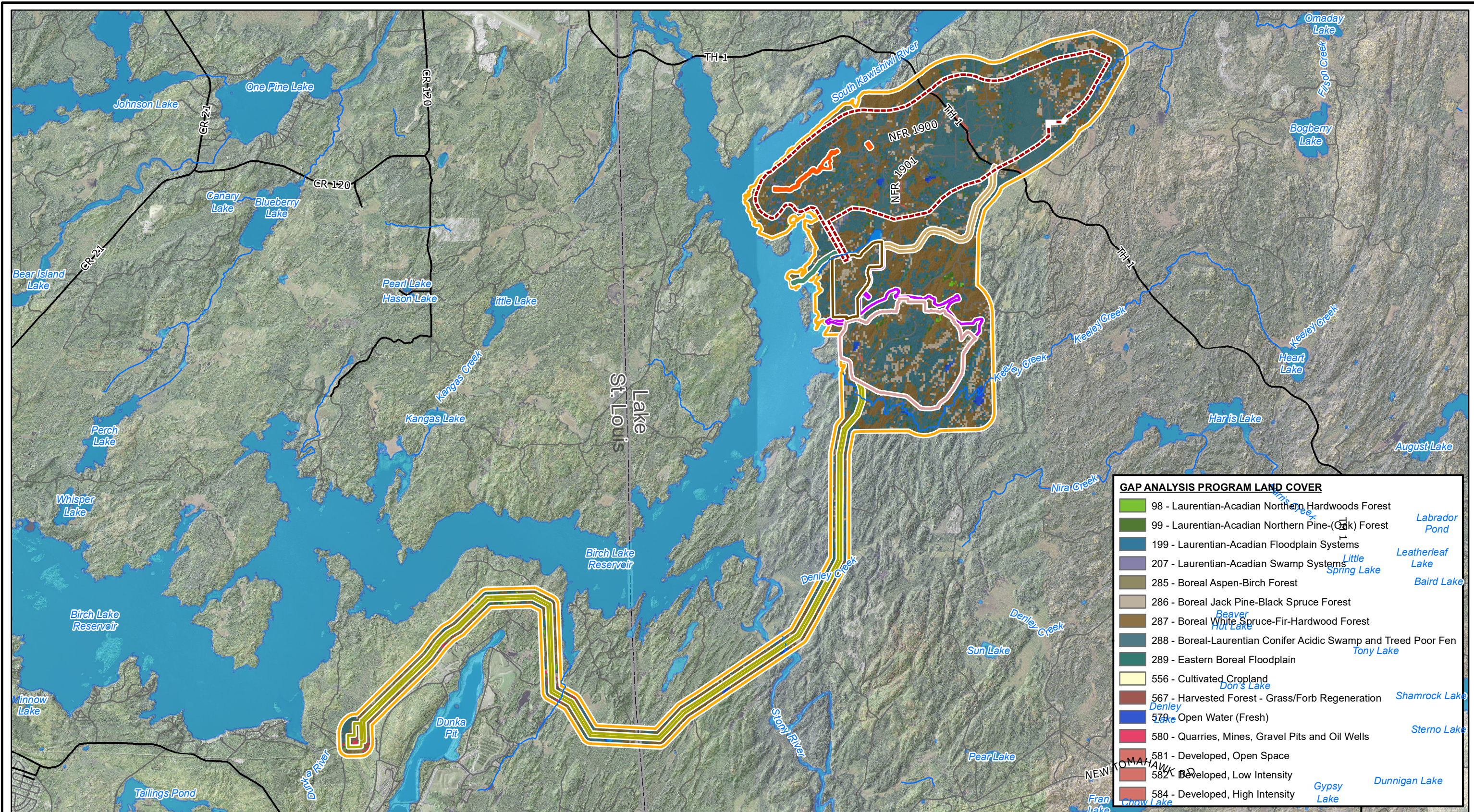
TWIN METALS MINNESOTA

FIGURE 8-1

ECOLOGICAL CLASSIFICATION SYSTEM SUBSECTIONS

Scale: 0 2,500 5,000 Feet

Date: SEPTEMBER 2019



NOTES:

1. Base air photo from the U.S. Department of Agriculture Farm Service Agency, Aerial Photography Field Office.
2. Hydrographic data from Minnesota Department of Natural Resources.
3. Horizontal datum based on NAD 1983. Horizontal coordinates based on Minnesota State Plane North (feet).
4. GAP Land Cover data downloaded from the U.S. Geological Survey. <https://www.usgs.gov/core-science-systems/science-analytics-and-synthesis/gap/science/land-cover>

LEGEND

Primary Road	Underground Mine Area	Transmission Corridor
Secondary Road	County Boundary	Water Intake Corridor
River/Stream	Plant Site	Ventilation Raises and Ventilation Raise Access Road
Lake/Pond	Tailings Management Site	Access Road Corridor
Project Area	Non-Contact Water Diversion Area	

TWIN METALS MINNESOTA

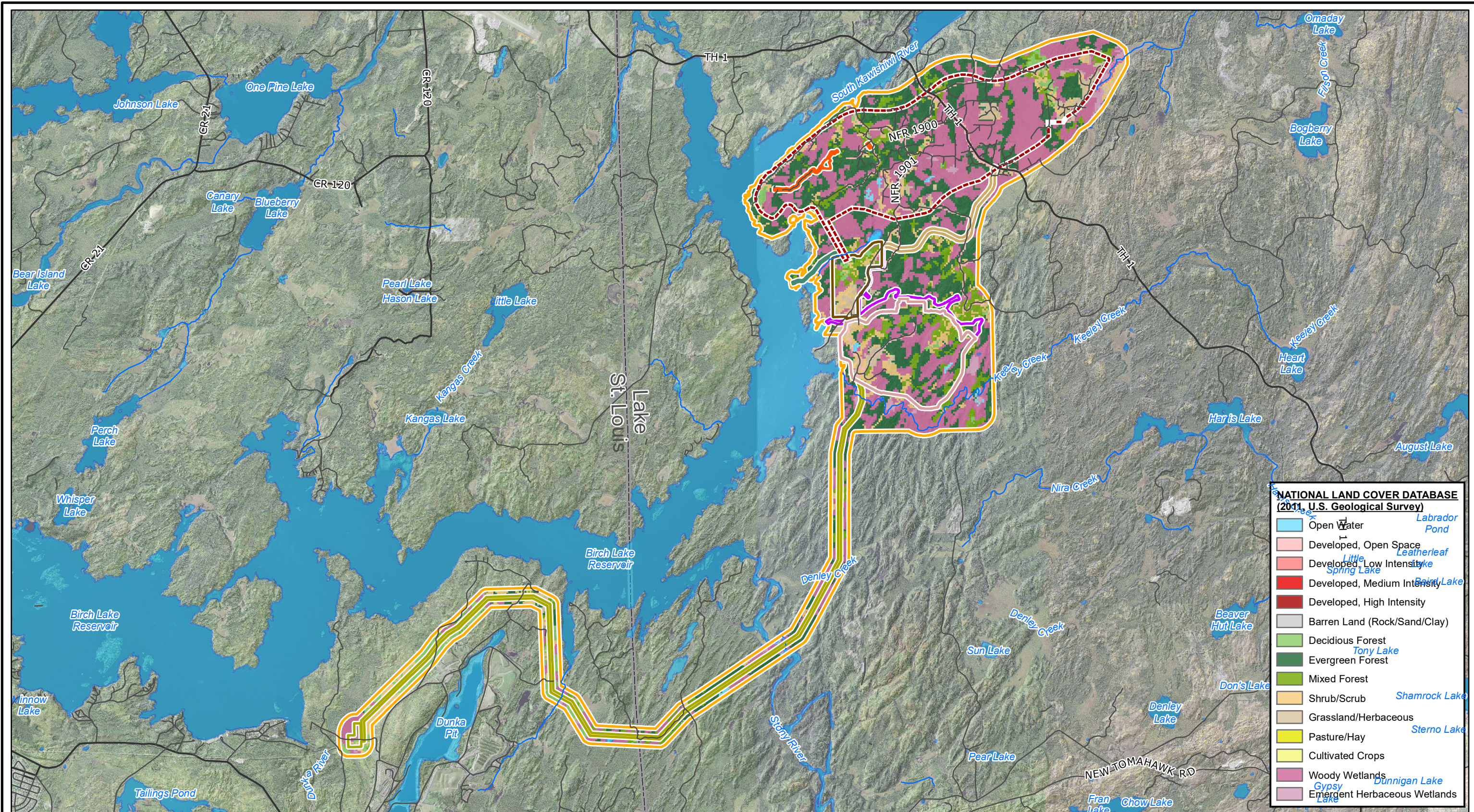
FIGURE 8-2

U.S. GEOLOGICAL SURVEY NATIONAL GAP ANALYSIS PROGRAM PROJECT LAND COVER

Scale: 0 2,500 5,000 Feet

Date: SEPTEMBER 2019





NOTES:

1. Base air photo from the U.S. Department of Agriculture Farm Service Agency, Aerial Photography Field Office.
2. Hydrographic data from Minnesota Department of Natural Resources.
3. Horizontal datum based on NAD 1983. Horizontal coordinates based on Minnesota State Plane North (feet).
4. National Land Cover Database classification data downloaded from the U.S. Geological Survey. <https://catalog.data.gov/dataset/usgs-national-land-cover-dataset-nlcd-downloadable-data-collection>

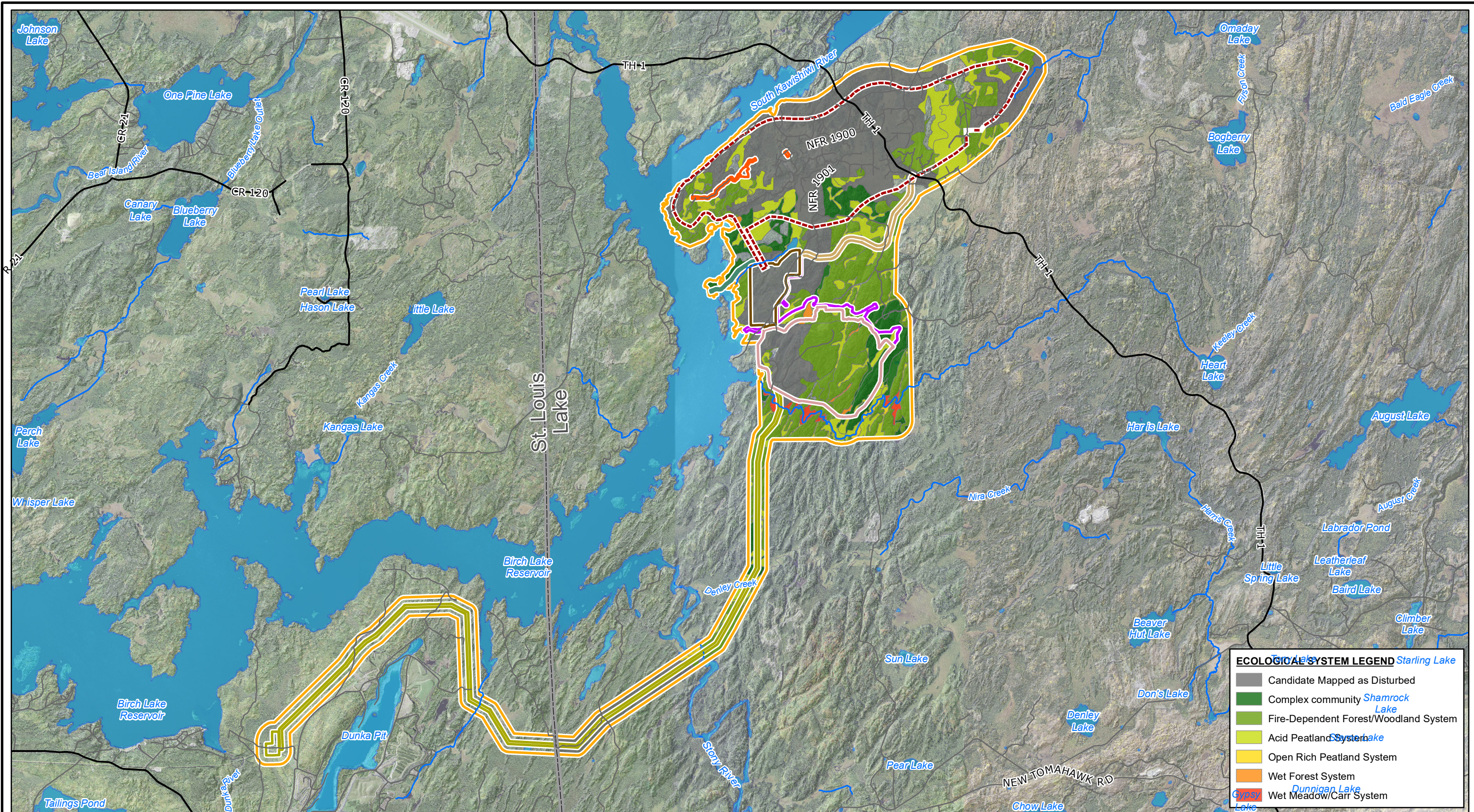
LEGEND			
	Primary Road		Project Area
	Secondary Road		Underground Mine Area
	River/Stream		Plant Site
	Lake/Pond		Tailings Management Site
	County Boundary		Non-Contact Water Diversion Area
	Transmission Corridor		Water Intake Corridor
	Ventilation Raises and Ventilation Raise Access Road		Access Road Corridor



TWIN METALS MINNESOTA

FIGURE 8-3
U.S. GEOLOGICAL SURVEY
NATIONAL LAND COVER DATABASE
LAND COVER

Scale: 0 2,500 5,000 Feet
Date: SEPTEMBER 2019



NOTES:

1. Base air photo from the U.S. Department of Agriculture Farm Service Agency, Aerial Photography Field Office.
2. Hydrographic and Minnesota Biological Survey (MBS) data from Minnesota Department of Natural Resources.
3. Horizontal datum based on NAD 1983. Horizontal coordinates based on Minnesota State Plane North (feet).

- LEGEND**
- | | | |
|-------------------|------------------------------------|--|
| — Primary Road | --- Underground Mine Area | — Transmission Corridor |
| — Secondary Road | — Plant Site | — Water Intake Corridor |
| — River/Stream | — Tailings Management Site | — Ventilation Raises and Ventilation Raise Access Road |
| — Lake/Pond | — Non-Contact Water Diversion Area | — Access Road Corridor |
| — County Boundary | | |
| — Project Area | | |

ECOLOGICAL SYSTEM LEGEND

— Candidate Mapped as Disturbed	— Shamrock Lake
— Complex community	— Shamrock Lake
— Fire-Dependent Forest/Woodland System	— Shamrock Lake
— Acid Peatland System	— Shamrock Lake
— Open Rich Peatland System	— Shamrock Lake
— Wet Forest System	— Shamrock Lake
— Wet Meadow/Carr System	— Shamrock Lake



TWIN METALS MINNESOTA

FIGURE 8-4

MINNESOTA BIOLOGICAL SURVEY DATA

Scale: 0 2,500 5,000 Feet

Date: SEPTEMBER 2019

Copyright 2017, State of Minnesota, Department of Natural Resources (DNR). Rare Features Data included here were provided by the Division of Ecological and Water Resources, Minnesota DNR, and were current as of October 2018. These data are not based on an exhaustive inventory of the state. The lack of data for any geographic area shall not be construed to mean that no significant features are present.

CRITICAL HABITAT AND NHIS LEGEND

Gray Wolf Critical Habitat

Canada Lynx Critical Habitat

Protection Status

Special Concern

Threatened

CR 21

NOTES:

1. Base air photo from the U.S. Department of Agriculture Farm Service Agency, Aerial Photography Field Office.
2. Hydrographic data from Minnesota Department of Natural Resources.
3. Horizontal datum based on NAD 1983. Horizontal coordinates based on Minnesota State Plane North (feet).
4. Rare Features Data included here were provided by the Division of Ecological and Water Resources, Minnesota Department of Natural Resources. (See Copyright Statement above)
5. Critical Habitat Data downloaded from U.S. Fish and Wildlife Service. <https://ecos.fws.gov/ecp/report/table/critical-habitat.html>

LEGEND

Primary Road

Secondary Road

River/Stream

Lake/Pond

County Boundary

Project Area

Underground Mine Area

Plant Site

Tailings Management Site

Non-Contact Water Diversion Area

Transmission Corridor

Water Intake Corridor

Ventilation Raises and Ventilation Raise Access Road

Access Road Corridor

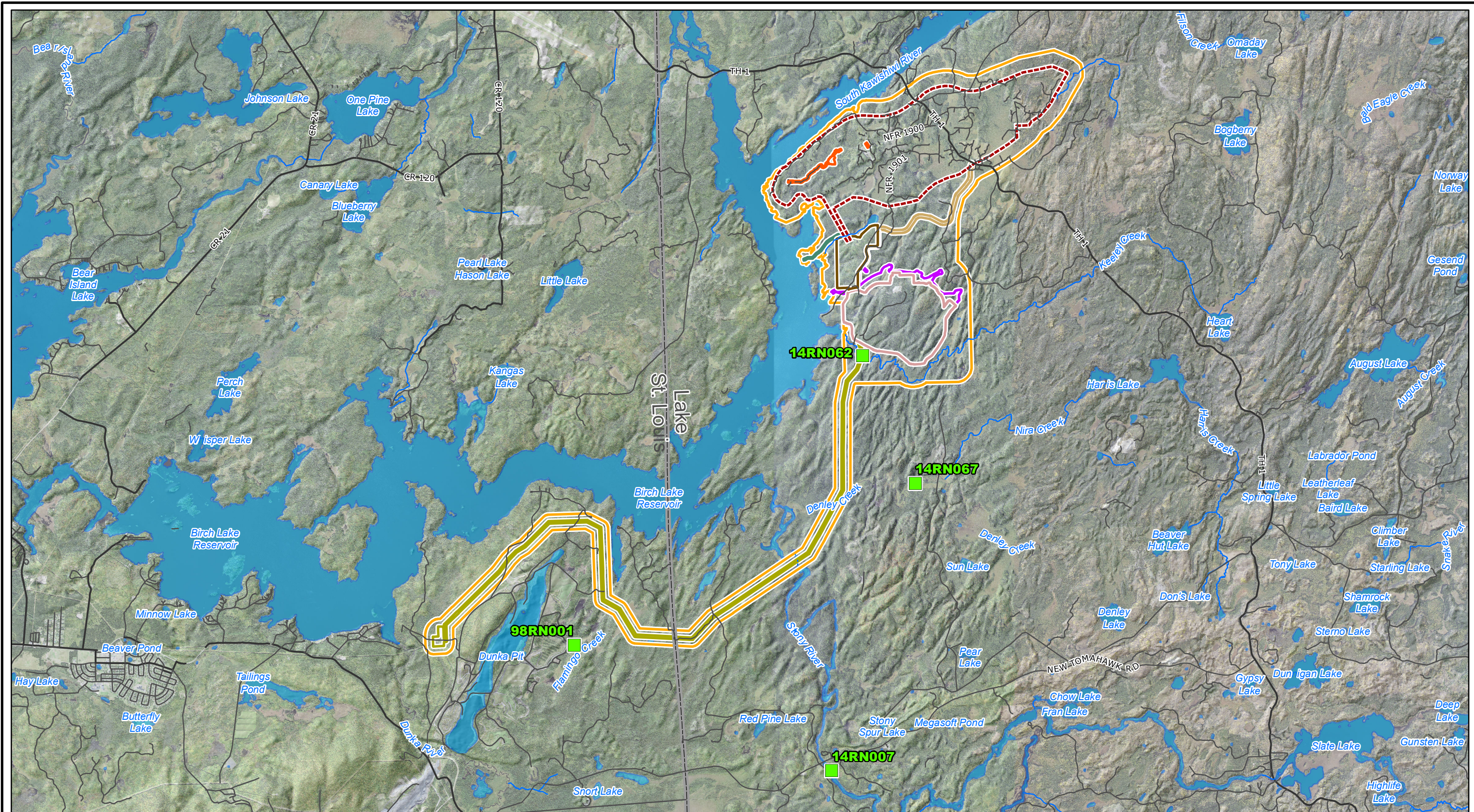
TWIN METALS MINNESOTA

FIGURE 8-5

VEGETATIVE AND TERRESTRIAL WILDLIFE NHIS DATA

Scale: 0 2,500 5,000 Feet

Date: SEPTEMBER 2019



NOTES:

1. Base air photo from the U.S. Department of Agriculture Farm Service Agency, Aerial Photography Field Office.
2. Hydrographic data from Minnesota Department of Natural Resources.
3. Horizontal datum based on NAD 1983. Horizontal coordinates based on Minnesota State Plane North (feet).

LEGEND

Minnesota Pollution Control Agency Stream Survey Site	Lake/Pond	Plant Site	Water Intake Corridor
Primary Road	County Boundary	Tailings Management Site	Ventilation Raises and Ventilation Raise Access Road
Secondary Road	Project Area	Non-Contact Water Diversion Area	Access Road Corridor
River/Stream	Underground Mine Area	Transmission Corridor	

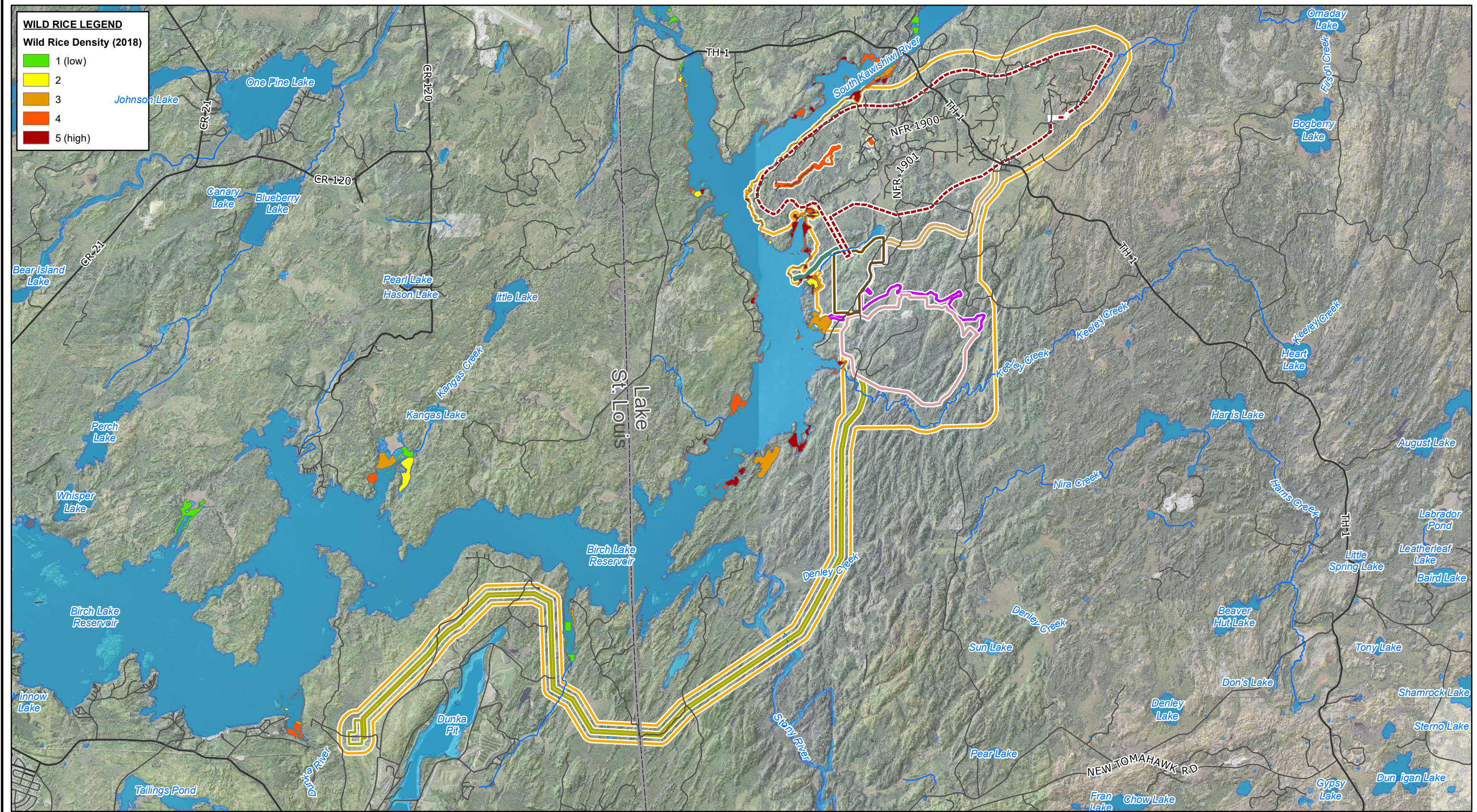
TWIN METALS MINNESOTA

FIGURE 8-6

MINNESOTA POLLUTION CONTROL AGENCY
STREAM SAMPLING STATIONS

Scale: 0 3,000 6,000 Feet

Date: SEPTEMBER 2019



NOTES:

1. Base air photo from the U.S. Department of Agriculture Farm Service Agency, Aerial Photography Field Office.
2. Hydrographic data from Minnesota Department of Natural Resources.
3. Wild rice survey data from Barr Engineering Co.
4. Horizontal datum based on NAD 1983. Horizontal coordinates based on Minnesota State Plane North (feet).

LEGEND

Primary Road	Project Area	Transmission Corridor
Secondary Road	Underground Mine Area	Water Intake Corridor
River/Stream	Plant Site	Ventilation Raises and Ventilation Raise Access Road
Lake/Pond	Tailings Management Site	Access Road Corridor
County Boundary	Non-Contact Water Diversion Area	

TWIN METALS MINNESOTA

FIGURE 8-7

WILD RICE SURVEYS

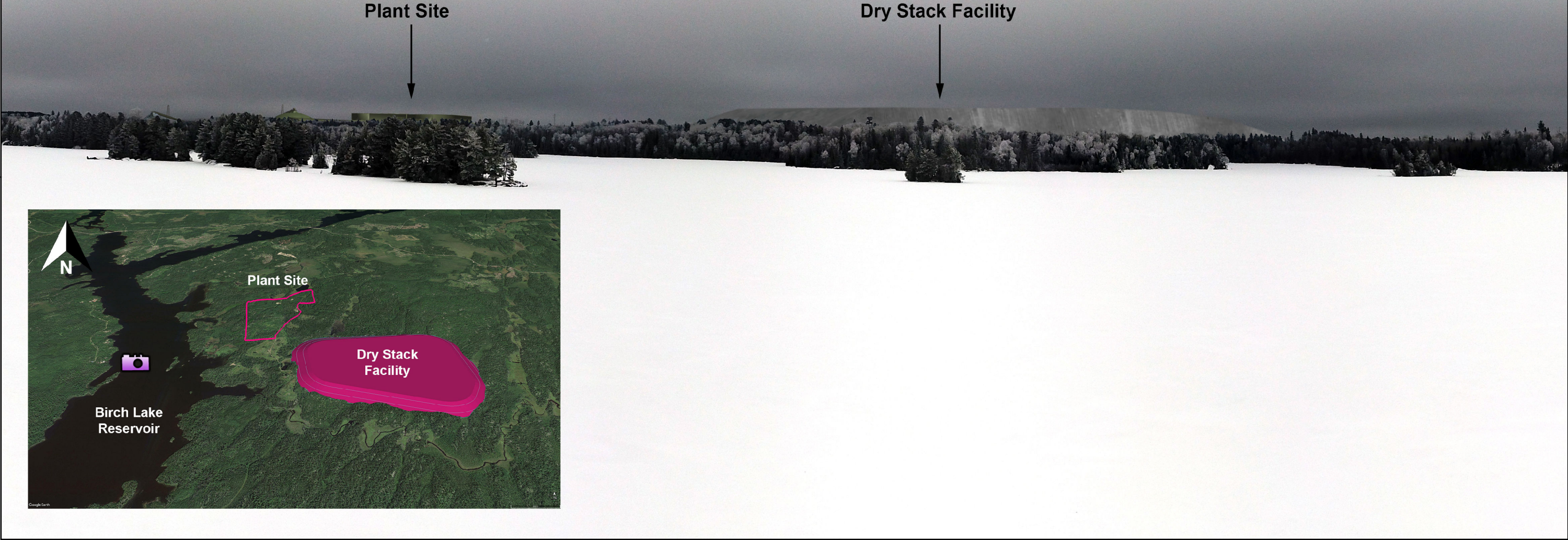
Scale: 0 2,500 5,000 Feet

Date: SEPTEMBER 2019

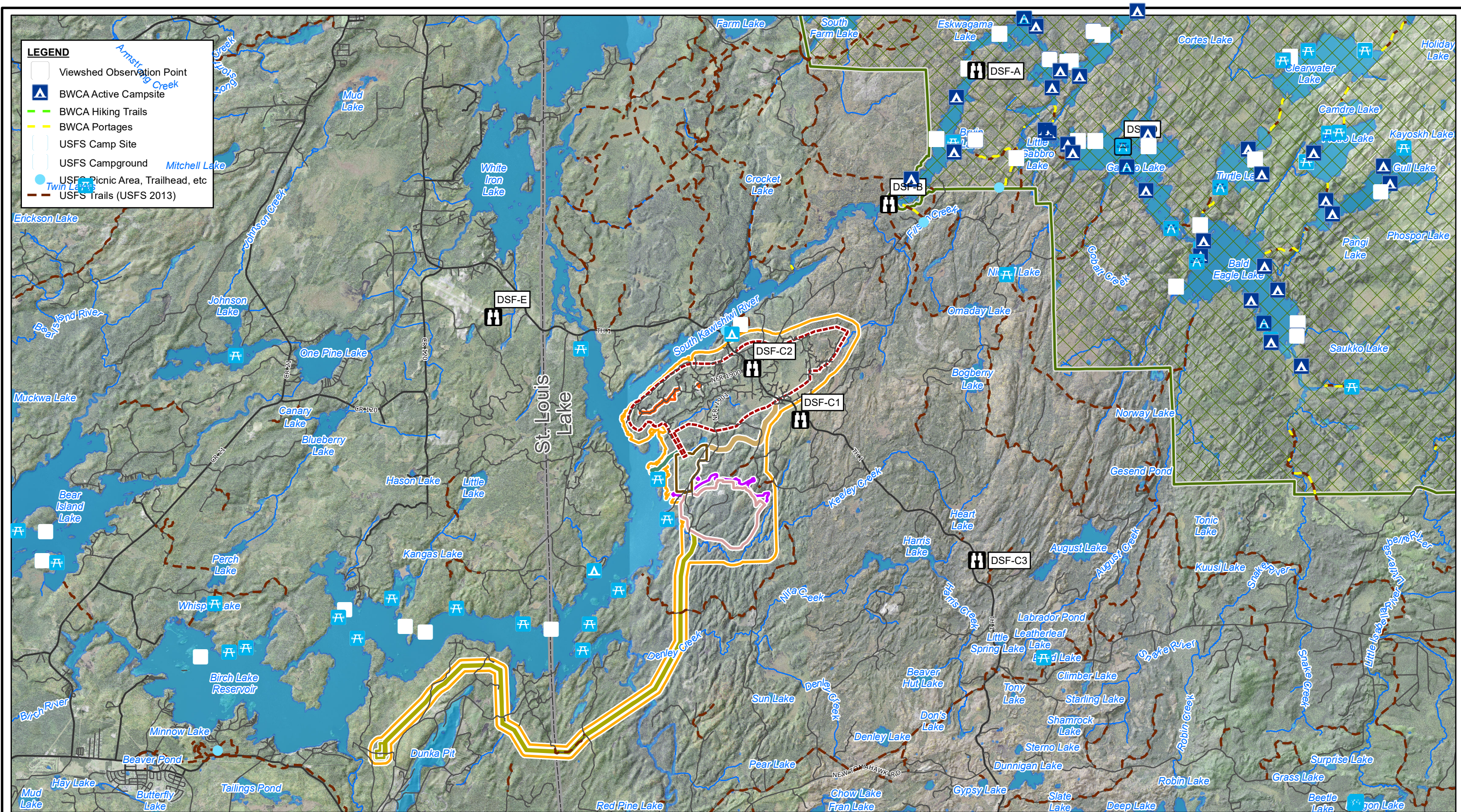
Twin Metals Minnesota

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Plant Site and Dry Stack Facility Visual Simulation



TWIN METALS MINNESOTA	
FIGURE 10-1	
VISUALIZATION SIMULATION	
Scale: NOT TO SCALE	Date: SEPTEMBER 2019



NOTES:

1. Base air photo from the U.S. Department of Agriculture Farm Service Agency, Aerial Photography Field Office.
2. Hydrographic data from Minnesota Department of Natural Resources.
3. Horizontal datum based on NAD 1983. Horizontal coordinates based on Minnesota State Plane North (feet).
4. Top of dry stack facility simulated at elevation 1,617.5 feet.

LEGEND

- | | | |
|---------------------------------------|----------------------------------|--|
| River/Stream | Underground Mine Area | Transmission Corridor |
| Lake/Pond | Plant Site | Water Intake Corridor |
| Boundary Waters Canoe Area Wilderness | Tailings Management Site | Ventilation Raises and Ventilation Raise Access Road |
| County Boundary | Non-Contact Water Diversion Area | Access Road Corridor |
| Project Area | | |

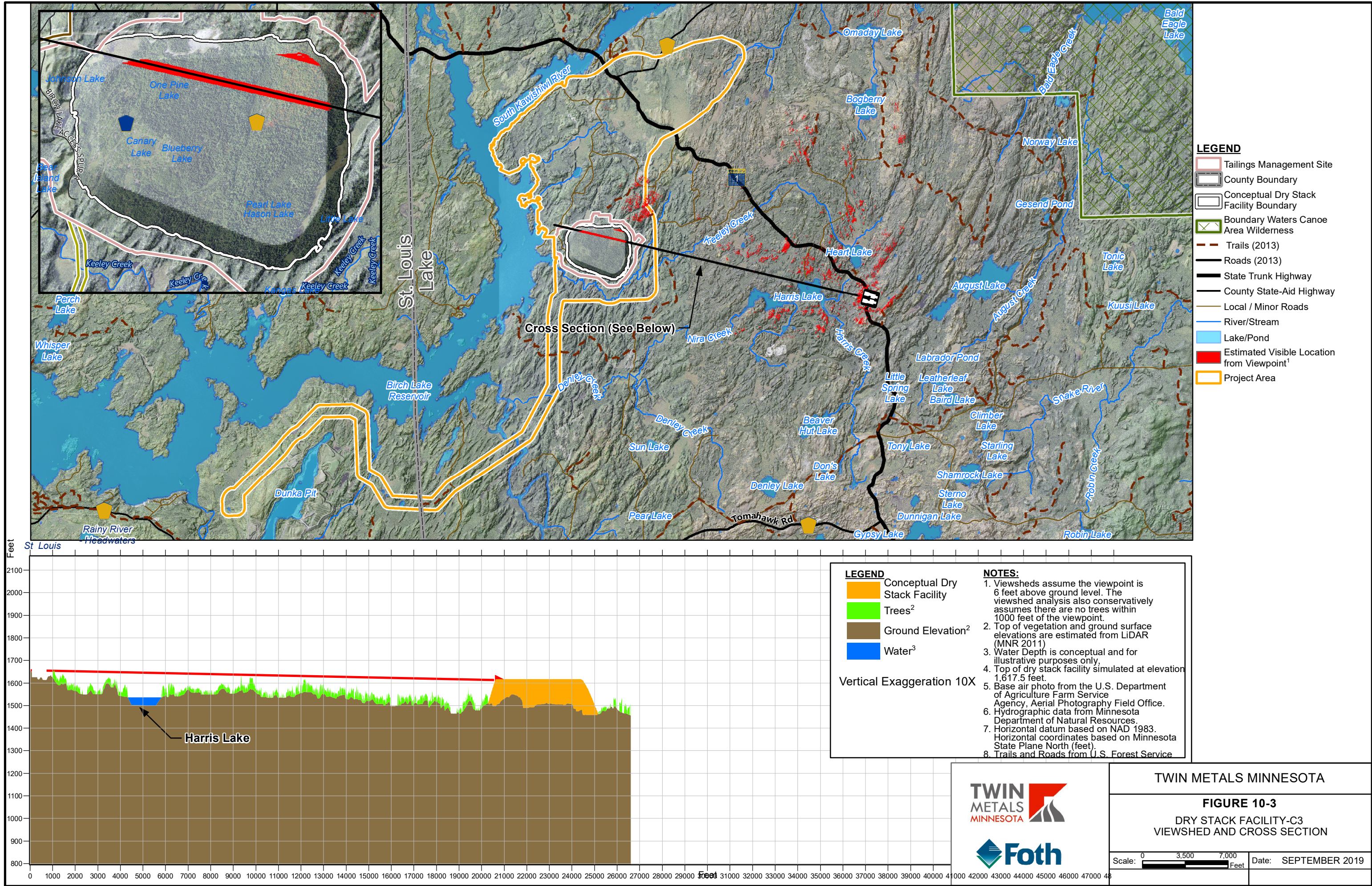


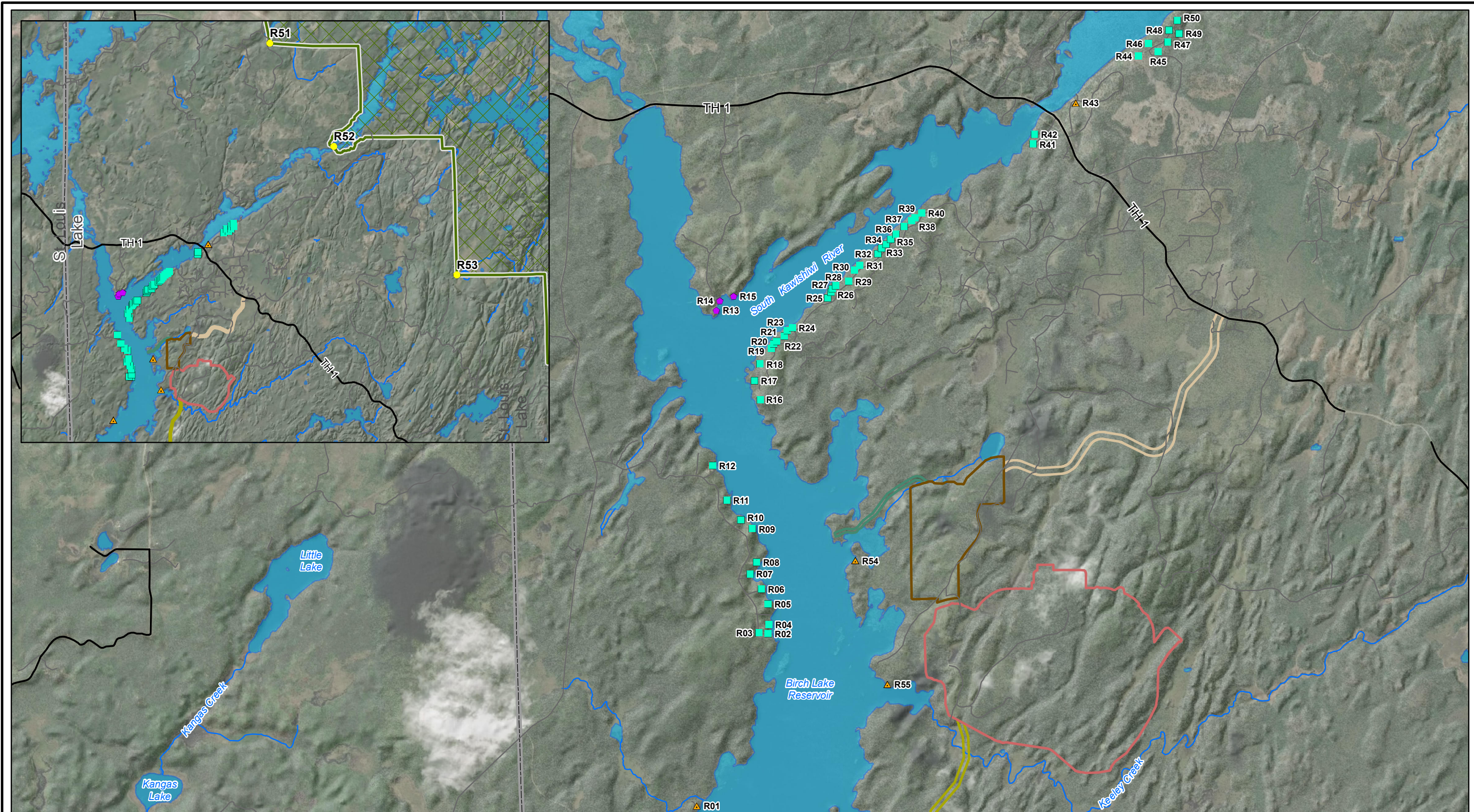
TWIN METALS MINNESOTA

FIGURE 10-2

VIEWSHED ANALYSIS LOCATIONS

Scale: 0 4,000 8,000 Feet Date: SEPTEMBER 2019





NOTES:
 1. Base air photo from Esri World Imagery map service.
 2. Horizontal datum based on NAD 1983. Horizontal coordinates based on Minnesota State Plane North (feet).
 3. Noise Receptors were supplied by HEI.

LEGEND	
● Boundary Waters	— Primary Road
▲ Recreation	— Secondary Road
■ Residence	— River/Stream
◆ Resort	 Plant Site
	 Tailings Management Site
	 Transmission Corridor
	 Water Intake Corridor
	 Access Road Corridor
	 Lake/Pond
	 County Boundary
	 Boundary Waters Canoe Area Wilderness

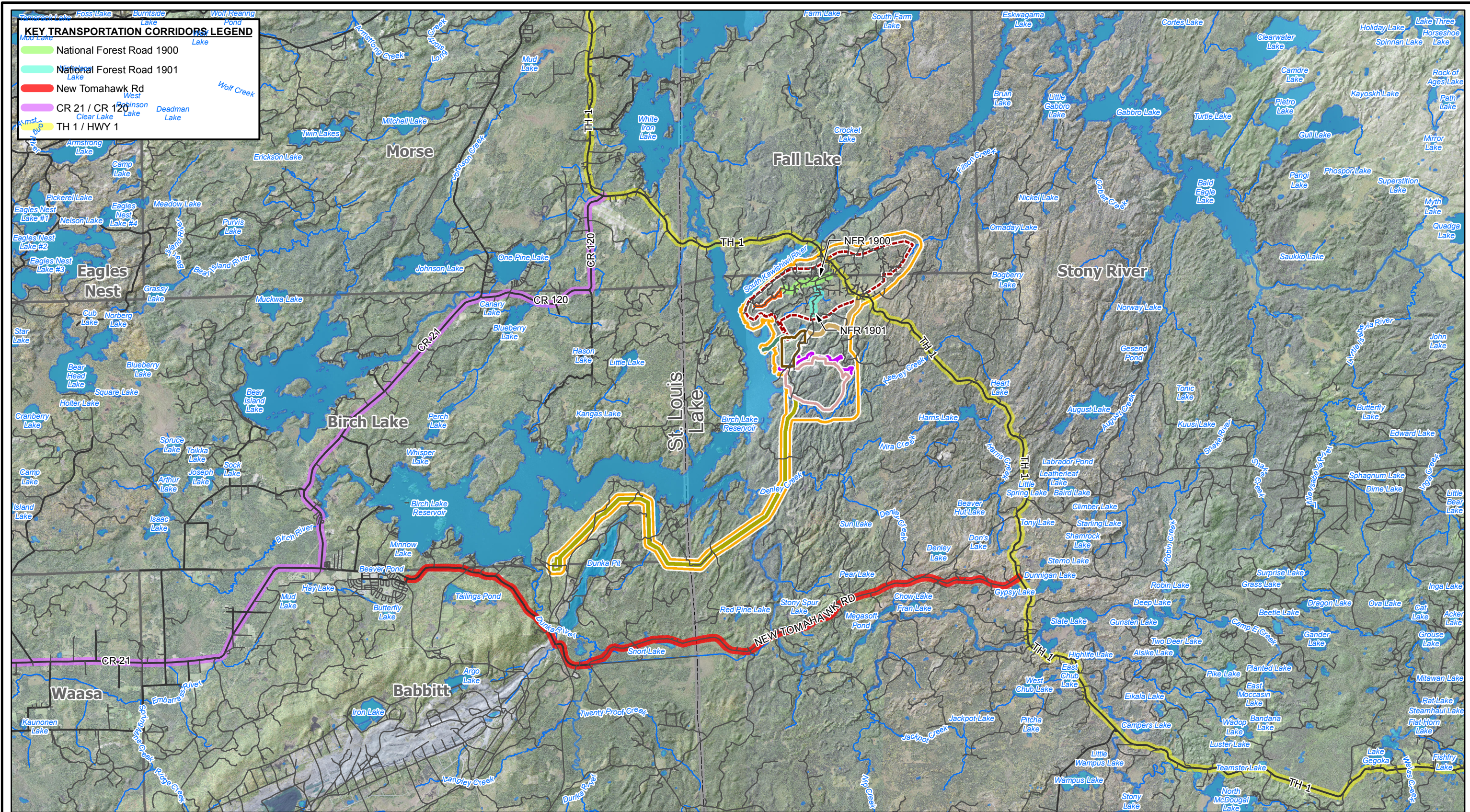


TWIN METALS MINNESOTA

FIGURE 12-2

SENSITIVE RECEPTORS - NOISE

Scale: 0 0.25 0.5 Miles Date: SEPTEMBER 2019



NOTES:

1. Base air photo from the USDA Farm Service Agency, Aerial Photography Field Office.
2. Project related facilities and road data supplied by Twin Metals Minnesota
3. Hydrographic data from MDNR.
4. Horizontal datum based on NAD 1983. Horizontal coordinates based on Minnesota State Plane North (feet).

LEGEND

Primary Road	Non-Contact Water Diversion Area	Municipal Boundary
Secondary Road	Transmission Corridor	County Boundary
River/Stream	Water Intake Corridor	Project Area
Lake/Pond	Ventilation Raises and Ventilation Raise Access Road	Underground Mine Area
Plant Site	Access Road Corridor	
Tailings Management Site		

TWIN METALS MINNESOTA

FIGURE 13-1

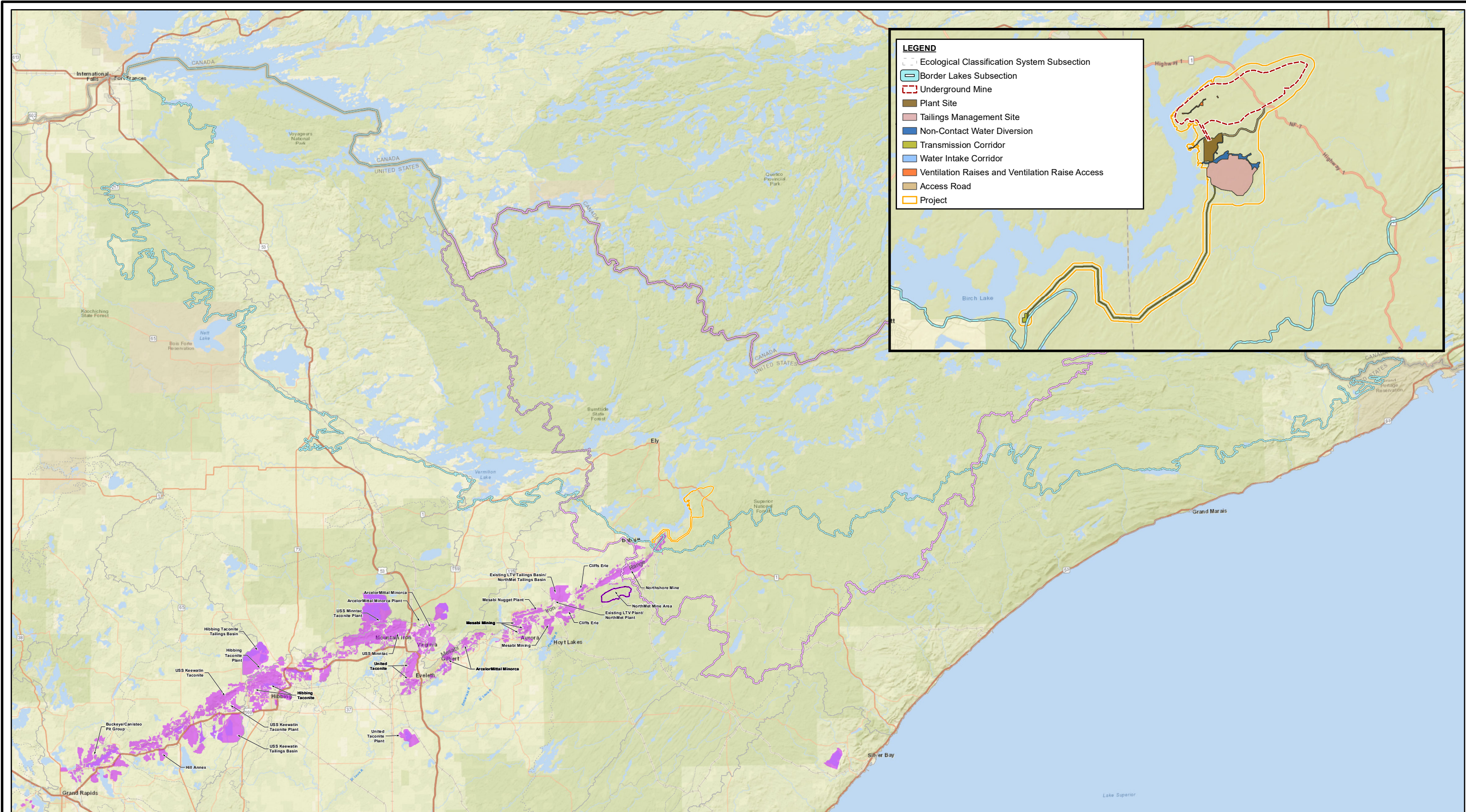
KEY TRANSPORTATION CORRIDORS

Scale: 0 1 2 Miles

Date: SEPTEMBER 2019

TWIN METALS MINNESOTA

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LEGEND

- Ecological Classification System Subsection
- Border Lakes Subsection
- Underground Mine
- Plant Site
- Tailings Management Site
- Non-Contact Water Diversion
- Transmission Corridor
- Water Intake Corridor
- Ventilation Raises and Ventilation Raise Access
- Access Road
- Project

- NOTES**
1. Basemap from Esri and its data suppliers.
 2. Watershed and Ecological Classification System data from the Minnesota Department of Natural Resources.
 3. Mining related data from Minnesota Department of Natural Resources Division of Lands and Minerals via email.
 4. Horizontal datum based on NAD 1983. Horizontal coordinates based on Minnesota State Plane North (feet).

LEGEND

- Project Area
- Mesabi Range Mining Features (Existing Pits, Tailings Basins, Stockpiles and other Mine Features)
- Major Watershed Boundaries
- Rainy River - Headwaters Watershed
- Ecological Classification System Subsection Boundaries
- Border Lakes Subsection



TWIN METALS MINNESOTA

FIGURE 14-1

PROJECT CUMULATIVE EFFECTS WATERSHED AND ECOLOGICAL CLASSIFICATION SYSTEM SUBSECTION

Scale: 0 5 10 Miles

Date: SEPTEMBER 2019